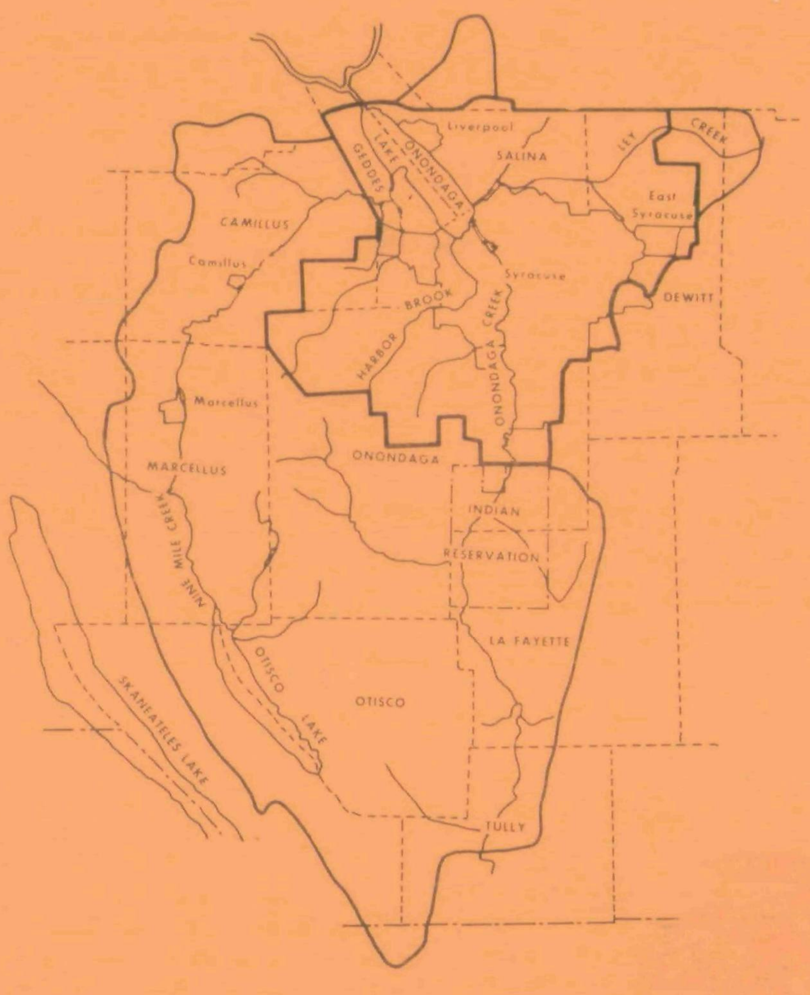
ENVIRONMENTAL IMPACT STATEMENT ON WASTEWATER TREATMENT FACILITIES CONSTRUCTION GRANTS FOR THE ONONDAGA LAKE DRAINAGE BASIN

Final

May 1974



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ENVIRONMENTAL IMPACT STATEMENT ON THE WASTEWATER TREATMENT FACILITIES CONSTRUCTION GRANTS FOR THE ONONDAGA LAKE DRAINAGE BASIN

FINAL
MAY 1974

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ENVIRONMENTAL IMPACT STATEMENT ON THE
WASTEWATER TREATMENT FACILITIES CONSTRUCTION GRANTS FOR
THE ONONDAGA LAKE DRAINAGE BASIN

SUMMARY

DATE: May 1974.

TYPE OF STATEMENT:

Final.

RESPONSIBLE FEDERAL AGENCY:

U.S. Environmental Protection Agency, Region II.

TYPE OF ACTION:

Administrative.

DESCRIPTION OF ACTION:

This environmental impact statement deals with two related projects. Funds have been requested from the U.S. Environmental Protection Agency (EPA) by the Onondaga County Department of Public Works in the State of New York for the expansion and upgrading of the existing Metropolitan Syracuse sewage treatment plant (MSSTP). The first project (C-36-659) involves the expansion and upgrading of the existing plant from a 189,000 cu m/day (50 mgd) primary treatment facility to a 327,000 cu m/day (86.5 mgd) advanced waste treatment facility (phosphorus removal) and the construction of a new shoreline outfall to Onondaga Lake.

The second project, which involves construction of force mains and additions and alterations to the existing West Side Pumping Station (C-36-692), has been funded by the EPA. However, the grant was made contingent upon the outcome of an environmental review as required by the

National Environmental Policy Act (NEPA).

(See DESCRIPTION OF THE PROPOSED PROJECTS).

SUMMARY OF ENVIRONMENTAL IMPACT AND ADVERSE ENVIRONMENTAL EFFECTS:

The beneficial effects of the proposed projects will be: 1) the reduction of BOD and suspended solids loadings to Onondaga Lake, 2) the reduction of phosphorus loadings to Onondaga Lake, and 3) the elimination of the visible calcium carbonate precipitation that now occurs in the Geddes Brook-Nine Mile Creek system.

The adverse effects of the proposed projects will be: 1) the possibility of a visible plume occurring when the MSSTP effluent mixes with Onondaga Lake waters, 2) the shortening of the useful life of the Allied Chemical Corporation's three existing settling lagoons, 3) the creation of a temporary noise pollution problem by the pile driving operations during construction at the MSSTP site, and 4) the permanent loss of approximately 1.2 ha (3 acres) of Onondaga Lake along its southwestern shoreline. In addition, the lack of nitrogen removal facilities at the MSSTP will allow continued nitrogen loadings to Onondaga Lake.

It was noted in the draft environmental impact statement that the formation of a visible plume by the MSSTP discharge would contravene New York State Department of Environmental Conservation (NYSDEC) water quality standards. New York State's water quality standards have since been revised such that only a substantial visible plume would violate the standards. (See Appendix A). (See ENVIRONMENTAL IMPACT OF THE PROPOSED PROJECTS and ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSED PROJECTS BE IMPLEMENTED).

ALTERNATIVES CONSIDERED:

New York State's water quality management plan for the Onondaga Lake drainage basin was divided into four components: collection system, treatment system, effluent disposal system, and sludge disposal system. Each of these systems and the alternatives available within each system were evaluated. On the basis of these evaluations, proposed alternatives were selected. In addition, the alternative of taking no action was evaluated and found unacceptable.

Collection System:

The service area for the proposed project is basically the same as that outlined in a sewerage plan that was developed for Onondaga County in 1968. Since enlargment of the service area is not part of the proposed project, the size of the existing collection system is not affected. Consequently, there are no collection system alternatives per se. However, the improvement of a portion of the collection system is the focus of the West Side Pumping Station and Force Main project.

Two alternative routes for the West Side Force Main were analyzed, the proposed lake route and an inland route. The implementation of either alternative would accomplish the transfer of raw sewage from the West Side Pumping Station to the MSSTP. However, the inland route is disadvantageous because it involves placement of the force main in the right-of-way of an interstate highway. The New York State Department of Transportation prohibits such occupancy.

Treatment System:

Treatment system alternatives were broken down into secondary and advanced waste treatment categories. The secondary treatment systems considered were:

1. Contact stabilization modification of the activated sludge process (proposed),
2. Trickling filters,
3. Wastewater stabilization lagoons,
4. Physical-chemical treatment using upflow clarifiers and carbon columns.

The most important factors in the choice of a secondary treatment alternative for the MSSTP were land availability, soil support capabilities, and process operation reliability.

The advanced waste treatment systems considered were:

1. Phosphorus removal using commercial lime in addition to the Allied Chemical Corporation's settling lagoon overflow (proposed),
2. Phosphorus removal using commercial lime only,
3. Phosphorus removal using alum with polymers,
4. Phosphorus removal using ferric chloride with polymers.

Low operating costs make the use of Allied's settling lagoon overflow in the advanced waste treatment system economically preferable.

Effluent Disposal System:

The following effluent disposal systems were considered:

1. Discharge to Onondaga Lake via a surface outfall (proposed),
2. Discharge to Onondaga Lake via a subsurface outfall,
3. Discharge to the Onondaga Lake outlet,
4. Discharge to the Seneca River,
5. Discharge to Lake Ontario,
6. Ground-water recharge via spray irrigation,
7. Ground-water recharge via deep-well injection.

Onondaga Lake is the obvious choice for receiving water body because of its proximity to the MSSTP. Discharge to any of the other surface water bodies listed above would markedly increase both the construction and operating costs of the project. The ground-water recharge alternatives were rejected for both environmental and economic reasons.

Sludge Disposal System:

The sludge disposal system was divided into four subsystems: conditioning, stabilization, dewatering, and final disposal. Alternatives within each of these subsystems were considered:

1. Conditioning
   a. Gravity thickening (proposed),
   b. Flotation thickening;
2. Stabilization
   a. Anaerobic digestion (proposed),
   b. Aerobic digestion,
   c. Chemical stabilization,
   d. Pyrolysis;
3. Dewatering
   a. None except for standby centrifuges and sludge storage lagoons (proposed),
   b. Centrifuges and sludge storage lagoons,
   c. Vacuum filters,
   d. Filter presses;
4. Final Disposal
   a. Allied Chemical Corporation's settling lagoons (proposed),
   b. Incineration and landfill,
   c. Land spreading,
   d. Landfill.

(See OBJECTIVES OF THE WATER QUALITY MANAGEMENT PLAN and ALTERNATIVES TO THE PROPOSED PROJECTS).

FEDERAL, STATE, AND LOCAL AGENCIES FROM WHICH COMMENTS HAVE BEEN REQUESTED:

Federal Agencies:

Department of Agriculture

Agricultural Stabilization and Research Service

Soil Conservation Service

Department of Defense

U.S. Army Corps of Engineers (Buffalo District)

Department of Health, Education and Welfare

Department of the Interior

Bureau of Outdoor Recreation

Bureau of Sport Fisheries and Wildlife

U.S. Geological Survey

Environmental Protection Agency

Process Technology Branch; Municipal Wastewater Systems Division

Rochester Field Office - Region II

United States Senate

Honorable Jacob Javits

Honorable James Buckley

United States House of Representatives

Honorable James Hanley

Honorable William Walsh

State Agencies:

Central New York Regional Planning and Development Board

New York State Department of Environmental Conservation

New York State Office of Planning and Development

County Agencies:

Onondaga County Department of Public Works

Onondaga County Environmental Management Council

Onondaga County Health Department

Syracuse-Onondaga County Planning Agency

Other:

New York Pure Water Association

O'Brien & Gere Engineers, Inc.

Onondaga Lake Reclamation Association, Inc.

Onondaga Audubon Society, Inc.

Sierra Club, Atlantic Chapter, Iroquois Group

DESCRIPTION OF THE PROPOSED PROJECTS

C-36-659: Metropolitan Syracuse Sewage Treatment Plant
Status: Final Design Completed

The MSSTP serves the City of Syracuse and the surrounding area. The most highly developed portions of the Onondaga Lake drainage basin are within the MSSTP service area. In 1970, there were approximately 261,000 persons residing in the service area. A population of about 343,000 is projected for the year 2000.

The MSSTP was built in 1960 as a 189,000 cu m/day (50 mgd) primary treatment plant. In addition to sewage flows from its own service area, the MSSTP receives the effluent from the Ley Creek sewage treatment plant (LCSTP). The MSSTP currently experiences severe hydraulic overloads: influent flows are on the order of 265,000 cu m/day (70 mgd). The MSSTP effluent is discharged into Onondaga Lake. Overloading and the relatively low treatment efficiencies provided by the primary treatment system are largely responsible for the highly degraded and eutrophic condition of Onondaga Lake.

The proposed project will expand and upgrade the existing MSSTP to a 327,000 cu m/day (86.5 mgd) advanced waste treatment facility (phosphorus removal). The project also provides for the construction of a new shoreline outfall to Onondaga Lake. The proposed primary and secondary facilities are designed to accommodate a flow of 300,000 cu m/day (80 mgd). The contact stabilization modification of the activated sludge process will be used in the secondary facilities.

The advanced waste treatment process (AWT) will consist of chemical precipitation of phosphorus-bearing compounds and their physical removal by sedimentation. In the AWT units, the MSSTP secondary effluent will be combined with the Allied Chemical Corporation's settling lagoon overflow (Discharge Serial No. 003, Refuse Act Permit Program application). The high calcium concentration of the settling lagoon overflow is expected to insure that the desired phosphate precipitation reactions occur in the AWT units. The AWT units will receive approximately 300,000 cu m/day (80 mgd) of secondary effluent and 27,000 cu m/day (6.5 mgd) of settling lagoon overflow.

The proposed project will increase the biochemical oxygen demand (BOD) and the suspended solids removal efficiencies to approximately 93 percent and 84 percent, respectively. These percentages represent average loadings to Onondaga Lake of 4580 kg/day (10,100 lb/day) BOD and 9810 kg/day (21,600 lb/day) suspended solids. The present BOD and suspended solids loadings exerted by the MSSTP are 27,000 kg/day (60,000 lb/day) and 18,000 kg/day (39,000 lb/day), respectively. The marked reductions in both BOD and suspended solids loadings that will be accomplished by the improved MSSTP will have a significant beneficial effect on the lake environment.

The present phosphorus loading exerted by the MSSTP is 1000 kg/day (2200 lb/day). With the proposed project, the total phosphorus concentration of the MSSTP effluent will be reduced to 1.0 mg/l or less. At a flow rate of 327,000 cu m/day (86.5 mgd), the average phosphorus loading exerted by the MSSTP will be 330 kg/day (720 lb/day) or less.

As of May 1974, the estimated total cost of the proposed project was $111,469,000. Part of this cost, $107,646,000 to be exact, is eligible for Federal funding. Current regulations set the Federal share at 75 percent of the eligible costs. Therefore, the EPA grant will amount to $80,734,500. A summary of the eligible and total costs for each portion of the proposed project is presented in Table 1.

C-36-692: West Side Pumping Station and Force Main
Status: Construction Grant Awarded Subject to Requirements of NEPA

On March 1, 1973, the U.S. Environmental Protection Agency awarded a wastewater treatment facilities construction grant to the Onondaga County Department of Public Works for the construction of force mains and additions and alterations to the existing West Side Pumping Station (U.S. EPA, 1973a). This grant was made contingent upon the outcome of an environmental impact statement as required by NEPA.

The West Side Pumping Station will be expanded from its present maximum capacity of 38,000 cu m/day (10 mgd) to 106,000 cu m/day (28 mgd). Two force mains will be installed: a 91 cm (36 in.) diameter raw sewage force main from the pumping station to the MSSTP, and a 30 cm (12 in.) diameter sludge disposal force main from the MSSTP to the Allied Chemical Corporation.

The funds allocated for the different portions of this project are summarized in Table 1. The estimated total cost of the project is $5,313,400. The amount eligible for Federal funding is $5,213,400. The EPA grant awarded on March 1, 1973 will finance 75 percent of the eligible costs, or $3,910,050.

TABLE 1

FINANCIAL SUMMARIES FOR THE PROPOSED PROJECTS

MSSTP:C-36-659

Cost Classification	Total Cost	Eligible Cost[1/]
Administrative expenses	1,352,837	1,311,667
Land, structures, right-of-way	316,000	---------
Architectural and engineering fees	10,571,385	10,141,737
Construction and project improvement cost	90,270,980	87,447,980
Contingencies	9,020,798	8,744,616
Totals	111,469,000	107,646,000

Source of Proposed Funds	Amount of Grant
EPA Grant	80,734,500
State Grant	13,455,750
Local Funds	17,278,750
Total	111,469,000

West Side Pumping Station and Force Main: C-36-692

Cost Classification	Total Cost	Eligible Cost[1/]
Administrative expenses	63,800	63,800
Land, structures, right-of-way	100,000	------
Architectural and engineering fees	474,605	474,605
Construction and project improvement cost	4,250,000	4,250,000
Contingencies	425,000	425,000
Totals	5,313,405	5,213,405

Source of Proposed Funds	Amount of Grant
EPA Grant	3,910,054
State Grant	651,675
Local Funds	751,676
Total	5,313,405

1/The eligible cost is that portion of the total project cost which is considered eligible for Federal funding.

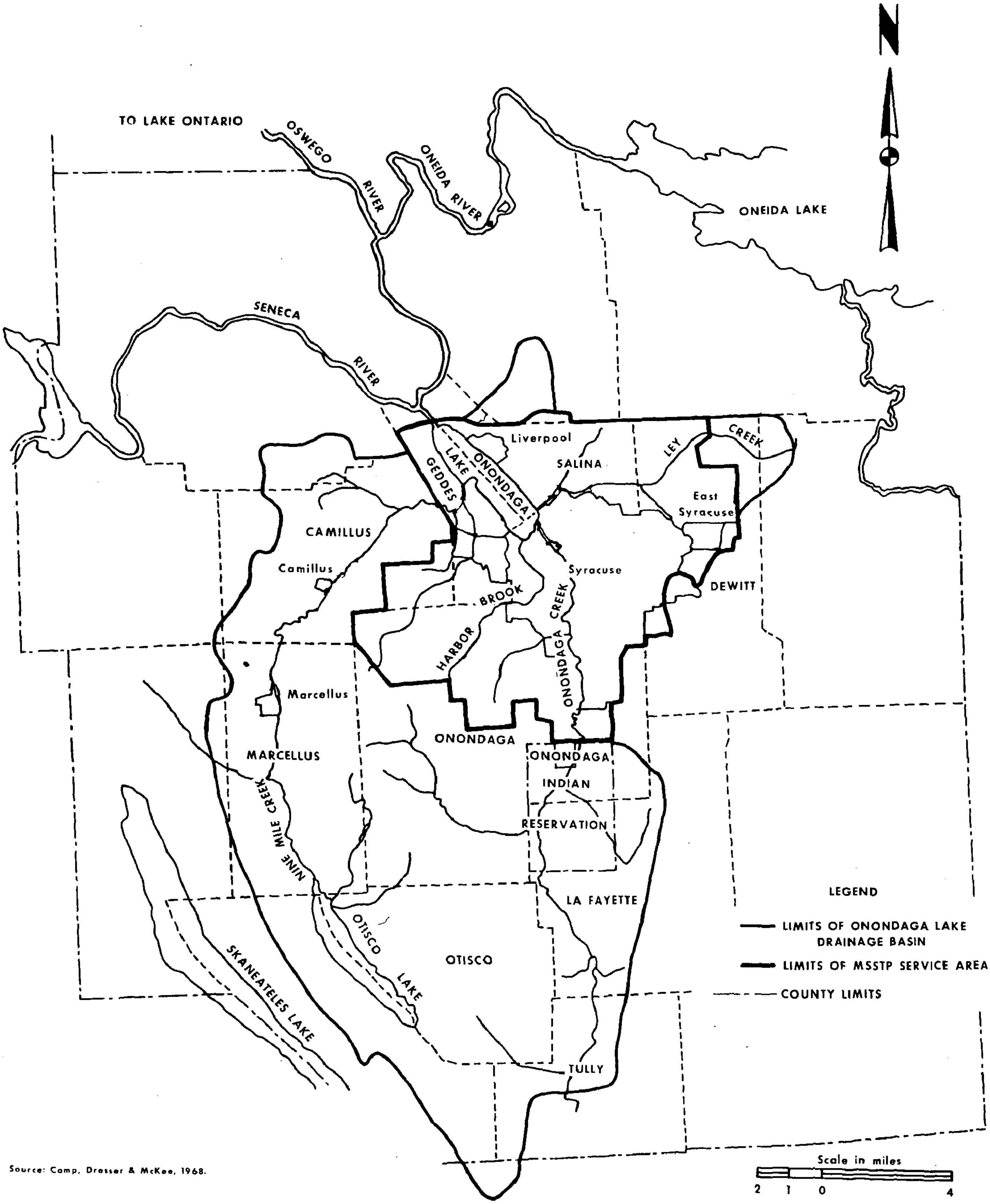
BACKGROUND

GENERAL DESCRIPTION OF THE PROJECT AREA

The Syracuse metropolitan area lies in central upstate New York. Syracuse is approximately 48 km (30 miles) south of Lake Ontario and 470 km (290 miles) northwest of New York City. The service area for the proposed project is in the northern portion of the Onondaga Lake drainage basin. The service area consists of most of the City of Syracuse plus the Village of East Syracuse, the Towns of Salina (including the Village of Liverpool) and Geddes(including the Village of Solvay), and portions of the Towns of Dewitt, Onondaga, and Camillus (see Figure 1).

The geography of the Syracuse area is rather unusual. The Onondaga Lake drainage basin is within the Ontario lowlands province. The drainage basin is situated upon beds of Silurian and Upper Devonian age sedimentary rock, including shale, siltstone, limestone, and gypsum. In general, the rock units dip very gently southward beneath sequentially younger strata (O'Brien & Gere, 1973a).

A unique aspect of the lowlands is the drumlin belt between Rochester and Syracuse; the Syracuse area occupies the southeastern portion of this drumlin belt (Cressey, 1966). Drumlins are half-egg-shaped, steeply sloped, glacial features. In certain areas there are thousands of drumlins so close together that they give a distinctly hilly appearance to the landscape. The drumlins adjoin the upland reaches of local streams. Downstream, the land surfaces gradually decline.



ONONDAGA LAKE DRAINAGE BASIN AND METROPOLITAN SYRACUSE SEWAGE TREATMENT PLANT SERVICE AREA

Figure 1

The steep grades that characterize the drumlins cause large amounts of soil to be eroded from the upland areas during spring rainstorms. The material eroded from the drumlins consists of the unconsolidated sediments that lie atop drumlin bedrock and the shale materials that outcrop in the lowland areas. Much of the unconsolidated sediment lying on the drumlins is mixed with glacial till. In the upland reaches, the soil is mainly gravel mixed with small amounts of clay and silt. In the flatter downstream areas, the soil is predominantly sandy in nature with little clay or silt content.

The MSSTP is located on the southern shore of Onondaga Lake. The lands bordering the southern shore generally consist of three layers. The top layer is mainly fill material comprised of sand, silt, brick, ashes and cinders. The middle layer consists of a soft white chemical residue ranging in thickness from 1.5 to 9 m (5 to 30 ft). The chemical residue dates from the time when Allied used the area for disposal of its process wastes. The lower layer consists of gray sand and brown clay silt; the uppermost portions of this layer also contain some organic material.

The climate of the area is moderate and the seasons are clearly differentiated. Winds are predominantly from the west and northwest (O'Brien & Gere, 1973a). The average annual precipitation is approximately 91 cm (36 in.) with an average snowfall of 315 cm/year (124 in./year). As shown in Table 2, precipitation in 1972 was substantially above average.

POPULATION, ECONOMICS, AND LAND USE

Population

As of 1970 there were 260,854 persons residing in the MSSTP service area. This is a decline of approximately 5 percent from the 1960 population of 273,501 (U.S. Bureau of the Census, 1962 and 1972). (See Table 3).

TABLE 2

MONTHLY PRECIPITATION
SYRACUSE, NEW YORK
HANCOCK AIRPORT
1969-1972

Month	Centimeters (Inches) of Precipitation				
	Record Mean	1969	1970	1971	1972
Jan.	6.88 (2.71)	8.56 (3.37)	2.59 (1.02)	4.83 (1.90)	2.80 (1.10)
Feb.	6.65 (2.62)	3.78 (1.49)	4.67 (1.84)	10.34 (4.07)	7.29 (2.87)
March	7.82 (3.08)	2.74 (1.08)	6.22 (2.45)	7.37 (2.90)	6.32 (2.49)
April	7.62 (3.00)	9.98 (3.93)	9.35 (3.68)	5.56 (2.19)	10.24 (4.03)
May	7.44 (2.93)	11.02 (4.34)	7.09 (2.79)	8.64 (3.40)	15.72 (6.19)
June	8.92 (3.51)	9.50 (3.74)	7.44 (2.93)	8.28 (3.26)	31.24(12.30)
July	8.38 (3.30)	2.29 (0.90)	11.23 (4.42)	16.48 (6.49)	8.76 (3.45)
Aug.	8.28 (3.26)	4.50 (1.77)	10.34 (4.07)	10.19 (4.01)	9.55 (3.76)
Sept.	7.11 (2.80)	2.87 (1.13)	11.00 (4.33)	6.50 (2.56)	10.46 (4.12)
Oct.	7.56 (2.98)	5.84 (2.30)	9.75 (3.84)	4.11 (1.62)	11.07 (4.36)
Nov.	7.24 (2.85)	11.58 (4.56)	8.97 (3.53)	8.94 (3.52)	17.25 (6.79)
Dec.	7.32 (2.88)	8.70 (3.42)	8.46 (3.33)	8.28 (3.26)	10.03 (3.95)
Total	91.24(35.92)	81.41(32.05)	97.10(38.23)	99.52(39.18)	140.74(55.41)

Source: U.S. Department of Commerce, 1973.

TABLE 3

PAST AND PRESENT POPULATION OF SELECTED POLITICAL SUBDIVISIONS IN THE MSSTP SERVICE AREA 1960 AND 1970

	1960	1970
Syracuse (City)	216,038	197,208
Salina (Town)	33,076	38,281
Geddes (Town)	19,679	21,032
East Syracuse (Village)	4,708	4,333
TOTAL	273,501	260,854

Source: U.S. Bureau of the Census, 1962 and 1972.

Population decreases did not affect every municipality in the service area; the Towns of Salina and Geddes experienced increases in population.

Several organizations have independently made population projections for municipalities in and around the service area (see Table 4). These sources expect the population of each of the towns to increase slightly and that of Syracuse to stabilize. These projections may be somewhat optimistic since potential population increases could be lost to competing developments, such as the Lysander New Community to the northwest of the service area. Nevertheless, all available information indicates that the applicant's population projection of 343,000 for the year 2000 is valid (see Table 5). This population figure was used to size the proposed MSSTP.

Economics

Income

As shown in Table 6, Syracuse proper has the lowest median income per household in the MSSTP service area. Its median income is also significantly lower than that for Onondaga County as a whole. With the exception of Syracuse, the median income of residents in the MSSTP service area is on a par with that for the county.

Occupations

The occupational make-up of four of the communities in the MSSTP service area and of Onondaga County is shown in Table 7. The MSSTP service area's occupational structure roughly parallels that of the county. Services and education dominate, followed by manufacturing and commerce.

Approximately 70 percent of the residents of Onondaga County have lived in the county for five years or more (see Table 8). The 1970 census also shows that at least 88 percent of employed Syracuse residents worked in Onondaga

TABLE 4

POPULATION PROJECTIONS FOR SELECTED TOWNSHIPS AND THE CITY OF SYRACUSE
IN THE MSSTP SERVICE AREA
1970-2000

Political Subdivision	Data Source	Year						
		1970	1975	1980	1985	1990	1995	2000
Dewitt	SOCPA	29198	30200	31700	33200	34200	35000	35800
	OPS		32044	45191	38733	42660	45621	48608
	CDM	32500		40000		43500		45500
Geddes	SOCPA	21032	21180	21330	21480	21630	21780	21930
	OPS		20952	21218	21554	21906	22085	22150
	CDM	21200		23600		24250		24700
Salina	SOCPA	38281	40800	41800	42800	43500	44100	44700
	OPS		40179	42436	44741	47272	48337	49223
	CDM	37600		43800		44700		45200
City of Syracuse		197297	200000	200000	200000	200000	200000	200000

Data Sources: SOCPA - Syracuse-Onondaga County Planning Agency (1972).
OPS - New York State Office of Planning Services (1972).
CDM - Camp, Dresser and McKee (1968).

Source: Syracuse-Onondaga County Planning Agency, 1973.

TABLE 5

PRESENT AND PROJECTED
SERVICE AREA POPULATION
MSSTP AND LCSTP

	Present Population	Projected Population Yr. 2000
MSSTP		
City of Syracuse	208,140	195,837
West Side San. District/ Onondaga San. District	40,500	100,000
Liverpool San. District	5,226	6,877
LCSTP		
Ley Creek San. District	33,718	40,891
Total	287,584	343,605

Source: O'Brien & Gere, 1973a.

TABLE 6

MEDIAN INCOME OF RESIDENTS OF ONONDAGA COUNTY AND SELECTED POLITICAL SUBDIVISIONS IN THE MSSTP SERVICE AREA 1960 AND 1970

	All Families		All Families plus Unrelated Individuals	
	1960	1970	1960	1970
Onondaga County	$ 6691	$ 10836	$ 5678	$ 8456
City of Syracuse	6247	9246	4860	6023
East Syracuse	6208	9976	5646	8310
Liverpool	7442	11148	6300	8886
Solvay	6658	10848	6234	9128

Source: U.S. Bureau of the Census, 1962 and 1972.

TABLE 7

OCCUPATIONS OF EMPLOYED RESIDENTS OF ONONDAGA COUNTY AND SELECTED POLITICAL SUBDIVISIONS IN THE MSSTP SERVICE AREA, 1960 AND 1970

Occupation	Onondaga County 1960	Onondaga County 1970	Percent Change, 1960-1970
Agriculture, forestry, fisheries, mining	2925	2231	-23.7
Contract construction	8612	8823	+ 2.5
Manufacturing	57590	49101	-14.7
Transportation, communication, public utilities	12024	12474	+ 3.7
Wholesale trade	6662	10706	+60.7
Retail trade	24372	30387	+24.6
Finance, insurance and real estate	8287	11534	+39.1
Services and education	35259	51754	+46.7
Public administration	6662	7523	+12.9
TOTAL	162393	184533	+13.6

	East Syracuse		Liverpool		Solvay		City of Syracuse	
	1960	1970	1960	1970	1960	1970	1960	1970
Agriculture, forestry, fisheries, mining	18		9		12		280	398
Contract construction	57	73	63	43	176	121	3867	2990
Manufacturing	531	457	523	395	1730	1348	27422	19056
Transportation, communication, public utilities	375	303	96	93	177	247	5904	5080

TABLE 7 (cont'd)

OCCUPATIONS OF EMPLOYED RESIDENTS OF ONONDAGA COUNTY AND SELECTED POLITICAL SUBDIVISIONS IN THE MSSTP SERVICE AREA, 1960 AND 1970

	East Syracuse		Liverpool		Solvay		City of Syracuse	
	1960	1970	1960	1970	1960	1970	1960	1970
Wholesale trade	274	453	247	272	659	813	3257	4011
Retail trade							13114	12567
Finance, insurance and real estate	336	281	417	383	623	763	4654	5169
Services and education							20640	25881
Public administration	137	66	50	86	163	173	3827	3562
Not reported	85		54		126		4722	
Other industries		46		39		158		
TOTAL	1813	1679	1459	1311	3666	3623	87687	78714

Source: U.S. Bureau of the Census, 1962 and 1972.

TABLE 8

RESIDENCE OF SYRACUSE CITY RESIDENTS
AND ONONDAGA COUNTY RESIDENTS
1970

Syracuse City

Residence in 1965	Number	Percentage
Total population, 5 yrs or older	180869	100.0
Moved, 1965 residence not reported	11663	6.4
Same house	94728	52.4
Different house in U.S.	71085	39.3
Same county	45494	25.2
Different county	25591	14.1
In armed forces in 1965	747	0.4
College attendees in 1965	3825	2.1
Same state	13541	7.5
Different state	12050	6.6
Abroad	3393	1.9

Onondaga County

Residence in 1965	Number	Percentage
Total population, 5 yrs. or older	430645	100.0
Moved, 1965 residence not reported	18683	4.3
Same house	241161	56.0
Different house in U.S.	165070	38.3
Same county	103463	24.0
Different county	61607	14.3
In armed forces in 1965	1918	0.4
College attendees in 1965	7774	1.8
Same state	33661	7.8
Different state	27946	6.5
Abroad	5731	1.3

Source: U.S. Bureau of the Census, 1962 and 1972.

County. It appears that most of the employed county residents live near their place of work. Consequently, any significant change in the employment situation would affect the residential situation.

Economic Profile and Trends

Onondaga County ranks tenth in New York State in both the number of jobs available and the size of the business payroll. Almost half of the jobs in the county are located in the City of Syracuse. In Onondaga County, blue collar jobs, e.g. in the manufacturing sector, are decreasing and white collar jobs, e.g. in the services and education sector, are increasing.

Within the manufacturing sector, the electrical equipment and supplies industry employs the greatest number of people. The non-electrical machinery industry and the chemical industry are the second and third largest employers. Over the last five years, employment in the two major manufacturing fields has steadily declined. (U.S. Bureau of the Census, 1962 and 1972). Conversely, employment in the chemical industry grew rapidly until recent national economic instability set in. Economic unrest is reflected in the gradual downward trend of employment in the chemical industry. The data in Table 7 clearly show that the Syracuse area is becoming the center for goods and services in the county.

Land Use Patterns and Trends

Residential, Industrial, Commercial

The present population is scattered throughout the service area, mainly on the fringes of industrial and commercial development. The industrially and commercially developed areas are located near Onondaga Lake, along Erie Boulevard and Genessee Street, along Interstate 90, and around the Village of East Syracuse. Residential zoning of a quarter acre or less is common in these areas. This pattern is not expected to change in the near future because most of the land in the service area is already developed.

Recreational

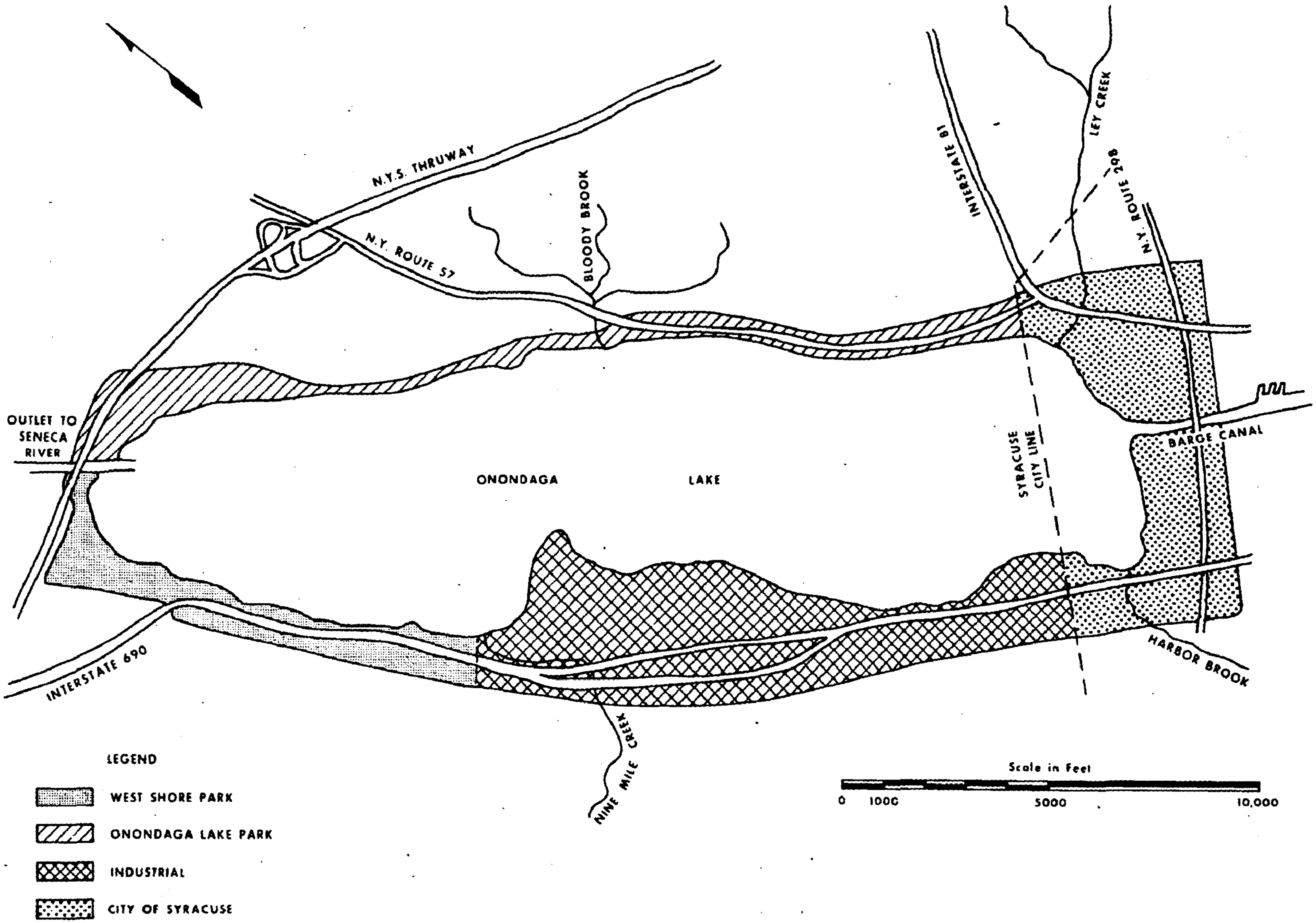
Onondaga Lake has a surface area of 11.7 sq km (4.5 sq miles) and a shoreline of about 17.7 km (11 miles). The lake and its shoreline provide limited recreational opportunities . In the metropolitan area, Skaneateles Lake and Lake Oneida also provide opportunities for water-related recreation.

Figure 2 shows the uses of the land bordering the lake. According to Faro and Nemerow (1969), almost 46 percent of the acreage around the lake is parkland. The quality of this parkland is severely diminished by 1) roadways and railroads cutting in along the shore, 2) frequent flooding, 3) the proximity of automobile graveyards, and 4) the presence of Allied's settling lagoons, both in use and abandoned, on the southwest shore. The following table is a breakdown of the shoreline acreage according to use.

Land Use	Hectares	Acres	Percent
County parks	209	515	45.8
Allied Chemical	162	399	35.8
City of Syracuse (industrial and commercial)	86	211	18.7
Total	456	1125	100.0

Source: Faro and Nemerow, 1969.

Shattuck (1968) esitmated that water-related activities drew 384,166 persons to Onondaga Lake County Park during fiscal 1967. Thus, water-related recreation accounted for 55 percent of all visits to the park. Faro and



Source: Faro and Nemerow, 1969

Figure 2

LAND USE IN THE VICINITY OF ONONDAGA LAKE

Nemerow (1969) reported that use of the park's yacht basin accounted for an average annual attendance of 15,747 for the years 1966 and 1967. In addition to the county facilities, there are two private marinas to serve Onondaga Lake boaters. Both of the above-mentioned reports predate New York State's 1970 ban on fishing in Onondaga Lake.

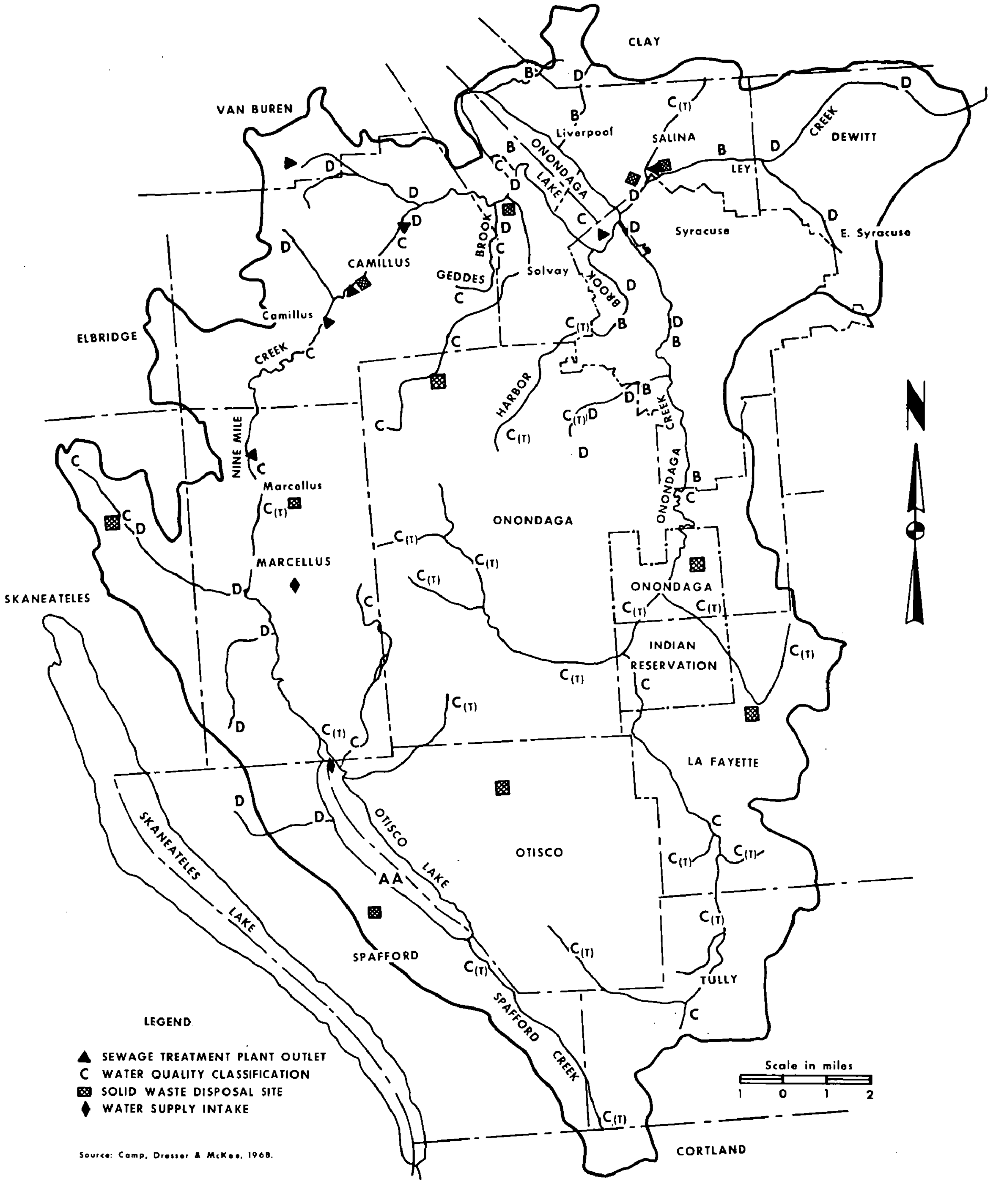
An analysis of New York State boat registration records for the years 1970 and 1971 (NYSDEC, n.d.a) indicates that there are 19,658 boats registered to residents of Onondaga County. Of this number, 11,861 boats have previously been used on waters within the county. Boat use in the county is high relative to population and income. Although Onondaga Lake is open to boating, it is closed to fishing and swimming.

SURFACE WATERS

Streams

The present New York State water quality classifications for Onondaga Lake and its tributaries are shown in Figure 3. A detailed description of these classifications and of the standards which apply to them is included in Appendix A. The Federal Water Pollution Control Act Amendments of 1972 (FWPCAA) require that the EPA review water quality standards to insure that the standards are consistent with the goals and policies in effect prior to the 1972 amendments. Under these goals and policies, all waters should be protected for recreational use in or on the water and for the preservation of desirable (indigenous) species of aquatic biota. New York State's water quality standards were recently revised to reflect the more stringent specifications of the FWPCAA.

Both the original and the revised standards are included in Appendix A. Data on Onondaga Lake's major tributaries are presented in Tables 9 and 10. The main source of water for streams in the area is surface runoff.



WATER QUALITY CLASSIFICATIONS IN THE ONONDAGA LAKE DRAINAGE BASIN

Figure 3

TABLE 9

MAJOR TRIBUTARIES OF ONONDAGA LAKE

Tributary	Watershed Area 1/		Mainstream Length 1/		Annual Flow 2/		
	sq km	sq mi	km	mi	cu m/day	mgd	cfs
Nine Mile Creek - including Otisco Lake Drainage Area	323.0	124.8	55.2	34.3	218,000	57.5	88.4
Onondaga Creek	265.0	102.5	44.2	27.5	358,000	94.5	145.4
Ley Creek	68.8	26.2	15.3	9.5	154,000	40.8	62.7
Harbor Brook	34.2	13.2	12.1	7.5	43,000	11.3	17.4
Bloody Brook	11.7	4.5	3.5	2.2	-	-	-

1/ New York State Department of Health, 1951.
2/ U.S. Geological Survey, 1965, 1967, and 1968.
The average annual rainfall for the years 1965, 1967 and 1968 was determined to be 92 cm (36.22 in.) as compared to 90.4 cm (35.6 in.) from 1931 to 1968.

Source: Onondaga County, 1971.

TABLE 10

FLOWS OF MAJOR TRIBUTARIES OF ONONDAGA LAKE[1]

	cu m/day	cfs
Onondaga Creek at Dorwin Ave.		
Max discharge of record (3/31/60)	3,621	2,130
Min discharge of record (8/17/65)	9.35	5.5
Avg discharge of record	190	112
Max discharge, 1971	2,618	1,540
Min discharge, 1971	35.7	21
Avg discharge, 1971	250	147
MA7CD10[2]	20.4	12
Harbor Brook at Syracuse, N.Y.		
Max discharge of record (5/19/69)	635.8	374
Min discharge of record (9/22/64)	3.06	1.8
Avg discharge of record	13.53	7.96
Max discharge, 1971	251.6	148
Min discharge, 1971	4.42	2.6
Avg discharge, 1971	18.02	10.6
MA7CD10[2]	3.14	2
Nine Mile Creek at Camillus		
Max discharge of record (3/30/60)	4,692	2,760
Min discharge of record (9/30/61)	27.2	16
Avg discharge of record	165.1	97.1
Max discharge, 1971	3,655	2,150
Min discharge, 1971	57.8	34
Avg discharge, 1971	265	156
MA7CD10[2]	28.9	17
Ley Creek at Townline Road		
MA7CD10[2]	3.14	2

1/It should be noted that the gauging stations are somewhat upstream of Onondaga Lake. The data represents 80, 85, and 73 percent of the drainage areas for Onondaga Creek, Harbor Brook and Nine Mile Creek, respectively.

2/Minimum average 7 consecutive day flow with 10 year frequency.

Source: U.S. Geological Survey, 1971.

Ground-water discharge is probably another significant source. The flows in Onondaga Creek can be regulated by release or detention of water in Onondaga Reservoir. Flows in Nine Mile Creek can be regulated at Otisco Lake.

Stream water quality in the upland reaches mainly depends upon the chemical reactions between the stream waters and the materials that comprise the predominant upstream geological formations (O'Brien & Gere, 1973a). Water quality data (New York State Department of Health, 1951) show that the headwaters typically have high dissolved oxygen levels (90-100 percent of saturation), low BOD levels (1-2 mg/l), slightly alkaline pH values (7.6-8.2), and an alkalinity of approximately 225 mg/l (as $CaCO_3$). However, as the waters enter the metropolitan Syracuse area they become more and more degraded. This deterioration in water quality is primarily due to combined sewer overflows, urban runoff, and industrial wastewater discharges. Table 11 is a reference table of water quality parameters. Table 12 gives the chemical characteristics of Harbor Brook, Onondaga Creek, Ley Creek, and Nine Mile Creek near Onondaga Lake.

Although all of the streams in the metropolitan Syracuse area suffer the effects of combined sewer overflows, Geddes Brook and Nine Mile Creek have yet another water quality problem. The overflow from Allied's settling lagoons enters Geddes Brook. When the overflow mixes with the brook water, a calcium carbonate precipitate ($CaCO_3$) forms. The brook carries the precipitate into Nine Mile Creek. Since the brook flows into the creek very near the creek's mouth, the creek has an extremely high dissolved solids content when it discharges into Onondaga Lake. The quiescent conditions prevailing in the lake allow the precipitate to settle out, forming a delta of $CaCO_3$ at the point where Nine Mile Creek joins Onondaga Lake.

TABLE 11

WATER QUALITY PARAMETERS

Parameter	Symbol	Units
Temperature	Temp	°C
Alkalinity	Alk	mg/l as $CaCO_3$
Biochemical oxygen demand	BOD	mg/l
Chloride	Cl	mg/l
Carbon dioxide	CO_2	mg/l
Organic nitrogen	Org-N	mg/l as N
Ammonia nitrogen	NH_3-N	mg/l as N
Nitrite	NO_2	mg/l as N
Nitrate	NO_3	mg/l as N
Total phosphorus	T-P	mg/l as P
Ortho phosphate	O-PO_4	mg/l as P
pH	pH	$-\log_{10}[H^+]$
Sulfate	SO_4	mg/l
Sulfide	S	$-\log_{10}[S^=]$
Dissolved oxygen	DO	mg/l
Calcium	Ca	mg/l
Sodium	Na	mg/l
Potassium	K	mg/l
Magnesium	Mg	mg/l
Conductivity	Cond	u mhos
Copper	Cu	mg/l
Chromium	Cr	mg/l
Iron	Fe	mg/l
Manganese	Mn	mg/l
Zinc	Zn	mg/l
Fluoride	F	$-\log_{10}[F^-]$
Silicon dioxide	SiO_2	mg/l
Secchi disk	Secchi	meters

Source: Onondaga County, 1971.

TABLE 12

WATER QUALITY DATA
WASTE DISCHARGE SURVEY
AVERAGE VALUES[1]

Parameter	Harbor Brook	Onondaga Creek	Ley Creek	Nine Mile Creek
BOD	26,309	3.536	4.838	0.702
DO	7.469	10.330	6.727	7.451
pH	7.634	7.891	7.595	7.765
Alk	226.782	217.217	200.000	135.639
Cond	1096.136	1135.454	942.619	8105.245
Ca	173.895	117.513	114.034	1278.559
Mg	37.795	27.654	26.361	24.580
Na	124.936	184.431	142.523	1061.671
K	3.433	3.792	5.120	15.526
Cl	110.434	213.913	152.954	3073.133
SiO_2	6.447	5.960	7.136	4.855
SO_4	0.000	0.000	0.000	0.000
T-P	0.941	0.185	0.346	0.082
$O-PO_4$	0.543	0.107	0.257	0.059
F	0.000	0.000	0.000	0.000
NH_3-N	2.729	0.747	1.627	0.218
ORG-N	2.751	0.844	0.877	0.374
NO_3	1.048	0.712	0.417	0.337
NO_2	0.069	0.032	0.072	0.013
Cr	0.23	0.16	0.051	0.026
Cu	0.057	0.054	0.048	0.062
Fe	0.613	1.802	1.508	0.582
Mn	0.000	0.000	0.000	0.000
Temp	9.652	9.409	10.650	11.931
Flow (cu m/day)	92,000	520,000	520,000	850,000

1/Units are those presented in Table 11.

Source: O'Brien & Gere, 1972.

The upper reaches of Nine Mile Creek and Onondaga Creek are stocked with trout. These streams are relatively clean and support an assortment of mayflies, caddisflies, and other insect larvae necessary to maintain the trout population. The lower reaches of these streams, however, do not support a detectable trout population: as mentioned before, water quality in the metropolitan Syracuse area is seriously degraded. Ley Creek and Harbor Brook do not appear to support a game fish population. Some fish (white perch, yellow perch and carp) have been known to reside in Onondaga Lake in and around the mouths of these tributaries.

The major recreational uses of these creeks are fishing, swimming and boating. However, degraded water quality precludes both fishing and swimming in the creeks' lower reaches.

Onondaga Lake

Onondaga Lake lies at the northern edge of the City of Syracuse. The lake has a surface area of 11.7 sq km (4.5 sq miles) and a drainage basin area of 620 sq km (240 sq miles). Approximately 325,000 people and essentially all of Onondaga County's major industries are located within the Onondaga Lake drainage basin (Onondaga County, 1971). The lake flows from the southeast to the northwest, discharging into the Seneca River. The confluence of the Seneca and Oneida rivers forms the Oswego River, which discharges into Lake Ontario. (See Figure 1).

Onondaga Lake consists of two deep pools. Each of the pools is approximately 21m (69 ft) deep. The average depth of the lake is 12m (40 ft). The lake is vertically stratified, but it is well-mixed horizontally. The lake is dimictic: in other words, it undergoes two major periods of vertical mixing per year, spring and fall.

Tributary streams and the MSSTP are the lake's major water sources. Partially treated municipal discharges from the treatment plant enrich the lake with organic and nutrient materials. Combined sewer overflows also contribute organic material, nutrients, and coliform bacteria to the lake. The major non-point source discharge is the nutrients washed from upland agricultural areas. Consequently, the lake is in a highly eutrophic state.

The lake also receives discharges from Allied's manufacturing plant. The plant has a number of outlets from which calcium, sodium, chloride and mercury are discharged; the outlet known as Discharge Serial No. 003 (U.S. EPA, 1971a) contributes the greatest amount of these materials to the lake. The Crucible Specialty Metals Division of Colt Industries discharges wastewater containing oil, grease and chromium directly into the lake. A treatment facility that will control these discharges is now under construction.

Onondaga Lake water quality data for the years 1969 to 1972 are shown in Tables 13 and 14. The data show that the lake has high levels of BOD, phosphorus, nitrogen, sodium, calcium and chlorides, and low dissolved oxygen levels. In discussing water quality and its effect on the biota in the lake, the following five points must be emphasized:

1. The chloride/salinity levels of the lake approach concentrations at which one would expect to find the smallest species diversity; that is, the chloride/salinity level is near the upper limit for freshwater organisms and near the lower limit for marine species. Figure 4 shows the effect that salinity has on species diversity (Remane and Schlieper, 1971).
2. Dissolved oxygen levels in the hypolimnion are at or near zero approximately eight months out of the year. The dissolved oxygen

TABLE 13

ONONDAGA LAKE WATER QUALITY - EPILIMNION[1/]
AVERAGE ANNUAL VALUES[2/]
1969-1972

Parameters	1969	1970	1971	1972
Alk	170.39	168.15	189.00	169.54
BOD	6.21	4.09	6.20	4.63
Cl	1458.41	1505.21	1321.46	1386.18
DO	4.79	3.99	5.04	5.95
T-P	2.34	1.43	1.03	0.50
$O-PO_4$	0.94	0.70	0.70	0.36
pH	7.64	7.64	7.65	7.69
SO_4	182.35	186.83	173.30	155.00
Org-N	1.96	1.90	3.03	1.84
NH_3-N	2.14	3.05	2.48	2.06
NO_3	0.39	0.36	0.46	0.42
Cond	4625.83	4577.00	4601.92	3939.40
Cr	0.02	0.05	0.05	0.036
Cu	0.05	0.06	0.04	0.050
Fe	0.02	0.22	0.38	0.305
Mg	30.38	41.07	66.47	27.50
K	17.17	17.29	14.69	11.97
Na	554.54	832.79	677.75	490.63
Ca	639.37	815.81	706.38	514.43
Secchi	1.09	3.26	1.11	1.08
Temp	13.91			

1/Station located at the southeastern end of lake.

2/Units are those presented in Table 11.

Sources: O'Brien & Gere, 1970, 1971, and 1972.
Onondaga County, 1971.

TABLE 14

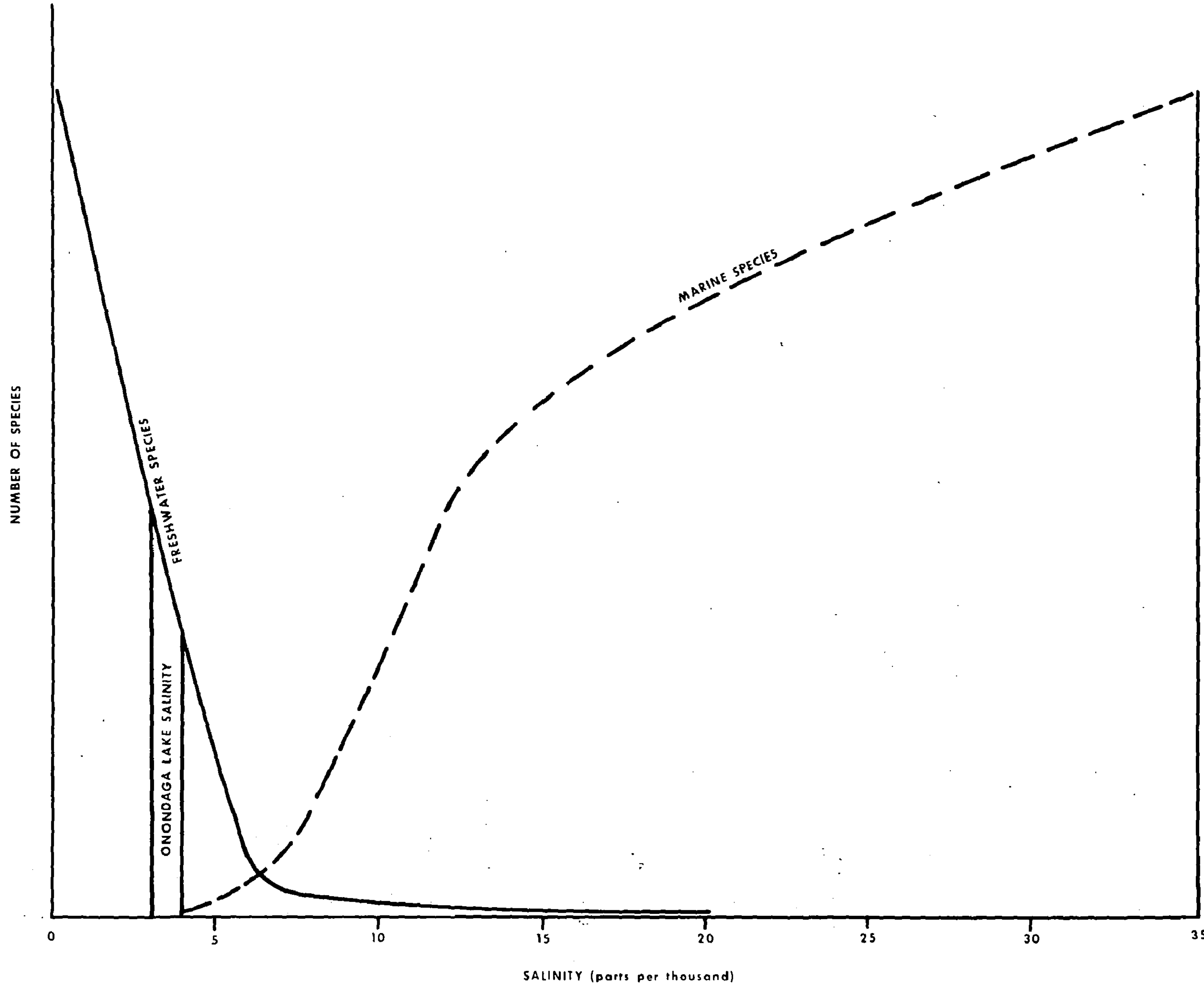
ONONDAGA LAKE WATER QUALITY - HYPOLIMNION[1/]
AVERAGE ANNUAL VALUES[2/]
1969-1972

Parameters	1969	1970	1971	1972
Alk	198.55	178.84	199.29	195.11
BOD	12.40	5.17	7.72	5.90
Cl	1930.23	2064.29	1761.38	2075.28
DO	1.53	1.29	0.81	0.97
T-P	3.17	1.77	1.95	1.12
$O-PO_4$	1.57	0.96	1.20	0.94
pH	7.39	7.43	7.34	7.41
SO_4	184.41	197.88	171.80	172.25
Org-N	1.48	1.34	3.13	1.33
NH_3-N	4.31	4.50	4.09	4.74
NO_3	0.13	0.01	0.34	0.18
Cond	5810.36	5934.25	5578.68	5371.79
Cr	0.02	0.06	0.05	0.036
Cu	0.05	0.04	0.05	0.038
Fe	0.26	0.25	0.31	0.237
Mg	30.99	41.64	69.36	28.42
K	17.79	19.02	16.35	15.13
Na	669.75	982.26	728.42	647.28
Ca	849.05	1084.24	978.24	634.02
Temp	8.13	8.86	6.78	5.23

1/Station located at southeastern end of lake.
2/Units are those presented in Table 11.

Sources: O'Brien & Gere, 1970, 1971, and 1972.
Onondaga County, 1971.

Figure 4



AFTER REMANE AND SCHLIEPER, 1971.

SALINITY VERSUS SPECIES DIVERSITY

levels in the epilimnion may fall to 1 to 2 mg/l for short periods of time. Therefore, only those species that can tolerate low dissolved oxygen levels remain in the lake.

3. Concentrations of copper and chromium have reached levels that may inhibit the growth of certain algae. According to Hutchinson (1957): "...it appears probable that certain species of Coelastrum, Navicula, and Uroglenopsis may be sensitive to amounts of copper, of the order of 30 mg. m. $^{-3}$ [correction: 30 mg. Cu m. $^{-3}$], that can occur in ionic form in the trophogenic zones of certain lakes during autumnal circulation. Anabaena, Aphanizomenon, Tabellaria, and Synura, though relatively susceptible, can apparently tolerate about 50 mg. Cu m.$^{-3}$ ..." The values cited in this passage can be stated another way: 30 mg. Cu m. $^{-3}$ is equal to 0.03 mg/l, and 50 mg Cu m. $^{-3}$ is equal to 0.05 mg/l. The mean concentration of copper in the epilimnion has ranged from 0.04 to 0.06 mg/l, exceeding the values cited by Hutchinson (see Table 13).

Onondaga County (1971) reports that Hervey (1949) found that concentrations of chromium ranging from 0.032 to 0.32 mg/l completely inhibited the growth of diatoms. The mean concentration of chromium in the epilimnion ranges from 0.02 to 0.05 mg/l (Table 13). Thus both copper and chromium reach levels that may inhibit the growth of algae.

4. According to the Federal Water Pollution Control Administration (1968):

> The toxicity of ammonia has been studied by several investigators but because of inadequate reporting and unsatisfactory experimental control, much of the work is not usable. Doudoroff and Katz (1950), Wuhrmann, et al. (1947), and Wuhrmann and Worker (1948) give a complete account of the pH effect on ammonia toxicity

and demonstrate that toxicity is dependent primarily on undissociated NH_4OH and nonionic ammonia. They found no obvious relationship between time until loss of equilibrium and total ammonium content. They also demonstrated a striking synergy between ammonia and cyanide. McKee and Wolf (1963) state that toxicity is increased markedly by reduced dissolved oxygen. Field studies by Ellis (1940) and other observations lead to the conclusion that at pH levels of 8.0 and above total ammonia expressed as N should not exceed 1.5 mg/l. It has been found that 2.5 mg/l total ammonia expressed as N is acutely toxic.

Table 13 shows that epilimnetic ammonia values have ranged from 2.06 to 3.05 mg/l. The hypolimnetic values are significantly higher (see Table 14). Although the lowest levels of ammonia occur during the summer months, probably due to phytoplankton utilizing the ammonia as a nutrient source, the pH values are at their highest, 8.0 to 9.0. High pH values increase the possibility that ammonia will have a toxic effect on certain species. The low dissolved oxygen levels in Onondaga Lake may also increase ammonia toxicity.

5. The mercury contamination of the biological food chain in Onondaga Lake is of major importance. The New York State Department of Environmental Conservation (NYSDEC) closed the lake to fishing in May 1970. In October 1973 Henry L. Diamond, who was then Commissioner of the NYSDEC, made the following statement:

> The cause of the unique mercury contamination of fish flesh in Onondaga Lake, has been virtually eliminated. However, there is no known scientific basis on which to estimate the duration of the existing fish contamination. Therefore, the ban on fishing in Onondaga Lake will remain in effect indefinitely until such time as continued monitoring substantiates a basis for repeal. (Diamond, written communication, 1973).

It is apparent that the lake is in a very degraded and highly eutrophic state. Yet, considering the present water quality conditions, the lake seems to support a somewhat diverse flora and fauna.

The nutrient rich waters of the lake support a variety of algal species (Table 15). Generally, diatoms prevail throughout the winter and early spring, followed by green algae in the late spring and early summer and blue-green algae in the late summer and early fall.

However, in the past two years (1971-72) few blue-greens have been observed. This may be a direct result of phosphate legislation enacted by Onondaga County in 1971 and New York State in 1972. This legislation has led to a substantial reduction in the amount of phosphorus entering the MSSTP. The influent level of total phosphorus fell from 11.4 mg/l in 1969 to 3.97 mg/l in 1973. The level of total phosphorus in the lake fell from 2.72 mg/l in 1969 to 1.80 mg/l in 1972. The decline in blue-green algae has been attributed to the reduction of phosphorus in the lake (O'Brien & Gere, 1972). However, this does not preclude the possibility that other causes may be directly responsible for the decline of the blue-green algae.

In Onondaga Lake, zooplankton densities are extremely low from December through April. This is probably due to the depressive effects of low temperature and ice cover on the algae which serve as a food source for the zooplankton. The winter low is followed by a rapid upsurge in population, suggesting that the population growth is not actively inhibited by environmental deficiencies. Thereafter, the population fluctuates markedly. The fluctuations have not been explained, but their pattern suggests the action of an inhibitor as well as a limiting factor. (Waterman, 1971).

Zooplankton populations appear to be more vulnerable to temperature than to any other element. However, Waterman (1971) maintains that "Explanation of the fluctuations neither requires nor excludes the possibility of relationship with specific chemical parameters." The zooplankton species found in Onondaga Lake are generally tolerant of a wide range of conditions.

TABLE 15

ALGAL SPECIES COLLECTED IN ONONDAGA LAKE IN 1969

Algal Species	Time of Abundance
CHLOROPHYCEAE	
VOLVOCALES	
Chlamydomonas epiphytica G. M. Smith	July-October: epiphytic on Polycystis
Chlamydomonas spp.	April-December
Carteria fritschii Takeda	May
TETRASPORALES	
Sphaerocystis schroeteri Chodat	June-October; irregular
ULOTRICHALES	
Ulothrix spp.	uncommon
Microthamnion kuetzingianum Naegeli	uncommon
OEDOGONIALES	
Oedogonium sp.	uncommon
CHLOROCOCCALES	
Micractinium pusillum Fresenius	May-June, September-October
Errerella bornhemiensis Conrad	uncommon; Outlet only
Dictyosphaerium pulchellum Wood	uncommon
Schroederia setigera (Schroed.) Lemmermann	August-October
Pediastrum boryanum (Turp.) Meneghini	April-October

TABLE 15 (Cont'd)

ALGAL SPECIES COLLECTED IN ONONDAGA LAKE IN 1969

Algal Species	Time of Abundance
CHLOROPHYCEAE	
Pediastrum duplex Meyen	April-November
Pediastrum simplex (Meyen) Lemmermann	July-November
Coelastrum microporum Naegeli	June-September
Chlorella vulgaris Beyerinck	May-November
Oocystis parva West & West	June-December
Oocystis elliptica W. West	September-October
Ankistrodesmus falcatus (Corda) Ralfs	May-June
Quadrigula lacustris (Chod.) G.M. Smith	uncommon; Outlet only
Scenedesmus bijuga (Turp.) Lagerheim	June-September
Scenedesmus dimorphus (Turp.) Kuetzing	uncommon; Outlet only
Scenedesmus obliquus (Turp.) Kuetzing	April-December
Scenedesmus opoliensis P. Richter	uncommon
Scenedesmus quadricauda (Turp.) Brebisson	April-December
Tetrastrum punctatum (Schmidle) Ahlstrom & Tiffany	uncommon; Outlet only
Actinastrum hantzschii Lagerheim	uncommon; Outlet only
ZYGNEMATALES	
Mougeotia sp.	uncommon
Spirogyra spp.	uncommon
Closterium sp.	uncommon; Outlet only
Closterium gracile Brebisson	September-December
Cosmarium sp.	uncommon; Outlet only
Staurastrum paradoxum Meyen	July-November

TABLE 15 (Cont'd)

ALGAL SPECIES COLLECTED IN ONONDAGA LAKE IN 1969

Algal Species	Time of Abundance
EUGLENOPHYCEAE	
EUGLENALES	
Euglena gracilis Klebs	November-December
Phacus sp.	uncommon; Outlet only
COLACIALES	
Colacium vesiculosum Ehrenberg	July-December; epizooic on copepods
CHRYSOPHYCEAE	
CHRYSOMONADALES	
Synura uvella Ehrenberg	April-June; November-December
Dinobryon sertularia Ehrenberg	May-July; November-December
BACILLARIOPHYCEAE	
CENTRALES	
Melosira granulata (Ehrenb.) Ralfs	January-December
Melosira islandica O. Muller	July-September
Melosira varians C. A. Agardh (?)	June
Cyclotella bodanica Eulenst. (?)	May-July
Cyclotella chaetoceras Lemm. (?)	May
Cyclotella comta (Ehr.) Kutzing	August-December

TABLE 15 (Cont'd)

ALGAL SPECIES COLLECTED IN ONONDAGA LAKE IN 1969

Algal Species	Time of Abundance
Cyclotella glomerata Bachm.	April-December
Stephanodiscus astraea (Ehr.) Grun.	May-July; October-December
Coscinodiscus subtilis Ehrenb. (var. *radiatus*)	June-December
Chaetoceros sp.	May
BACILLARIOPHYCEAE	
PENNALES	
Tabellaria fenestrata (Lyngb.) Kutzing	uncommon; Outlet only
Diatoma tenue Ag. (var. *elongatum*)	April-July; October
Diatoma vulgare Bory.	February-May
Fragilaria capucina Desmarziers	April-July
Fragilaria crotonensis Kitton	August-November
Synedra spp.	April-July; November
Asterionella formosa Hassall	January-July; October-December
Navicula sp.	April-July; September
Pinnularia sp.	uncommon
Neidium spp.	August-November
Gyrosigma spp.	uncommon
Amphiprora alata Kutzing	April-June
Gomphonema spp.	uncommon
Cymbella spp.	uncommon; Outlet only
Amphora spp.	uncommon
Nitzschia palea (Kg.) W. Smith	April-December
Nitzschia holsatica Hustedt	uncommon; Nine Mile only
Cymatopleura solea (Breb.) W. Smith	uncommon; Ley Creek only
Surirella sp.	uncommon; Outlet only

TABLE 15 (Cont'd)

ALGAL SPECIES COLLECTED IN ONONDAGA LAKE IN 1969

Algal Species	Time of Abundance
DINOPHYCEAE	
PERIDINIALES	
Glenodinium pulvisculus (Ehrenb.) Stein	July-October
Peridinium sp.	uncommon; Outlet only
Ceratium hirundinella (O. F. Muell.) Dujardin	July-September
CRYPTOPHYCEAE	
CRYPTOMONADALES	
Chroomonas nordstetii Hansgirg	July-November
Cryptomonas ovata Ehrenberg	May-December
MYXOPHYCEAE	
CHROOCOCCALES	
Polycystis aeruginosa Kutzing (*Microcystis*)	June-November
OSCILLATORIALES	
Phormidium mucicola Naumann & Huber-Pestalozzi	July-November; within sheath of Polycystis
Phormidium retzii (C. A. Ag.) Gomont	May-November
Lyngbya martensiana Meneghini	July-November

TABLE 15 (Cont'd)

ALGAL SPECIES COLLECTED IN ONONDAGA LAKE IN 1969

Algal Species	Time of Abundance
Anabaena circinalis Rabenhorst	July-October
Anabaena flos-aquae (Lyngb.) Brebisson	June-December
Aphanizomenon flos-aquae (L.) Ralfs	June-December
Hapalosiphon hibernicus West & West (?)	uncommon

Source: Sze and Kingsbury, 1972.

Noble and Forney (1971) reported that Onondaga Lake has "...a fairly diverse fish fauna, typical of many warm water lakes in Central New York State." Table 16 lists the fish species found in the lake in 1927, 1946, 1969 and 1972. The table shows that species composition has remained essentially the same over the last fifty years.

Noble and Forney (1971) also reported that the growth of most game and pan fish was good, and that although reproduction was "...very limited in 1969,...those young taken were of good size and condition." They also found that the distribution of fish appeared to be related to favorable conditions in the lake. More fish were found in the northeast part of the lake where water quality is better than anywhere else. Nevertheless, recreational use of Onondaga Lake is very limited. The lake is open to boating, but closed to fishing and swimming.

Effect of Onondaga Lake on the Seneca River, the Oswego River and Lake Ontario

As mentioned earlier, Onondaga Lake flows into the Seneca River, which converges with the Oneida River to form the Oswego River. The Oswego River discharges into Lake Ontario. Therefore, water quality in Onondaga Lake is of more than local importance. Data pertaining to the effect of Onondaga Lake waters on the Seneca (Class B) and the Oswego (Classes B and C) rivers and on Lake Ontario (Special Class A) are contained in Tables 17, 18, 19, and 20. (See Appendix A for an explanation of the water quality classifications). Figure 5 pinpoints the sampling stations at which data were collected.

On the Seneca River, the nearest upstream sampling station from the Onondaga Lake outlet is at Montezuma (Table 17); the nearest downstream station is at Belgium (Table 18). These stations are some distance from the outlet,

TABLE 16

FISH SPECIES FOUND IN ONONDAGA LAKE
1927, 1946, 1969 AND 1972

1927[1/]	
Scientific name	Common name
Cyprinus carpio	Carp
Notemigonus crysoleucas	Golden shiner
Pimephales notatus	Bluntnose minnow
Esox americanus vermiculatus	Grass pickerel[2/]
Fundulus diaphanus	Killifish
Perca flavescens	Yellow perch
Micropterus salmoides	Largemouth bass
Lepomis gibbosus	Common sunfish
Catostomus commersoni	Common sucker
Moxostoma sp.	White-nosed red-fin sucker

1946[3/]	
Scientific name	Common name
Stizostedion v. vitreum	Pike-perch (walleye)
Perca flavescens	Yellow perch
Esox lucius	Northern pike
Lepibema chrysops	Silver bass
Lepomis gibbosus	Common sunfish (mainly young)
Ictalurus l. lacustris	Catfish
Moxostoma aureolum	Redfin sucker
Moxostoma sp.	Redfin sucker
Cyprinus carpio	Carp
Notemigonus c. crysoleucas	Golden shiner
Pomolobus pseudoharengus	Alewife
Percina caprodes semifasciate	Logperch
Fundulus diaphanus	Killifish
Notropis atherinoides	Buckeye shiner

TABLE 16 (Cont'd)

FISH SPECIES FOUND IN ONONDAGA LAKE
1927, 1946, 1969 AND 1972

1969[4/]	
Scientific name	Common name
Cyprinus carpio	Carp
Notropis atherinoides	Emerald shiner
Catostomus commersoni	White sucker
Moxostoma macrolepidotum	Northern redhorse
Moxostoma sp.	Redhorse sucker
Ictalurus punctatus	Channel catfish
Ictalurus nebulosus	Brown bullhead
Culaea inconstans	Brook stickleback
Roccus americanus	White perch
Micropterus dolomieui	Smallmouth bass
Lepomis macrochirus	Bluegill
Lepomis gibbosus	Pumpkinseed
Lepomis sp.	Bluegill or Pumpkinseed
Perca flavescens	Yellow perch
Stizostedion v. vitreum	Walleye
Aplodinotus grunniens	Fresh water drum

1972[5/]	
Scientific name	Common name
Ictalurus natalis	Yellow bullhead
Micropterus salmoides	Largemouth bass
Pomoxis annularis	White crappie
Stizostedion v. vitreum	Walleye
Morone chrysops	White bass
Catostomus commersoni	White sucker
Esox lucius	Northern pike
Cyprinus carpio	Carp
Notemigonus crysoleucas	Golden shiner
Roccus americanus	White perch

1/ Source: Greely, 1928.
2/ Called little pickerel in original text.
3/ Source: Stone and Pasko, 1946.
4/ Source: Noble and Forney, 1971.
5/ Source: U.S. EPA, 1973b.

TABLE 17

WATER QUALITY OF THE SENECA RIVER AT MONTEZUMA[1/]
WATER QUALITY PERCENTILE SUMMARY
OCTOBER 1, 1964 - SEPTEMBER 30, 1967

Parameters	Units	Samples	50 Percentile	90 Percentile
Color	Platinum cobalt	10	11.0	80.0
Turbidity	Jackson cobalt	25	30.0	60.0
Water temperature	°C	26	11.0	24.5
Water temperature[2/]	°F	26	51.8	76.1
Dissolved oxygen	mg/l	26	8.8	14.0
Dissolved oxygen	Percent SAT.	26	88.8	123.4
BOD (5-day)	mg/l	26	2.1	2.9
COD (dichromate)	mg/l	25	14.2	33.6
Conductivity	u Mhos	26	584.0	723.5
Chlorides (as Cl)	mg/l	26	114.1	140.4
pH	Units	26	7.7	8.2
Hardness (as $CaCO_3$)	mg/l	26	153.0	190.0
Mg hardness (as $CaCO_3$)[2/]	mg/l	25	42.2	51.3
Ca hardness (as $CaCO_3$)[2/]	mg/l	25	110.3	145.4
Carb. alk. (as $CaCO_3$)	mg/l	4	0.0	
Bicarb. alk. (as $CaCO_3$)	mg/l	4	92.0	
Total alk. (as $CaCO_3$)	mg/l	4	92.0	

TABLE 17 (Cont'd)

WATER QUALITY OF THE SENECA RIVER AT MONTEZUMA[1]
WATER QUALITY PERCENTILE SUMMARY
OCTOBER 1, 1964 - SEPTEMBER 30, 1967

Parameters	Units	Samples	50 Percentile	90 Percentile
Calcium (as Ca)	mg/l	25	44.1	58.2
Magnesium (as Mg)	mg/l	25	10.3	12.5
Sodium (as Na)	mg/l	26	91.0	207.0
Potassium (as K)	mg/l	26	2.0	3.0
Iron (as Fe)	mg/l	25	0.14	0.38
Manganese (as Mn)	mg/l	21	0.01	0.04
Ammonia (as N)	mg/l	26	0.637	1.217
Organic nitrogen (as N)	mg/l	26	0.33	0.73
Nitrites (as N)	mg/l	26	0.011	0.030
Nitrates (as N)	mg/l	26	0.28	0.82
Ammonia (as NH_3)[2]	mg/l	26	0.772	1.475
Nitrites (as NO_2)[2]	mg/l	26	0.035	0.099
Nitrates (as NO_3)[2]	mg/l	26	1.24	3.63
Phosphates (as P)[2]	mg/l	26	0.05	0.12
Phosphates (as PO_4)	mg/l	26	0.16	0.38
Sulfates (as S)[2]	mg/l	25	17.4	20.2
Sulfates (as SO_4)	mg/l	25	52.0	60.6
MBAS (ABS & LAS)	mg/l	26	0.01	0.07

TABLE 17 (Cont'd)

WATER QUALITY OF THE SENECA RIVER AT MONTEZUMA[1/]
WATER QUALITY PERCENTILE SUMMARY
OCTOBER 1, 1964 - SEPTEMBER 30, 1967

Parameters	Units	Samples	50 Percentile	90 Percentile
Res. on evap. (total)	mg/l	26	404.0	497.0
Res. on evap. (fixed)	mg/l	24	318.0	357.0
Res. on evap. (volatile)[2/]	mg/l	24	106.0	178.0
Susp. solids (total)	mg/l	26	15.0	29.0
Susp. solids (fixed)	mg/l	4	11.0	
Susp. solids (volatile)	mg/l	4	7.0	
Dissolved solids (total)[2/]	mg/l	26	394.0	481.0
Dissolved solids (fixed)[2/]	mg/l	4	314.0	
Dissolved solids (volatile)[2/]	mg/l	4	133.0	
Coliform (MPN)	No./100ml	26	2400.0	2400.0

1/ Location: At Rts. 5 and 20 bridge in Montezuma National Wildlife Refuge and just west of Cayuga Co. line.

2/ Calculated values.

Source: NYSDEC, n.d. b.

TABLE 18

WATER QUALITY OF THE SENECA RIVER AT BELGIUM [1]
WATER QUALITY PERCENTILE SUMMARY
OCTOBER 1, 1964 - SEPTEMBER 30, 1967

Parameters	Units	Samples	50 Percentile	90 Percentile
Color	Platinum cobalt	48	30.0	45.0
Turbidity	Jackson candle	49	22.0	35.0
Water temperature	°C	47	13.0	25.2
Water temperature[2]	°F	47	55.4	77.4
Dissolved oxygen	mg/1	49	10.0	12.8
Dissolved oxygen[2]	Percent SAT.	47	91.8	133.1
BOD (5-day)	mg/1	47	3.1	5.0
COD (dichromate)	mg/1	29	21.8	47.1
Conductivity	u Mhos	31	1330.0	1800.0
Chlorides (as Cl)	mg/1	31	336.0	450.2
pH	Units	50	7.8	8.4
Hardness (as $CaCO_3$)	mg/1	30	413.0	543.0
Mg hardness (as $CaCO_3$)[2]	mg/1	27	60.7	70.5
Ca hardness (as $CaCO_3$)[2]	mg/1	30	343.5	471.5
Carb. alk. (as $CaCO_3$)	mg/1	27	0.0	5.0
Bicarb. alk. (as $CaCO_3$)	mg/1	27	119.0	138.0
Total alk. (as $CaCO_3$	mg/1	27	120.0	138.0

TABLE 18 (Cont'd)

WATER QUALITY OF THE SENECA RIVER AT BELGIUM[1]
WATER QUALITY PERCENTILE SUMMARY
OCTOBER 1, 1964 - SEPTEMBER 30, 1967

Parameters	Units	Samples	50 Percentile	90 Percentile
Calcium (as Ca)	mg/l	30	137.4	188.6
Magnesium (as Mg)	mg/l	27	14.8	17.2
Sodium (as Na)	mg/l	30	179.5	426.2
Potassium (as K)	mg/l	30	4.1	6.6
Iron (as Fe)	mg/l	30	0.13	0.21
Manganese (as Mn)	mg/l	28	0.00	0.01
Ammonia (as N)	mg/l	30	0.824	1.201
Organic nitrogen (as N)	mg/l	29	0.64	1.29
Nitrites (as N)	mg/l	27	0.031	0.057
Nitrates (as N)	mg/l	28	0.58	1.22
Ammonia (as NH_3)[2]	mg/l	30	0.999	1.456
Nitrites (as NO_2)[2]	mg/l	27	0.102	0.188
Nitrates (as NO_3)[2]	mg/l	28	2.54	5.39
Phosphates (as P)[2]	mg/l	30	0.19	0.36
Phosphates (as PO_4)	mg/l	30	0.59	1.09
Sulfates (as S)[2]	mg/l	27	35.0	50.8
Sulfates (as SO_4)	mg/l	27	105.0	152.2
MBAS (ABS & LAS)	mg/l	29	0.03	0.09
Res. on evap. (total)	mg/l	29	1000.0	1379.0
Res. on evap. (fixed)	mg/l	27	703.0	979.0
Res. on evap. (volatile)[2]	mg/l	26	253.0	413.0

TABLE 18 (Cont'd)

WATER QUALITY OF THE SENECA RIVER AT BELGIUM[1/]
WATER QUALITY PERCENTILE SUMMARY
OCTOBER 1, 1964 - SEPTEMBER 30, 1967

Parameters	Units	Samples	50 Percentile	90 Percentile
Susp. solids (total)	mg/l	26	23.0	38.0
Susp. solids (fixed)	mg/l	26	14.0	22.0
Susp. solids (volatile)[2/]	mg/l	26	10.0	21.0
Dissolved solids (total)[2/]	mg/l	26	1002.0	1303.0
Dissolved solids (fixed)[2/]	mg/l	26	675.0	964.0
Dissolved solids (volatile)[2/]	mg/l	26	242.0	408.0
Coliform (MPN)	No./100ml	49	2400.0	24000.0

1/ Location: At midstream on north side of Belgium Bridge which carries Route 31 over Seneca River at Belgium.

2/ Calculated values.

Source: NYSDEC, n.d. b.

TABLE 19

WATER QUALITY OF LAKE ONTARIO AT ROCHESTER[1/]
WATER QUALITY PERCENTILE SUMMARY
OCTOBER 1, 1964 - SEPTEMBER 30, 1967

Parameters	Units	Samples	50 Percentile	90 Percentile
Color	Platinum cobalt	4	8,0	10.0
Turbidity	Jackson candle	6	3.0	
Water temperature	°C	4	5.2	
Water temperature[2/]	°F	4	41.4	
Dissolved oxygen	mg/l	1	9.2	
Dissolved oxygen[2/]	Percent SAT.	1	70.8	
BOD (5-day)	mg/l	5	1.0	1.5
COD (dichromate)	mg/l	23	7.4	14.2
Conductivity	u Mhos	24	288.0	319.4
Chlorides (as Cl)	mg/l	26	27.3	31.0
Fluorides (as F)	mg/l	1	0.28	
pH	Units	14	8.0	8.2
Hardness (as $CaCO_3$)	mg/l	24	137.0	142.0
Mg hardness (as $CaCO_3$)[2/]	mg/l	24	32.0	42.5
Ca hardness (as $CaCO_3$)[2/]	mg/l	24	105.3	111.7
Carb. alk. (as $CaCO_3$)	mg/l	16	0.0	0.0
Bicarb. alk. (as $CaCO_3$)	mg/l	16	95.0	98.0
Total alk. (as $CaCO_3$)	mg/l	16	95.0	98.0

TABLE 19 (Cont'd)

WATER QUALITY OF LAKE ONTARIO AT ROCHESTER[1/]
WATER QUALITY PERCENTILE SUMMARY
OCTOBER 1, 1964 - SPETEMBER 30, 1967

Parameters	Units	Samples	50 Percentile	90 Percentile
Calcium (as Ca)	mg/l	24	42.1	44.7
Magnesium (as Mg)	mg/l	24	7.8	10.4
Sodium (as Na)	mg/l	24	14.0	23.7
Potassium (as K)	mg/l	24	1.4	2.0
Iron (as Fe)	mg/l	26	0.06	0.16
Manganese (as Mn)	mg/l	24	0.00	0.01
Ammonia (as N)	mg/l	24	0.314	0.671
Organic nitrogen (as N)	mg/l	23	0.32	0.59
Nitrites (as N)	mg/l	24	0.003	0.005
Nitrates (as N)	mg/l	24	0.13	0.27
Ammonia (as NH_3)[2/]	mg/l	24	0.381	0.813
Nitrites (as NO_2)[2/]	mg/l	24	0.009	0.016
Nitrates (as NO_3)[2/]	mg/l	24	0.58	1.18
Phosphates (as P)[2/]	mg/l	24	0.05	0.11
Phosphates (as PO_4)	mg/l	24	0.15	0.35
Sulfates (as S)[2/]	mg/l	24	10.0	15.1
Sulfates (as SO_4)	mg/l	24	30.0	45.2
MBAS (ABS & LAS)	mg/l	24	0.02	0.06

TABLE 19 (Cont'd)

WATER QUALITY OF LAKE ONTARIO AT ROCHESTER[1]
WATER QUALITY PERCENTILE SUMMARY
OCTOBER 1, 1964 - SEPTEMBER 30, 1967

Parameters	Units	Sample	50 Percentile	90 Percentile
Res. on evap. (total)	mg/l	24	225.0	285.0
Res. on evap. (fixed)	mg/l	23	124.0	209.0
Res. on evap. (volatile)[2]	mg/l	22	108.0	134.0
Susp. solids (total)	mg/l	24	7.0	29.0
Susp. solids (fixed)	mg/l	14	4.0	15.0
Susp. solids (volatile)[2]	mg/l	14	3.0	13.0
Dissolved solids (total)[2]	mg/l	24	215.0	272.0
Dissolved solids (fixed)[2]	mg/l	14	106.0	194.0
Dissolved solids (voltatile)[2]	mg/l	14	110.0	138.0
Coliform (MPN)	No./100ml	2	2.2	
Coliform (MF)	No./100ml	4	80.0	

1/ Location: Monroe County Water Authority water intake 2438.4m (8,000 ft) out and 12.2m (40 ft) below lake level, sample taken from raw water tap at Rochester City Filtration Plant.

2/ Calculated values.

Source: NYSDEC, n.d. b.

TABLE 20

WATER QUALITY OF LAKE ONTARIO AT OSWEGO[1]
WATER QUALITY PERCENTILE SUMMARY
OCTOBER 1, 1964 - SEPTEMBER 30, 1967

Parameters	Units	Samples	50 Percentile	90 Percentile
Color	Platinum cobalt	32	7.0	15.0
Turbidity	Jackson candle	32	10.5	16.9
Water temperature	°C	32	8.0	19.6
Water temperature[2]	°F	32	46.4	67.3
Dissolved oxygen	mg/l	32	11.1	13.3
Dissolved oxygen[2]	Percent SAT.	32	91.8	101.5
BOD (5-day)	mg/l	30	1.2	2.3
COD (dichromate)	mg/l	27	9.2	18.9
Conductivity	u Mhos	28	281.0	330.0
Chlorides	mg/l	29	28.5	34.5
pH	Units	32	8.0	8.4
Hardness (as $CaCO_3$)	mg/l	28	139.0	155.0
Mg hardness (as $CaCO_3$)[2]	mg/l	27	33.6	43.2
Ca hardness (as $CaCO_3$)[2]	mg/l	29	106.3	123.3
Carb. alk. (as $CaCO_3$)	mg/l	3	4.0	
Bicarb. alk. (as $CaCO_3$)	mg/l	3	73.0	
Total alk. (as $CaCO_3$)	mg/l	3	77.0	

TABLE 20 (Cont'd)

WATER QUALITY OF LAKE ONTARIO AT OSWEGO[1]
WATER QUALITY PERCENTILE SUMMARY
OCTOBER 1, 1964 - SEPTEMBER 30, 1967

Parameters	Units	Samples	50 Percentile	90 Percentile
Calcium (as Ca)	mg/l	29	42.5	49.3
Magnesium (as Mg)	mg/l	27	8.2	10.5
Sodium (as Na)	mg/l	29	15.0	33.4
Potassium (as K)	mg/l	29	1.5	2.1
Iron (as Fe)	mg/l	29	0.05	0.11
Manganese (as Mn)	mg/l	29	0.00	0.01
Ammonia (as N)	mg/l	28	0.333	0.694
Organic nitrogen (as N)	mg/l	27	0.23	0.52
Nitrites (as N)	mg/l	28	0.001	0.008
Nitrates (as N)	mg/l	28	0.14	0.25
Ammonia (as NH_3)[2]	mg/l	28	0.404	0.841
Nitrites (as NO_2)[2]	mg/l	28	0.003	0.027
Nitrates (as NO_3)[2]	mg/l	28	0.62	1.10
Phosphates (as P)[2]	mg/l	29	0.04	0.08
Phosphates (as PO_4)	mg/l	29	0.13	0.25
Sulfates (as S)[2]	mg/l	29	9.7	13.4
Sulfates (as SO_4)	mg/l	29	29.0	40.2
Res. on evap. (total)	mg/l	28	225.0	275.0
Res. on evap. (fixed)	mg/l	27	141.0	222.0
Res. on evap. (volatile)[2]	mg/l	26	85.0	152.0

TABLE 20 (Cont'd)

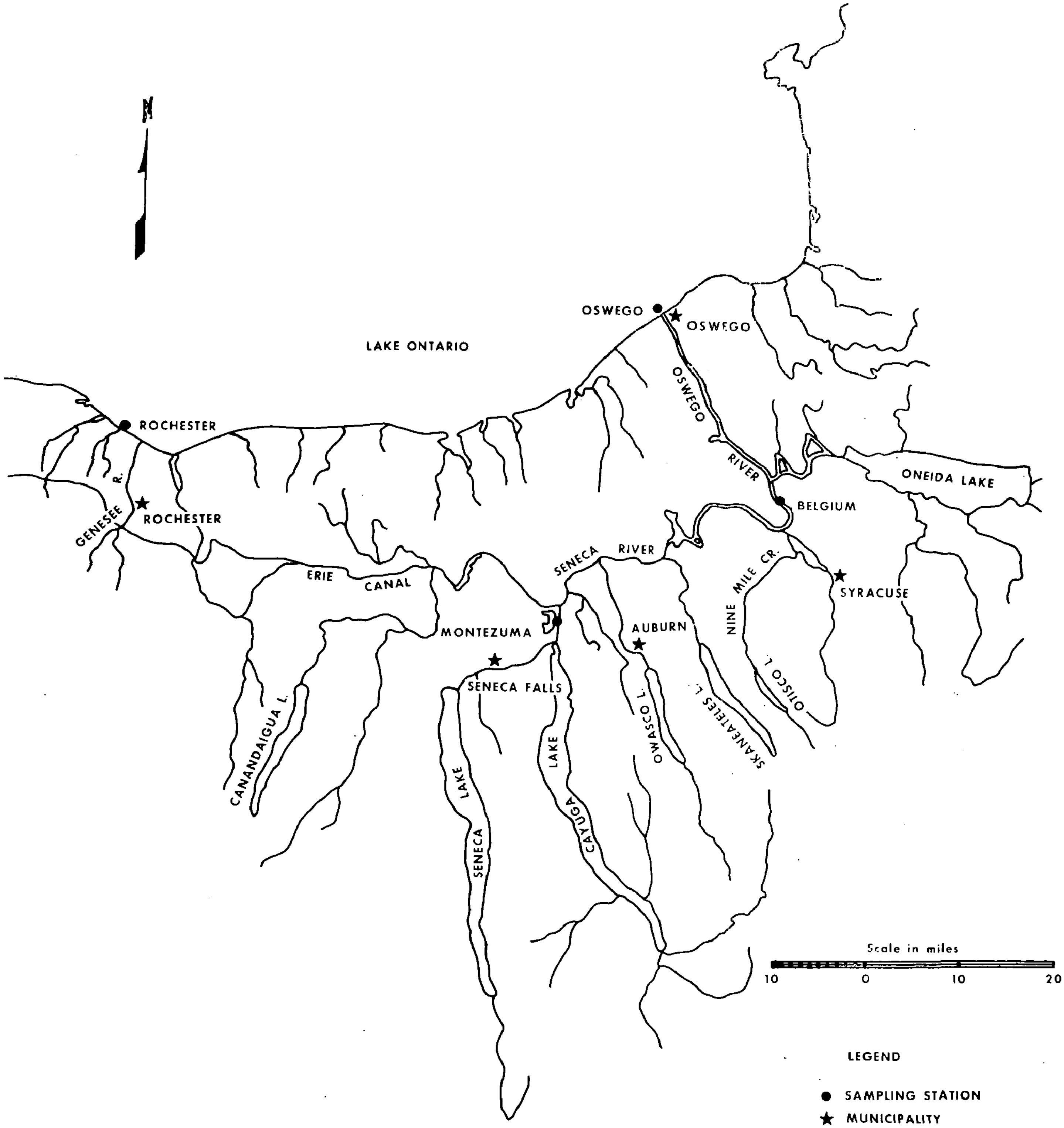
WATER QUALITY OF LAKE ONTARIO AT OSWEGO[1/]
WATER QUALITY PERCENTILE SUMMARY
OCTOBER 1, 1964 - SEPTEMBER 30, 1967

Parameters	Units	Samples	50 Percentile	90 Percentile
Susp. solids (total)	mg/l	26	8.0	22.0
Susp. solids (fixed)	mg/l	1	2.0	
Susp. solids (volatile)[2/]	mg/l	1	0.0	
Dissolved solids (total)[2/]	mg/l	26	209.0	273.0
Dissolved solids (fixed)[2/]	mg/l	1	85.0	
Dissolved solids (volatile)[2/]	mg/l	1	167.0	
Coliform (MPN)	No./100ml	32	23.0	93.0

1/ Location: Oswego City water intake 1981.2m (6,500 ft) into lake at 12.2m (40 ft) below lake level, sample taken from intake pipe inside City water intake building on Sheldon Avenue off Rt. 104.

2/ Calculated values.

Source: NYSDEC, n.d. b.



Source: NYSDEC,n.d.b.

SAMPLING LOCATIONS ON LAKE ONTARIO AND THE SENECA RIVER

Figure 5

and a number of sewage discharges influence the data. Nevertheless, the data indicate that the lake waters have the following effects:

1. Mean dissolved oxygen in the northern portion of the lake for the epilimnion and hypolimnion as indicated by 1968 data in the Onondaga Lake Study is 5.8 mg/l and 1.6 mg/l, respectively. Mean dissolved oxygen in the Seneca River upstream of the lake outlet, as indicated by NYSDEC data of Montezuma is 8.8 mg/l. Mean dissolved oxygen in the Seneca River downstream of the lake outlet as indicated by NYSDEC data at Belgium is 10.0 mg/l. It would appear that lake water has no deleterious effect on the Seneca River as far as dissolved oxygen is concerned.

2. Mean coliform numbers in the northern portion of the lake for the epilimnion and hypolimnion, as indicated by 1968 data in the Onondaga Lake Study are 407 and 120 per 100 ml respectively. Mean coliform numbers in the Seneca River at both Montezuma and Belgium are 2,400 per 100 ml as indicated by NYSDEC data. It should be noted that the 90% coliform value increases from 2,400 per 100 ml at Montezuma to 24,000 per 100 ml at Belgium. Since both values are far in excess of those observed in the lake it seems reasonable to assume that the increase is not due to the influence of the lake.

   It may be due to the discharge of the seven sewage treatment plants on the Seneca River ranging in size from 0.07 to 3.5 MGD. These treatment plants provide disinfection of the effluent. The probable cause in the increase of extreme coliform numbers is discharges from numerous camps and homes along the Seneca River. These discharges are not subject to the same degree of control as are those from sewage treatment plants.

3. The most appreciable difference in Seneca River water downstream of the lake outlet is in terms of chlorides, calcium, sodium and...[total dissolved solids]. As an example the mean chloride level in the epilimnion and hypolimnion of the lake is 1,475 mg/l and 1,887 mg/l. The mean chloride concentrations at Montezuma and Belgium are 114 mg/l and 336 mg/l, respectively. This increase is primarily attributable to the effect of the lake water. (O'Brien & Gere, 1973a).

T
The influence of the lake waters can be seen in the increases of calcium, sodium and total dissolved solids in the Seneca River to 95, 90, and 600 mg/l, respectively. Simpson (1973) reported that the Onondaga Lake discharge had no adverse effects on macroinvertebrates in the Seneca River. However, it is quite possible that this study did not measure the true impact of the lake on the macroinvertebrates in the river. (See <u>DISCUSSION OF PROBLEMS AND OBJECTIONS RAISED BY ALL REVIEWERS</u>).

Increased calcium will lead to increased water hardness in the Seneca River. However, the Seneca River is not used as a public water supply source and its use for industrial purposes is limited. McKee and Wolf (1963) report that "Calcium in water reduces the toxicity of many chemical compounds to fish and other aquatic fauna."

The chloride concentration of 336 mg/l at Belgium far exceeds the 250 mg/l limit recommended for public drinking water supplies by the U.S. Public Health Service (1962). Therefore, the Seneca River below the Onondaga Lake outlet is unsuitable as a potable water supply.

The total dissolved solids (TDS) concentration increases by 600 mg/l between Montezuma and Belgium. Most of this increase is attributable to waters from Onondaga Lake. The U.S. Public Health Service (1962) recommends a TDS limit of 500 mg/l for a public water supply. Since the Seneca River exceeds this limit, it cannot be used as a potable water supply source.

There are no plans to use either the Seneca River or the Oswego River as a potable water supply source. Therefore, Onondaga Lake waters cannot be said to have a deleterious effect on the best water usage of these rivers, as defined by the New York State water quality standards (Appendix A). Still, Onondaga Lake does affect the water quality of these waterways (see DISCUSSION OF PROBLEMS AND OBJECTIONS RAISED BY ALL REVIEWERS).

Data obtained from samples taken at two sampling stations on Lake Ontario are quite similar, indicating that Onondaga Lake has little impact on the water quality in Lake Ontario. One of the sampling stations is located at Greece near Rochester (Table 19) and the other at Oswego (Table 20) just west of the point at which the Oswego River flows into the lake.

GROUND WATER

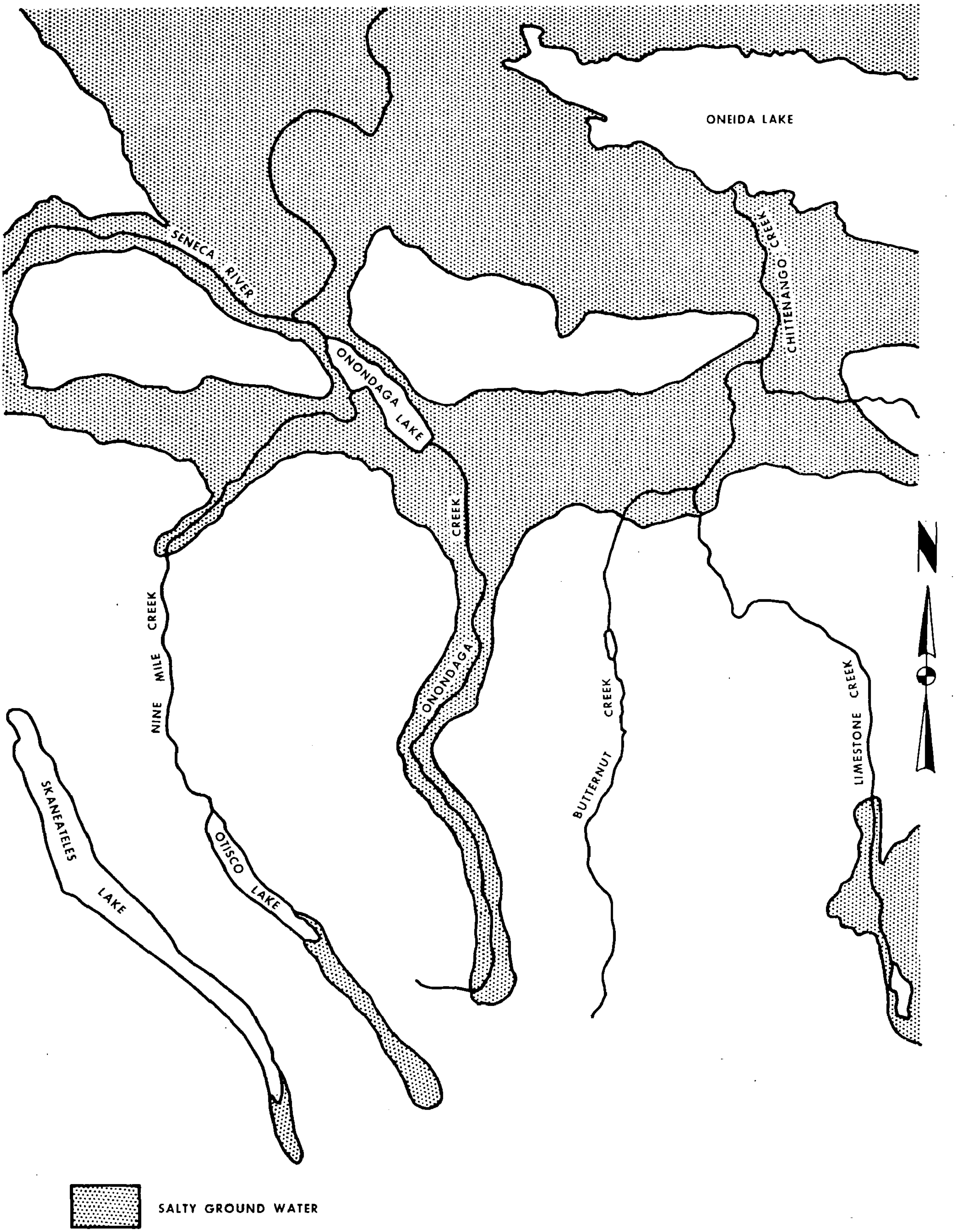
Onondaga Lake is located in the eastern half of the Oswego River basin. According to Kantrowitz (1970):

> Ground water in much of the Eastern Oswego River basin is of poor quality. Wells tapping either the limestone and middle shale units or the unconsolidated deposits overlying these units are likely to yield very hard water. Water from the middle shale unit may be so hard as to make treatment uneconomical. Large parts of the basin are underlain by relatively shallow salty ground water. The salt water is derived in part from layers of rock salt within the middle shale unit and in part from upward movement of salt water from deeper parts of the bedrock.
>
> The presence of highly salty ground water in Onondaga Creek valley is evidence of both the occurrence of brine in the middle shale unit and its movement along the zone of rock-salt solution. The bedrock underlying parts of the valley has been eroded to below sea level to form a trough-like depression. In places this trough has cut through the zone where rock salt has been dissolved but nowhere has it penetrated the rock-salt zone itself. Because the bedrock trough is partly filled with permeable deposits of sand and gravel, it acts as a huge collector well. Ground water from the bedrock moves into the sand and gravel and then moves toward a discharge area near Onondaga Lake. The water formerly used for salt manufacture at Onondaga Lake was pumped from these sand and gravel aquifers. The water had a chloride content of about 100,000 ppm (Clark, 1924, p. 184) which is about five times as salty as the ocean. Doubtless, some of the water that moved into the sand and gravel was fresh and some was salty. In order to account for chlorides of about 100,000 ppm, the salt water component from the bedrock must have been close to a saturated brine containing about 155,000 ppm of chloride (Hem, 1959, p.111).

Figure 6 shows the area around Onondaga Lake where salty ground water occurs. Table 21 presents the results of a field survey performed by the applicant. The table shows that chloride concentrations increase near the mouth of Onondaga Creek.

Data derived from samples taken at three ponds on the eastern shore of Onondaga Lake (Figure 7) show the chloride levels in the ponds:

Pond	Chloride Level
1 (Sampling point A)	1200 mg/l
1 (Sampling point B)	1200 mg/l
2	2480 mg/l
3	300 mg/l



Source: O'Brien & Gere, 1973a.

AREAS OF SALTY GROUND WATER

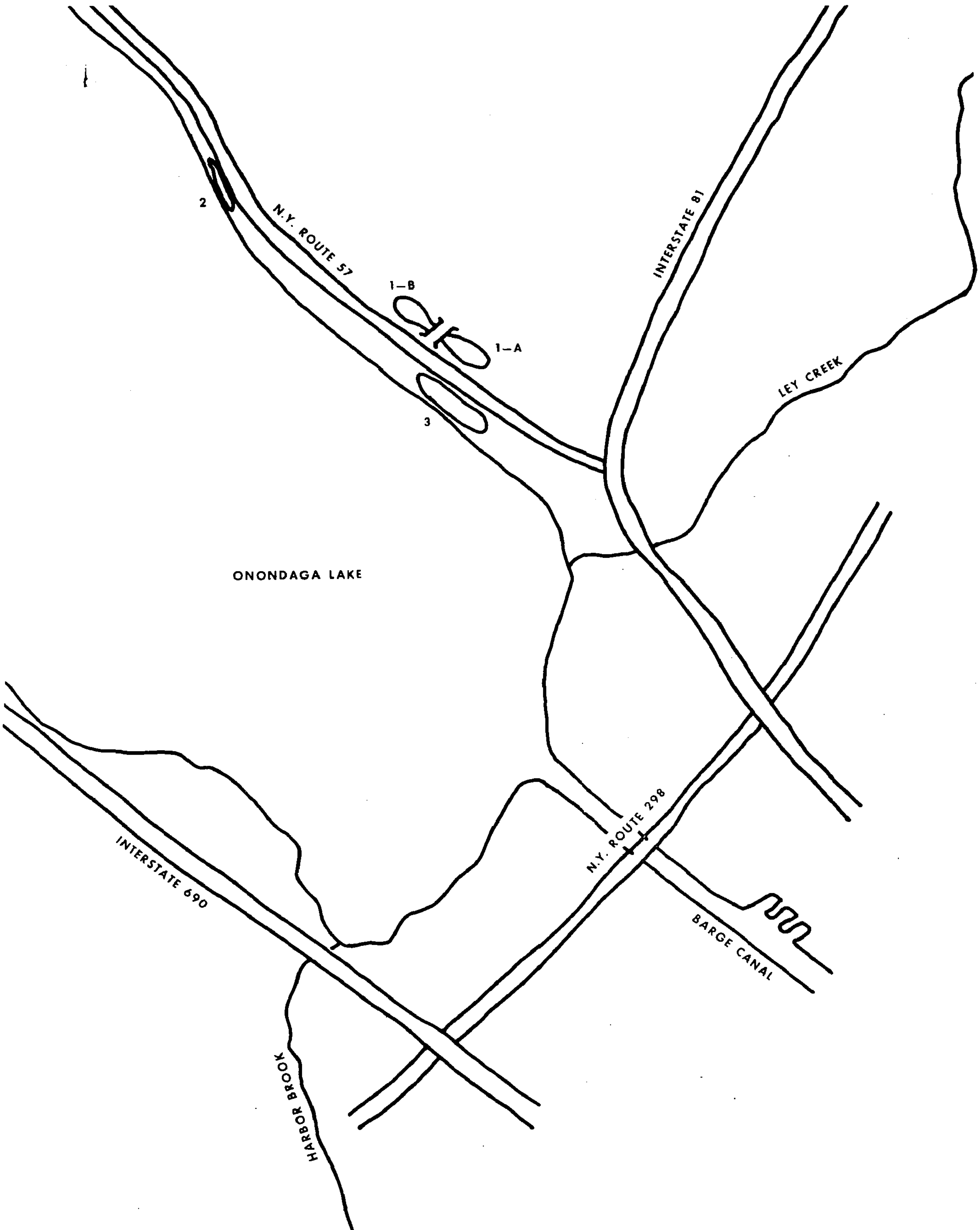
Figure 6

TABLE 21

INSTREAM CHLORIDE MEASUREMENTS AND LOADING DETERMINED
AT VARIOUS POINTS ON ONONDAGA CREEK
MAY 1973

	5/10/73 Sampling					5/16/73 Sampling					5/18/73 Sampling				
	Cl^- conc.	Flow		Cl^- Loading		Cl^- conc.	Flow		Cl^- Loading		Cl^- conc.	Flow		Cl^- Loading	
Sampling Location	mg/l	cu m/day	mgd	kg/day	lbs/day	mg/l	cu m/day	mgd	kg/day	lbs/day	mg/l	cu m/day	mgd	kg/day	lbs/day
Dorwin Avenue	80	326,000	86	26,000	57,400	94	308,000	81.5	29,100	64,000	71.0	375,000	99	26,600	58,700
South Avenue	82	386,000	102	31,700	69,800	94	331,000	87.4	31,100	68,600	76.0	394,000	104	30,000	66,000
Midland Avenue	-	-	-	-	-	100	353,000	93.3	35,400	78,000	85.5	416,000	110	35,600	78,500
W. Onondaga St.	-	-	-	-	-	100	375,000	99.2	37,500	82,600	85.5	435,000	115	37,200	82,000
W. Genesee St.	-	-	-	-	-	160	398,000	105.1	63,600	140,000	145.0	458,000	121	64,500	142,000
Spencer St.	156	450,415	119	70,300	154,800	178	420,000	111.0	74,800	164,800	148.5	477,000	126	70,800	156,000

Source: O'Brien & Gere, 1973a.



Source: O'Brien & Gere, 1973a.

LOCATION OF SALTY PONDS

Figure 7

It appears that salty ground water may indeed be discharged near the southeastern end of Onondaga Lake. However, the significance of this discharge to the chloride level of Onondaga Lake has not been determined. It is possible that the salt water contributed by ground waters alone causes the high chloride concentrations in Onondaga Lake. These concentrations exceed the maximum 250 mg/l level that was established by the U.S. Public Health Service (1962) to prevent salty tasting drinking waters. The question of chlorides in Onondaga Lake is discussed in Appendix B.

WATER RESOURCES

O'Brien & Gere (1968) estimated that the present water demand in Onondaga County is 350,000 cu m/day (92.5 mgd). This is expected to reach 647,000 cu m/day (171 mgd) by the year 2000. However, in the MSSTP service area, water consumption is not expected to increase significantly.

Onondaga County's main water supply sources are Skaneateles Lake and Otisco Lake, which have safe yields of 165,000 cu m/day (43.5 mgd) and 76,000 cu m/day (20.0 mgd), respectively. Water is being withdrawn from these lakes at or near their maximum safe yields. (O'Brien & Gere, 1973a). Other, smaller sources, primarily wells, are capable of supplying approximately 15,000 cu m/day (4.0 mgd). Thus the total capacity from sources within the county is approximately 255,000 cu m/day (67.5 mgd).

In 1967, Onondaga County completed construction of a water supply system to obtain water from the Oswego intake on Lake Ontario. This system has a capacity of 95,000 cu m/day (25 mgd). It may be expanded to 237,000 cu m/day (62.5 mgd) by construction of additional pumping and treatment facilities. It may be even further expanded by construction of additional intake, pumping, treatment and transmission facilities.

No public water supplies are derived from Onondaga Lake or from the Seneca-Oneida-Oswego River system. Furthermore, there are no plans to use these waterways as sources of public water supplies in the future.

Use of ground water in the area is expected to decline in the future. In fact, it has been recommended that all public well supplies in the county, with the exception of those at Baldwinsville and Tully, be abandoned (O'Brien & Gere, 1968). The following reasons were offered:

1. These sources are or will be located in densely developed areas where the pollution hazard is high; many wells already show evidence of pollution;
2. Rated capacities are inadequate to meet future demands;
3. Present water quality does not compare favorably with that now or potentially available from alternative sources. (O'Brien & Gere,1968).

AIR QUALITY

Available monitoring data reveal that in the vicinity of the MSSTP, ambient air quality standards for suspended particulates were exceeded between 1969 and 1972 (Table 22). Air quality standards for total oxidants were exceeded between 1971 and 1972 (Table 22). Current levels of sulfur oxides, carbon monoxide, and nitrogen dioxide are in compliance with the national standards.

Since there are no emissions from the MSSTP primary treatment plant, the air quality violations must be ascribed to other, primarily industrial, sources in the area. Odors are the main air quality problem presented by sewage treatment plants; there are no Federal, State or local standards for the control of odors. However, the upgraded and expanded MSSTP is not expected to cause any odor problems.

TABLE 22

AIR QUALITY MONITORING DATA FOR SYRACUSE, NEW YORK[1/]
1969 - 1972

Pollutant	Year	Max. Conc.	Arith. Mean	Geom. Mean	Violation of Standard
Particulates (ug/m^3)	1969	294	95	-	Yes
	1970	279	100	-	Yes
	1971	417	114	101	Yes
	1972	210	92	83	Yes
Carbon monoxide (ppm)	1971	23.7	-	-	No
	1972	18.9	-	-	No
Sulfur dioxide (ppm)	1971	-	.022	-	No
	1972	-	.011	-	No
Nitrogen dioxide (ppm)	1971	-	.02	-	No
Oxidants (ppm)	1971	.130	-	-	Yes
	1972	.092	-	-	Yes

1/Monitoring station at MSSTP, Hiawatha Boulevard.

Source: NYSDEC, 1973.

MUNICIPAL WASTEWATER FACILITIES

There are now twenty-nine public and private sewage treatment plants serving Onondaga County; those plants that serve specific industries and schools are not included in this number (Camp, Dresser & McKee, 1968). As shown in Figure 8, there are eight municipal treatment facilities within the Onondaga Lake drainage basin. Basic descriptions of these facilities are given in Table 23. The industrial wastewater discharges within the drainage basin are discussed on pages 89 to 98.

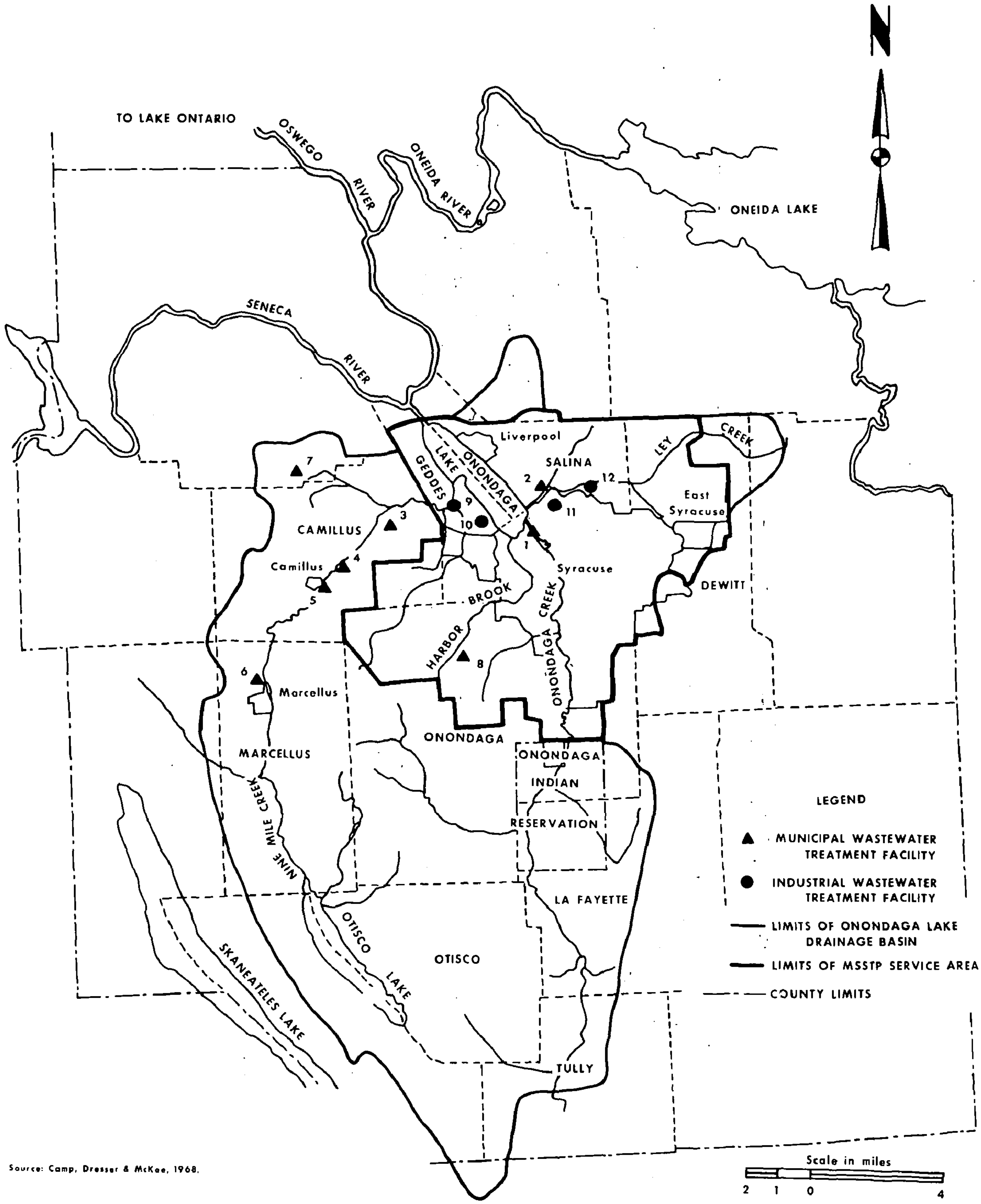
The major point source discharges in the basin are those from the Metropolitan Syracuse sewage treatment plant, the Allied Chemical Corporation, and Crucible Incorporated.

Detailed Description Of The Existing Facilities Of The Metropolitan Syracuse Sewage Treatment Plant

The MSSTP is the largest wastewater treatment facility in Onondaga County. It has been providing primary treatment for domestic wastewaters since 1960. Prior to 1960, the City of Syracuse operated its own sewage treatment facility. This facility, which was built in 1925, was located on the southern shore of Onondaga Lake, just west of the present MSSTP outfall. (Onondaga County, 1971). In addition to sewage flows from its own service area, the MSSTP receives the effluent from the Ley Creek sewage treatment plant (LCSTP), the county's second largest municipal wastewater treatment facility. The service area of the MSSTP is shown in Figures 8 and 9.

Collection System

As shown in Figure 9, sewage is conveyed to the MSSTP by two interceptors and two force mains. Basic data on the principal sewers in the MSSTP service area are given in Table 24. The interceptors serve the City of Syracuse, transferring raw sewage from local collection systems to the treatment plant.



EXISTING WASTEWATER TREATMENT FACILITIES IN THE ONONDAGA LAKE DRAINAGE BASIN

Figure 8

TABLE 23

BASIC DATA FOR EXISTING MUNICIPAL WASTEWATER TREATMENT PLANTS IN THE ONONDAGA LAKE DRAINAGE BASIN

Map Identity Code Number (See Fig. 8)	Name and Location of Sewage Treatment Plant	Year Built	Design Capacity		Receiving Waters	Type of Treatment
			cu m/day	mgd		
1	Metropolitan Syracuse, Syracuse	1960	189,000	50.0	Onondaga Lake	Primary: Bar screen, Grit chamber, Sedimentation basins, Chemical flocculation, Pre- and postchlorination, Anaerobic sludge digestion, Lagoons.
2	Ley Creek, Salina	1935	34,000	9.0	Metropolitan Syracuse Treatment Plant (since 1969)	Secondary: Bar screen, Grit chamber, Sedimentation basins, Activated sludge, Pre- and post-chlorination, Aerobic sludge digestion, Sludge drying beds.
3	Greenfield Village, Camillus	1967	380	0.10	Nine Mile Creek	Secondary: Bar screen, Comminutor, Contact stabilization, Post-chlorination, Aerobic sludge digestion.
4	Nine Mile Sanitary District, Camillus	1967	2,800	0.75	Nine Mile Creek	Secondary: Bar screen, Comminutor, Grit chamber, Sedimentation basin, Contact stabilization, Post-chlorination, Aerobic digestion.
5	Camillus Village	1932	570	0.15	Nine Mile Creek	Primary: Bar screens, Imhoff tanks, Sludge drying beds.
6	Marcellus, Village of Marcellus	1959	950	0.25	Nine Mile Creek	Secondary.

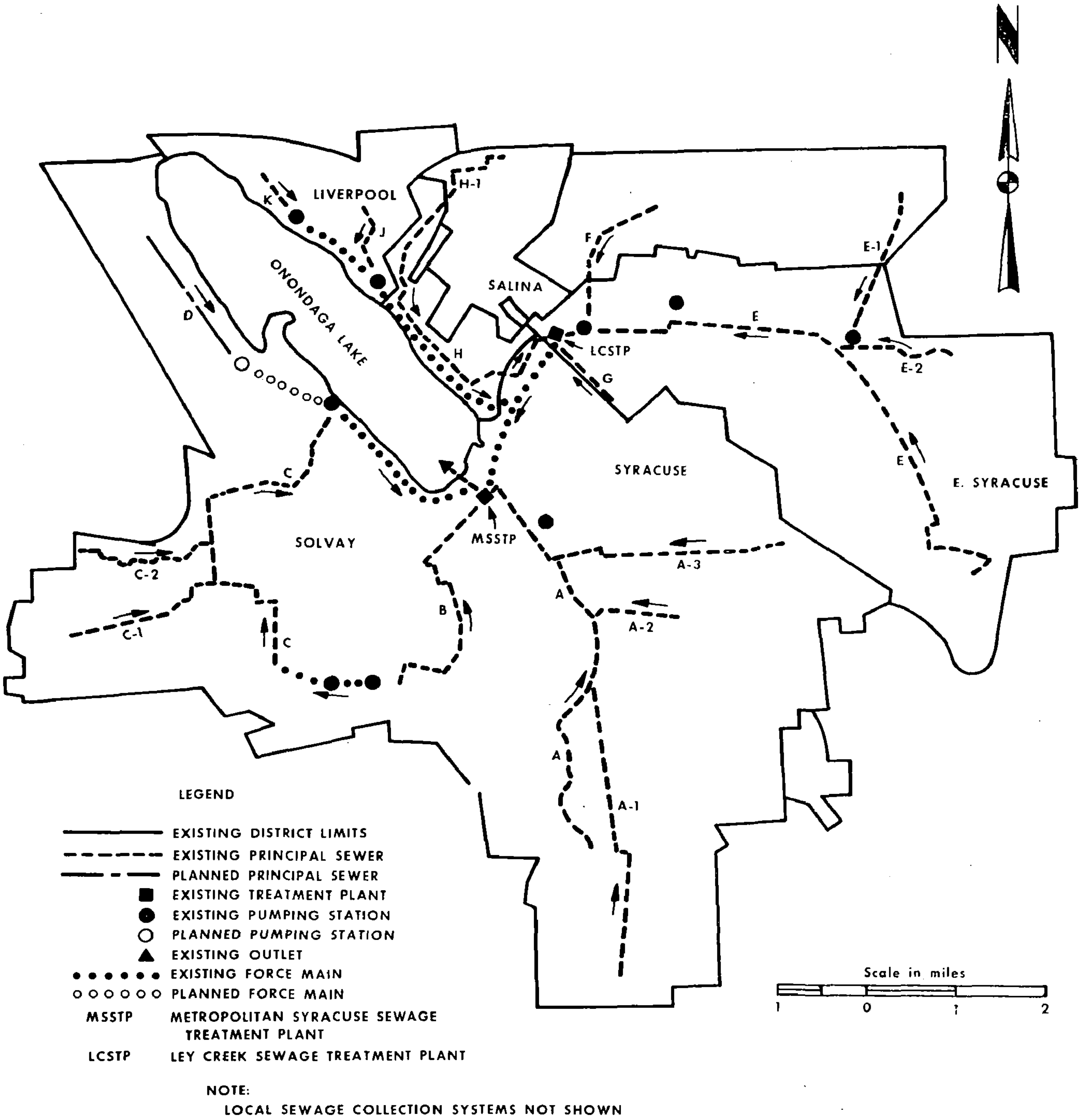
TABLE 23 (Cont'd)

BASIC DATA FOR EXISTING MUNICIPAL WASTEWATER TREATMENT PLANTS IN THE ONONDAGA LAKE DRAINAGE BASIN

Map Identity Code Number (See Fig. 8)	Name and Location of Sewage Treatment Plant	Year Built	Design Capacity		Receiving Waters	Type of Treatment
			cu m/day	mgd		
7	Warners, New York Thruway, Westbound service area	-	-	-	-	Tertiary.
8	Harris Hill[1/]	1970-71	420	0.11	Harbor Brook	Secondary: Comminutor, Settling, Activated sludge, Chlorination.

1/ O'Brien & Gere, 1973a.

Source: Camp, Dresser & McKee, 1968.



Source: Camp, Dresser & McKee, 1968.

METROPOLITAN SYRACUSE AND LEY CREEK SEWAGE TREATMENT PLANTS
SERVICE AREAS AND FACILITIES

Figure 9

TABLE 24

SUMMARY OF EXISTING SEWERS IN MSSTP SERVICE AREA
INCLUDING LCSTP SERVICE AREA

Identity Code Designation (See Fig. 9)	Sewer Name	Sewer Location	Pipe Size[1/] cm (in.)	Nominal Capacity [2/] cu m/day (mgd)
A	Main Intercepting Sewer	City of Syracuse Plum Street to Metropolitan Syracuse Treatment Plant	230[3/] (90)	469,000 (124)
A-1	Midland Avenue	City of Syracuse West Kennedy Street to Main Intercepting Sewer	200 (80)	530,000 (140)
A-2	Harrison Street Trunk Sewer	City of Syracuse Harrison Street to South Clinton Street	120 x 180 (48 x 72)	265,000 (70)
A-3	Burnet Avenue Trunk Sewer	City of Syracuse James Street to Main Intercepting Sewer	180 (72)	681,000 (180)
B	Harbor Brook Intercepting Sewer	City of Syracuse State Fair Boulevard to Metropolitan Syracuse Treatment Plant	140[4/] (54)	87,000[5/] (23)
C	West Side Trunk Sewer	Towns of Geddes and Camillus Route 690 to West Side Pumping Station	110 (42)	90,100 (23.8)

TABLE 24 (Cont'd)

SUMMARY OF EXISTING SEWERS IN MSSTP SERVICE AREA
INCLUDING LCSTP SERVICE AREA

Identity Code Designation (See Fig. 9)	Sewer Name	Sewer Location	Pipe Size[1/] cm (in.)	Nominal Capacity[2/] cu m/day (mgd)
C-1	Geddes Brook Trunk Sewer	Town of Camillus Onondaga Road to West Side Trunk Sewer	53 (21)	28,000 (7.3)
C-2	Milton Avenue Trunk Sewer	Town of Camillus Jones Street to West Side Trunk Sewer	51 (20)	12,000 (3.3)
D	Lakeland Trunk Sewer (Planned)	Town of Geddes Tarolli Street to Lakeside Pumping Station (Planned)	-	16,000 (4.3)
E	Ley Creek Trunk Sewer	Towns of Salina and Dewitt Route 11 to Ley Creek Treatment Plant	120 (48)	80,200 (21.2)
E-1	Brooklawn Trunk Sewer	Town of Dewitt Molloy Road to Brooklawn Pumping Station	61 (24)	24,000 (6.4)
E-2	Extension Ley Creek Trunk Sewer	Town of Dewitt Deere Road to Ley Creek Trunk Sewer	69 (27)	-
F	Beartrap Trunk Sewer	Town of Salina New York State Thruway to Ley Creek Trunk Sewer	76 (30)	26,000 (7.0)

TABLE 24 (Cont'd)

SUMMARY OF EXISTING SEWERS IN MSSTP SERVICE AREA
INCLUDING LCSTP SERVICE AREA

Identity Code Designation (See Fig. 9)	Sewer Name	Sewer Location	Pipe Size 1/ cm (in.)	Nominal Capacity 2/ cu m/day (mgd)
G	Seventh North Street Trunk Sewer	City of Syracuse and Town of Salina Seventh North Street to Ley Creek Pumping Station	53 (21)	14,000 (3.6)
H	Electronics Park Trunk Sewer	Town of Salina Beartrap Creek to Ley Creek Pumping Station	61 (24)	16,000 (4.3)
H-1	Hopkins Road Trunk Sewer	Town of Salina Electronics Parkway to Electronics Park Trunk Sewer	46 (18)	8,700 5/ (2.3)
J	Bloody Brook Trunk Sewer	Town of Salina Old Liverpool Road to Liverpool Pumping Station	76 (30)	45,000 (12)
K	Iroquois Lane Trunk Sewer	Town of Salina Hiawatha Trail to Hickory Street Pumping Station	30 (12)	3,400 5/ (0.9)

1/Diameter of circular pipe, unless noted otherwise.

2/Nominal capacity, based on full flow with hyraulic grade line parallel to average invert slope, for Manning coefficient n=0.013, unless noted otherwise.

3/230 cm (90 in.) and 230 cm (90 in.) equivalent sections.

4/140 cm (54 in.) equivalent diameter.

5/Manning coefficient n=0.015.

Source: Camp, Dresser & McKee, 1968.

Most of these local systems are combined sewerage systems; they transmit both sanitary sewage and stormwater flows. The more recently constructed systems have separate facilities for stormwater and sanitary sewage. The major interceptors serving the City of Syracuse are the Main Intercepting Sewer and the Harbor Brook Intercepting Sewer.

The areas west of Syracuse are served by the West Side Trunk Sewer and the West Side Force Main. The force main and its concomitant pumping station will be enlarged as a separate project during expansion and upgrading of the MSSTP.

The second force main tributary to the MSSTP transmits wastewaters from the Ley Creek service area and sections of Liverpool. The Ley Creek service area includes areas to the east and northeast of Syracuse; it is discussed in subsequent sections.

The two intercepting sewers serving the City of Syracuse were built between 1907 and 1926 (Camp, Dresser & McKee, 1968). Deterioration has occurred over the years, particularly in the overflow devices. Recent improvements to eliminate dry weather overflows have been made by the Onondaga County Department of Public Works. These improvements have increased the average daily flow rate received at the MSSTP from approximately 208,000 cu m/day (55 mgd) to 265,000 cu m/day (70 mgd).

Onondaga County is currently performing an infiltration/inflow analysis on its entire sewerage system, including the local collection systems feeding the main interceptors. The purpose of the study is to eliminate excessive infiltration and/or inflow. Based on a contributing population of 261,000, the present flows at the MSSTP indicate an individual contribution of approximately 1000 lpcd (260 gpcd). This value is unusually high in light of the national average individual contribution of 380 lpcd (100 gpcd).

Sources of wastewater, other than domestic discharges, include industrial contributions, stormwater runoff, and infiltration. The EPA will make its financial grant for the MSSTP project contingent upon the abatement of excessive inflow and/or infiltration to the collection systems. Excessive infiltration/inflow is defined as "The quantities of infiltration/inflow which can be economically eliminated from a sewer system by rehabilitation, as determined by a cost-effectiveness analysis that (for the design life of the treatment works) compares correcting the infiltration/inflow conditions with increasing the treatment works capacity to provide the required waste water treatment for the quantities of infiltration/inflow." (U.S. EPA, 1973c).

In March 1973, the EPA awarded construction grants to the Onondaga County Department of Public Works for the following projects:

1. WPC-NY-658 - Kirkpatrick Street Pumping Station
2. C-36-763 - Harbor Brook Interceptor and Pumping Station.

The Kirkpatrick Street Pumping Station project will include the construction of a new pumping station to convey wastewaters from a portion of the City of Syracuse to the Main Intercepting Sewer. The wastewater will then flow by gravity to the MSSTP. The average, peak, and stormwater pumping capacities of the station will be 9500 cu m/day (2.5 mgd), 19,000 cu m/day (5.0 mgd), and 87,000 cu m/day (23.0 mgd), respectively. The new pumping station will be constructed on the site of the existing Kirkpatrick Street Pumping Station.

The Harbor Brook Interceptor, constructed in 1910, has settled and deteriorated in its length between the MSSTP and the Interstate 690 - Hiawatha Boulevard underpass. This limits the hydraulic capacity of the sewer and causes excessive daily overflows to Harbor Brook. A further reduction in hydraulic capacity is evidenced by grit accumulation in the sewer pipe. Under the proposed project, a new 140 cm (54 in.) diameter prestressed concrete cylinder pipe interceptor on a prestressed concrete mat supported by 73 m (240 ft) piles will be constructed. The slope of this section will be increased over that of the original section. The steeper slope will effect a higher velocity of flow in the sewer, thereby preventing the sedimentation of grit in the sewer. A low lift pumping station will be constructed to transfer wastewater flows from the sewer line to the MSSTP. The station will provide three 180 cm (72 in.) Archimedes screws, each with a capacity of 57,000 cu m/day (15 mgd); one of the screws will provide standby capacity. The station will also include a Parshall flume.

Treatment System

The MSSTP, located on the southeastern shore of Onondaga Lake, is designed to treat an average daily flow of 189,000 cu m/day (50 mgd). It provides primary treatment, including grit removal, screening, sedimentation and chlorination. A plant pumping station, situated directly behind the bar screens, provides a pumping capacity of 643,000 cu m/day (170 mgd) to lift wastewaters to the sedimentation tanks. Flows in excess of this quantity are bypassed directly to Onondaga Lake without further treatment.

Sludge is anaerobically digested and pumped to the Allied Chemical Corporation for disposal. At present, Allied deposits the sludge in settling lagoons which it formerly used for disposal of its own wastes. Sludge can also be transferred to Allied by truck. If, for some reason, disposal at Allied is impossible, the sludge can be dewatered by centrifuging and disposed of at a sanitary landfill site run by the Onondaga County Solid Waste Authority.

The basic operating data for the MSSTP for 1972 are given in Table 25. In 1972, the average flow was 254,000 cu m/day (67 mgd), or approximately 35 percent above design flow. Hydraulic overloading was also experienced in 1970 and 1971. Overloading has resulted in decreased treatment efficiencies. In 1972, the suspended solids and BOD (5-day) removals were 51.3 and 26.0 percent, respectively. According to Metcalf & Eddy (1972): "Efficiently designed and operated primary sedimentation tanks should remove from 50 to 65 percent of the suspended solids, and from 25 to 40 percent of the BOD_5." In 1972, the suspended solids loading imposed on Onondaga Lake by the MSSTP was 18,000 kg/day (39,000 lb/day), and the BOD (5-day) loading was 29,000 kg/day (60,000 lb/day).

Effluent Disposal System

There are two outfalls available for disposal of the MSSTP effluent. The outfall normally used is a 150 cm (60 in.) diameter pipe extending 520 m (1700 ft) offshore into Onondaga Lake. Treated flows are usually discharged through this deep outfall. The alternate outfall is also a 150 cm (60 in.) diameter pipe. It terminates at the southeastern shore of Onondaga Lake as a surface discharge. This outfall is used primarily for bypassing flows in excess of the MSSTP peak capacity of 643,000 cu m/day (170 mgd).

Detailed Description Of The Existing Facilities Of The Ley Creek Sewage Treatment Plant

The LCSTP provides partial secondary treatment for influent wastewaters. However, the plant is severely overloaded, causing BOD and suspended solids removals to fall far below those expected of a secondary treatment process. The effluent from the LCSTP is transferred to the MSSTP for further treatment and disposal.

TABLE 25

SUMMARY OF OPERATING RESULTS
MSSTP AND LCSTP
1972

Month	Flow		BOD (5-day)			Suspended Solids		
	(cu m/day)	(mgd)	Influent (mg/1)	Effluent (mg/1)	Removal (percent)	Influent (mg/1)	Effluent (mg/1)	Removal (percent)
				MSSTP				
Jan.	237,000	62.5	206	165	19.1	163	81	48.2
Feb.	226,000	59.8	202	151	24.2	180	90	48.9
March	279,000	73.7	150	111	22.0	183	82	48.8
April	277,000	73.1	136	110	16.3	143	72	46.3
May	268,000	70.7	114	80	27.5	124	55	43.0
June	271,000	71.6	110	81	26.3	150	66	49.2
July	250,000	66.0	122	85	26.0	142	54	49.2
Aug.	235,000	62.1	140	89	33.6	145	59	50.4
Sept.	234,000	61.8	161	116	26.8	178	67	60.3
Oct.	244,000	64.4	179	123	31.0	205	74	61.3
Nov.	247,000	65.3	146	94	33.1	174	71	54.1
Dec.	276,000	72.8	129	94	26.1	167	70	55.7
1972 Avg	254,000	67.0	150	108	26.0	163	70	51.3
1971 Avg	228,000	60.2	203	158	20.4	162	75	49.2
1970 Avg	223,000	59.0	215	164	23.0	198	73	63.0

TABLE 25 (Cont'd)

SUMMARY OF OPERATING RESULTS
MSSTP AND LCSTP
1972

Month	Flow		BOD (5-day)			Suspended Solids		
	(cu m/day)	(mgd)	Influent (mg/l)	Effluent (mg/l)	Removal (percent)	Influent (mg/l)	Effluent (mg/l)	Removal (percent)
LCSTP								
Jan.	36,000	9.5	652	315	48.4	303	77	70.7
Feb.	34,000	9.1	555	329	39.0	399	69	79.6
March	39,000	10.3	283	173	35.9	256	39	82.7
April	59,000	15.6	389	179	48.1	253	31	70.5
May	54,500	14.4	233	99	36.3	197	138	30.0
June	52,600	13.9	261	68	40.8	215	45	65.0
July	53,000	14.0	271	197	23.1	179	55	68.7
Aug.	47,700	12.6	382	197	45.0	242	48	77.4
Sept.	45,400	12.0	556	310	41.3	377	62	81.2
Oct.	50,300	13.3	572	286	45.8	401	55	85.5
Nov.	63,200	16.7	363	220	35.3	304	48	82.8
Dec.	68,900	18.2	363	221	37.8	329	57	81.1
1972 Avg	50,300	13.3	407	216	39.7	288	60.0	72.9
1971 Avg	60,200	15.9	590	298	44.9	404	63.7	83.9
1970 Avg	61,700	16.3	578	369	36.0	411	61.0	85.0

Source: O'Brien & Gere, 1973a.

Collection System

The service area of the LCSTP is shown in Figure 9. The main interceptors tributary to this facility are the Ley Creek Trunk Sewer and the Electronics Park Trunk Sewer. Pertinent data on these sewers are given in Table 24.

The LCSTP's service area is characterized by a rather large number of industrial wastewater discharges. The major industries, or those with wastewater flows in excess of 1900 cu m/day (0.5 mgd), are listed in Table 26. Of the 139 industries in the service area, only six can be considered major.

Treatment and Effluent Disposal Systems

The LCSTP was built in 1934 as a 34,000 cu m/day (9.0 mgd) secondary wastewater treatment facility. As shown in Table 25, the plant is both hydraulically and organically overloaded. The high organic load is primarily the result of large industrial wastewater flows to the plant.

Raw sewage entering the LCSTP is treated by screening, grit removal, sedimentation, and activated sludge biological treatment. The effluent is not chlorinated because it is transferred to the MSSTP for further treatment. Three effluent pumps, each rated at 108,000 cu m/day (28.5 mgd), are provided; the force main connecting the two plants is 110 cm (42 in.) in diameter.

Sludge digesters and drying beds are available, but usually the sludge is pumped through a 15 cm (6 in.) diameter force main to the MSSTP. Approximately 340 cu m/day (90,000 gpd) of sludge are transferred to the MSSTP for further treatment and disposal. Under normal circumstances, the sludge from the MSSTP is transferred to the Allied Chemical Corporation for final disposal.

TABLE 26

MAJOR INDUSTRIAL WASTEWATER DISCHARGES IN THE ONONDAGA LAKE DRAINAGE BASIN[1/]

Map Identification Code Number (See Fig. 8)	Company	No. of Employees	Plant Effluent Flow		Receiving Waters	Plant Contribution to Receiving Waters	
			cu m/day	mgd		cu m/day	mgd
9	Allied Chemical Corp.[2/]	1788					
	Discharge 001		272,000	71.8	Onondaga Lake	272,000	71.8
	Discharge 002		77,200	20.4	Geddes Brook	77,200	20.4
	Discharge 003		25,000	6.6	Geddes Brook	25,000	6.6
10	Crucible Inc.[2/]	2000	19,800	5.24	Tributary of Onondaga Lake	19,800	5.24
11	Crouse Hinds[3/]	2500	2,700	0.71	LCSTP	negligible	
					Ley Creek	2,800	0.74
12	General Motors Corp.[3/]	1550	5,680	1.50	LCSTP	110	0.03
					Ley Creek	5,560	1.47
-	Bristol Laboratories[3/]	1960	7,150	1.89	LCSTP	7,080	1.87
					Ley Creek	70	0.06
-	Carrier Corp.[3/]	6000	6,060	1.60	LCSTP	1,900	0.50

TABLE 26 (Cont'd)

MAJOR INDUSTRIAL WASTEWATER DISCHARGES IN THE ONONDAGA LAKE DRAINAGE BASIN[1/]

Map Identification Code Number (See Fig. 8)	Company	No. of Employees	Plant Effluent Flow		Receiving Waters	Plant Contribution to Receiving Waters	
			cu m/day	mgd		cu m/day	mgd
-	General Electric Electronics Park[3/]	-	6,660	1.76	LCSTP Ley Creek	5,700 800	1.5 0.2
-	Prestolite Division Eltra Corp.	950	2,460	0.65	LCSTP Ley Creek	2,300 150	0.61 0.04

1/ Major discharges are those with flows greater than 1900 cu m/day (0.5 mgd).

2/ Source: U.S. EPA, 1971a.

3/ Source: Roy F. Weston, 1969

INDUSTRIAL WASTEWATER DISCHARGES

The industrial development of Onondaga County began in the early 1800's with the establishment of a salt and brine trade. Development continued with the establishment of industries for the manufacture of such products as soda ash, steel, vehicular accessories, and pottery. Since the turn of the century, other major manufacturing enterprises have been established, including pharmaceutical, air conditioning, general appliance, and electrical plants.

Most of the industries in Onondaga County can be classified as minor water users. Thus most industrial wastewater discharges amount to less than 1900 cu m/day (0.5 mgd). The major discharges are listed in Table 26. The greatest number of industrial discharges, both major and minor, are located within the Ley Creek Sanitary District which is part of the MSSTP service area. Industrial loadings to the LCSTP are expected to decrease slightly in the future as a result of more stringent pretreatment requirements.

The Allied Chemical Corporation and Crucible Incorporated account for the major industrial wastewater discharges in the Onondaga Lake drainage basin. As shown in Table 26, each of these companies discharges more than 19,000 cu m/day (5.0 mgd).

Crucible Incorporated

Crucible is one of the country's largest producers of specialty steels. Crucible's major product is stainless steel, which it manufactures from recycled scrap metals.

The Crucible plant is located west of Syracuse on the southwestern shore of Onondaga Lake. The site is approximately 26 ha (65 acres). Plant operations include melting, rolling, pickling, grinding, and finishing.

For the most part, water is used for cooling purposes. Water consumption at the plant ranges from about 19,000 to 26,000 cu m/day (5 to 7 mgd). As reported in Crucible's Refuse Act Permit Program application, water consumption amounts to 20,200 cu m/day (5.35 mgd). Of this amount, 19,800 cu m/day (5.24 mgd) are used for cooling, 300 cu m/day (0.08 mgd) are used for boiler feed, and 110 cu m/day (0.03 mgd) are used for sanitary facilities. (U.S. EPA, 1971a).

Crucible's wastewaters contain large quantities of oil and grease (15 mg/l); total suspended solids (319 mg/l); and metals, including iron (11.63 mg/l), copper (0.381 mg/l), and chromium (0.488 mg/l). Acidic and alkaline wastes from Crucible's pickling processes are collected in tanks and turned over to a private firm for separate treatment.

Crucible is now building facilities to treat its wastewater. The treatment process will consist of chemical precipitation and sedimentation with recirculation of clarified effluent through the plant. About 90 percent of the effluent will be recirculated, thereby reducing the plant's water consumption from the present rate of 20,200 cu m/day (5.35 mgd) to approximately 2300 cu m/day (0.6 mgd). The remaining 10 percent, containing the residue from the initial treatment processes, will be further treated to remove metals (lime precipitation). The effluent will then be discharged into Onondaga Lake via a small waterway known as Tributary 5A. Interim EPA requirements will establish limits for certain constituents in the Crucible discharge. The limits will be as follows: total suspended solids - 18 kg/day (40 lb/day), oil and grease - 14 kg/day (30 lb/day), total chromium - 0.6 kg/day (1.3 lb/day), total copper - 2.7 kg/day (6.0 lb/day), and total iron - 2.3 kg/day (5.0 lb/day). (U.S. EPA, 1973d). Crucible's treatment facilities should be completed by December 1974.

Allied Chemical Corporation

Allied's Syracuse plant is located in the Village of Solvay in Onondaga County, New York. The main plant facilities occupy a site of approximately 1200 ha (3000 acres), southwest of Onondaga Lake. The manufacturing facilities are supplied by a 1200 ha (3000 acre) limestone quarry at Jamesville, N.Y., and a 1200 ha (3000 acre) brine operation at Tully, N.Y. Allied's Syracuse plant is engaged in two distinct manufacturing areas; each area has its particular products and byproducts. Allied also operates its own power plant to supply its facilities.

The first group of manufacturing processes produces soda ash (sodium carbonate - Na_2CO_3) and soda ash derivatives. The soda ash production processes are responsible for the largest wastewater flow in the plant. The synthetic ammonia-soda process, or Solvay Process, is used. Raw materials consumed in this operation include brine, limestone, ammonia, hydrogen sulfide and fuel. Ammonia is recovered for reuse by reacting ammonium chloride, an intermediate product, with excess quantities of lime; the reaction also produces calcium chloride ($CaCl_2$). The wastewaters resulting from this process contain high concentrations of sodium chloride, calcium chloride and lime, as well as natural impurities found in both the limestone and brine raw materials. For each ton of soda ash produced, about one-half ton of salt and one ton of calcium chloride have to be disposed of. These wastes are common to all soda ash plants.

The second group of processes center around the electrolytic decomposition of salt brine (NaCl) to form chlorine and caustic soda (NaOH). Two types of electrolytic cells are used in the process, the mercury cell and the diaphragm cell. Trace amounts of mercury, lead and asbestos enter the wastewater streams from these operations. In the summer of 1970, the U.S. Department of Justice took legal action to compel Allied to reduce or eliminate its mercury discharge. Allied reduced its mercury discharge from 10.0 kg/day (22 lb/day) to 0.4 kg/day (1 lb/day), as recommended in a stipulation, dated September 14, 1970, between the U.S. Attorney and the attorneys for Allied Chemical Corporation.

The power plant is the third area in which wastes are generated. Boiler feed waters must be treated to remove hardness; during this water treatment operation, sludges are formed. Residual hardness and some treatment chemicals remain in the feed waters and are concentrated during use. The boilers must be cleansed of these impurities. The resultant blowdown waters contain suspended and dissolved solids.

The above description is a simplified representation of a very complex manufacturing operation. The products themselves are the end result of a variety of interrelated processes. Allied currently produces about twenty different chemical products. The wastewaters generated by the manufacturing processes are discussed below.

Allied disposes of its wastewaters at three separate discharge points. Cooling waters from the power plant operation are discharged directly into Onondaga Lake through Discharge Serial No. 001 (east flume). This discharge is disinfected and contains approximately 0.3 mg/l residual chlorine. In addition to cooling water, this discharge contains stormwater runoff from the Syracuse plant and sections of the Village of Solvay. Discharge Serial No. 002 (west flume) contains wastewaters similar to those discharged via the east flume plus sodium chloride, sodium chlorate, and traces of sodium hypochlorite. These salts represent a small percentage of the total salt discharged by the plant. Discharge Serial No. 003 contains the overflow from Allied's settling lagoons. Under the proposed water quality management plan, this overflow will be pumped to the advanced waste treatment facilities of the expanded MSSTP. The characteristics of the three discharges are given in Table 27. The locations are shown in Figure 10.

At the Syracuse plant the first step in wastewater treatment is separation of the wastewater streams. Almost every processing area in the plant is sumped, and unintentional spills and floor sweepings are quickly reclaimed. Oil-bearing waters are settled and skimmed before being discharged. Waters contaminated with mercury-bearing solids are filtered before being sent to the settling lagoons.

With the exception of cooling waters, all wastewaters are collected and pumped to one of the three settling lagoons currently being used by Allied. Because certain of the materials in soda ash wastes act as coagulants, the suspended solids removal in the lagoons is good, approaching 99 percent. Dissolved solids, however, remain in solution and are discharged to Geddes Brook.

Allied pumps about 1,000,000 kg (1100 tons) of solids to the lagoons daily. Continual solids deposition results in the filling of the lagoons, thereby exhausting their sedimentation volume. Together the three existing Allied lagoons have a life expectancy of about nine years; new lagoons will be required sometime before 1982. Allied is currently investigating the possibility of additional land purchases and rezoning requirements for the construction of new settling lagoons.

As shown in Table 26, the overflow from the lagoons goes directly into Geddes Brook. The brook is tributary to Nine Mile Creek, which flows

TABLE 27

CHARACTERISTICS OF ALLIED CHEMICAL CORPORATION'S WASTEWATER DISCHARGE

Parameter	Units	Intake Values	Serial Discharge No.001	Serial Discharge No.002	Serial Discharge No.003
Flow	cu m/day (mgd)	- -	272,000 (71.8)	77,200 (20.4)	25,000 (6.6)
pH	S.U.	7.7	8.01	8.01	11.5
BOD (5-day)	mg/l kg/day (lb/day)	10 - -	7 1,900 (4,193)	6 463 (1,020)	5 130 (286)
Total solids	mg/l kg/day (lb/day)	3,185 - -	3,230 878,000 (1,935,000)	4,786 370,000 (814,800)	110,247 2,760,000 (6,072,000)
Total dissolved solids	mg/l kg/day (lb/day)	3,178 - -	3,208 873,000 (1,922,000)	4,753 367,000 (809,000)	110,180 2,750,000 (6,068,000)
Total suspended solids	mg/l kg/day (lb/day)	7 - -	22 5,940 (13,180)	33 2,550 (5,620)	67 1,680 (3,690)
Total phosphorus (as P)	mg/l kg/day (lb/day)	0.80 - -	0.66 179 (395)	0.61 47.1 (103.8)	Not Detected - -

TABLE 27 (Cont'd)

CHARACTERISTICS OF ALLIED CHEMICAL CORPORATION'S WASTEWATER DISCHARGE

Parameter	Units	Intake Values	Serial Discharge No.001	Serial Discharge No.002	Serial Discharge No.003
Alkalinity (as $CaCO_3$)	mg/l	164	190	186	744
	kg/day	-	51,700	14,400	18,600
	(lb/day)	-	(113,842)	(31,660)	(40,980)
Ammonia (as N)	mg/l	3.10	5.45	0.23	6.70
	kg/day	-	1,480	17.8	168
	(lb/day)	-	(3,265)	(39.2)	(369)
Chloride	mg/l	1,638	1,800	2,687	53,700
	kg/day	-	490,000	207,000	1,340,000
	(lb/day)	-	(1,079,000)	(457,000)	(2,960,000)
Calcium (total)	mg/l	582	593	667	20,000
	kg/day	-	161,000	51,300	499,000
	(lb/day)	-	(355,400)	(113,000)	(1,100,000)
Total hardness	mg/l	1,800	1,200	1,743	44,600
	kg/day	-	326,000	135,000	1,170,000
	(lb/day)	-	(719,000)	(297,000)	(2,460,000)
Sodium (total)	mg/l	519	665	1,359	11,000
	kg/day	-	181,000	105,000	276,000
	(lb/day)	-	(398,000)	(231,000)	(609,000)
Mercury (total)	mg/l	0.17	0.45	1.44	0.46
	kg/day	-	0.12	0.111	0.011
	(lb/day)	-	(0.27)	(0.245)	(0.025)

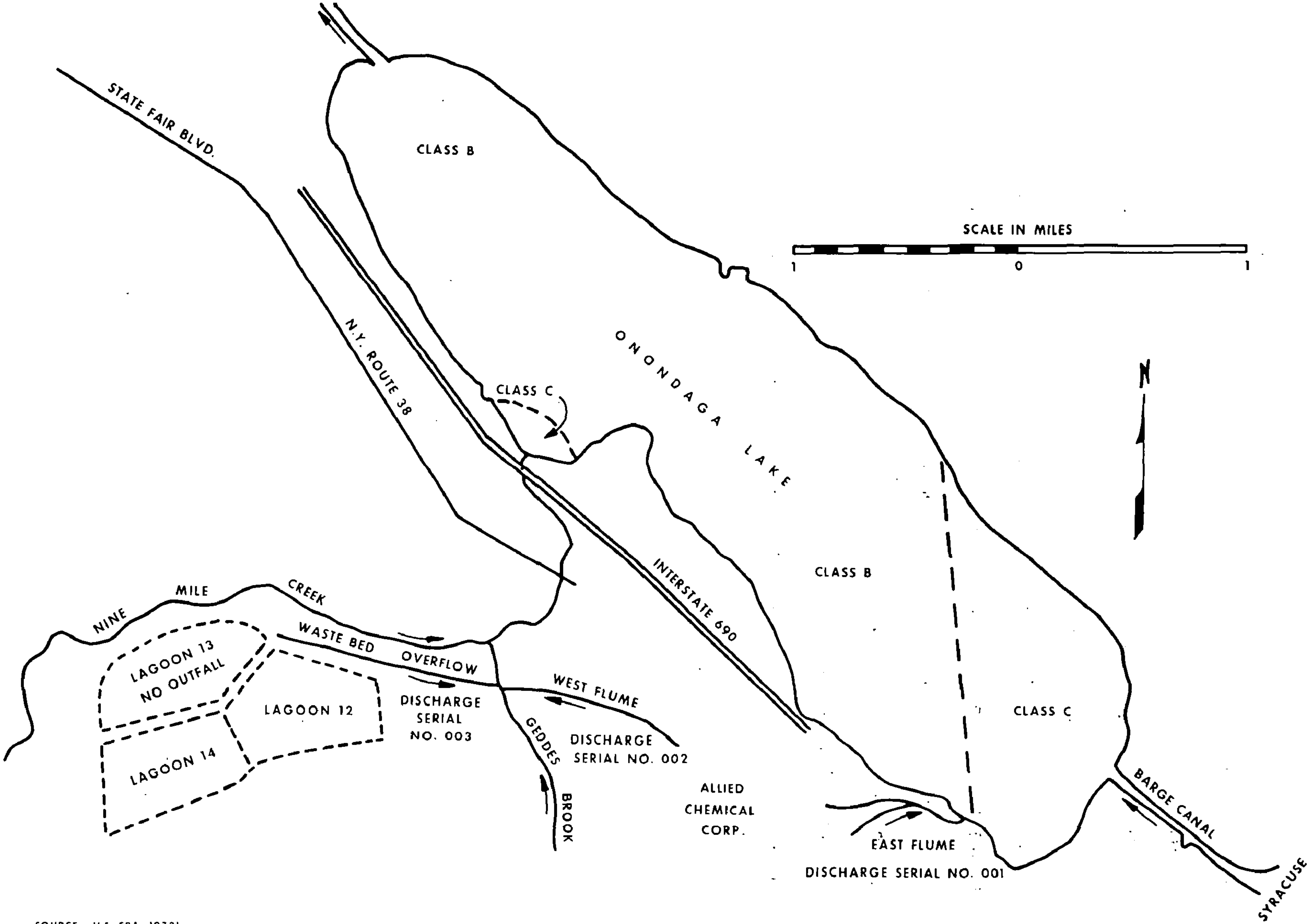
TABLE 27 (Cont'd)

CHARACTERISTICS OF ALLIED CHEMICAL CORPORATION'S WASTEWATER DISCHARGE

Parameter	Units	Intake Values	Serial Discharge No.001	Serial Discharge No.002	Serial Discharge No.003
Temperature					
winter	°C	6.6	18.9	20.6	-6
summer	°C	17.6	29.1	32.5	19.5
Discharge Point	- -	- -	Onondaga Lake	Geddes Brook	Geddes Brook

Source: U.S. EPA, 1971a.

Figure 10



SOURCE: U.S. EPA. 1973b.

LOCATION MAP
ALLIED CHEMICAL CORPORATION DISCHARGE POINTS

into Onondaga Lake. When the lagoon overflow, which has a high calcium content, mixes with the waters of Geddes Brook, a calcium carbonate ($CaCO_3$) precipitate is formed. The effect of this is that Geddes Brook is a milky white color by the time it empties into Nine Mile Creek. Although some of the $CaCO_3$ precipitates out of solution and settles as a solid in Geddes Brook and Nine Mile Creek, the rapid rate of flow in both of these streams keeps most of the $CaCO_3$ in suspension until Nine Mile Creek reaches Onondaga Lake. At the juncture of Nine Mile Creek and Onondaga Lake, a delta is formed as the $CaCO_3$ settles out under the quiescent conditions prevailing in the lake. (O'Brien & Gere, 1973a). This precipitation problem is discussed in Appendix D.

OBJECTIVES OF THE WATER QUALITY MANAGEMENT PLAN

The purpose of water quality management planning is "...to provide for continuous, systematic and coordinated development of an efficient and effective course of action to protect or enhance the quality of the waters of a discrete area" (U.S. EPA, 1971b). In 1971, the New York State Department of Environmental Conservation prepared an Interim Basin Plan (IBP-NY-07-07) for the Onondaga Lake drainage basin. The proposed project, involving the expansion and upgrading of the existing MSSTP to a 327,000 cu m/day (86.5 mgd) advanced wastewater treatment facility, is in agreement with the State's basin plan. The treatment facility is designed to remove 93 percent of the influent BOD (5-day) and 85 percent of the influent suspended solids, and to reduce the phosphorus concentrations in the wastewater to 1.0 mg/l or less.

The proposed project will not completely eliminate the pollution of Onondaga Lake waters. A number of pollutants will continue to enter the lake via point and non-point sources. Among these pollutants are nitrogen, phosphorus, total dissolved solids (especially chlorides and calcium), and pathogenic organisms. Other areas of concern are the control of toxic or deleterious substances in the treatment plant, the levels of copper and chromium in the lake, and the concentrations of mercury in the lake's bottom sediments and in fish. Each of these water quality problems will be discussed in turn.

NITROGEN

One of the forms of nitrogen (N) commonly found in lake waters is ammonia (NH_3). When the pH is above 8.0, ammonia concentrations of more than 2.0 mg/l can be very toxic to aquatic life. Ammonia's toxicity may be further increased by low dissolved oxygen levels.

The 1972 monitoring survey of Onondaga Lake (O'Brien & Gere, 1972) indicated that average ammonia concentrations in the lake ranged from 2.06 mg/l in the epilimnion to 4.74 mg/l in the hypolimnion. At the same time, average pH values ranged from 7.69 in the epilimnion to 7.41 in the hypolimnion. (See Tables 13 and 14).

New York State water quality standards for Class B and Class C waters, both of which categories apply to Onondaga Lake, require that the ammonia concentration not exceed 2.0 mg/l at a pH of 8.0 or above (see Appendix A). Average ammonia concentrations in Onondaga Lake exceed 2.0 mg/l; in certain sections of the lake, the pH at times exceeds 8.0. According to Onondaga County (1974), the Onondaga Lake monitoring program reports (O'Brien & Gere, 1970, 1971, and 1972) indicate that these conditions have occurred simultaneously, resulting in contravention of the water quality standards. Conditions in the lake should be carefully monitored to determine whether or not contravention continues after the improved MSSTP is put into operation. If the monitoring program reveals continuing contravention, plans to control nitrogen sources within the Onondaga Lake drainage basin should be implemented.

There is another problem associated with the ammonia levels in Onondaga Lake. Ammonia can stimulate biological processes, thereby exerting a high oxygen demand and depleting the supply of dissolved oxygen in the lake. In a receiving waterway, ammonia can be converted to elemental nitrogen by the nitrification/denitrification process. During nitrification, Nitrosomonas bacteria oxidize ammonia to nitrite (NO_2^-), then Nitrobacter bacteria oxidize the nitrite to nitrate (NO_3^-). This process requires 4.5 moles of oxygen for every mole of ammonia oxidized. During denitrification, the nitrate is reduced to nitrogen gas (N_2). Nitrification is of particular importance in

Onondaga Lake because of the presence of both types of nitrifying bacteria, Nitrosomonas and Nitrobacter.

The type of oxygen demand exerted by the nitrification process is called a nitrogenous oxygen demand (NOD). NOD is comparable to the carbonaceous oxygen demand exerted during the oxidation of organic material. Together, the nitrogenous oxygen demand and the carbonaceous oxygen demand make up what is called the ultimate biochemical oxygen demand (BOD_{ult}). Studies undertaken to determine the oxygen demand in Onondaga Lake showed that"...nitrifying bacteria were present in sufficient concentrations within the lake to exert a significant oxygen demand within the first 5-day period of the conventional BOD_5 test...." (Onondaga County, 1971). High NOD's could drastically reduce the already depleted dissolved oxygen supply in Onondaga Lake.

In summary, the high concentrations of ammonia in Onondaga Lake present two very important water quality problems: toxicity to aquatic life and reduction of dissolved oxygen levels. Therefore, the ammonia situation should be carefully studied to determine if plans should be developed for removing nitrogen from wastewater discharges within the Onondaga Lake drainage basin.

PHOSPHORUS

The objective of every wastewater treatment project must be to remove potential pollutants from incoming flows in order to protect and enhance the quality of the receiving water. Widespread concern about the presence of phosphorus in wastewater treatment plant discharges stems from the important role that phosphorus plays in the eutrophication of freshwater systems, including lakes. Although eutrophication is a natural process of lake ageing, it normally occurs at a very slow rate. Artificial influences, such as the addition of large quantities of nutrients in domestic sewage discharges, can accelerate the eutrophication process. Within a relatively short period of time, a clear beautiful lake can be turned into a lake troubled by excessive algal and plant growth, low dissolved oxygen levels in the hypolimnion, odors, and fish kills.

The phosphorus levels in Onondaga Lake are listed in Table 28. These values are far above the level required for algal growth. O'Brien & Gere (1971) report:

> Concentrations of total phosphorus and phosphate (orthophosphate) in the epilimnion do not show changes which can be correlated with growths of phytoplankton. In particular, there is no evidence for depletion of phosphorus at any time during the lake study. Concentrations above 1 ugm/l [0.001 mg/l] are considered sufficient to support growth of many species (Lund, 1965; Fuhs et al., 1972). Phosphate in Onondaga Lake rarely falls below 0.5 mg/l and total phosphorus generally remains above 1.0 mg/l. It appears that the level of phosphorus is more than sufficient to support growth of phytoplankton throughout the year, although it no doubt exercises a selective effect on the composition (Rodhe, 1948; deNoyelles, 1971).

The two major sources of the phosphorus in Onondaga Lake are municipal wastewater discharges and stormwater runoff from combined sewer overflows or from agricultural areas. Other sources, such as the release of phosphorus from the lake's bottom sediments, leaf fall, and the droppings of birds and animals, are relatively minor. The control of phosphorus levels in Onondaga Lake would, at the very least, require regulation of all the major sources in the basin.

Municipal wastewaters commonly receive phosphorus from raw sewage (30-50 percent) and household laundry detergents (50-70 percent). The average total phosphorus concentration in raw domestic sewage is about 10 mg/l (Black & Veatch, 1971; Metcalf & Eddy, 1972). In the metropolitan Syracuse area, however, recently enacted legislation banning the use of high phosphate

TABLE 28

PHOSPHORUS CONCENTRATIONS IN ONONDAGA LAKE
1968-1972

Sampling Period	Parameter	Onondaga Lake Location						Average Value (mg/l)
		Station No. 1[1/]			Station No. 2[1/]			
		Epilimnion (mg/l)	Hypolimnion (mg/l)	Average (mg/l)	Epilimnion (mg/l)	Hypolimnion (mg/l)	Average (mg/l)	
1972[2/]	Total P	0.50	1.12	0.81	-	-	-	0.81
	Ortho PO_4	0.36	0.94	0.65	-	-	-	0.65
1971[3/]	Total P	1.03	1.95	1.49	-	-	-	1.49
	Ortho PO_4	0.70	1.20	1.45	-	-	-	1.45
1970[4/]	Total P	1.43	1.77	1.60	1.95	2.06	2.00	1.80
	Ortho PO_4	0.70	0.96	0.83	0.72	1.05	0.88	0.86
1968-69[5/]	Total P	2.34	3.17	2.75	2.60	2.80	2.70	2.72
	Ortho PO_4	0.94	1.57	1.26	0.97	1,49	1.23	1.24

1/Station No. 1 located at southern end of lake, Station No. 2 located at northern end of lake.

Sources: 2/O'Brien & Gere, 1972.

3/O'Brien & Gere, 1971.

4/O'Brien & Gere, 1970.

5/Onondaga County, 1971.

detergents has helped to reduce the phosphorus levels in wastewater. The Common Council of the City of Syracuse passed a law limiting the phosphate composition of detergents to 8.7 percent, effective July 1, 1971. Shortly thereafter the New York State Legislature adopted Chapter 716 of the Laws of 1971, limiting phosphates in detergents to 8.7 percent after December 31, 1971 and to trace levels after May 30, 1972. The lower phosphorus levels in wastewater are reflected in the lower phosphorus concentration of the MSSTP effluent (see Table 29).

Onondaga Lake receives relatively large amounts of phosphorus via stormwater runoff from both rural and urban areas. Rural, or agricultural, runoff contains some of the fertilizer used in upland agricultural areas. Urban runoff, or combined sewer overflow, contains a variety of contaminants, including domestic sewage and street and surface runoff. According to O'Brien & Gere (1973a), "It is probable that the phosphorus input to Onondaga Lake includes between 15-30% from agriculture sources or sources other than sewage." Neither agricultural runoff nor combined sewer overflows can be easily controlled with conventional treatment methods.

Removing phosphorus from wastewater at the MSSTP will effect a significant reduction in the phosphorus input to Onondaga Lake. However, this cannot be considered a final solution to the problem because other major sources of phosphorus will continue to feed the lake. These sources can provide enough phosphorus to support algal activity indefinitely. The best reason for instituting phosphorus removal at the MSSTP is protection of Lake Ontario.

TABLE 29

PHOSPHORUS CONCENTRATIONS IN THE EFFLUENT OF THE EXISTING MSSTP

Sampling Period	Effluent Phosphorus Concentration: Average of Values Reported as Total-P1/ (mg/1)	Effluent Phosphorus Concentration: Average of Values Reported as Dissolved-P1/ (mg/1)
September 18, 1973		
8:00 AM to 12 noon	3.02	1.25
12 noon to 4:00 PM	3.82	1.44
4:00 PM to 8:00 PM	4.32	2.18
8:00 PM to 12 midnight	5.00	1.76
September 19, 1973		
12 midnight to 4:00 AM	4.44	2.27
4:00 AM to 8:00 AM	4.16	1.97
8:00 AM to 9:00 [PM]	3.00	1.32
Average Value	3.97	1.74
	Average of Values Reported as Total Inorganic-P2/ (mg/1)	Average of Values Reported as Ortho-phosphate-2/ (mg/1)
January 1972	2.98	1.57
February 1972	2.77	1.48
March 1972	1.63	1.13
April 1972	2.32	2.81
May 1972	2.36	1.34
June 1972	1.85	1.27
July 1972	1.98	1.34
August 1972	2.29	1.37
September 1972	3.40	2.07
October 1972	3.49	2.01
November 1972	2.49	1.36
December 1972	1.81	-
Average Value 1972	2.45	1.61

TABLE 29 (Cont'd)

PHOSPHORUS CONCENTRATIONS IN THE EFFLUENT OF THE EXISTING MSSTP

Sampling Period	Effluent Phosphorus Concentration	
	Average of Values Reported as Total Inorganic-P2/ (mg/l)	Average of Values Reported as Ortho-phosphate-2/ (mg/l)
January 1971	-	-
February 1971	2.57	1.09
March 1971	3.12	-
April 1971	3.12	-
May 1971	6.04	-
June 1971	3.00	-
July 1971	2.74	2.08
August 1971	3.90	2.64
September 1971	4.32	2.78
October 1971	4.97	3.48
November 1971	4.24	2.50
December 1971	2.80	2.04
Average Value 1971	3.40	2.37
January 1970	13.00	6.40
February 1970	6.90	3.10
March 1970	5.02	3.58
April 1970	4.15	1.65
May 1970	7.60	3.18
June 1970	6.65	2.48
July 1970	3.40	2.10
August 1970	5.10	1.82
September 1970	3.48	2.80
October 1970	4.83	2.67
November 1970	4.38	1.90
December 1970	-	-
Average Value 1970	5.86	2.88
Average Value 1968-693/ (as Total Phosphorus)	11.4	3.5

Sources: 1/U.S. EPA,1973h.

2/O'Brien & Gere, 1973a.

3/Onondaga County, 1971.

TOTAL DISSOLVED SOLIDS

Allied's Solvay process discharge is the main source of the total dissolved solids (TDS) in Onondaga Lake. Included under the TDS heading are chlorides, calcium, and sodium. Concerning the Solvay process, recently published U.S. Environmental Protection Agency guidelines state:

> This process generates extremely large quantities of pollutants, most of which are currently discharged with little treatment. An alternate process, mining trona, exists for producing soda ash. This mining operation is relatively clean and produces soda ash at an equitable price. (Shipping costs are offset by large operating costs for the Solvay process plants.) Currently forty percent of the soda ash manufactured in the United States results from mining trona, and production figures indicate that this percentage will continue to increase. There appears to be an ample supply of this ore sufficient to accommodate the soda ash market for years to come.
>
> It was concluded that no technology is available and economically achievable for the elimination of discharges from Solvay plants. Although the mining option exists, it was felt that Congress did not intend to eliminate large scale operations. The 1983, standard proposed herein requires implementation of the best available treatment technology which is economically achievable for Solvay plants. New source Solvay plants are required to achieve zero discharge of process waste water pollutants, but this will have no impact on existing facilities. (U.S. EPA, 1973e).

It is neither economically nor technically feasible to remove the pollutants generated by the operations at existing Solvay manufacturing plants.

The EPA guidelines cited above require a reduction in the total suspended solids (TSS) concentration discharged by existing Solvay plants. The EPA guidelines contain effluent limitations aimed at effecting such a reduction:

> The following limitations establish the quantity or quality of pollutants or pollutant properties, controlled by this section, which may be discharged by a point source subject to the provisions of this

subpart after application of the best available technology economically achievable:

Effluent Characteristic	Effluent Limitations	
	Maximum for any 1 day	Average of daily values for 30 consecutive days shall not exceed
	Metric units (kilograms per 1,000 kg of product)	
TSS.	0.34	0.17
pH	Within the range 6.0 to 9.0	
	English units (pounds per 1,000 lb of product)	
TSS.	0.34	0.17
pH	Within the range 6.0 to 9.0	

(U.S. EPA, 1974).

These effluent limitations represent best available, economically achievable technology. They will have to be achieved by July 1, 1977. Allied's settling lagoon overflow meets the TSS requirements, but not the pH requirement.

The implementation of best practicable control technology will require even more stringent effluent limitations. The EPA guidelines will limit the maximum daily TSS loading to 0.2 kg/kkg (0.2 lb/1000 lb) product and the maximum average of daily TSS values for any period of thirty consecutive days to 0.1 kg/kkg (0.1 lb/1000 lb). The acceptable pH range will be 6.0 to 9.0. (U.S. EPA, 1974).

PATHOGENIC ORGANISMS

Pathogenic organisms, or pathogens, are capable of producing disease. Pathogenic organisms include certain bacteria, rickettsiae, fungi, and protozoa, and all viruses (McKinney, 1962). Two major sources of pathogens are domestic sewage and combined sewer overflows. Untreated sewage or combined sewer overflows can introduce great numbers of pathogens into a receiving water, creating health hazards.

Domestic Sewage

The pathogenic organisms present in raw domestic sewage can be destroyed by disinfection at a sewage treatment plant. The usual method of disinfection is chlorination, although recent developments indicate that other chemical disinfectants, such as ozone, may be effective substitutes. According to New York State's treatment plant design standards, "Disinfection usually is accomplished with liquid chlorine, calcium or sodium hypochlorite or chlorine dioxide" (NYSDEC, 1970). At the MSSTP, liquid chlorine will be used for disinfection. The chlorination facilities that will be provided at the MSSTP are discussed in a later section of this report.

Chlorination is usually the final step in the wastewater treatment process. Therefore, a chlorine residual is usually maintained in the effluent at discharge. At the MSSTP, however, the secondary treatment system effluent will be chlorinated before it enters the advanced waste treatment units. In the advanced waste treatment units, it will be mixed with Allied's settling lagoon overflow. There will be a chlorine residual in the MSSTP effluent because of the high chlorine demand of the settling lagoon overflow. Nevertheless, adequate disinfection is expected.

According to O'Brien & Gere (1973a), an additional coliform reduction is expected to result from the mixture of the secondary effluent with the settling lagoon overflow, which has a high mineral content. This additional coliform reduction should augment the disinfection provided by the chlorination system.

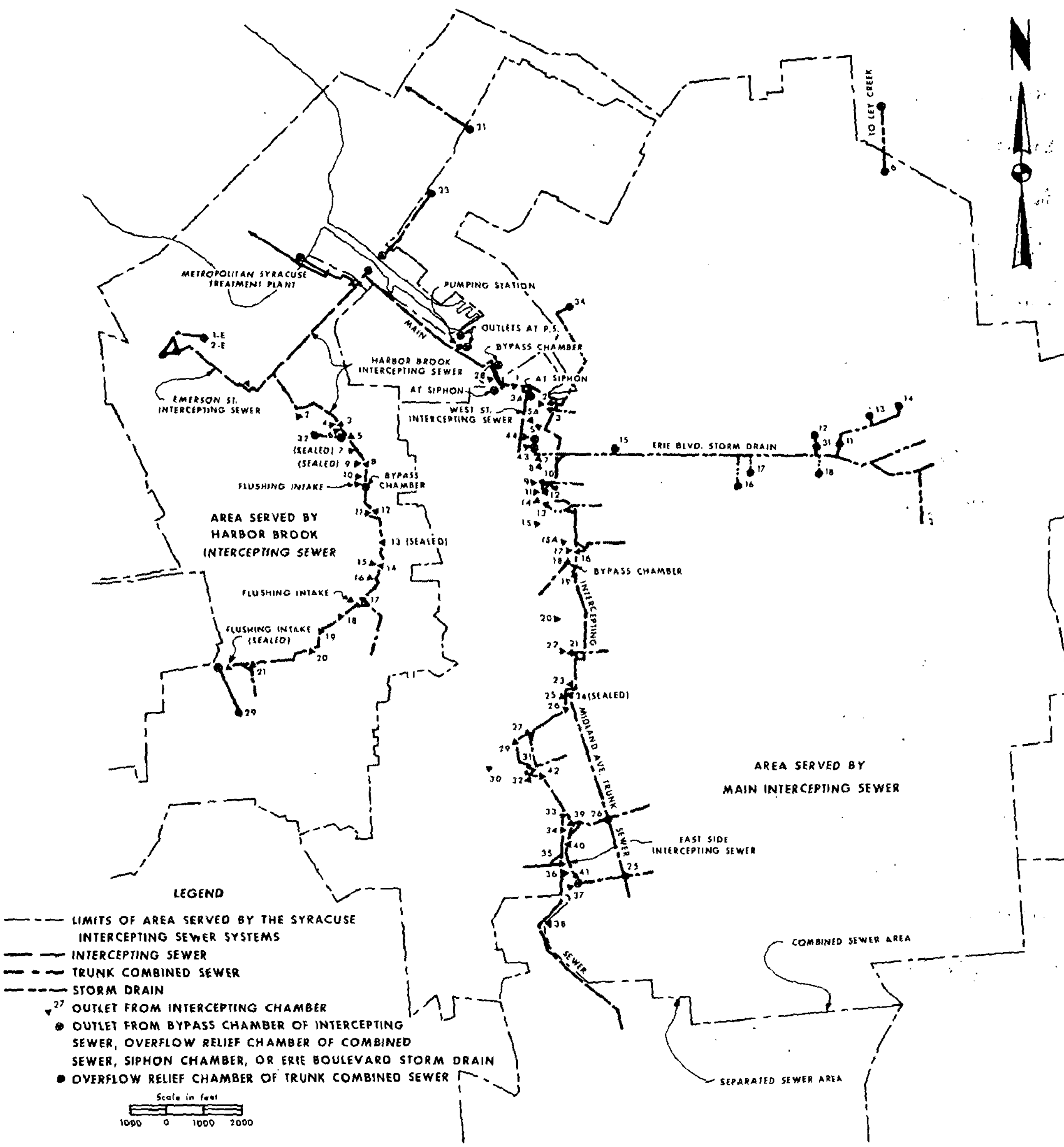
Combined Sewer Overflows

During rainstorms, wastewater flows in excess of the collection system's or the treatment plant's capacity bypass both of these components and directly enter local receiving waters. O'Brien & Gere (1973a) estimate that "...wet weather overflows occur on an average of 9 times per month, and that the total duration of such overflows is approximately 24 hours per month." In combined systems, these discharges carry contaminants that have been washed from roofs, streets, sidewalks, and other impervious surfaces, along with some sanitary sewage. These overflows seriously affect receiving water quality.

The City of Syracuse has ninety-seven overflow devices in its sewer system (see Figure 11). Camp, Dresser & McKee (1968) described the pollution caused by combined sewer overflows:

> Pollution of water courses is frequently severe for extensive periods during and after storms. In heavy prolonged storms almost all the sanitary sewage is discharged directly to the watercourses, rather than to the intercepting sewers. Disease-producing organisms abound in such polluted waters, severely limiting their suitability for recreational uses. Such organisms, isolated and identified in samples of overflow wastewater consisting of mixed sewage and storm water, include pathogenic bacteria and viruses of types often found in raw sanitary sewage. In addition, early portions of the overflow, particularly, contain high concentrations of suspended solids and associated BOD (Biochemical Oxygen Demand). The sludge and debris which have settled or stranded in the combined sewer during flow at relatively low rates in the preceding dry-weather period, are scoured from the combined system laterals and trunk sewers, and are rejected to the watercourse. Other nuisance-causing substances common to overflows include grease, oil, floating solids and debris. The formation of sludge banks in the vicinity of outlets is a common result of such overflows. This condition is undesirable and gives rise to odor nuisances.
>
> Thus, the problem of pollution from combined sewer discharges is of major significance to the general health and welfare of people in metropolitan areas such as Syracuse.

Continued bacterial pollution from combined sewer overflows is the main reason why Onondaga Lake is closed to swimming (O'Brien & Gere, 1973a).



Source: Camp, Dresser & McKee, 1968.

OUTLETS OF COMBINED SEWER SYSTEM

Figure 11

The local combined sewer system in Syracuse reportedly can handle a stormwater runoff rate of about 1.3 cm/hr (0.50 in./hr). A storm producing a runoff rate of this magnitude is expected to occur once in twenty-five years. The interceptors that receive wastewater from the local collection systems are capable of handling a stormwater runoff rate of only 0.05 to 0.1 cm/hr (0.02 to 0.04 in./hr); excess flows must, therefore, be conveyed out of the main intercepting sewers and into local receiving waters. The stormwater flow rate into the combined system is approximately 11,000,000 cu m/day (3000 mgd) for the twenty-five year frequency storm; the capacity of the intercepting sewers receiving this flow is about 568,000 cu m/day (150 mgd).

Three alternative methods of combined sewer overflow abatement were considered feasible for Syracuse:

1. Interdiction and treatment at the southern end of Onondaga Lake,
2. Complete sewer separation, and
3. Interdiction, transfer, and treatment near the Seneca River.

(Camp, Dresser & McKee, 1968).

A comparison of these methods is presented in Table 30.

The first alternative was recommended for adoption in 1968. It would involve the construction of rather large overflow conduits along Onondaga Creek and Harbor Brook; the conduits would receive and transmit overflows to a centralized treatment facility. Treatment would include screening, grit removal, sedimentation, and chlorination. Under this alternative, a sedimentation lagoon would be constructed in the southern end of Onondaga Lake. Treated effluent would be discharged directly into Onondaga Lake.

Implementing any one of these alternatives would be very expensive. Therefore, further study of the combined sewer overflow problem is underway.

TABLE 30

COMPARISON OF ALTERNATIVE STORMWATER TREATMENT METHODS

Stormwater Treatment Alternative	Estimated Construction Cost1/	Estimated Average Annual Cost2/	Effect on Water Quality of Lake and Streams3/	Degree of Surface Disruption4/
Interdiction and treatment at south end of Onondaga Lake	$225,000,000	$10,800,000	A	Minor
Complete separation	450,000,000	18,800,000	B	Major
Interdiction, transfer, and treatment near Seneca River	460,000,000	21,100,000	A	Minor

1/O'Brien & Gere, 1973a.
2/Including amortization, operation, and maintenance; 1968 dollars.
3/A: Major effect - Pollution from overflows (sewage and stormwater) and surface runoff discharges would be eliminated.

B: Minor effect - Pollution from overflows would be eliminated, but surface runoff discharges would continue.

4/During construction period only.

Source: Camp, Dresser & McKee, 1968.

Onondaga County is participating in an EPA sponsored research program (EPA Project No. 11020 HFR) on combined sewer overflows:

> The objective of this project is to demonstrate the prevention of pollution of Lake Onondaga caused by enteric organisms in combined sewage discharge. The treatment proposed is fine screening and oxidation/disinfection at selected stationary, sequential, microstrainer and high speed rotary. There will also be a solids/liquid separation utilizing the swirl separator. Disinfection will be evaluated utilizing gaseous chlorine and chlorine dioxide generated on site, by a new and improved technique. Dosage, points of application, aftergrowth, and other factors in kill efficiency, will be carried out. A special virus disinfectant study will also be included in the project. (Field, written communication, 1973).

A supplemental project (EPA Project No. 802400) is also underway:

> This work will be a supplement to the ongoing Onondaga County, New York grant 11020 HFR. It will test/evaluate the feasibility of nutrient removal with additional process units at a full-scale combined sewer overflow treatment demonstration site in Syracuse, New York.
>
> Alum will be fed at the proposed filter inlet and the alum floc will be allowed to penetrate into the anthracite media which will affect phosphate removal. Furthermore, the ammonia nitrogen will be reduced by the zeolite media at the bottom layer of the filter bed.
>
> The system is expected to have 80% of nutrient removal efficiencies.
>
> Regeneration of alum sludge and exhausted zeolite as well as Badger solids monitor will also be evaluated. (Field, written communication, 1973).

These studies are scheduled for completion in October 1975. At that time, a more definitive solution to the problem of combined sewer overflows can be formulated.

TOXIC OR DELETERIOUS SUBSTANCES

There are basically two ways to prevent the introduction of toxic or deleterious substances to the environment: 1) by controlling the entrance of these substances into municipal sewerage systems, and 2) by controlling the discharge from municipal wastewater treatment plants. Both of these control methods have application to the proposed project.

Implementation of the first method will require strict adherence to local and Federal pretreatment guidelines, specifically those issued by the Onondaga County Department of Public Works (Onondaga County, 1972) and those issued by the U.S. Environmental Protection Agency (U.S. EPA, 1973f). Both sets of guidelines require municipal sewerage system clients to remove toxic or deleterious substances from their wastewaters before discharging those wastewaters into the municipal sewerage system.

The basis for the second control method will be the National Pollutant Discharge Elimination System (U.S. EPA, 1973g). Under this system, a permit to discharge wastewater into a navigable waterway of the United States will have to be obtained for every point source discharge. This requirement applies to all types of discharges, including municipal, commercial, and industrial effluents.

COPPER AND CHROMIUM

The copper and chromium concentrations in the lake may be inhibitory to aquatic life (see p.38). Although it has not been conclusively shown that either of these elements inhibit aquatic life in Onondaga Lake, it may be prudent to control their discharge into the lake.

MERCURY

The present mercury levels in Onondaga Lake are very perplexing. The amount of mercury being discharged into the basin's waterways has been greatly reduced in recent years. However, large quantities of mercury persist in the bottom sediments of Onondaga Lake. The mercury remaining in the lake is a continuing source of contamination. Contamination is apparent from the accumulation of mercury and mercury compounds in fish flesh.

In 1970, New York State officials prohibited fishing in Onondaga Lake because of the high concentrations of mercury found in the lake's fish population. This ban on fishing is still in effect.

The mercury levels prevailing in the Onondaga Lake ecosystem prompted the New York State Department of Environmental Conservation to request that the whole of Onondaga Lake be exempted from proposed Federal water quality standards. Specifically, the State requested:

> ...EPA Region II approval for the exemption of the waters of Onondaga Lake, in Onondaga County, New York...from the designated equivalent federal use classifications described in Federal Class B (and to the extent applicable, Federal Class A): "recreational use in or on the water (fishing, wading, boating, etc.) and the preservation and propagation of desirable (indigenous) species of aquatic biota".

The State further requested:

> ...exemption of said Onondaga Lake waters from federal water quality criteria promulgated on behalf of these federal use classifications since application and compliance with these standards would not permit intended usages. (Diamond, written communication, 1973).

The U.S. EPA, Region II reviewed the situation and determined that an exemption from water quality standards was unnecessary:

> Onondaga Lake is classified by New York State as Class B, in part, and Class C, in part. These Federally-approved New York State use classifications are consistent with EPA's policy that all waters should provide for recreation in or on the water and for the preservation and propagation of desirable (indigenous) aquatic biota. I recognize that the State has banned fishing in Onondaga Lake because of mercury contamination. In my judgement, this ban does not require an exemption from water quality standards. (Hansler, written communication, 1973).

WATER QUALITY STANDARDS

Pursuant to the Federal Water Pollution Control Act Amendments of 1972, the New York State water quality standards were revised to more accurately reflect the goals and policies in effect prior to the 1972 amendments. Under these goals and policies, state waters should provide for recreation in or on the water and preservation and propagation of desirable (indigenous) aquatic biota. Now that revised water quality standards have been adopted by the State of New York, all point source discharges will have to comply with the standards. The revised standards for waters classified B, C or Special Class A are given in Appendix A.

ALTERNATIVES TO THE PROPOSED ACTION

There are several alternatives to the proposed MSSTP project, including the option of taking no action whatsoever. The "no action" alternative will be evaluated first, then each of the viable "action" alternatives will be discussed.

THE "NO ACTION" ALTERNATIVE

The primary objective of the proposed MSSTP project is to provide the Syracuse metropolitan area with adequate sewage treatment and, thereby, to improve water quality in Onondaga Lake. The "no action" alternative is not a viable one because it would allow the already severe degradation of Onondaga Lake to proceed unchecked.

The southern end of Onondaga Lake and the section of the lake near Nine Mile Creek have been designated Class C by the State of New York. The rest of the lake has been designated Class B. (See Figure 10). In its present state, the lake is unsuitable for the best uses described for Class B and Class C waters. Furthermore, the lake does not now meet certain of the applicable water quality standards, such as those for dissolved oxygen and settleable solids. It is incumbent upon Federal, State and local officials to correct this situation.

"ACTION" ALTERNATIVES

The water quality management plan for the Onondaga Lake drainage basin can be broken down into the following components:

1. Collection system
2. Treatment system

3. Effluent disposal system

4. Sludge disposal system.

Each of these systems and the alternatives available within each system are discussed below.

Collection System

The collection facilities of a sewerage system convey wastewaters from their source to the sewage treatment plant. Local collection sewers are those that initially receive the wastewater. These sewers empty into larger interceptor sewers which transport the sewage to the treatment plant. Each collection system is tailored to its service area. Therefore, the size of the collection system is based on many factors: for example, land use, population density, and sewage treatment requirements.

In 1968 a comprehensive sewerage study (Camp, Dresser & McKee, 1968) was performed to assess the sewerage needs of Onondaga County. The study delineated five major service areas in the county, each of which would be served by a separate treatment facility. The service area for the proposed project is basically the same as that outlined in the 1968 sewerage plan.

Generally, the service area of the MSSTP encompasses the most highly developed portions of Onondaga County. The area is nearing its saturation point in terms of residential and industrial development and, consequently, is not expected to undergo any substantial development in the future. Conversely, the areas to the north, east and west of the MSSTP service area are expected to continue developing well into the future. To the immediate south of the service area is the Onondaga Indian Reservation, which should essentially maintain its present character.

Areas beyond the MSSTP service area will be better served by separate sewerage facilities. There are several reasons for this:

1. It is more economical to provide separate treatment facilities than to construct the facilities required to transport sewage to the Metropolitan Syracuse plant.

2. The existing collection system, and the proposed improvements do not have capacity to handle these additional flows.

3. Treatment capacity for these additional flows could not be provided at the site of the Metropolitan Syracuse plant, which is extremely limited in size.

4. The water courses which receive effluents from the plants surrounding the Metropolitan Syracuse plant service area do have assimilative capacity to handle flows from these areas. It is probable that Onondaga Lake does not. (O'Brien & Gere, 1973a).

Sewerage facilities for the other service areas in the county will be constructed sometime in the future.

Secondary Treatment System

The Federal Water Pollution Control Act Amendments (FWPCAA) of 1972 require that effluent limitations based upon secondary treatment be achieved "(B) for publicly owned treatment works in existence on July 1, 1977, or approved pursuant to section 203 of this Act prior to June 30, 1974 (for which construction must be completed within four years of approval)...." (FWPCAA, 1972). Therefore to be eligible for construction monies from the U.S. Environmental Protection Agency, the upgraded MSSTP must provide at least secondary treatment. Information on secondary treatment requirements was published in the Federal Register, August 17, 1973, under 40 CFR Part 133. In summary, the regulations require either minimum BOD (5-day) and suspended solids removals of 85 percent each or BOD (5-day) and suspended solids concentrations in the treatment plant effluent of no more than 30 mg/l each, whichever is more stringent. Exceptions to these rules will be allowed in special cases: for example, in cases where high combined sewer flows or strong industrial wastes make the required removals unattainable.

Several methods are currently available for effecting the removal of BOD and suspended solids from wastewater. Generally, the removal process is physical, chemical or biological in nature. Combining the processes to increase treatment efficiency is also possible. The physical, chemical, and biological methods of BOD and suspended solids removal are discussed in most textbooks on wastewater engineering (Metcalf & Eddy, 1972; Fair, Geyer, and Okun, 1966; Fair, Geyer, and Okun, 1968). The choice of which treatment system to use in a particular situation depends upon many factors, among them engineering, economic and environmental considerations.

In the metropolitan Syracuse situation, the factors most strongly influencing the choice of a treatment process were land availability, soil support capabilities, and process operation reliability. Trickling filters were eliminated from consideration because of their high construction costs, resulting primarily from the additional land required and the extensive support foundation required. The soil at the MSSTP site consists of approximately 76 m (250 ft) of compressible clay. Long piles will have to be driven through this clay layer to provide adequate support for the treatment plant. The number of piles required to support a trickling filter system would be far greater than the number required to support the units for the selected treatment process. Lagoons and wastewater stabilization ponds were also eliminated from consideration because of the unstable subsurface conditions and the lack of sufficient land.

With respect to physical-chemical treatment, Onondaga County performed pilot plant studies using upflow clarifiers and carbon columns. The studies indicated that a constant flow rate into the clarifiers must be maintained to prevent upsets and consequent high solids loadings on the carbon columns. The design engineers for the county found this alternative unacceptable for use as a full-scale system because of its susceptibility to upset.

The secondary treatment system selected for use in the expanded and upgraded MSSTP is the contact stabilization modification of the activated sludge process. Pilot plant studies conducted in 1966 and 1967 demonstrated the suitability of this process for use in the metropolitan Syracuse situation. The secondary treatment system is expected to remove between 85 and 90 percent of both the BOD and the suspended solids (O'Brien & Gere, 1969). The upgraded MSSTP will, therefore, be capable of meeting the above-mentioned secondary treatment requirements.

After secondary treatment, the MSSTP effluent will be conveyed to the advanced waste treatment (AWT) units where it will be combined with Allied's settling lagoon overflow. The unusually high dissolved solids loading exerted by the settling lagoon overflow and the resultant chemical precipitation reactions expected in the AWT units will serve to raise the suspended solids level in the effluent. Consequently, the amount of suspended solids ultimately discharged by the MSSTP will actually be higher than the amount contained in the effluent after secondary treatment. This increase in suspended solids from secondary to AWT stage would not be expected if Allied's settling lagoon overflow was not used in the AWT system. A detailed description of the proposed treatment system is presented in a later section of this report.

Advanced Waste Treatment System

The main objective of providing advanced waste treatment at the MSSTP is reduction of total phosphorus in the plant effluent to 1.0 mg/l (as P) or less. The purpose of phosphorus removal is the maintenance and enhancement of water quality in Lake Ontario.

One of the most practical methods of phosphorus removal used in recent years is the chemical precipitation of phosphorus-bearing compounds. After the phosphorus has been precipitated, it can be removed by sedimentation. Several compounds, including certain calcium (Ca^{2+}), aluminum (Al^{3+}), and iron (Fe^{3+}) compounds, will react with phosphorus to form a settleable precipitate. The facilities required for the chemical precipitation reactions include a chemical mixing chamber and some form of sedimentation tank.

Phosphorus is found in wastewater in three principal forms: orthophosphate ions, polyphosphates or condensed phosphates, and organic phosphorus compounds (Black & Veatch, 1971). After biological (secondary) treatment, the predominant form is the orthophosphate. This form is the most easily precipitated because it readily combines with the multivalent ions Ca^{2+}, Al^{3+}, and Fe^{3+}.

Both the aluminum and iron ions will combine directly with the phosphate ion to form the precipitate, as follows:

$$Al^{3+} + PO_4^{3-} \rightleftharpoons AlPO_4 \downarrow$$

$$Fe^{3+} + PO_4^{3-} \rightleftharpoons FePO_4 \downarrow \quad .$$

The most commonly used form of aluminum is alum; the most commonly used forms of iron are ferric chloride and ferric sulfate. Sometimes polymers are added to these mixtures to enhance flocculation and encourage settling.

The use of lime as a precipitant is a complex proposition because of interfering reactions. According to Metcalf & Eddy (1972):

> The chemistry of the removal of phosphate with lime is quite different from that of alum or iron. [Note that]... when lime is added to water it reacts with the natural bicarbonate alkalinity to precipitate $CaCO_3$. Excess calcium ions will then react with the phosphorus...to precipitate hydroxylapatite $Ca_{10}(PO_4)_6(OH)_2$. Therefore,

> the quantity of lime required will, in general, be independent of the amount of phosphorus present and will depend primarily on the alkalinity of the waste-water.

This is, of course, a very simplified account of the actual chemical reactions that occur. Interfering chemical reactions that can severely hamper phosphorus removal are a possibility regardless of the precipitant used.

As part of the proposed project, the MSSTP's existing primary settling tanks will be converted for use as AWT flocculation/sedimentation tanks. Several sources of the required calcium, aluminum or iron ions were considered: 1) lime from commercial sources in addition to Allied's settling lagoon overflow (high Ca^{2+}); 2) lime from commercial sources; 3) alum from commercial sources, with polymer addition; 4) ferric chloride from commercial sources, with polymer addition. The costs associated with these alternatives are outlined in Table 31. Using Allied's settling lagoon overflow for this purpose is economically preferable because of the low operating costs of this alternative. Furthermore, this alternative allows disposal of the MSSTP's domestic sludge in Allied's settling lagoons.

Effluent Disposal System

The treated effluent from the MSSTP must be disposed of in an environmentally acceptable manner. The alternatives considered were 1) discharge to Onondaga Lake, 2) discharge to the Onondaga Lake outlet, 3) discharge to the Seneca River, 4) discharge to Lake Ontario, 5) ground-water recharge via spray irrigation, and 6) ground-water recharge via deep-well injection. Each of these alternatives will be discussed in turn. For reasons that will be enumerated later, both of the ground-water recharge alternatives were rejected. Effluent discharge to Onondaga Lake was found to be the most acceptable effluent disposal alternative.

TABLE 31

COSTS FOR ADVANCED WASTE TREATMENT ALTERNATIVES

Alternative	Costs (1973 dollars)	
	Capital	Annual Operating 1/
a) Commercial lime in addition to the Allied settling lagoon overflow	Paid by Allied	20,000 2/
b) Commercial lime	3,000,000 3/	300,000
c) Alum, with polymer	500,000	1,200,000
d) Ferric chloride, with polymer	400,000	1,500,000

1/ Operating costs include chemicals, power, fuel, and personnel costs.
2/ Includes only cost of personnel who will spend a portion of their time operating and maintaining the AWT facilities. Costs for sludge disposal are discussed in another section. Allied will provide lime in quantities up to 31,000 kg/day (68,000 lb/day) at no cost to the County.
3/ Includes recalcination facilities.

Source: O'Brien & Gere, 1973a.

Onondaga Lake's proximity to the MSSTP makes it the obvious choice for receiving water body. The lake has two distinct layers, the epilimnion and the hypolimnion, which are separated by a thermocline. The effluent can be discharged to the epilimnion via a surface outfall or to the hypolimnion via a subsurface outfall. There are advantages and disadvantages to each of these outfall types.

The effluent from the upgraded MSSTP will exert both a carbonaceous oxygen demand and a nitrogenous oxygen demand; together, these will comprise the ultimate BOD of the effluent. Therefore, the amount of oxygen available in the lake to satisfy the effluent's ultimate BOD is a matter of great importance.

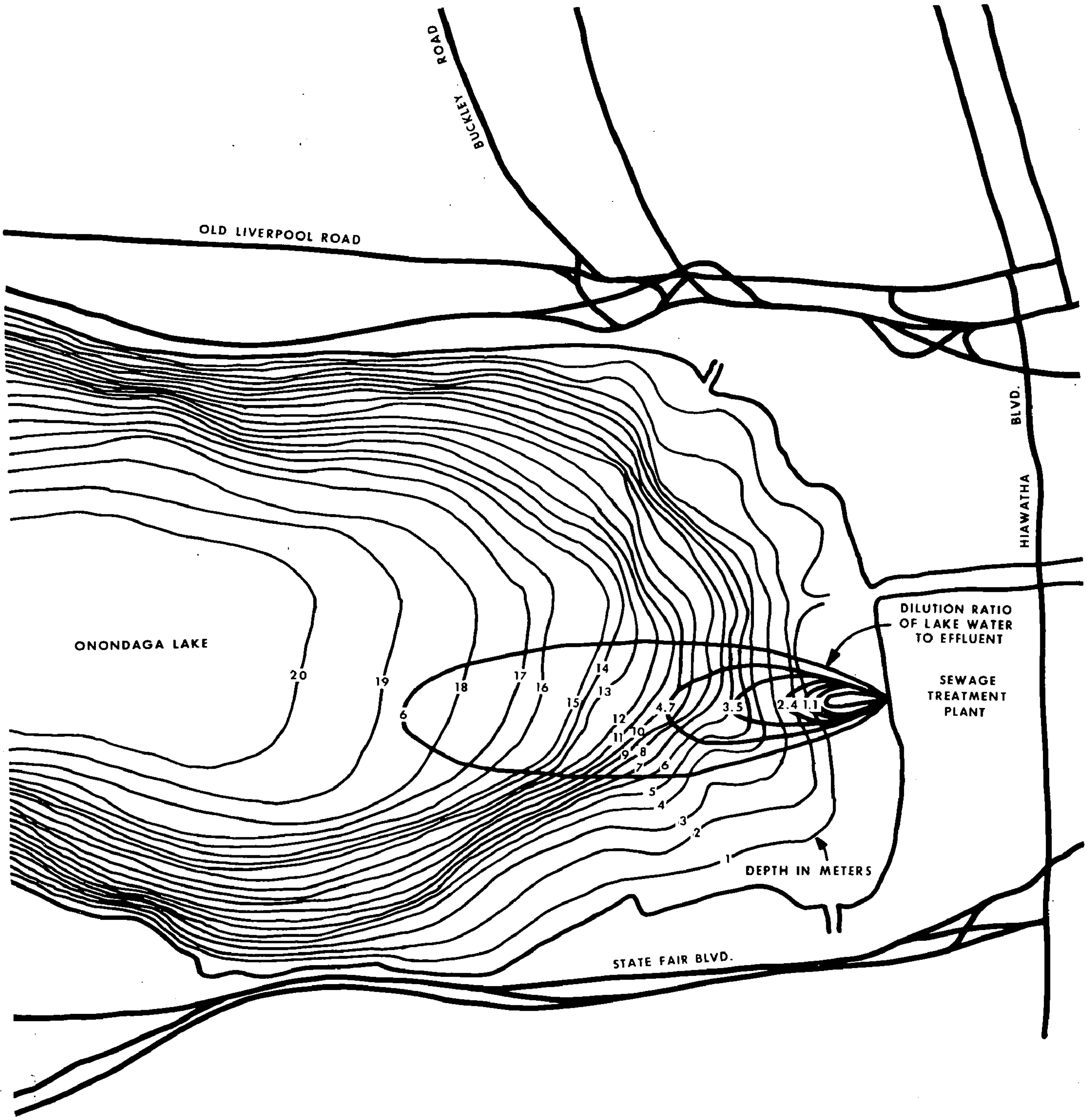
As shown in Tables 13 and 14, the dissolved oxygen concentrations in the epilimnion of the lake are three to four times greater than those in the hypolimnion. The use of a surface outfall would permit the effluent to mix with the oxygen-rich epilimnetic waters. However, one of the results of using Allied's settling lagoon overflow in the MSSTP's AWT units will be to make the effluent denser than the lake waters. Consequently, the effluent will tend to sink to the hypolimnion of the lake. Since the organic material in the effluent will be relatively inert, it will not readily decompose. It is, therefore, possible that the effluent will sink to the hypolimnion before the ultimate BOD has been satisfied.

Allied's settling lagoon overflow will impart a high total dissolved solids (TDS) concentration to the MSSTP effluent. This is the reason why the effluent will be denser than the lake waters into which it is discharged. Density differences of this sort can often be balanced by temperature because water generally decreases in density as it increases in temperature.

Assuming that a surface outfall is used and that the temperature of the effluent is equal to or less than that of the lake waters, the effluent should rapidly sink through the epilimnion to the hypolimnion. Assuming that a surface outfall is used and that the temperature of the effluent is approximately 6 C° (10 F°) higher than that of the lake waters, the effluent should remain in the epilimnion for a longer period of time. However, since both the temperature of the effluent and the temperature of the lake waters are subject to change, it is impossible to predict how long the MSSTP effluent will remain in the epilimnion of Onondaga Lake.

O'Brien & Gere (1973a) developed a model of the dispersion pattern that would be formed by a surface discharge under quiescent conditions in Onondaga Lake. The dispersion pattern is illustrated in Figure 12. The model is limited in several respects: "...1) the model itself and its application to non-thermal discharges is unverified 2) the model does not account for the limiting effects of impingement and reduced entrainment of ambient waters due to the shallow nature of the lake ($\leq$ 3 feet) near the discharge point and 3) the model evaluates the proposed discharge under quiescient [sic] conditions and does not address potentially more critical conditions which may occur due to specific meteorologic and/or hydrologic conditions." (Rooney, written communication, 1973).

The major disadvantage of a surface discharge at the southern end of Onondaga Lake is that any substantial difference between the appearance of the effluent and the appearance of the lake waters will be plainly visible. Any upset in the treatment plant operation will be immediately apparent at the discharge point. The visibility of the outfall is especially important because of the high probability that a limited calcium carbonate precipitation



Source: O'Brien & Gere, 1973a.

MSSTP EFFLUENT DISPERSION PATTERN

Figure 12

reaction will occur when the effluent, containing Allied's wastewater, mixes with the waters of Onondaga Lake. A discharge plume that created a substantial visible contrast to natural conditions would violate New York State water quality standards.

The use of a subsurface discharge could disturb the lake's bottom sediments, releasing nutrients, organic material, and mercury. The release of nutrients would encourage the growth of algae; the release of organic material would exert an increased oxygen demand; and the release of mercury would further contaminate the waters of Onondaga Lake. However, to date it has not been demonstrated that the use of a subsurface outfall would actually disturb the lake's bottom sediments.

The major advantages of a surface outfall are its low construction and maintenance costs. The use of a subsurface outfall would increase the construction cost of the proposed project by about $1,060,000. If the surface outfall is constructed as proposed and problems do arise, a subsurface outfall can be installed. Construction of a subsurface outfall would entail the extension of the 240 cm (96 in.) diameter surface outfall line about 520 m (1700 ft) offshore into Onondaga Lake.

The other alternative surface water effluent disposal systems are compared in Table 32. The table shows that both construction and operating costs increase as the discharge point is moved farther away from the MSSTP. Adoption of any of these alternatives would markedly increase the project costs.

Discharge of the MSSTP effluent to the Onondaga Lake outlet has several possible adverse effects. The waters of the Seneca River sometimes flow into Onondaga Lake. At such times, the plant effluent could come uncomfortably

TABLE 32

COMPARISON OF ALTERNATIVE SURFACE WATER EFFLUENT DISPOSAL SYSTEMS EXCLUDING ONONDAGA LAKE

Receiving Water	Construction Costs (1973 dollars)	Remarks
Onondaga Lake outlet	8,000,000	Requires 2200 kw (3000 hp) pumping station, and 9.1 km (5.7 miles) of 200 cm (78 in.) conduit. Contravention of water quality standards (dissolved oxygen) in Seneca River.
Seneca River	9,500,000	Pumping and conduit requirements essentially identical to those of Onondaga Lake outlet alternative. Contravention of water quality standards (dissolved oxygen) in Seneca River.
Lake Ontario	55,000,000	Requires two 4500 kw (6000 hp) pumping stations, and 72 km (45 miles) of 200 cm (78 in.) conduit. No probable adverse effects on Lake Ontario water quality.

Source: O'Brien & Gere, 1973a.

close to the recreational areas at the northern end of the lake. Furthermore, an analysis of the dissolved oxygen balance in the receiving waters indicates that if this alternative was adopted, there would be a contravention of the 4.0 mg/l minimum dissolved oxygen concentration requirement for the Seneca River. (O'Brien & Gere, 1973a). The high nitrogenous oxygen demand (NOD) expected in the MSSTP effluent would be the cause of the contravention. The NOD could be substantially reduced if additional AWT systems (e.g., nitrification/denitrification) were provided. This would, of course, result in increased construction and operating costs for the treatment plant.

The alternative of discharging the effluent to the Seneca River was evaluated. This alternative's effect on water quality would be essentially the same as that of effluent discharge to the Onondaga Lake outlet.

Discharge of the MSSTP effluent to Lake Ontario would not significantly impair the lake's water quality. However, a deepwater submerged outfall located at a safe distance from the lake's public water supply intakes would be needed. Consequently, this alternative would be very expensive.

Ground-water recharge, either by spray irrigation or by deep-well injection, was considered. If the effluent from the MSSTP was disposed of through spray irrigation, the estimated application rate would be 1.3 cm/day (0.5 in./day). A parcel of land measuring approximately 26 sq km (10 sq miles) would be needed to accommodate this effluent application rate. The only area in Onondaga County that might be suitable for such a system is west of Beaver Lake in the Town of Lysander, a distance of about 32 km (20 miles) from the MSSTP. It is estimated that such a system would cost about $30,000,000. For these reasons, the spray irrigation alternative was rejected.

The deep-well injection alternative was rejected for both environmental and economic reasons. The lack of information on the possible effects of such recharge on the ground-water resources of the area and the high cost of constructing and maintaining a deep-well injection system make this alternative unacceptable.

Sludge Disposal System

The sludge disposal system for a sewage treatment facility must collect, treat and dispose of the solids that are removed from the influent wastewater during treatment. The selection of a sludge disposal method is based upon the types of solids removed from the wastewater and the types of facilities available for handling. In the expanded and upgraded MSSTP, the organic solids will be collected in both the primary and secondary settling tanks, and the inorganic precipitates will be collected in the AWT units. The collected sludge will then be transfered to the sludge disposal system, where it will be conditioned; stabilized; dewatered, if necessary; and finally disposed of. Within each of the four subsystems, there are alternative methods of sludge handling.

Conditioning prepares the sludge for treatment and disposal. In the MSSTP, conditioning will consist of sludge thickening only. The purpose of thickening is to decrease the volume of sludge and, thereby, to facilitate the treatment and disposal processes. Thickening can be accomplished with either a gravity sedimentation or a flotation system. As shown in Table 33, the flotation system has a higher annual operating cost than the gravity system. Therefore, the expanded MSSTP will employ gravity sludge thickeners.

Perhaps the most important components of a sludge handling system are the stabilization units. Stabilization means that the sludge is made

TABLE 33

COSTS OF THE ALTERNATIVE COMPONENTS
OF THE SLUDGE DISPOSAL SYSTEM

Component of Sludge Disposal System	Costs (1973 dollars)	
	Capital	Annual Operating
Conditioning		
Gravity thickening (proposed)	1,140,000	20,000
Flotation thickening	1,100,000	120,000
Stabilization		
Anaerobic digestion (proposed)	1,271,000	50,000
Aerobic digestion	7,500,000	250,000
Chemical	500,000	410,000
Pyrolysis	7,900,000	185,000
Dewatering		
None except for standby centrifuges and sludge storage lagoons (proposed)	1,500,000	10,000
Centrifuges and sludge storage lagoons	1,500,000	100,000
Vacuum filters	1,700,000	80,000
Filter presses	1,700,000	80,000
Final Disposal		
Allied's settling lagoons (proposed)	1,000,000	170,000 1/
Incineration and landfill	8,000,000	220,000
Land spreading	3,100,000	60,000
Landfill	1,000,000	650,000

1/ See p. 136

Source: O'Brien & Gere, 1973a.

relatively inert through biological, chemical, or physical processes. Once sludge has been stabilized, it can usually be disposed of without creating health hazards.

The biological processes used to stabilize sludge are aerobic and anaerobic digestion. In each case, a suitable environment must be established to encourage the growth of microorganisms that are capable of utilizing the sludge as a food source. In this way, the microorganisms break down the solids into simpler organic compounds which are relatively inert. Chemical stabilization processes use highly reactive chemicals (such as chlorine) to oxidize the organic sludge. The physical sludge stabilization methods, pyrolysis for example, involve the application of heat to the sludge. In this way, the sludge is transformed into a relatively harmless slurry.

The most economical method of sludge stabilization for the MSSTP is anaerobic digestion. As shown in Table 33, this alternative involves a low capital investment and the lowest annual operating cost. The existing MSSTP sludge digesters will be used for the expanded facility.

Dewatering removes the excess water from stabilized sludge so that it can be disposed of more easily. There are several devices available for dewatering sludge, including centrifuges, vacuum filters and/or filter presses. The costs associated with each of these methods are given in Table 33. Onondaga County personnel have used both centrifuges and vacuum filters to dewater sludge, and they prefer the former (O'Brien & Gere, 1973a).

Whether or not dewatering is needed, and if so, what degree of dewatering is needed depends upon the final disposal method selected. In the case of the proposed project, there will be no need to dewater the sludge because digested sludge will be pumped to Allied's settling lagoons for disposal. However, dewatering facilities will be provided as a precautionary measure.

Finally, the stabilized sludge must be disposed of in an environmentally acceptable manner. The sludge can be deposited either in liquid form or as a solid inert material. The alternatives open to the MSSTP include transfer of the sludge to Allied, incineration of the sludge followed by landfill of the remaining ash, and land spreading or landfill of dewatered sludge. The cost of each of these alternatives is given in Table 33.

As discussed on pages 91 to 98, Allied operates three settling lagoons for disposal of its wastewaters. The accumulation of solids in the lagoons is causing the lagoons to fill in. At the present rate of solids deposition, the existing lagoons will have to be abandoned in about nine years.

Under the proposed project, the MSSTP will pump its digested sludge to Allied. Allied will then deposit the sludge in one of its three lagoons. Dewatering facilities will be required only as a standby capability. The proposed project also calls for the construction of sludge holding lagoons at the MSSTP site to provide a three-day sludge storage capability. The holding lagoons and dewatering facilities will be used if a breakdown of the sludge pumping facilities occurs or if Allied is unable to accept the sludge.

Allied has been using settling lagoons ever since it commenced operations in the late 1890's. Thirty to fifty years after abandonment, the lagoon areas are generally stable enough to support low load uses. Much of Route 690 in the vicinity of the New York State Fairgrounds was constructed on an abandoned settling lagoon. The existing MSSTP was likewise constructed on an abandoned settling lagoon. Although construction on the long-abandoned lagoons is possible, extensive pile driving is required to provide adequate support for any planned structure.

The cost of each of the other final disposal alternatives is given in Table 33. Adoption of any of these alternatives would increase both the capital and annual costs of the MSSTP. Project construction would also have to be delayed until the present design could be revised. The additional design costs and the inflationary cost increases during the delay would substantially boost the overall cost of the project. At this point, the use of Allied's lagoons for sludge disposal is the most economical alternative.

In August 1971, Onondaga County and the Allied Chemical Corporation entered into an agreement outlining the terms of joint treatment of Allied's settling lagoon overflow in the advanced waste treatment units of the proposed MSSTP (Onondaga County and Allied Chemical Corporation, 1971). According to Article V of this agreement:

> A. If the County should elect to dispose of the sludge from the Metropolitan treatment plant [MSSTP] through the construction of facilities [as proposed]...,Allied Chemical, so long as its process effluents are treated at the Metropolitan plant, shall
>
> (1) provide and operate, at all times when its Syracuse Works are in normal operation, its pumping and pipe facilities for conveying the sludge from the terminus of the sludge facilities [West Side sludge force main] to its active waste beds [settling lagoons], at an annual charge to the County of $0.25 per thousand gallons of treated sludge through the calender year 1974; and
>
> (2) make available its active waste bed areas for the disposal of the sludge at an annual charge to the County of $1.60 per ton of treated solids deposited upon the beds through the calender year 1974.

Based on the quantities of sludge that the MSSTP is expected to produce, sludge disposal at Allied will cost the county approximately $170,000 per year. The cost will increase annually according to the terms of the joint agreement. Another provision of the agreement is that Allied can withdraw from the joint treatment contract at any time.

This poses a potentially serious problem for the county because none of the other sludge disposal alternatives has been developed to a point where it could be quickly implemented should Allied decide to withdraw. Although this may never happen, the county should be prepared for any contingency. Therefore, the county should develop a viable long-term alternative sludge disposal plan and the means to implement it.

DETAILED DESCRIPTION OF THE PROPOSED PROJECTS

METROPOLITAN SYRACUSE SEWAGE TREATMENT PLANT

The facilities and processes involved in expanding and upgrading the MSSTP can be divided into three main groups.

1. Treatment System
   a. secondary treatment using the contact stabilization modification of the activated sludge process;
   b. advanced waste treatment to remove phosphorus by lime precipitation, using the Allied Chemical Corporation's settling lagoon overflow and a supplementary source of commercial lime.
2. Effluent Disposal System

   construction of a gravity flow surface outfall at the southern end of Onondaga Lake.
3. Sludge Disposal System
   a. sludge conditioning using gravity thickening units;
   b. stabilization of organic sludge through anaerobic digestion;
   c. sludge disposal by pumping digested organic sludge (from the primary and secondary clarifiers) and inorganic sludge (from the AWT clarifiers) to the Allied Chemical Corporation; Allied will deposit the sludge in one of its operational settling lagoons.

Under a separate contract, the existing collection system will be improved while the proposed treatment plant project is under construction (see pp.150 to 152).

Treatment System

The proposed project provides for the construction of new primary clarifiers, activated sludge units (contact and stabilization tanks), secondary clarifiers, chlorine contact tanks, and several pumping stations at the treatment plant. The existing MSSTP primary clarifiers will be converted for use as AWT units. Ancillary facilities, such as grit chambers, screens, and bypass chlorination facilities, will also be provided. The necessary sludge handling facilities will be discussed later in this section.

The treatment facilities are designed to accommodate an influent raw sewage BOD (5-day) of 200 ppm and a suspended solids concentration of 180 ppm. The effluent BOD and suspended solids concentrations are expected to be 14 and 30 ppm, respectively. At an average effluent flow rate of 327,000 cu m/day (86.5 mgd), Onondaga Lake will receive an average loading of 4580 kg/day (10,100 lb/day) BOD and 9810 kg/day (21,600 lb/day) suspended solids. In 1972, the average loadings on the lake were 27,000 kg/day (60,000 lb/day) BOD and 18,000 kg/day (39,000 lb/day) suspended solids. AWT is expected to reduce the total phosphorus concentration in the effluent to 1.0 mg/l or less. Therefore, the average phosphorus loading on the lake will be 330 kg/day (720 lb/day) or less.

The primary and secondary facilities are designed to handle a minimum flow of 140,000 cu m/day (36 mgd), an average flow of 300,000 cu m/day (80 mgd), a maximum dry weather flow of 450,000 cu m/day (120 mgd), and a maximum wet weather flow of 844,000 cu m/day (223 mgd). The AWT facilities are designed to handle an average flow of 327,000 cu m/day (86.5 mgd). The major treatment units that will be provided at the MSSTP are listed in Table 34; the plant layout is shown in Figure 13.

TABLE 34

MAJOR TREATMENT UNITS FOR THE PROPOSED MSSTP

Treatment Unit	Dimensions or Detention Time1/	Remarks
Sewage Treatment Units		
Two mechanical trash racks	Clear bar spacing 10 cm (4 in.)	Velocity through screen 0.37 to 2.2 m/sec (1.2 to 7.1 ft/sec) Screenings disposal in sanitary landfill
Two aerated grit chambers (new)	DT at max flow 7.4 min.	Grit disposal in sanitary landfill
Three aerated grit chambers (existing)	DT at max flow 2.2 min.	Grit disposal in sanitary landfill
Two screens	Clear bar spacing 2 cm (3/4 in.)	Velocity through screen 0.37 to 2.2 m/sec (1.2 to 7.1 ft/sec)
Raw sewage pumping station	Design peak flow 844,000 cu m/day (223 mgd)	Four mixed flow centrifugal pumps and one standby pump Total five pumps
Eight primary clarifiers	41.1 m (135 ft) diameter x 3 m (10 ft) side depth DT 2.4 hours	Surface settling rate at avg flow 30 cu m/day/ sq m (740 gpd/sq ft)

1/ Detention times (DT) based on average flow unless otherwise noted.

TABLE 34 (Cont'd)

MAJOR TREATMENT UNITS FOR THE PROPOSED MSSTP

Treatment Unit	Dimensions or Detention Time	Remarks
Sewage Treatment Units		
Contact stabilization activated sludge process - four aeration tanks	30 m (100 ft) x 40 m (130 ft) x 4.33 m (14.2 ft) DT at 50 percent recycle 1.6 hours	Six platform-mounted mechanical aerators in each aeration and stabilization tank Total 48 aerators
Contact stabilization activated sludge process - four stabilization tanks	30 m (100 ft) x 40 m (130 ft) x 4.33 m (14.2 ft) DT at 50 percent recycle 3.3 hours	Capability of using eight tanks in a conventional activated sludge configuration DT 3.16 hours
Four secondary clarifiers	52 m (170 ft) x 52 m (170 ft) x 3.4 m (11 ft)	Surface settling rate at avg flow 28 cu m/day/sq m (690 gpd/sq ft)
Four chlorine contact tanks	52 m (170 ft) x 5.94 m (19.5 ft) x 3.4 m (11 ft) DT at peak flow 13.0 min.	Additional contact time (3.5 min.) provided in 210 cm (84 in.) diameter gravity sewer to tertiary pumping station Two chlorine feeders, each 3600 kg/day (8000 lb/day)
AWT pumping station	Design peak flow 450,000 cu m/day (120 mgd)	Two propeller pumps and one standby, total three pumps

TABLE 34 (Cont'd)

MAJOR TREATMENT UNITS FOR THE PROPOSED MSSTP

Treatment Unit	Dimensions or Detention Time	Remarks
	Sewage Treatment Units	
Six AWT clari-flocculators (existing)	37.2 m (122 ft) diameter x 3 m deep (10 ft) DT 70 min.	Two flash mixing chambers for chemical mixing Effective settling rate at avg flow with tube settlers 38 cu m/day/sq m (930 gpd/sq ft)
	Storm Water Treatment Units	
Primary treatment	Primary treatment provided in eight new primary clarifiers described above. Flows in excess of 450,000 cu m/day (120 mgd) will be bypassed to the secondary treatment units.	
Peak wet weather flow chlorination - two chlorine contact tanks	9.4 m (31 ft) x 30 m (100 ft) x 6 m (20 ft) DT at peak flow 13 min.	Additional contact time (2 min.) provided in gravity outfall to Onondaga Lake shoreline Two chlorine feeders, each 3600 kg/day (8000 lb/day)
Outfall	150 cm (60 in.) diameter outfall (existing)	Discharge through existing deepwater outfall conduit

TABLE 34 (Cont'd)

MAJOR TREATMENT UNITS FOR THE PROPOSED MSSTP

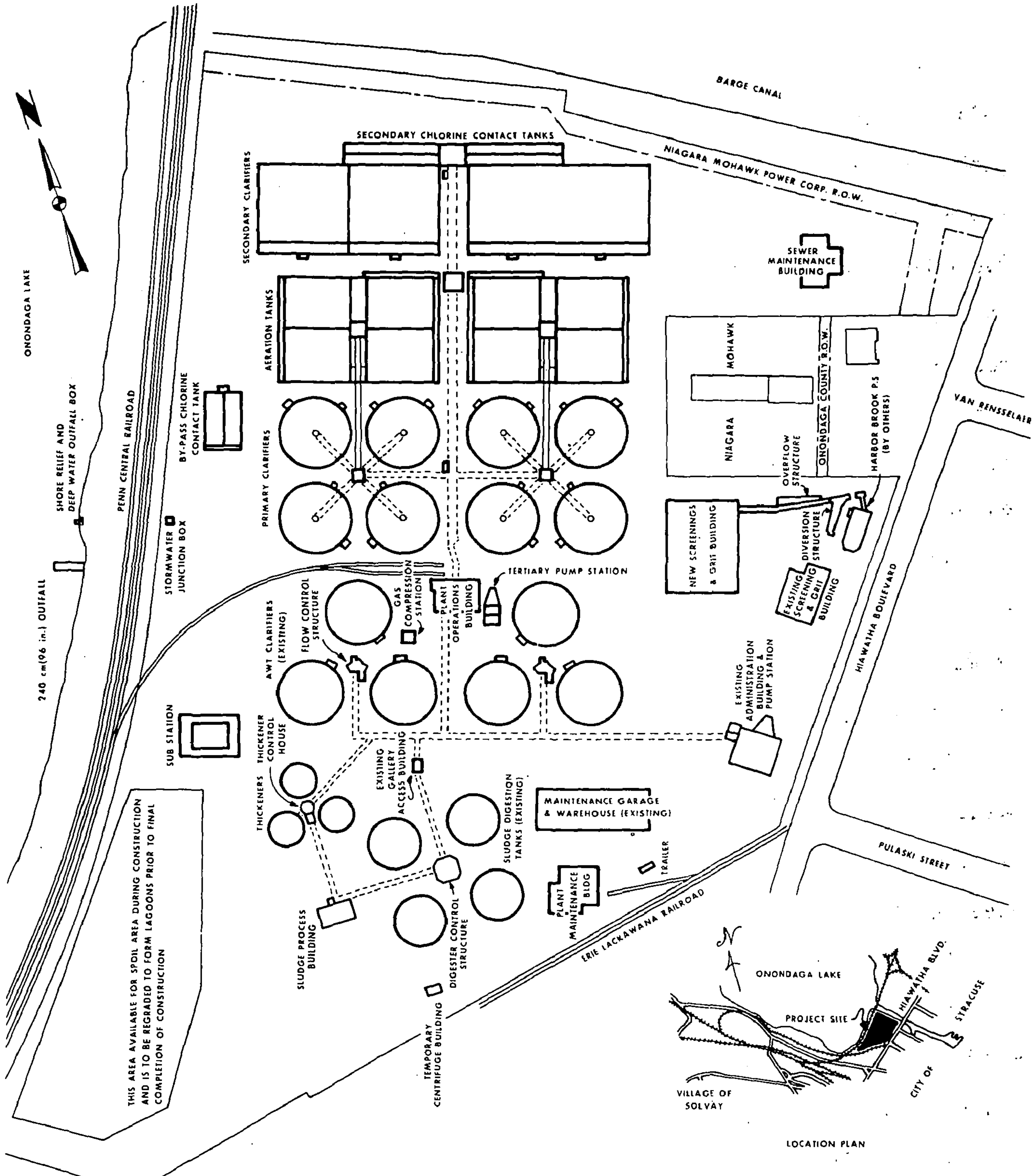
Treatment Unit	Dimensions or Detention Time	Remarks
	Sludge Treatment Units	
Primary clarifiers' sludge pumping	540 cu m/day (0.14 mgd) pumps	Sixteen (eight operating, eight standby) positive displacement variable speed pumps Discharge to sludge thickeners
Secondary clarifiers' sludge pumping	4,500 cu m/day (1.2 mgd) pumps	Six (four operating, two standby) centrifugal slurry pumps Discharge to sludge thickeners
Three sludge thickeners	20 m (65 ft) diameter x 3.7 m (12 ft) side water depth	Gravity-type thickeners for primary and secondary sludges Thickened sludge (6 percent solids) pumped to digesters
Three primary sludge digesters (existing) High rate	30 m (100 ft) diameter x 8.38 m (27.5 ft) side water depth Total volume 20,000 cu m (715,000 cu ft) DT 14.5 days	Primary digesters heated to 32 - 35°C (90 - 95°F) by external heat exchangers Mixing by gas dispersion

TABLE 34 (Cont'd)

MAJOR TREATMENT UNITS FOR THE PROPOSED MSSTP

Treatment Unit	Dimensions or Detention Time	Remarks
	Sludge Treatment Units	
One secondary sludge digester (existing)	30 m (100 ft) diameter x 7.47 m (24.5 ft) side water depth Total volume 6,130 cu m (219,000 cu ft) DT 4.4 days	Secondary digesters unheated and unmixed
Sludge disposal pumping station	Capacity 8,020 cu m/day (2.12 mgd)	Two (one operating, one standby) variable speed centrifugal slurry pumps operating continuously
Two centrifuges	Solids loading 2000 kg/hr each (4500 lb/hr)	For emergency use only Cake disposal by sanitary landfill
Sludge holding lagoons	Three day storage volume	For emergency use only Lagoons to be constructed on treatment plant site

Source: O'Brien & Gere, 1973a.



Source: O'Brien & Gere, 1973a.

PROPOSED MSSTP TREATMENT FACILITY LAYOUT

Figure 13

New collection and transmission facilities are needed to convey Allied's settling lagoon overflow to the MSSTP. A holding/equalization pond and a pumping station will be constructed near Allied's lagoons. A new 51 cm (20 in.) diameter force main will be built to transport the lagoon overflow from the pumping station to an existing 61 cm (24 in.) diameter force main which is connected to the treatment plant. This existing force main currently carries wastewater from the West Side Pumping Station to the MSSTP. Since a new 91 cm (36 in.) diameter force main will be constructed for these flows, the existing force main can be used to transport the lagoon overflow to the MSSTP AWT units.

All of the facilities for collecting Allied's lagoon overflow and transporting it to the MSSTP will be owned and operated by Onondaga County. As mentioned earlier, these facilities will be constructed under a separate contract concurrent with the expansion and upgrading of the MSSTP.

Rainfall will increase the wastewater flow to the MSSTP. Flows up to 450,000 cu m/day (120 mgd) will undergo the entire treatment process. Once the flow exceeds 450,000 cu m/day (120 mgd), the MSSTP will not provide complete advanced waste treatment.

The primary clarifiers are designed to handle a peak flow of 450,000 cu m/day (120 mgd); the primary clarifiers will be used under both dry and wet weather conditions. Stormwater chlorination facilities are designed to handle a maximum flow of 390,000 cu m/day (103 mgd). Therefore, flows up to 390,000 cu m/day (103 mgd) will receive primary treatment and chlorination.

The maximum wet weather flow to the MSSTP is expected to be 844,000 cu m/day (223 mgd). A flow of this magnitude is expected to occur once or twice a year. Under these conditions, 390,000 cu m/day (103 mgd) of the influent will be bypassed around the primary clarifiers. The other 450,000 cu m/day (120 mgd) will receive primary treatment; of this amount, 390,000 cu m/day (103 mgd) will be sent to the stormwater chlorination facilities and will then be discharged into Onondaga Lake through the existing 150 cm (60 in.) diameter subsurface outfall. The remaining 60,000 cu m/day (17 mgd) that has undergone primary treatment will be mixed with the 390,000 cu m/day that has not undergone primary treatment. This combined flow will be sent through the secondary and advanced waste treatment facilities. The effluent will then be discharged through the 240 cm (96 in.) diameter surface outfall.

Effluent Disposal System

As part of the proposed project, a new 240 cm (96 in.) diameter shoreline outfall will be constructed at the southern end of Onondaga Lake. This outfall line will carry the treated effluent from the entire treatment process. The average daily flow through this outfall line will be 327,000 cu m/day (86.5 mgd).

As discussed on pages 124 to 132, 156 to 163, and in Appendix D, there is one problem associated with the surface outfall alternative: the $CaCO_3$ precipitation reaction that is expected to occur when the MSSTP effluent mixes with the waters of Onondaga Lake. Controls will be implemented to limit the pH of the MSSTP effluent to 9.0. This will, in turn, limit the extent of the $CaCO_3$ precipitation reaction. Therefore, a surface outfall is probably the most suitable effluent disposal alternative.

Sludge Disposal System

The sludge that is removed from the wastewater during operation of the expanded and upgraded MSSTP will generally be of two types: 1) organic sludge from the plant's primary and secondary clarifiers, and 2) inorganic sludge from the plant's AWT units. The organic sludge will be thickened and digested and then mixed with the unthickened, undigested inorganic sludge. The sludge mixture will then be pumped to the Allied Chemical Corporation for disposal. The sludge handling facilities for the proposed project are listed in Table 34.

The sludge thickeners will receive organic sludge from the MSSTP primary and secondary clarifiers. In addition, they will receive the sludge removed in the Ley Creek sewage treatment plant. Any overflow from the sludge thickeners will flow by gravity to the raw sewage pumping station and will be reintroduced to the MSSTP for treatment.

Sludge digestion in the upgraded MSSTP will be accomplished using the plant's four existing sludge digesters. The digesters will be modified as part of the proposed project. Three of the existing digesters will be outfitted with gas mixing equipment and expanded external heating facilities so that they can be operated as high rate primary digesters. The fourth digester will not require alteration; it will serve as a secondary digester.

Digested sludge from the primary digesters will be transferred to the secondary digester. The secondary digester will act as a clarifier, separating the digested solids from the sludge supernatant. The supernatant will be recycled to the influent end of the MSSTP and the digested solids will be transferred to the sludge pumping station wet well. Provisions have also been made for recycling a portion of the digested solids from the secondary digester to the sludge thickeners. This will permit a denser underflow in the thickeners and, in effect, will increase the solids detention time of the primary digesters.

Since the sludge that is removed from the AWT clarifiers will be mainly inorganic, biological digestion will not be necessary. This inorganic sludge will be sent directly to the sludge pumping station wet well. There it will be mixed with the organic sludge from the primary and secondary clarifiers. The final sludge product will be pumped to the Allied Chemical Corporation for disposal. Allied will deposit the sludge in one of its operational settling lagoons.

When the sludge from the MSSTP combines with Allied's wastewaters in the lagoons, two things should result: 1) sterilization of the digested organic sludge, and 2) increased sludge settleability (O'Brien & Gere, 1973a). Approximately 3800 cu m/day (1 mgd) of sludge will be pumped from the MSSTP to Allied. The solids content will be approximately 90,000 kg (100 tons). This solids loading is comparable to 10 percent of Allied's solids loading of 1,000,000 kg/day (1100 tons/day).

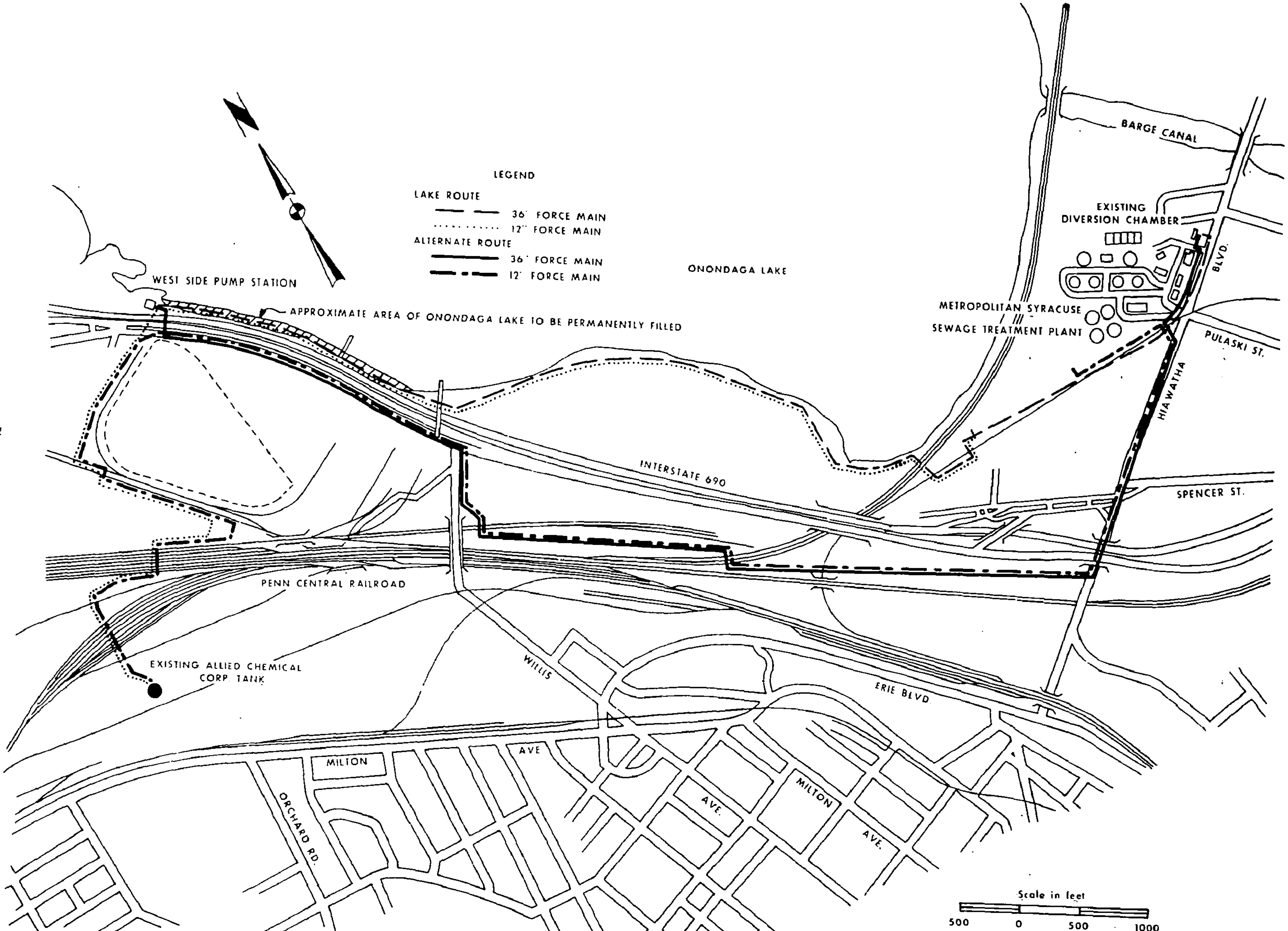
The sludge disposal system of the proposed project also includes two centrifuges that will serve as emergency standby facilities for sludge dewatering. The centrifuges will be used in the event of a sludge pumping station or force main malfunction or if, for some reason, Allied cannot accept the sludge. The MSSTP already has one standby centrifuge. If and when the centrifuges are used, the solids that are removed during the operation will be delivered to the Onondaga County Solid Waste Authority for final disposal in a sanitary landfill. Finally, emergency sludge lagoons with a three day detention time will be built at the MSSTP site.

WEST SIDE PUMPING STATION AND FORCE MAIN

On March 1, 1973, the U.S. Environmental Protection Agency awarded a construction grant for the West Side Pumping Station and Force Main project to the Onondaga County Department of Public Works. However, the grant was made contingent upon fulfillment of the requirements of the National Environmental Policy Act. The project involves 1) additions and alterations to the existing West Side Pumping Station, 2) construction of a 91 cm (36 in.) diameter raw sewage force main from the pumping station to the MSSTP, and 3) construction of a 30 cm (12 in.) diameter sludge disposal force main from the MSSTP to the Allied Chemical Corporation.

The pumping station will be expanded from its present maximum capacity of 38,000 cu m/day (10 mgd) to 106,000 cu m/day (28 mgd) by the addition of three variable speed self-regulating pumps. The average capacity of the expanded facility will be 45,000 cu m/day (12 mgd). A new mechanical screen, a screenings' shredder and other miscellaneous equipment will be added. Some structural modifications to the existing pump house will also be made.

For the better part of their length, the two force mains will be installed side-by-side in a single trench. As shown in Figure 14, two alternative routes for this trench were evaluated. The estimated project costs are $3,371,150 for the proposed lake route and $4,033,150 for the inland route (O'Brien & Gere, 1973a). In addition to its higher construction cost, the inland route is disadvantageous because it lies in the right-of-way of Interstate 690. The New York State Department of Transportation prohibits such occupancy (Towlson, written communication, 1970). The proposed route requires filling of a section adjacent to the Onondaga Lake shoreline.



Source: O'Brien & Gere 1973a

PROPOSED AND ALTERNATE ROUTES OF THE WEST SIDE FORCE MAIN

Figure 14

The new 91 cm (36 in.) diameter raw sewage force main will replace the xisting 61 cm (24 in.) diameter force main between the pumping station and he MSSTP. The existing force main will then be used to transmit Allied's ettling lagoon overflow to the MSSTP. Allied will build a holding pond, a umping station, and a 76 cm (30 in.) diameter force main to connect its ettling lagoons with the existing force main.

ENVIRONMENTAL IMPACT OF THE PROPOSED PROJECTS

The proposed projects have both environmental and socio-economic implications. Environmental considerations include the effects on aquatic and terrestrial ecosystems caused by construction and operation of the facilities. Socio-economic impacts are generally of a secondary nature: for example, changes in population, land use, and economic development patterns. The primary and secondary environmental effects of both the MSSTP project and the West Side Pumping Station and Force Main project are discussed below.

METROPOLITAN SYRACUSE SEWAGE TREATMENT PLANT PROJECT

Environmental Impact of Construction

Proper construction procedures will lessen the potential for detrimental environmental effects. Of particular importance are specific procedures to prevent environmental degradation and to retore any areas damaged during construction. The impact on Onondaga Lake of treatment plant construction will be limited to the effects of the silt loads that will be carried into the lake by surface water runoff. Erosion and consequent siltation in Onondaga Lake will be more of a problem during installation of the outfall line from the treatment plant to the southern end of the lake. Contractors must be required to institute effective temporary and permanent erosion control measures.

Construction inevitably involves the release of dust and, thereby contributes to the particulate load in the air around the construction site. The area near the plant site is already in violation of air quality standards for particulates; the proposed construction program will probably increase the extent of this violation on a temporary basis. The release of hydrocarbons by construction machinery will also temporarily degrade air quality, but the effects will probably be negligible.

In the case of the MSSTP construction, noise will probably be the most significant problem. Extensive pile driving will be necessary to provide an adequate foundation for the plant structure. There is very little that can be done to control the noise made by a pile driver. However, by restricting the hours during which pile driving can be done, some respite can be provided. Operation of the pile driver should not be allowed to interfere with the normal sleeping habits of area residents.

Federal guidelines (FWQA, 1970) require continuation of the same degree of treatment by the existing plant during the alteration period. The guidelines also require that a minimum of primary treatment and disinfection be provided at all times, except for brief periods when piping connections are being made. The construction schedule for this project will allow continuation of primary treatment and disinfection while the plant is being expanded and upgraded.

Environmental Impact of Operation

Certain constituents in the effluent of the MSSTP will have the potential to adversely affect the water quality of Onondaga Lake. These constituents are 1) chlorides, 2) calcium, 3) organic material, 4) pathogenic organisms, and 5) nutrients.

Chlorides

The MSSTP will not remove the chlorides that are introduced to the treatment plant by Allied's settling lagoon overflow. Therefore, chloride concentrations in the lake will remain high, on the order of 1700 mg/l.

Questions have been raised about the condition of Onondaga Lake prior to the start of Allied's Solvay process for the manufacture of soda ash. The plant began operation in 1884. The Syracuse area location was probably chosen because of the availability of the raw materials required for the process, namely limestone and salt. The salt deposits are located just south of Onondaga Lake in the foothills of the Appalachian Plateau. These salt deposits may indicate the presence of salty ground water. It is also possible that this salty ground water flows into Onondaga Lake or its tributaries. However, the exact influence of ground water on the chloride concentrations in the lake has not been determined.

Several historical accounts describe Onondaga Lake as a "salty" body of water (Onondaga County, 1971). Unfortunately, they contain no data that might support or precisely define the use of this term. The accounts do indicate that the water tasted salty. From this, we can conclude that the chloride level was at least 250 mg/l, the approximate taste threshold (U. S. Public Health Service, 1962).

If Allied eliminated the chlorides in its wastewater flow, the chloride level in Onondaga Lake would decline. Allied is responsible for about 60 percent of the chlorides that enter Onondaga Lake via surface discharges. If Allied halted this discharge, the lake's chloride level would be cut approximately in half. The applicant concluded that the elimination of Allied's discharge would mean a decrease in the lake's chloride level from 1700 mg/l to between 800 and 900 mg/l (O'Brien & Gere, 1973a). The EPA concluded that the final equilibrium concentration would be somewhat lower, between 600 and 800 mg/l (Rooney, written communication, 1973). Appendix C contains a more detailed discussion of Allied's chloride discharge and its effect on chloride concentrations in the lake.

The lack of information on the past condition of Onondaga Lake makes it impossible to precisely determine the effect of present chloride concentrations on the lake's flora and fauna. As mentioned earlier (see p.34), waters that have salinity concentrations similar to those reported for Onondaga Lake generally have a low diversity of aquatic species. However, salinity may not be the sole reason, or even the primary reason, for the low species diversity in Onondaga Lake. Other factors (DO, NH_3, Cr, and Cu) may play an even more important part in limiting the diversity of organisms in the lake. The species that are present in the lake seem capable of tolerating a wide range of pollutants.

If the chloride concentration in Onondaga Lake decreased to a level of between 600 and 900 mg/l, strictly freshwater species might still find the chloride concentrations in the lake intolerable. Thus, even if Allied's discharge was eliminated, the lake might not achieve the high species diversity typical of freshwater lakes.

Calcium

A major water quality problem in the Onondaga Lake drainage basin is the presence of a visible calcium carbonate ($CaCO_3$) precipitate in Geddes Brook, Nine Mile Creek, and Onondaga Lake. The precipitate is formed by the reaction of the waters with Allied's settling lagoon overflow, as shown in the following equation:

$$Ca^{2+} + CO_3^{2-} \rightleftharpoons CaCO_3 \downarrow$$

The calcium ions (Ca^{2+}) are provided by the settling lagoon overflow and the carbonate ions (CO_3^{2-}) naturally exist in the receiving streams as alkalinity. The precipitation reaction is very rapid: essentially, it is completed in the Geddes Brook-Nine Mile Creek system. However, the $CaCO_3$ precipitate is carried by the relatively swift current of the brook to Nine Mile Creek and thence to Onondaga Lake. Under the quiescent conditions prevailing in the lake, the precipitate settles out forming a delta of $CaCO_3$ at the mouth of Nine Mile Creek. The predominant source of the high calcium concentrations in Onondaga Lake is the Allied Chemical Corporation. Allied is responsible for 70 to 75 percent of the calcium in the lake.

Calcium also reacts with certain other constituents of the Onondaga Lake waters, such as bicarbonate ions (HCO_3^-) and various forms of phosphorus. With reference to the calcium-bicarbonate ion reaction, Rand et al. (1971) found that "The relatively high Ca^{++} concentrations in both the epilimnion and hypolimnion drive the above reaction [$Ca^{++} + HCO_3^- \rightleftharpoons CaCO_3 + H^+$] toward the formation of $CaCO_3$ (calcite)." They also calculated that approximately 4.2×10^{-6} to 66.4×10^{-6} moles/liter of $CaCO_3$ are now precipitated daily in Onondaga Lake. This is equivalent to 61,000 to 980,000 kg/day (135,000 to 2,160,000 lb/day) of $CaCO_3$ precipitate.

Calcium can also react with phosphorus-bearing compounds. Major precipitates formed by these reactions include $Ca_{10}(PO_4)_6(OH)_2$ (hydroxylapatite) and $Ca_5(HPO_4)_3(F)\ (OH)_3$ (fluorapatite). Sutherland (1971) reported that Onondaga Lake was oversaturated with these two compounds. He estimated that "The precipitation of fluorapatite, $Ca_{10}F_2(PO_4)_6$, might remove the equivalent of 4.0 mg/l orthophosphate phosphorus from the hypolimnetic waters over a period of time, less than one year." Therefore, certain amounts of phosphorus are removed as solid precipitates.

Under the proposed project, Allied's settling lagoon overflow will be pumped to the MSSTP's advanced waste treatment units. According to

O'Brien & Gere (1974), approximately 36,000 kg/day (79,300 lb/day) of $CaCO_3$ will be precipitated in the MSSTP's AWT units (see Appendix D). This is equivalent to 14,400 kg/day (31,700 lb/day) of the dissolved calcium in the settling lagoon overflow, or between 1.5 and 4 percent of the total dissolved calcium present. The remaining calcium, or between 96 and 98.5 percent of that originally present in the overflow, will remain in solution and will be discharged into Onondaga Lake through the proposed MSSTP shoreline surface outfall.

The chemistry of the $CaCO_3$ precipitation reaction is very complex; the reaction is affected by alkalinity, pH, temperature, salinity, and other chemical parameters. Competing reactions, such as the hydroxylapatite and fluorapatite precipitation reactions previously described, also interfere. In discussing the quantity of lime required to bring about a precipitation reaction for the removal of phosphorus in a sewage treatment plant, Black & Veatch (1971) noted, "In addition to the reaction of lime with hardness, other competing reactions occur in lime treatment of wastewater. Also, there may be incomplete reaction of the lime. All of these complications make calculation of lime dose difficult. The result is that, at present, determination of lime dose is largely empirical." In short, it is extremely difficult to accurately predict the behavior of the calcium carbonate precipitation reaction.

When Allied's settling lagoon overflow is introduced into the MSSTP's AWT units, the calcium in the overflow will react with the effluent from the plant's secondary treatment units. As shown in Appendix D, two major reactions are expected: one between calcium and phosphorus, and another between calcium and carbonate ions. In both cases, the amount of reactant, whether phosphorus or carbonate ions, contained in the secondary effluent will limit the extent of the reaction.

For example, calcium and phosphorus are needed in certain proportions for the formation of $Ca_5OH(PO_4)_3$ (hydroxyapatite). Allied's settling lagoon overflow contains an abundance of calcium, but the treatment plant's secondary effluent contains a relatively small amount of phosphorus. Under the circumstances, one can expect most of the phosphorus, but very little of the calcium to be consumed in the formation of the hydroxyapatite precipitate.

The same is true of the reaction between calcium and carbonate ions in the formation $CaCO_3$ (calcium carbonate). Only a limited number of carbonate ions are available in the secondary effluent (as measured by the alkalinity of the secondary effluent). The availability of carbonate ions will determine the amount of calcium carbonate precipitate that can be formed.

The disproportion of calcium to the reactants available in the MSSTP's secondary effluent means that very little calcium will be removed in the MSSTP by the above-mentioned precipitation reactions. Between 1.5 and 4 percent of the total calcium load will be removed at the treatment plant. The other 96 to 98.5 percent will be discharged in the treatment plant effluent.

The quantity of calcium in the MSSTP effluent will be extremely large: a calcium carbonate precipitation reaction is expected to occur as soon as the effluent comes in contact with the waters of Onondaga Lake (see Appendix D). The particles of $CaCO_3$ formed should not be visible because adequate controls will maintain the pH of the MSSTP effluent within the range of 8.5 to 9.0. A substantial visible discharge plume would violate the revised New York State water quality standards for Class C waters (see Appendix A). The standards prohibit any discharge that would "...cause a substantial visible contrast to natural conditions." It was the existence of just such a visible discharge in Geddes Brook, Nine Mile Creek, and Onondaga Lake that prompted the New York State Department of Health (1966 and 1967) to bring court action against the Allied Chemical Corporation.

There are two major impacts associated with the continued imposition of high calcium loadings on Onondaga Lake. First, the $CaCO_3$ precipitation reaction that now occurs throughout Onondaga Lake will probably continue. The precipitation results from the mixture of dissolved calcium with the alkalinity of the lake waters.

Second, high calcium loadings on Onondaga Lake will allow the continued imposition of high calcium loadings on the waterways downstream of Onondaga Lake, especially the Seneca-Oswego River system. As shown in Table 35 and Figure 15, the waterways downstream of the lake already have high calcium concentrations. Allied's settling lagoon overflow is largely responsible for the high calcium levels in the downstream waters. At present, municipal use of these waters is nonexistent and industrial use is very limited. The high calcium concentrations will restrict any proposed uses. Calcium causes hardness in water, which results in "...excessive soap consumption in homes and laundries; the formation of scums and curds in homes, laundries, and textile mills; the gallowing of fabrics, the toughening of vegetables cooked in hard waters; and the formation of scales in boilers, hot-water heaters, pipes, and utensils." (McKee and Wolf, 1963).

The high calcium content of Allied's settling lagoon overflow may even pose problems for the treatment plant itself. The calcium carbonate precipitation reaction that is expected to occur in the AWT units may cause scaling. Although normally associated with boiler waters, scales can be formed in any

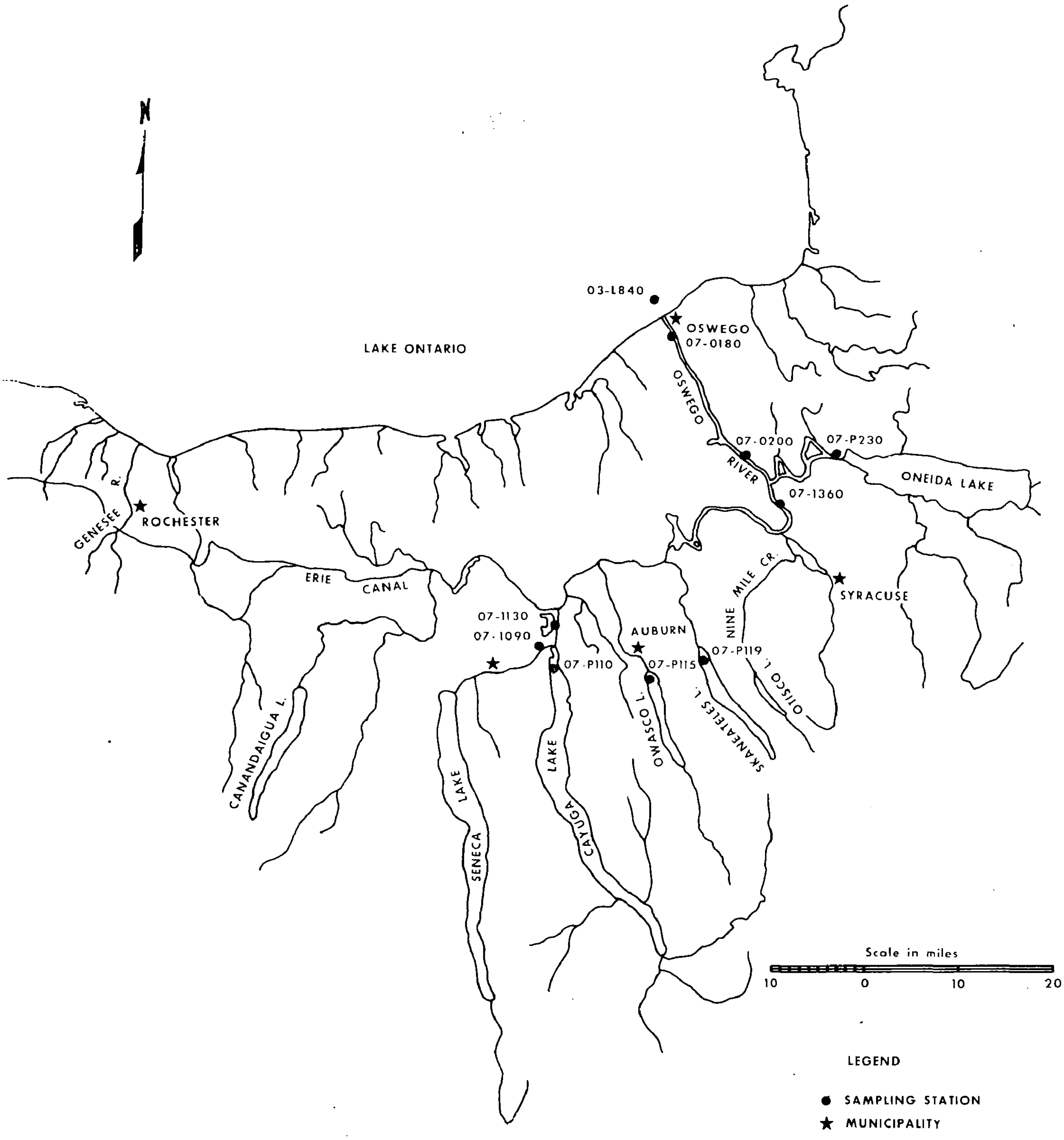
TABLE 35

CALCIUM CONCENTRATIONS IN THE SENECA-ONEIDA-OSWEGO RIVER SYSTEM DRAINAGE BASIN

Station Identification Number (See Fig. 15)	Station Location	Calcium Concentration (mg/1)	
		50 Percentile	90 Percentile
07-P110	Cayuga Lake outlet	44.4	49.3
07-1090	Seneca River	47.1	54.8
07-1130	Seneca River	44.1	58.2
07-P115	Owasco Lake outlet	40.9	44.1
07-P119	Skaneateles Lake outlet	36.1	37.2
-	Onondaga Lake	745.2 1/	
07-P230	Oneida Lake outlet	42.4	48.2
07-1360	Seneca River	137.4	188.6
07-0200	Oswego River	108.9	126.9
07-0180	Oswego River	114.5	167.5
03-L840	Lake Ontario	42.5	49.3

1/ Average of four values (Onondaga County, 1971).

Source: NYSDEC, n. d. b.



Source: NYSDEC n.d.b.

SAMPLING LOCATIONS ON THE SENECA - ONEIDA - OSWEGO RIVER SYSTEM

Figure 15

equipment carrying high quantities of calcium carbonate. In discussing water system distribution conduits, Riehl (1970) notes, "Where treatment in the past has not been adequate, the lines may have their carrying capacity greatly reduced by deposited scale...or by rough interior due to tubercles and scale."

Scales are described as "hard and firmly adhesive" (Skeat, 1969). Once they have formed on a surface, scales are not easily removed. Deposition problems may be encountered in the AWT units of the MSSTP, especially in the proposed tube settlers. Since scaling is a potential problem, provisions should be made to insure that the AWT units can be easily maintained.

Organic Matter

The parameter currently used to assess the impact of discharges containing organic matter on a receiving waterway is the BOD (5-day). The proposed project will reduce the BOD (5-day) loadings to Onondaga Lake from the present level of 27,000 kg/day (60,000 lb/day) to an estimated level of 4600 kg/day (10,100 lb/day). This represents an 83 percent reduction in the BOD (5-day) loading to the lake. The proposed project should help to raise the dissolved oxygen concentrations in the epilimnion. This represents a significant and beneficial impact on the lake environment. Even though the dissolved oxygen levels in the lake should increase, other adverse influences could prevent many species from inhabiting the lake. These undesirable influences include high ammonia (NH_3), copper (Cu), chromium (Cr), and chlorine (Cl) concentrations.

At the MSSTP, organic matter will be removed from the wastewater in both the primary and secondary treatment units. In the primary clarifiers, the settleable organic solids will be removed as sludge. In the secondary system, organic materials will be biologically oxidized and will be removed as sludge in the secondary clarifiers. The solids removed in the AWT units will be mainly inorganic since they will be basically derived from the precipitation of calcium carbonate and various forms of calcium-phosphorus compounds.

The proposed project provides for disposal of about 90,000 kg/day (100 tons/day) of sludge from the MSSTP in Allied's operational settling lagoons. The three lagoons that are now in use have a combined life expectancy of nine years. Recognizing that new lagoons will be required in a relatively few years, Allied has petitioned the Town of Camillus to approve a zoning variance that would clear the way for construction of new lagoons. (Syracuse University Research Corporation, 1973). The disposal of sludge from the MSSTP in Allied's lagoons will slightly accelerate the filling of those lagoons and, therefore, the need for new ones. For this reason, the environmental effects of constructing and operating settling lagoons are discussed below even though lagoon construction is not strictly part of the proposed project.

Settling lagoons have several serious environmental effects. The major areas of concern are 1) aesthetics and the restoration of abandoned lagoons, 2) the changes in land use patterns associated with lagoon construction, 3) the impact of lagoon leachate on ground water and of lagoon overflow on surface waters, and 4) the impact of lagoon construction on nearby residential areas.

Allied has used settling lagoons for waste disposal ever since it commenced operations in 1884. To date, none of the abandoned lagoons has been restored to a productive biological ecosystem. A sparse ground cover has been established on abandoned lagoons in the area of the Nine Mile Creek delta. However, the present vegetation is not of the same quality as that which existed prior to lagoon construction or as that which exists today on adjacent lands. The lagoons are an unsightly addition to the western shoreline of Onondaga Lake. They are especially unsightly in comparison with the eastern shoreline of the lake, which is mainly parkland.

The application of organic sludge to the abandoned lagoons as a means of enhancing lagoon restoration has received some attention. O'Brien & Gere (1973a) reported:

> For the past twenty years, Onondaga County has disposed of digested and undigested organic sludge on the old [abandoned] Allied waste beds [settling lagoons] immediately adjacent to Route 690. Since the application of sewage sludge to these beds, they have supported substantial quantities of plant life.
>
> It appears reasonable that disposal of sludge on the Allied waste beds in the future will have the same beneficial effect.

The above statement does not take into account two very important factors. First, the beneficial effect produced by application of sewage sludge to the abandoned lagoons may be due to improved media structure rather than to the organic matter in the sludge. The solids in the abandoned lagoons are highly compressed and plastic in nature. As a result, the lagoons may not be well enough aerated to support plant root systems. Sewage sludge is much less compact, allowing the aeration necessary to support plant root systems. The fact that the sludge contains organic matter may be only of secondary importance.

Second, even if organic matter is accepted as the crucial factor in lagoon restoration, the above statement may be inaccurate. In the past, organic sludge was disposed of on the abandoned lagoons. Under the proposed project, the organic sludge from the MSSTP's primary and secondary units will be mixed with inorganic sludge from the AWT units. This sludge mixture will be disposed of in Allied's operational lagoons rather than on the abandoned lagoons. Combining the sludge from the MSSTP with Allied's wastewaters in the operational lagoons should result in 1) sterilization of the digested organic sludge, and 2) increased sludge settleability (O'Brien & Gere, 1973a). If this happened, the organic sludge would settle and be compacted along with the other materials in the lagoons: any benefit that might be attributed to the organic sludge would be lost.

In any case, the potential effects of inorganic sludge and Allied's wastewaters on lagoon restoration have not been adequately investigated. Among other things, the effects of chloride ions and pH on plant establishment and growth should be studied.

Boecher (n.d., in O'Brien & Gere, 1973a) came to the conclusion that restoration of the abandoned lagoons could be effected if a layer of top soil was placed over the waste solids and if proper drainage was provided through the use of sand drains and drainage tiles. Restoration should not be construed as a return to the pre-lagoon state because, as Boecher goes on to say, "The waste is a soft, sensitive material resembling a clay that can never be expected to support large structures."

If the Town of Camillus grants the requested zoning variance, Allied will be free to construct new settling lagoons on land adjoining its operational lagoons. After describing the site and the biological communities currently occupying it, the Syracuse University Research Corporation (1973) states, "The potential for establishing desirable types of vegetation with its associated wildlife upon completion of filling of the bed [i.e., upon abandonment of the lagoon] might be considered an enhancement of the general environment." Although restoration is possible, it is doubtful whether an abandoned settling lagoon will ever rival the desirability of unaltered land as biological habitat.

The commitment of land to settling lagoons has both immediate and long-range implications. It forecloses all other land use options not only for the useful life of the lagoon (which in this case is about fifteen to twenty years), but for thirty to fifty years after abandonment. Thereafter, the resultant unstable subsurface conditions prohibit all but low-load uses. Boecher (n.d., in O'Brien & Gere, 1973a) reports that after rehabilitation, a former settling lagoon can "...support parks, golf courses, and other low-load bearing facilities if proper drainage facilities are furnished and maintained." The fact that abandoned lagoons can eventually be put to some beneficial use is a positive aspect, but it does not offset the negative aspects of the loss of open land and the curtailment of land use options.

The impact of settling lagoons on ground-water and surface water quality is another area of concern. According to O'Brien & Gere (1973a) and the Syracuse University Research Corporation (1973), monitoring wells surrounding Allied's operational settling lagoons indicate that lagoon leachate does not permeate to the ground-water aquifer. However, U.S. Geological Survey (1970) data indicate that 1) there are high chloride ion concentrations in the subsurface aquifer near the operational settling lagoons, and 2) these high chloride ion concentrations may not be due to natural causes. There is a definite possibility that waters from Allied's operational lagoons enter the area's subsurface aquifer as leachate either through the lagoons themselves or through the overflow waterways.

The adverse effects of settling lagoon overflow on water quality in Geddes Brook, Nine Mile Creek, and Onondaga Lake are discussed at length in other sections of this report. Here it is sufficient to note that in Geddes Brook and Nine Mile Creek these effects will be eliminated if the lagoon overflow is diverted to the MSSTP. After the overflow discharge is terminated, the affected waterways should progressively improve in water quality.

There are three residential areas in the immediate vicinity of the proposed settling lagoon site: the Belle Isle Road area, the Bennett and Warner's Roads area, and the Home Town Park Tract. Settling lagoon construction may affect residents of these areas by decreasing the aesthetic and the economic value of the residential property. Before new lagoons are constructed, the feasibility of eventually restoring the lagoons to a condition that is compatible with the residential communities should be demonstrated.

Pathogenic Organisms

The existing MSSTP provides primary treatment and chlorination for a peak wet weather flow of 643,000 cu m/day (170 mgd). Higher flows are not treated, but are simply discharged into Onondaga Lake. The expanded MSSTP will be able to provide primary treatment and chlorination for flows up to 840,000 cu m/day (223 mgd). The increased chlorination capacity of the plant is expected to effect a slight decrease in the total number of pathogenic organisms in Onondaga Lake.

As discussed on pages 110 to 114, the proposed project will not eliminate the combined sewer overflow problem. Along with continued stormwater overflows will come continued discharge of coliform organisms into the lake. As mentioned previously, bacterial pollution of Onondaga Lake is the main reason why the lake is closed to swimmers.

Nutrients

Phosphorus and nitrogen are the two nutrients most closely associated with the eutrophication of lakes. In the metropolitan Syracuse area, phosphorus levels in domestic wastewaters have declined in recent years. According to O'Brien & Gere (1972), this phosphorus reduction has had a marked effect on Onondaga Lake.

O'Brien & Gere (1972) reported a decrease in the number of blue-green algae in Onondaga Lake. They also noted that algal patterns in the lake had been disrupted. Blue-green algae blooms normally occur in the late summer. Recently, however, green algae blooms, which generally occur in the late spring and early summer, have persisted through the summer and fall. Green algae, which are distributed throughout the water column, are preferable to blue-green algae, which form mats on the water surface and emit obnoxious odors.

Another positive sign is the increase in the diversity of algal species in the lake. The algal diversity index rose from 0.695 in 1971 to 0.801 in 1972. This may reflect a higher degree of stability in the algal community and a general improvement in the trophic status of Onondaga Lake (Murphy, 1973).

The proposed project will further reduce the phosphorus level of the MSSTP effluent. This should further improve the trophic status of Onondaga Lake by increasing the algal diversity index and by decreasing the probability of blue-green algae blooms. Phosphorus removal at the MSSTP may also help to lower the phosphorus concentrations downstream of Onondaga Lake in the Seneca-Oswego River system and in Lake Ontario.

The proposed project will also reduce the amount of nitrogen in the MSSTP effluent. How substantial the reduction will be is not yet known. At present, the nitrogenous oxygen demand (NOD) exerted in the lake by bacteria utilizing nitrogen compounds appears to be high (Onondaga County, 1971). The high NOD may be effecting significant reductions in the dissolved oxygen levels in the lake. At times, the ammonia concentrations in Onondaga Lake contravene New York State water quality standards (see p.100). Ammonia concentrations may also approach levels that are harmful to the lake's flora and fauna (see pp.38 to 39). According to O'Brien & Gere (1974), the county has expanded its sampling program to include more frequent sampling of such critical nutrients as ammonia and organic nitrogen. Through monitoring and analysis, the true impact of ammonia on the lake's biota can be determined.

Socio-Economic Effects

The potential economic and social effects of the proposed project generally concern the Syracuse area's economic make-up, its land use patterns, the size of its population, and the overall quality of life.

Economic Impact

The economic impact of expanding and upgrading the MSSTP depends on two things: 1) the extent to which increased treatment capacity will influence the economic development patterns of those industries in which municipal wastewater treatment facilities are considered an amenity, and 2) the potential change in the Allied Chemical Corporation's economic profile as a result of that company's reaction to the wastewater treatment alternative selected.

The project is not expected to significantly boost employment by attracting new industries to the Syracuse area. All other factors being equal, the existence of adequate sewerage facilities might give the Syracuse area a slight competitive edge over other areas not so well-equipped. However, this is at best a marginal advantage. The main focus of improved sewerage facilities will be residential service rather than attraction of new industry.

If Allied Chemical Corporation is not included in the proposed project, it may be required by the New York State Department of Environmental Conservation to pretreat its wastewater in order to reduce the calcium levels in the wastewater discharge. Allied executives have raised the possibility of a plant shutdown if such requirements are imposed on the company. They maintain that the cost of the calcium reduction requirements would be prohibitive.

Allied reportedly employs about 1800 persons at its Syracuse plant. This represents slightly less than 1 percent of the total number of persons employed in Onondaga County. Allied's reported payroll of 26 million dollars accounts for about 2 percent of the total payroll in the county.

In addition to Allied's employees, a plant shutdown would affect the suppliers, shippers, and customers connected with the Allied operation. How severe the impact of a shutdown would be is not known at present.

Social Impact

The proposed project is not likely to influence the size or distribution of the population in the service area. The project has more relevance in terms of the overall quality of life and the recreational potential of the Syracuse area. The magnitude of the project's social impact is difficult to predict. It depends to a great extent on the importance to area residents of water quality in general and recreational use of Onondaga Lake in particular. Although the social effects of this project cannot be precisely determined, there are indications that the project will be of some social benefit.

In 1967, Fredrickson (1969) investigated social priorities and preferences in Syracuse. Fredrickson used a stratified random sample of 1036 persons of voting age in Onondaga County. He found that 56 percent of the individuals in the sample considered water pollution an important urban problem, ranking it third out of a total of ten urban problems. Water pollution was ranked above such items as employment, housing, and traffic. Fredrickson noted that an individual's socio-economic status seemed to have little bearing on his responses.

In an earlier publication, Fredrickson and Magnus (1968) reported on the same sample group. With reference to Onondaga Lake, they found that "Slightly more than 85% of the residents either 'agree' or 'strongly agree' that county governments should clean the lake for swimming and boating; 88% 'agreed' or 'strongly agreed' for the supporting of fish and animal life."

The importance attached to water pollution as an urban problem can probably be traced to two main sources: 1) the prime example of pollution provided by Onondaga Lake, and 2) the attention paid water pollution in general as a public issue. In light of the above, the proposed project, by improving water quality in Onondaga Lake, should be of social benefit.

WEST SIDE PUMPING STATION AND FORCE MAIN PROJECT

This project is an adjunct to the proposed MSSTP project: it will enable the transfer of raw sewage from the West Side Pumping Station to the MSSTP via the West Side Force Main. As such, its environmental effects, with the exception of construction effects, will be the same as those described for the MSSTP project.

The severity of the environmental effects of the West Side Pumping Station and Force Main project will mainly depend upon the constraints exercised during project construction. The additions and alterations planned for the existing pumping station will present no significant adverse impacts. The same cannot be said for construction of the West Side Force Main. This part of the project involves the installation of approximately 600 m (2000 ft) of force main in an embankment that will be built in Onondaga Lake along its southwest shore (see Figure 14).

Construction of the embankment will entail the filling of approximately 1.2 ha (3 acres) of the lake shore area with solid embankment materials. The shoreline will thus be realigned into the lake waters. The distance from the existing shoreline to the shoreline that will be created by the embankment will be as much as 24 m (79 ft). The embankment will also extend landward from the present shoreline to a maximum distance of 19 m (62 ft). A similar embankment will be built to carry the force main along its route across abandoned Allied settling lagoons.

The loss of areas on both the land-side and the water-side of the existing shoreline will have an adverse impact on the southern area of Onondaga Lake. The water-side areas fall in the littoral zone of Onondaga Lake. The littoral zone of a lake is normally a zone of great biological productivity. In some lakes it is the most productive zone. Primary producers such as aquatic vascular plants and algae abound in this zone. Such vegetation provides food and shelter for many invertebrate and vertebrate species. The zone also serves as the nursery and spawning area for many types of fish. In a healthy lake, any filling of the littoral zone means the loss of a very productive area.

The adverse effects of the proposed embankment should be viewed in light of the present condition of the Onondaga Lake shoreline. Trash and debris are scattered along the shore and in the littoral zone of the lake. The shoreline is also coated with oily substances. These substances can probably be traced to nearby oil terminals or petroleum transport barges that operate on the lake.

In its present condition, Onondaga Lake's littoral zone cannot be considered a productive fish spawning area. If this area was reclaimed and the oil discharges were halted, the productivity of the littoral zone could be restored. Construction of the proposed force main embankment will eliminate this possibility.

Some of the other possible adverse effects of embankment construction are: 1) turbidity in Onondaga Lake caused by the dredging of muck prior to emplacement of the embankment, 2) degradation of nearby areas caused by improper disposal of muck and other dredged materials, and 3) siltation in Onondaga Lake caused by erosion of the embankment materials by rainfall or by lake waters.

The Contract Specifications for this project (Calocerinos & Spina, 1971) do not contain detailed guidelines for construction practices or restraints aimed at protecting the lake environment. There are several notable deficiencies. For example, no constraints are specified for the protection of the lake during dredging. No indication is given of acceptable disposal sites for the solid wastes (trash and muck) removed during construction. No guidelines are given for proper restoration of unimproved surface areas. No mention is made of the type of fill material that will be used or of the precautions that will be taken to contain this material within the section of the lake that is to be filled.

The Contract Specifications should be revised to insure protection and enhancement of the environment. To this end, specific procedures to prevent environmental degradation and to restore any areas damaged during construction should be incorporated into the Contract Specifications.

Although installation of the West Side Force Main has its environmental drawbacks, it can be turned to some benefit through the application of multiple use concepts. At present, there is only limited access to the southwestern s shore of Onondaga Lake. The force main right-of-way could open up this area to greater public use if adequate recreational facilities were provided. For example, hiking and bike trails could be developed along the right-of-way.

ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSED PROJECTS BE IMPLEMENTED

METROPOLITAN SYRACUSE SEWAGE TREATMENT PLANT PROJECT

Construction of the proposed MSSTP will present erosion and siltation problems, particularly during the installation of the proposed surface outfall line. Erosion and siltation are problems that accompany almost every type of construction project. Contractors must be required to institute effective temporary and permanent erosion control measures to minimize the adverse effects of siltation. According to the NYSDEC adequate erosion control provisions are contained in the Contract Specifications (I-1.04) for this project. (Pederson, written communication, 1974).

Dust and other particulate matter will be raised during construction, causing an air quality problem in the vicinity of the construction site. However, the problem will be temporary and its effects insignificant.

Extensive pile driving will be required to provide adequate support for several of the treatment units. The piles must be driven through the clay layers underlying the treatment plant site to a depth of about 76 m (250 ft). The noise caused by the pile driving operation will constitute a serious adverse effect during the early stages of construction. Pile driving should be restricted to hours when it will not interfere with the normal sleeping habits of area residents.

Limited calcium carbonate ($CaCO_3$) precipitation will probably occur when the effluent from the MSSTP mixes with the waters of Onondaga Lake. The discharge plume will not be visible. Only a substantial visible plume would violate the revised New York State water quality standards for Class C waters (see Appendix A).

The proposed project will not remove the chlorides that are being discharged into the lake in Allied's settling lagoon overflow. While the chloride level in the lake may have been doubled or tripled by Allied's discharge, the exact impact of the increased chloride level on the biota of the lake has not yet been determined.

The discharge of ammonia (NH_3) and other nitrogen compounds from the MSSTP will be somewhat reduced. Ammonia concentrations in the lake may exceed levels known to be toxic to certain aquatic organisms. At certain times of the year, in certain sections of Onondaga Lake, current ammonia levels contravene New York State water quality standards (see pp.99 to 100 and Appendix A). The utilization of nitrogen compounds by bacteria exerts a nitrogenous oxygen demand (NOD) which depletes the dissolved oxygen in the lake.

The sludge from the MSSTP will be transferred to Allied's settling lagoons for final disposal. This will shorten the lifespan of the operational lagoons.

WEST SIDE PUMPING STATION AND FORCE MAIN PROJECT

In conjunction with the installation of the West Side Force Main, approximately 1.2 ha (3 acres) of Onondaga Lake along its southwest shore will be filled in with solid embankment materials. This will eliminate a portion of Onondaga Lake's littoral zone. In view of the area's present degraded condition and in view of the potential recreational value of the area after restoration, the loss of the littoral zone is not very significant.

RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Implementation of the proposed MSSTP project will reduce the biochemical oxygen demand (BOD) loadings currently imposed on Onondaga Lake by the existing facility. This should substantially increase the dissolved oxygen levels in the lake. However, BOD loadings from sources other than the MSSTP will continue to enter Onondaga Lake and its tributaries. The BOD exerted by combined sewer overflows will continue to affect the waters of Onondaga Lake.

When the overflow from Allied's settling lagoons mixes with the waters of Geddes Brook and Nine Mile Creek, calcium carbonate precipitation occurs. The proposed project will eliminate this problem because the settling lagoon overflow will be pumped to the MSSTP. Substantial precipitation of $CaCO_3$ will take place in the advanced waste treatment units of the MSSTP and limited precipitation of $CaCO_3$ will probably occur at the discharge point in Onondaga Lake. Limited calcium carbonate precipitation in Onondaga Lake will not contravene the revised New York State water quality standards.

The immediate impact of depositing sludge from the MSSTP in Allied's settling lagoons will be to accelerate the filling in of the lagoons. The sooner the capacity of the existing lagoons is exhausted, the sooner new lagoons will be required. Settling lagoons mar the landscape, foreclose many of the potential uses of a given piece of land, and are aesthetically displeasing. Onondaga County should carefully consider the available sludge disposal alternatives to settling lagoons. Furthermore, a program should be instituted to rehabilitate the lagoons that have already been abandoned.

Construction of the West Side Force Main will involve the filling in of 1.2 ha (3 acres) of Onondaga Lake's littoral zone. In its present condition, this area is only a marginally productive biological zone. Any possibility of restoring this area's value as a littoral zone will be permanently eliminated by the proposed project.

IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED PROJECTS SHOULD THEY BE IMPLEMENTED

Certain resource commitments will be involved in the construction and operation of the Metropolitan Syracuse sewage treatment plant (MSSTP) project and the West Side Pumping Station and Force Main project. The major resource commitments will be construction materials and land.

Several acres of woodland and open land at the proposed MSSTP site will be lost. There are no rare or endangered species in the area. The proposed treatment plant site was chosen because it adjoins the existing MSSTP facilities, which will be incorporated into the new system. The loss of woodland and open land is considered acceptable in light of the environmentally beneficial effects of the project on Onondaga Lake and downstream waterways.

The disposal of sludge from the MSSTP in Allied's settling lagoons will shorten the life expectancy of those lagoons. Three lagoons are currently in use; together they have a life expectancy of nine years. Allied is already making plans for the construction of additional lagoons. The construction of additional lagoons will permanently alter the land use patterns of the area chosen by Allied. The new lagoons will be in operation for 15 to 20 years; after that 30 to 50 years will have to elapse before the former lagoons can be put to some beneficial use. Even then, use of the former lagoon areas will be limited to parks, golf courses and other low-load facilities. Plans should be made to restore these abandoned lagoons to some degree of usefulness.

At the proposed MSSTP, chlorine will be used for disinfection of wastewaters. This will require the commitment of as much as 15,000 kg/day (32,000 lb/day) of chlorine for an indefinite period of time. The current chlorine shortage in the United States may necessitate the future implementation of some other means of disinfection at the MSSTP.

Improvements to the West Side Pumping Station will be mainly internal modifications of an existing structure. Resource commitments will be negligible. On the other hand, construction of the West Side Force Main will result in the permanent loss of approximately 1.2 ha (3 acres) of Onondaga Lake along its southwestern shoreline. Placement of the force main requires that this section of the lake be filled in. The affected area is now coated with oil and littered with tires, metal cans and other debris. Its present condition severly limits its biological productivity. In conjunction with the force main project, a general clean up of the area is planned.

DISCUSSION OF PROBLEMS AND OBJECTIONS RAISED BY ALL REVIEWERS

INTRODUCTION

According to the requirements of the National Environmental Policy Act of 1969, as stated in the Environmental Protection Agency's "Preparation of Environmental Impact Statements: Interim Regulation", dated January 17, 1973:

> Final statements. . . shall summarize the comments and suggestions made by reviewing organizations and shall describe the disposition of issues surfaced (e.g., revisions to the proposed action to mitigate anticipated impacts or objections). In particular, they shall address in detail the major issues raised when the Agency position is at variance with recommendations and objections (e.g., reasons why specific comments and suggestions could not be accepted, and factors of overriding importance prohibiting the incorporation of suggestions). Reviewer's statements should be set forth in a Comment and discussed in a Response. In addition, the source of all comments should be clearly identified.

Immediately following this introduction is a list of the reviewers of the draft environmental impact statement (EIS) on the proposed projects. The list is followed by a table that identifies the concerns expressed by reviewers of the draft EIS. Those reviewers not cited in the table offered no comment on the draft EIS.

Wherever possible, valid alterations or corrections suggested by reviewers were incorporated into the text. Three major areas of concern warranted detailed consideration; these are addressed in the section entitled "Comments and Responses". All of the comments dealing with a particular subject were synthesized into a representative Comment. Each Comment is followed by the EPA's Response.

LIST OF REVIEWERS OF THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

Central New York Regional Planning
and Development Board (CNYRPDB)
321 East Water Street
Syracuse, New York 13202
Robert L. Anderson, Review Specialist
February 6, 1974*

New York Pure Water Association
401 Larned Bldg.
Syracuse, New York 13202
William A. Maloney, President
January 25, 1974*

New York State Department of Environmental
Conservation (NYSDEC)
50 Wolf Road
Albany, New York 12201
Ronald W. Pedersen, First Deputy Commissioner
February 12, 1974*

Onondaga Audubon Society, Inc. (OAS)
Box 620, Syracuse, New York 13201
Robert E. Long, M.D., Vice President
January 31, 1974*

Onondaga County Department of
Public Works (OCDPW)
Division of Drainage and Sanitation
650 West Hiawatha Boulevard
Syracuse, New York 13204
John M. Karanik, Projects Officer
January 14, 1974*

Onondaga Lake Reclamation Association, Inc. (OLRA)
114 South Warren Street
Syracuse, New York 13202
William A. Maloney, Director
January 30, 1974*

*Letter dated

Sierra Club (SC)
Iroquois Group: Atlantic Chapter
1217 Jamesville Avenue
Syracuse, New York 13210
Martin L. Sage, Chairman
January 27, 1974*

Syracuse-Onondaga County Planning Agency (SOCPA)
300 East Fayette St.
Syracuse, New York 13202
William O. Thomas, Director
January 30, 1974*

U.S. Department of Agriculture
Soil Conservation Service (SCS)
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A.C. Addison, State Conservationist
January 23, 1974*

U.S. Department of Health, Education, and Welfare
Region II
26 Federal Plaza
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Charles Josinsky, P.E.
Regional Environmental Officer
January 10, 1974*

U.S. Department of the Interior (USDI)
Office of the Secretary
Washington, D.C. 20240
William A. Vogoly, Acting Deputy
Assistant Secretary of the Interior
February 28, 1974*

*Letter dated

TABLE 36

COMMENTS ON THE DRAFT EIS

Subject of Comment	Reviewing Organization								
	CNYRPDB	NYSDEC	OAS	OCDPW	OLRA	SC	SOCPA	SCS	USDI
Precipitation of Calcium Carbonate	X	X		X		X			X
Nitrogen Removal in MSSTP				X		X			
Phosphorus Removal in MSSTP	X	X		X		X		X	X
Salinity of Onondaga Lake		X		X	X	X			
Water Quality Standards	X	X		X	X	X			
Effect of Onondaga Lake on Downstream Waterways		X							
Siltation and Erosion Control		X						X	X
Wastewater Disposal System (Outfall Line)				X					X
Sludge Disposal System		X	X	X		X	X		
West Side Force Main	X	X	X	X		X		X	X
Industrial Clients of the MSSTP					X				

COMMENTS AND RESPONSES

Effect of Onondaga Lake on Downstream Waterways

Comment

New information shows that the waters of Onondaga Lake do have an adverse impact on the water quality of the Seneca-Oswego River system between Baldwinsville and Phoenix.

Response

A recent U.S. Geological Survey report (1973) shows that Onondaga Lake is very important to the chemistry of the Seneca-Oswego River system. The lake is so mineralized that it substantially controls the water quality of the Oswego River at Oswego, which is 46.7 km (29 miles) downstream of the Onondaga Lake outlet.

In measuring the effect of Onondaga Lake waters on the Seneca River, it cannot be assumed that the lake waters continuously flow into the river. The Seneca River from Baldwinsville to Phoenix is part of the Erie Canal system. Dams on the Seneca River at Baldwinsville and Phoenix control the flow of the river. The flow direction of the waters in the Onondaga Lake outlet may be into the Seneca River, into Onondaga Lake, or both. In the last case, the top layer, containing Seneca River water, moves into the lake and the bottom layer, containing Onondaga Lake water, moves into the river.

According to the U.S. Geological Survey (1973), "The high density of Onondaga Lake water and the increasing depth of the outlet toward Seneca River probably combine to insure an almost permanent chemical stratification in the outlet and its junction with the Seneca River." In other words, in the area where the lake and the river meet, the upper water layers are dominated by the lighter Seneca River waters and the lower water layers are dominated by the denser Onondaga Lake waters. Consequently, if sampling in this area is confined to the surface water layers, the data will not reflect the true impact of the Onondaga Lake waters on the river. This seems to have been the case in the biological sampling conducted by Simpson (1973):

> Because our samplers were located fairly close to the water surface (3-4 feet), some important effects of organic discharges may have been overlooked. There is recent evidence that shows a definite stratification of dissolved oxygen within the river, with high concentrations near the surface (due to photosynthesis), and much lower concentrations at greater depths (Unpublished data, Basin Plans Group, New York State Department of Environmental Conservation). Inter-station comparisons of communities from greater depths could uncover impacts of pollution not revealed in the near-surface samples.

In commenting on the draft EIS, the NYSDEC stated:

> Dr. Simpson noted that recent evidence had been obtained that a definite stratification of dissolved oxygen occurred within the river and hence some important effects of organic discharges may have been overlooked. It does appear, however, that the lake has little impact upon the biology of the upper layer water of either the Seneca River or the Oswego River. (Pederson, written communication, 1974).

The NYSDEC also noted:

> The Onondaga Lake waters haven't been shown to have deleterious effect upon the biological conditions in the upper layers of water within these rivers. However, the secondary effect, resulting from the induced chemical stratification, does result in some local adverse conditions. (Pederson, written communication, 1974).

The NYSDEC believes that its monitoring network will be a useful tool in determining the true impact of Onondaga Lake waters on the water quality of the Seneca-Oswego River system.

West Side Force Main

Comment

Construction of the West Side Force Main as proposed would permanently destroy 1.2 hectares (3 acres) of lake shoreline and would also destroy mud flats and marsh. Other alternatives should be considered.

Response

According to Calocerinos & Spina, the consulting engineers for the West Side Pumping Station and Force Main Project:

> The original route of the force main, for the most part, paralleled Interstate Route 690 from the pumping station to the treatment plant. This location was not approved by the New York State Department of Transportation, since their policy is not to allow parallel occupation of utilities within an interstate highway right-of-way. Further inquiries with the U.S. Bureau of Public Roads upheld this policy thereby requiring the force main to be moved.
>
> Several alternative routes were studied and the present location was selected as the most feasible. (Spina, written communication, 1974).

The area of the lake to be filled is adjacent to the Route 690 right-of-way. As mentioned in the EIS (p. 172) this area is of low environmental value. As the proposed route nears Harbor Brook, it crosses a marsh area. The force main was routed through this marsh area to avoid an abandoned Allied settling lagoon. According to Calocerinos & Spina: "Samples of the material in the waste bed [settling lagoon] had indicated very poor support capability requiring extensive piling and expensive construction. The only route remaining was at its present location requiring an embankment construction as shown on the plans." (Spina, written communication, 1974). The quality of the marsh area to be filled is rather poor.

Furthermore, the alteration of this area could provide the basis for a recreational project of significant social value. A relatively new land use concept is that of using public rights-of-way as parks and recreational areas. If this multiple use concept is applied to the West Side Force Main situation, the southwest shore of Onondaga Lake, which currently lacks any kind of recreational facility, can be provided with hiking trails, bicycle paths, and similar recreational facilities. The Syracuse-Onondaga County Planning Agency (1974) stated "...the Onondaga County Environmental Management Council has contracted with Schum and Associates (Landscape Architects) for a Land Use Implementation Plan of Onondaga Lake and Related Environs." The EPA strongly recommends that the Onondaga County Department of Public Works and the Onondaga County Environmental Management Council coordinate their efforts so that a multiple use facility may be realized.

Industrial Clients of the MSSTP

Comment

The MSSTP should be strictly for public use. Industrial and chemical wastes should be excluded because such wastes could have toxic or deleterious effects.

Response

In the past, the inclusion of industrial wastes in municipal sewerage systems posed many serious problems, including introduction of toxic or deleterious materials to the sewerage system, hydraulic overloading of the treatment plant, and inequitable distribution of the cost of the sewerage system. Now, pretreatment guidelines (U.S. EPA, 1973f; Onondaga County, 1972) require that municipal sewerage system clients remove any toxic or deleterious substances from their wastewaters before discharging those wastewaters into the municipal sewerage system. This protects the sewerage system and the environment from the harmful effects that certain industrial wastes may have on them. In addition, industrial clients of municipal sewerage systems are now required to pay not only their fair share of the treatment costs, but also their fair share of the capital cost of constructing the sewerage system (U.S. EPA, 1973i).

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. Onondaga Lake is in a degraded and highly eutrophic state. Both the epilimnion and the hypolimnion of the lake have high average concentrations of calcium (600 mg/l) and chlorides (1700 mg/l). In 1972, the average phosphorus concentration in the epilimnion was 0.50 mg/l as total phosphorus; the average ammonia nitrogen level in the epilimnion was 2.06 mg/l; the pH of the epilimnion was 7.69. In the hypolimnion, dissolved oxygen (DO) levels are at or near zero approximately eight months out of the year. In the epilimnion, DO levels fall to 1 to 2 mg/l for short periods of time.

2. The existing Metropolitan Syracuse sewage treatment plant (MSSTP) is a 189,000 cu m/day (50 mgd) primary treatment facility. The present average flow to the MSSTP is 265,000 cu m/day (70 mgd); the present treatment efficiencies are approximately 26 percent BOD (5-day) removal and 51 percent suspended solids removal. The proposed expansion and upgrading of the MSSTP is a necessary first step toward improving water quality in Onondaga Lake.

3. The critical element in determining the biological make-up of Onondaga Lake appears to be DO concentrations. The present low DO levels in the lake may mask the toxic effects of other constituents, including chlorides, ammonia, copper, zinc, and chromium.

4. Under the proposed project, the Allied Chemical Corporation's settling lagoon overflow will be included in the advanced waste treatment (AWT) units of the upgraded and expanded MSSTP. In this way, the overflow discharge will be diverted from its present receiving water, Geddes Brook. This will eliminate the calcium carbonate precipitation that now occurs in the Geddes Brook-Nine Mile Creek system.

5. A calcium carbonate precipitation reaction should occur in the AWT units of the MSSTP because of the lime contained in the Allied settling lagoon overflow. However, the alkalinity of the MSSTP secondary flow into the AWT units will limit the quantity of calcium carbonate that can be formed. Approximately 96 to 98.5 percent of the calcium originally present in Allied's settling lagoon overflow will be passed through the AWT units and will be discharged into Onondaga Lake. Analysis indicates that a limited calcium carbonate precipitation reaction will occur in Onondaga Lake at the proposed shoreline outfall. Under normal operating conditions, the precipitation reaction should not contravene the revised New York State water quality standards.

6. Possible operational upsets in the AWT units of the MSSTP could raise the pH of the effluent to an unacceptably high level (above 9.0). Add to this the fact that during the summer the pH of the lake water can be high (in the range of 8.5 to 9.5). The result is a set of conditions under which significant amounts of calcium carbonate can be expected to precipitate in Onondaga Lake. The amount of $CaCO_3$ precipitated under these conditions could cause a contravention of New York State water quality standards. The Onondaga County

Department of Public Works has proposed a pH control system to solve this problem (see Appendix D).

7. The inclusion of Allied's settling lagoon overflow in the AWT units of the MSSTP will allow continued high total dissolved solids loadings on Onondaga Lake. The MSSTP discharge will be high in calcium and chlorides; average daily concentrations of calcium and chlorides will be on the order of 1500 mg/l and 4000 mg/l, respectively. Approximately 1.5 to 4 percent of the calcium in the lagoon overflow will be removed in the MSSTP; essentially none of the chlorides will be removed.

8. If Allied's chloride discharge into Onondaga Lake was discontinued, the chloride concentrations in the lake would decline by at least 50 percent. However, at present there is no economically feasible way to remove the pollutants generated by plants such as Allied's Solvay plant (U.S. EPA, 1973e). Furthermore, some of the chlorides in the lake appear to be contributed by natural, uncontrollable sources, including ground-water discharge and the bottom sediments of the lake. At present, the effect of chlorides on the aquatic life of the lake is unknown. Fish life does exist even though the lake is eutrophic and has very low DO levels.

9. Legislation that bans the use of high phosphate detergents in Onondaga County and in New York will continue to effect decreases in the total phosphorus concentrations in domestic raw sewage flows. The upgraded and expanded MSSTP will provide for the reduction of phosphorus to 1.0 mg/l or less (as total phosphorus), as required by the New York State Department of Environmental

Conservation (NYSDEC). Together, detergent use limitations and phosphorus removal treatment at the MSSTP should result in a beneficial change in the algal species composition of Onondaga Lake and in protection and enhancement of Lake Ontario.

10. The proposed project will not allow the restoration of fishing or swimming activities in Onondaga Lake. In 1970, the NYSDEC banned fishing in Onondaga Lake because of the high mercury levels found in fish. Since 1970, the discharge of mercury into the lake has been greatly reduced, but the lake's bottom sediments and fish are still contaminated. Swimming is and will remain prohibited because of the high concentrations of pathogenic organisms that enter the lake via combined sewer overflows. Two alternative methods of controlling combined sewer overflows are now being studied: 1) control of infiltration/inflow, and 2) treatment of combined sewer overflows at selected points in the sewer system.

11. The high calcium and chloride levels in Onondaga Lake are reflected in the high concentrations of these elements in the downstream waterways, specifically the Seneca-Oswego River system. By virtue of their potential to interfere with domestic, commercial, and industrial use of the affected waters, these high calcium and chloride concentrations will restrict future use of the waterways. The affected Seneca-Oswego River waters are not now used as a source of domestic water supply nor are they proposed as a future source of domestic water supply. Allied is the main contributor of the chlorides in Onondaga Lake. However, even if Allied stopped discharging chlorides into the

lake, the natural chloride level in the lake might still keep the chloride level in the Seneca-Oswego River system above the 250 mg/l drinking water standard established by the U.S. Public Health Service.

12. The high ammonia levels in Onondaga Lake may be somewhat reduced by the upgraded and expanded MSSTP. At present, none of the municipal or industrial wastewater treatment plants in the Onondaga Lake drainage basin provide facilities for nitrogen removal.

13. The introduction of toxic or deleterious substances into the MSSTP's sewerage system is subject to local rules and regulations and to Federal pretreatment guidelines. These control measures must be strictly enforced to prevent the discharge of toxic metals and other deleterious substances into Onondaga Lake.

14. Under the proposed project, Allied's operational settling lagoons will be used for final disposal of the sludge from the MSSTP. This will slightly accelerate the filling of the lagoons, shortening their useful lifespan. The sludge will have no beneficial effect in terms of eventual restoration of the lagoons. None of the abandoned Allied lagoons have been restored to date.

15. Communities within the service area of the MSSTP are almost completely developed; very little growth is expected in the future. Therefore, wastewater flows to the MSSTP are not expected to exceed the 300,000 cu m/day (80 mgd) design capacity of the treatment plant. The proposed project will alleviate the hydraulic overloading that occurs at the existing MSSTP.

16. Crucible Incorporated is now constructing its own wastewater treatment facility. The effluent from this plant will meet all applicable New York State and U.S. Environmental Protection Agency standards, including those for oil and grease, iron, chromium, and copper. In addition, the treated water will be reusable, enabling Crucible to decrease its water consumption by about 90 percent.

17. Construction of the proposed West Side Force Main will necessitate the emplacement of fill materials in approximately 1.2 ha (3 acres) of Onondaga Lake along its southwest shore. The loss of this portion of the littoral zone is an adverse environmental impact of the project. However, the significance of this impact is somewhat mitigated by the present degraded condition of the area and the fact that this area is only a small part of Onondaga Lake's total littoral acreage.

18. The applicant outlined an alternative inland route for the West Side Force Main. This alternative route cannot be implemented because it lies in the right-of-way of an existing interstate highway. There are no other feasible alternatives to the proposed route because the area in question is highly congested.

19. The Contract Specifications for the West Side Pumping Station and Force Main project do not include specific provisions to insure protection of the lake environment during construction, or restoration of damaged areas after construction. There are no specific guidelines for erosion control procedures, disposal of dredged materials, or effective restoration of unimproved areas after construction.

RECOMMENDATIONS

1. The existing MSSTP should be expanded and upgraded as proposed to provide secondary treatment along with advanced waste treatment for phosphorus removal. This will help to raise the dissolved oxygen concentrations in the epilimnion of Onondaga Lake. It will also insure that the MSSTP meets the NYSDEC's phosphorus limit of 1.0 mg/l or less (as P) for the protection of Lake Ontario.

2. In order to insure that the New York State water quality standards on turbidity are not contravened in Onondaga Lake, the pH of the MSSTP effluent must not exceed 9.0. The pH of the effluent is not expected to exceed 9.0 unless operational upsets occur in the AWT units. The county's proposed pH control system (see Appendix D) should be incorporated into the treatment system to preclude any possibility of a precipitation problem occurring in Onondaga Lake.

3. The applicant must develop an alternative sludge disposal plan so that the MSSTP can continue to operate even if Allied's settling lagoons become unavailable. An alternative sludge disposal plan should be presented to the NYSDEC and the EPA for their approval within a year after the start of construction.

4. The combined sewer overflow control studies that are currently underway in Onondaga County should be continued. When the studies are completed, the applicant should move toward implementation of an effective combined sewer overflow control program so that Onondaga Lake can be opened to swimming.

5. Monitoring and evaluation of the nitrogen and ammonia levels in Onondaga Lake should be continued by the county. The results of the monitoring and

analysis program should be used to determine whether nitrogen removal capabilities should be instituted to control the amounts of nitrogen from point source discharges in the Onondaga Lake drainage basin.

6. The Contract Specifications for the West Side Pumping Station and Force Main project must be revised to include specific conditions and constraints on construction procedures for the purpose of insuring environmental protection. The kinds of restoration procedures that will be implemented and the timeframe for restoration should also be included.

ABBREVIATIONS USED

Al^{3+}	-	aluminum
Alk	-	alkalinity
$AlPO_4$	-	aluminum phosphate
avg	-	average
AWT	-	advanced waste treatment
BOD	-	biochemical oxygen demand
BOD(5-day), BOD_5	-	biochemical oxygen demand (exerted over a five-day period)
BOD_{ult}	-	biochemical oxygen demand (ultimate)
Ca, Ca^{++}, Ca^{+2}, Ca^{2+}	-	calcium
$CaCl_2$	-	calcium chloride
$CaCO_3$	-	calcium carbonate
C_e	-	equilibrium concentration
Cl, Cl^-	-	chloride
Cl	-	chlorine
CO_2	-	carbon dioxide
$CO_3{}^{2-}$	-	carbonate
conc.	-	concentration
cond.	-	conductivity
Cr, Cr^{++}	-	chromium
Cu, Cu^{++}	-	copper
DO	-	dissolved oxygen
DS	-	dissolved solids
DT	-	detention time

e.g.	-	for example
epi.	-	epilimnion
et al.	-	and others
F	-	fluoride
Fe, Fe^{+++}, Fe^{+3}, Fe^{3+}	-	iron
$FePO_4$	-	ferric phosphate
FWPCAA	-	Federal Water Pollution Control Act Amendments
g, gm	-	grams
HCO_3^-	-	bicarbonate
hypo.	-	hypolimnion
K_{sp}	-	solubility product
l	-	liter
lb, lbs	-	pounds
LCSTP	-	Ley Creek Sewage Treatment Plant
max	-	maximum
Mg	-	magnesium
MG	-	million gallons
min	-	minimum
min.	-	minute
Mn	-	manganese
MSSTP	-	Metropolitan Syracuse Sewage Treatment Plant
N, N_2	-	nitrogen
Na	-	sodium
NaCl	-	sodium chloride
Na_2CO_3	-	sodium carbonate

NaOH	-	sodium hydroxide
NEPA	-	National Environmental Policy Act
NH_3	-	ammonia
NH_3^-N	-	ammonia nitrogen
NH_4^+	-	ammonium
NH_4OH	-	ammonium hydroxide
NO_2, NO_2^-	-	nitrite
NO_3, NO_3^-	-	nitrate
NOD	-	nitrogenous oxygen demand
NYSDEC	-	New York State Department of Environmental Conservation
NYSDH	-	New York State Department of Health
$O-PO_4$	-	ortho-phosphate
Org-N	-	organic nitrogen
P	-	phosphorus
RAPP	-	Refuse Act Permit Program
S	-	sulfide
SiO_2	-	silicon dioxide
SO_4	-	sulfate
SS	-	suspended solids
TDS	-	total dissolved solids
T-P	-	total phosphate
TSS	-	total suspended solids
U.S. EPA	-	United States Environmental Protection Agency
U.S.G.S.	-	United States Geological Survey

U.S. PHS	-	United States Public Health Service
vol.	-	volume
Zn	-	zinc
u gm, u g	-	microgram
u mhos	-	micromhos
°	-	degrees
=	-	equal
>	-	greater than
<	-	less than
%	-	percent
[ ]	-	molar concentration

METRIC EQUIVALENTS OF ENGLISH UNITS

Metric	English
Centigrade (C°)	Farenheit (F°)
centimeters (cm)	inches (in.)
centimeters/hour (cm/hr)	inches/hour (in./hr)
centimeters/year (cm/year)	inches/year (in./year)
cubic meters/day (cu m/day)	million gallons/day (mgd)
cubic meters/day/square meter (cu m/d/sq m)	gallons/day/square foot (gpd/sq ft)
hectares (ha)	acres (acres)
kilograms (kg)	pounds (lb) or tons (tons)
kilograms/day (kg/day)	pounds/day (lb/day),(lbs/day) or tons/day (tons/day)
kilograms/hour (kg/hr)	pounds/hour (lb/hr)
kilograms/thousand kilograms (kg/kkg)	pounds/thousand pounds (lb/1000 lb)
kilometers (km)	miles (miles)
kilowatts (kw)	horsepower (hp)
liters per capita per day (lpcd)	gallons per capita per day (gpcd)
meters (m)	feet (ft)
meters/second (m/sec)	feet/second (ft/sec)
milligrams/liter(mg/l)	parts per million (ppm) (this is an approximate equivalent)
square kilometers (sq km)	square miles (sq miles)

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APPENDIX A

SELECTED NEW YORK STATE WATER QUALITY CLASSIFICATIONS AND STANDARDS IN EFFECT PRIOR TO MARCH 27, 1974

CLASS B

Best usage of waters. Bathing and any other usages except as source of water supply for drinking, culinary or food processing purposes.

Quality Standards for Class B Waters1/

Items	Specifications
1. Floating solids; settleable solids; sludge deposits	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.
2. Sewage or wastes effluents	None which are not effectively disinfected.
3. pH	Range between 6.5 and 8.5
4. Dissolved oxygen	For trout waters, not less than 5.0 parts per million; for non-trout waters, not less than 4.0 parts per million.

1/Note 2 on page A-3 is also applicable to class B standards.

CLASS B (Cont'd)

Quality Standards for Class B Waters

Items	Specifications
5. Toxic wastes, oil, deleterious substances, colored or other wastes, or heated liquids	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to fish life, make the waters unsafe or unsuitable for bathing or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.

CLASS C

Best usage of waters. Fishing and any other usages except for bathing [and] as source of water supply for drinking, culinary or food processing purposes.

Quality Standards for Class C Waters1/

Items	Specifications
1. Floating solids; settleable solids; sludge deposits	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.
2. pH	Range between 6.5 and 8.5

1/ Note 2 on page A-3 is also applicable to class C standards.

CLASS C (Cont'd)

Quality Standards for Class C Waters

Items	Specifications
3. Dissolved oxygen	For trout waters, not less than 5.0 parts per million; for non-trout waters, not less than 4.0 parts per million.
4. Toxic wastes, oil, deleterious substances, colored or other wastes, or heated liquids	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to fish life or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.

Note 2: With reference to certain toxic substances as affecting fish life, the establishment of any single numerical standard for waters of New York State would be too restrictive. There are many waters, which because of poor buffering capacity and composition will require special study to determine safe concentrations of toxic substances. However, based on non-trout waters of approximately median alkalinity (80 ppm) or above for the State, in which groups most of the waters near industrial areas in this State will fall, and without considering increased or decreased toxicity from possible combinations, the following may be considered as safe stream concentrations for certain substances to comply with the above standards for this type of water. Waters of lower alkalinity must be specially considered since the toxic effect of most pollutants will be greatly increased.

Ammonia or Ammonium compounds	Not greater than 2.0 parts per million (NH_3) at pH of 8.0 or above
Cyanide	Not greater than 0.1 part per million (CN)
Ferro- or Ferricyanide	Not greater than 0.4 parts per million ($Fe(CN)_6$)

Copper	Not greater than 0.2 parts per million (Cu)
Zinc	Not greater than 0.3 parts per million (Zn)
Cadmium	Not greater than 0.3 parts per million (Cd)

SPECIAL CLASS A (International Boundary Waters)

Best usage of waters. Those as stated under "Objectives for Boundary Water Quality Control" in the 1951 Report of the International Joint Commission United States and Canada on the Pollution of Boundary Waters, subdivision (c) below; namely, source of domestic water supply ... or industrial water supply, navigation, fish and wildlife, bathing, recreation, agriculture and other riparian activities.

General Objectives

All wastes, including sanitary sewage, storm water, and industrial effluents, shall be in such condition when discharged into any stream that they will not create conditions in the boundary waters which will adversely affect the use of those waters for the following purposes: source of domestic water supply or industrial water supply, navigation, fish and wildlife, bathing, recreation, agriculture and other riparian activities. In general, adverse conditions are caused by:

(A) Excessive bacterial, physical or chemical contamination.

(B) Unnatural deposits in the stream, interfering with navigation, fish and wildlife, bathing, recreation, or destruction of aesthetic values.

(C) Toxic substances and materials imparting objectionable tastes and odors to waters used for domestic or industrial purposes.

(D) Floating materials, including oils, grease, garbage, sewage solids, or other refuse.

Specific Objectives

In more specific terms, adequate controls of pollution will necessitate the following objectives for:

(A) Sanitary sewage, storm water, and wastes from water craft. Sufficient treatment for adequate removal or reduction of solids, bacteria and chemical constituents which may interfere unreasonably with the use of these waters for purposes aforementioned. Adequate protection for these waters, except in certain specific instances influenced by local conditions, should be provided if the coliform M.P.N. median value does not exceed 2,400 per 100 ml. at any point in the waters following initial dilution.

(B) Industrial wastes.

(1) Chemical wastes-Phenolic type. Industrial waste effluents from phenolic hydro-carbon and other chemical plants will cause objectionable tastes or odors in drinking or industrial water supplies and may taint the flesh of fish.

Adequate protection should be provided for these waters if the concentration of phenol or phenol equivalents does not exceed an average of 2 ppb and a maximum of 5 ppb at any point in these waters following initial dilution. This quality in the receiving waters will probably be attained if plant effluents are limited to 20 ppb of phenol or phenol equivalents.

Some of the industries producing phenolic wastes are: coke, synthetic resin, oil refining, petroleum cracking, tar, road oil, creosoting, wood distillation, and dye manufacturing plants.

(2) Chemical wastes - other than Phenolic. Adequate protection should be provided if:

(a) The pH of these waters following initial dilution is not less than 6.7 nor more than 8.5. This quality in the receiving waters will probably be attained if plant effluents are adjusted to a pH value within the range of 5.5 and 10.6.

(b) The iron content of these waters following initial dilution does not exceed 0.3 ppm. This quality in the receiving waters will probably be attained if plant effluents are limited to 17 ppm of iron in terms of Fe.

(c) The odor producing substances in the effluent are reduced to a point that following initial dilution with these waters the mixture does not have a threshold odor number in excess of 8 due to such added material.

(d) Unnatural color and turbidity of the wastes are reduced to a point that these waters will not be offensive in appearance or otherwise unattractive for the aforementioned purposes.

(e) Oils and floating solids are reduced to a point that they will not create fire hazards, coat hulls or water craft, injure fish or wildlife or their habitat, or will adversely affect public or private recreational development or other legitimate shore-line developments or uses. Protection should be provided for these waters if plant effluents or storm water discharges from premises do not contain oils, as determined by extraction, in excess of 15 ppm, or a sufficient amount to create more than a faint iridescence. Some of the industries producing chemical wastes other than phenolic are: oil wells and petroleum refineries, gasoline filling stations and bulk stations, styrene copolymor, synthetic pharmaceutical, synthetic fibre, iron and steel, alkali chemical, rubber fabricating, dye manufacturing, and acid manufacturing plants.

(3) Highly toxic wastes. Adequate protection should be provided for these waters if substances highly toxic to human, fish, aquatic, or wildlife are eliminated or reduced to safe limits.

Some of the industries producing highly toxic wastes are: metal plating and finishing plants discharging cyanides, chromium or other toxic wastes; chemical or pharmaceutical plants and coke ovens. Wastes containing toxic concentrations of free halogens are included in this category.

(4) Deoxygenating wastes. Adequate protection of these waters should result, if sufficient treatment is provided for the substantial removal of solids, bacteria, chemical constitutents and

other substances capable of reducing the dissolved oxygen content of these waters unreasonably. Some of the industries producing these wastes are: tanneries, glue and gelatin plants, alcohol, including breweries and distilleries, wool scouring, pulp and paper, food processing plants such as meat packing and dairy plants, corn products, beet sugar, fish processing and dehydration plants.

(d) Quality standards for class A-special (International boundary waters). Supplemental to the above-referred to "Objectives for Boundary Waters Quality Control", the following quality standards are established for waters of this class.

Items	Specifications
1. Floating solids; settleable solids; sludge deposits	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.
2. Sewage or waste effluents	None which are not effectively disinfected.
3. Odor producing substances contained in sewage, industrial wastes or other wastes	The waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto shall not have an increased threshold odor number greater than 8, due to such added wastes.
4. Phenolic compounds	Not greater than 5 parts per billion (Phenol).

Items	Specifications
5. pH	Range between 6.7 and 8.5
6. Dissolved oxygen	Not less than 4.0 parts per million.
7. Toxic wastes, oil, deleterious substances, colored or other wastes or heated liquids	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to adversely affect the usages recognized for this class of waters.

(e) Standards subject to revision at any time. If and when necessary to attain the above referred to "Objectives for Boundary Waters Control", the standards specified herein shall be subject to revision from time to time after further hearings on due notice.

SELECTED NEW YORK STATE WATER QUALITY CLASSIFICATIONS AND STANDARDS IN EFFECT AFTER MARCH 27, 1974

Section 701.4 CLASSES AND STANDARDS FOR FRESH SURFACE WATERS

The following items and specifications shall be the standards applicable to all New York fresh waters which are assigned the classification of AA, A, B, C, or D, in addition to the specific standards which are found in this Part under the heading of each such classification.

Quality Standards for Fresh Surface Waters

Items	Specifications
1. Turbidity	No increase except from natural sources that will cause a substantial visible contrast to natural conditions. In cases of naturally turbid waters, the contrast will be due to increased turbidity.
2. Color	None from man-made sources that will be detrimental to anticipated best usage of waters.
3. Suspended, collodial or settleable solids.	None from sewage, industrial wastes or other wastes which will cause deposition or be deleterious for any best usage determined for the specific waters which are assigned to each class.
4. Oil and floating substances.	No residue attributable to sewage, industrial wastes or other wastes nor visible oil film nor globules of grease.
5. Taste and odor-producing substances, toxic wastes and deleterious substances.	None in amounts that will be injurious to fishlife or which in any manner shall adversely affect the flavor, color or odor thereof, or impair the waters for any best usage as determined for the specific waters which are assigned to each class.

Items	Specifications
6. Thermal discharges	No discharge which will be injurious to fishlife or make the waters unsafe or unsuitable for any best usage determined for the specific waters which are assigned to each class. See Part 704.

CLASS B

Best usage of waters. Primary contact recreation and any other uses except as a source of water supply for drinking, culinary or food processing purposes.

Quality Standards for Class B Waters1/

Items	Specifications
1. Coliform	The monthly median coliform value for one hundred ml of sample shall not exceed two thousand four hundred from a minimum of five examinations and provided that not more than twenty percent of the samples shall exceed a coliform value of five thousand for one hundred ml of sample and the monthly geometric mean fecal coliform value for one hundred ml of sample shall not exceed two hundred (200) from a minimum of five examinations. This standard shall be met during all periods when disinfection is practiced.
2. pH	Shall be between 6.5 and 8.5
3. Total Dissolved Solids	None at concentrations which will be detrimental to the growth and propagation of aquatic life. Waters having present levels less than 500 milligrams per liter shall be kept below this limit.

1/Note 1 on page A-13 is also applicable to Class B standards.

CLASS B (Cont'd)

Quality Standards for Class B Waters

Items	Specifications
4. Dissolved Oxygen	For cold waters suitable for trout spawning, the DO concentration shall not be less than 7.0 mg/l from other than natural conditions. For trout waters, the minimum daily average shall not be less than 6.0 mg/l. At no time shall the DO concentration be less than 5.0 mg/l. For non-trout waters, the minimum daily average shall not be less than 5.0 mg/l. At no time shall the DO concentration be less than 4.0 mg/l.

CLASS C

Best usage of waters. Suitable for fishing and all other uses except as a source of water supply for drinking, culinary or food processing purposes and primary contact recreation.

Quality Standards for Class C Waters[1/]

Items	Specifications
1. Coliform	The monthly geometric mean total coliform value for one hundred ml of sample shall not exceed ten thousand and the monthly geometric mean fecal coliform value for one hundred ml of sample shall not exceed two thousand from a minimum of five examinations. This standard shall be met during all periods when disinfection is practiced.
2. pH	Shall be between 6.5 and 8.5.
3. Total Dissolved Solids	None at concentrations which will be detrimental to the growth and propagation of aquatic life. Waters having present levels less than 500 milligrams per liter shall be kept below this limit.

1/Note 1 on page A-13 is also applicable to Class C standards.

Quality Standards for Class C Waters

Items	Specifications
4. Dissolved Oxygen	For cold waters suitable for trout spawning, the DO concentration shall not be less than 7.0 mg/l from other than natural conditions. For trout waters, the minimum daily average shall not be less than 6.0 mg/l. At no time shall the DO concentration be less than 5.0 mg/l. For non-trout waters, the minimum daily average shall not be less than 5.0 mg/l. At no time shall the DO concentration be less than 4.0 mg/l.

Note 1: With reference to certain toxic substances affecting fishlife, the establishment of any single numerical standard for waters of New York State would be too restrictive. There are many waters, which because of poor buffering capacity and composition will require special study to determine safe concentrations of toxic substances. However, most of the non-trout waters near industrial areas in this state will have an alkalinity of 80 milligrams per liter or above. Without considering increased or decreased toxicity from possible combinations, the following may be considered as safe stream concentrations for certain substances to comply with the above standard for this type of water. Waters of lower alkalinity must be specifically considered since the toxic effect of most pollutants will be greatly increased.

Ammonia or Ammonium Compounds	Not greater than 2.0 milligrams per liter expressed as NH_3 at pH of 8.0 or above.
Cyanide	Not greater than 0.1 milligrams per liter expressed as CN.
Ferro- or Ferricyanide	Not greater than 0.4 milligrams per liter expressed as Fe(CN)6.
Copper	Not greater than 0.2 milligrams per liter expressed as Cu.
Zinc	Not greater than 0.3 milligrams per liter expressed as Zn.

Cadmium	Not greater than 0.3 milligrams per liter expressed as Cd.

Section 702.1 CLASS A-SPECIAL (INTERNATIONAL BOUNDARY WATERS)

(GREAT LAKES WATER QUALITY AGREEMENT OF 1972)

Best usage of waters. Source of water supply for drinking, culinary or food processing purposes, primary contact recreation and any other usages. Conditions related to best usage. The waters, if subjected to approved treatment, equal to coagulation, sedimentation, filtration and disinfection with additional treatment, if necessary, to reduce naturally present impurities, meet or will meet New York State Department of Health drinking water standards and are or will be considered safe and satisfactory for drinking water purposes.

Quality Standards for Class A-Special Waters1/

(International Boundary Waters)

Items	Specifications
1. Coliform	The geometric mean of not less than five samples taken over not more than a thirty-day period should not exceed 1,000 per 100 ml total coliform nor 200 per 100 ml fecal coliform.
2. Dissolved Oxygen	In the rivers and upper waters of the lakes not less than 6.0 mg/l at any time. In hypolimnetic waters, it should be not less than necessary for the support of fishlife, particularly cold water species.
3. Total Dissolved Solids	Should not exceed 200 milligrams per liter.

1/Note 1 on page A-13 is also applicable to Class A-Special standards.

Items	Specifications
4. pH	Should not be outside the range of 6.7 to 8.5.
5. Iron	Should not exceed 0.3 milligrams per liter as Fe.
6. Phosphorus	Concentrations should be limited to the extent necessary to prevent nuisance growths of algae, weeds and slimes that are or may become injurious to any beneficial water use.
7. Radioactivity	Should be kept at the lowest practicable levels and in any event should be controlled to the extent necessary to prevent harmful effects on health.
8. Taste and odor-producing substances, toxic wastes and deleterious substances	None in amounts that will interfere with use for primary contact recreation or that will be injurious to the growth and propagation of fish, or which in any manner shall adversely affect the flavor, color or odor thereof or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
9. Suspended, collodial or settleable solids	None from sewage, industrial wastes or other wastes which will cause deposition or be deleterious for any best usage determined for the specific waters which are assigned to this class.
10. Oil and floating substances	No residue attributable to sewage, industrial wastes or other wastes nor visible oil film nor globules of grease.
11. Thermal discharges	No discharge which will be injurious to fishlife or make the waters unsafe or unsuitable for any best usage determined for the specific waters which are assigned to this class. See Part 704.

To meet the water quality objectives referred to in the "Great Lakes Water Quality Agreement of 1972," the standards listed above shall be subject to revision from time to time after further hearings on due notice.

APPENDIX B

EARLY HISTORY OF ONONDAGA LAKE

Stewart (n.d.) compiled the following information on the early history of Onondaga Lake and its salty nature.

Perhaps the earliest recording of Onondaga Lake and its salt springs was by a Jesuit Missionary, Father Simon LeMoyne, who visited the lake in 1653[1/]. LeMoyne wrote an account of the lake, which at that time was called Ganentaha by the Onondaga Indians:

> We arrive at the entrance of a small lake in a large half dried basin; we taste the water of a spring that they (the Indians) durst not drink, saying that there is a demon in it, which render it fetid. Having tasted it, I found it a fountain of salt water; and, in fact, we made salt from it as natural as that from the sea, of which we carried a sample to Quebec. (Geddes, 1860)

A detailed history concerning the gradual utilization of salt by the Indians, the white man's influence in the development of a salt industry and the eventual takeover of the lands around the lake to the exclusion of the Indians, is provided by Geddes (1860) and Clark (1859). Clark also described some interesting features of the shoreline of Onondaga Lake:

> The shores of the Onondaga Lake, at an early period of the settlement of the Country, were composed of soft, spongy bog, into which a pole could be thrust to an almost interminable depth. Since the clearing up of the hills in the neighborhood, sand gravel and other substances, have been washed down, and by the action of the waves, have become so solid

1/ Geddes (1860) gave the date of this first visit as 16 Aug. 1654.

> that loaded teams can now be driven along the beach, without making scarecely [sic] any indentation, while but forty years ago, the same ground could only be traversed by flat bottomed boats.

Schultz (1810), in a portion of his travelogue which concerned Onondaga Lake,2/ described the local belief that the lake was bottomless and that the lower waters were extremely saline. Schultz examined these local beliefs by having some boatmen row him around to different areas of the lake in an attempt to find an area where the bottom could not be found. However, most of their soundings produced only 9.2 m to 15.1 m of water with one final sounding giving them 19.5 m of water3/. Schultz also lowered a bottle in such a manner that he could withdraw a cork when it arrived at the bottom, then drew it up, and "found the water a little cooler, but not otherwise different from that on the surface." This implies that the lake did not have a deep saline layer in those early years as was mistakenly believed.

2/ Called Onondaga or Salt Lake at that time.
3/ Geddes (1860) mentioned soundings in the early years of 16.7 and 19.8 m.

APPENDIX C

CHLORIDES

The Onondaga Lake Study (Onondaga County, 1971) showed that approximately 70 percent of the chlorides discharged into Onondaga Lake from point sources could be attributed to tributaries containing discharges from the Allied Chemical Corporation. Onondaga County through its consultant, O'Brien & Gere, attempted to estimate the input of chlorides to the lake from sources other than Allied by 1) correlation analyses, 2) chloride to sodium ratios, and 3) a chloride mass balance. The following is O'Brien & Gere's analysis.[1/]

> In an attempt to determine the impact of Allied Chemical Corporation's production activity on the level of chlorides in Onondaga Lake, a statistical analysis was conducted to determine the correlation of Allied's production activity with mean lake concentrations. The correlation between the two variables indicates the degree of relationship between the variables or how well a linear equation describes or explains the relationship between the variables. The correlation coefficient varies between -1 and +1 with a value of 0 indicating that no relationship exists between the two variables. A value of -1 and +1 indicates that one variable fully explains the variation of the other in either a direct or inverse relationship.
>
> The linear correlation between the average annual concentration of chlorides in Onondaga Lake and the loading of chlorides by Allied Chemical Corporation yielded a correlation coefficient of 0.61. This generally indicates that the changes in the level of chlorides in Onondaga Lake respond in a less than predictable manner to the change in production level and hence discharge of chlorides from the Allied facility. The raw data is shown in the Table C-1 and plotted in Figures C-1 and C-2.

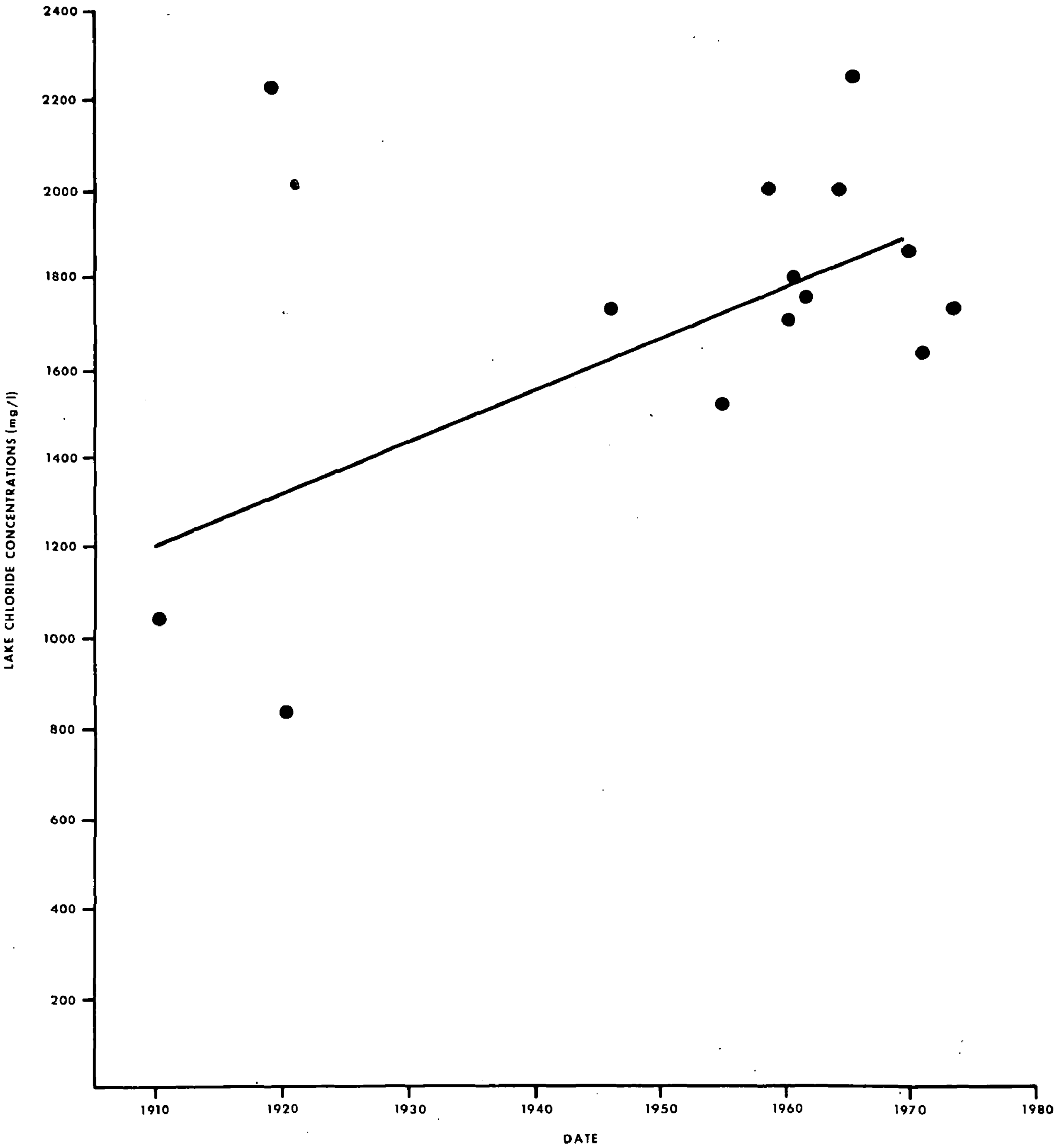
1/ The table and figure numbers in this passage have been changed to correspond with the numbering system used in this report.

TABLE C-1

DATA USED IN STATISTICAL ANALYSES TO DETERMINE THE SIGNIFICANCE OF ALLIED'S CHLORIDE DISCHARGE TO ONONDAGA LAKE

Year	Average chloride concentration in Onondaga Lake mg/l	Chlorides discharged by Allied		Average annual precipitation	
		kg x 10^6/year	tons/year	cm/year	in./year
1910	1,050	202	223,000	78.1	30.74
1918	2,020	347	383,000	83.3	32.79
1920	850	319	352,000	87.7	34.52
1947	1,724	358	395,000	103.5	40.75
1955	1,460	547	603,000	101.5	39.95
1959	2,000	556	613,000	104.6	41.20
1960	1,700	557	614,000	81.8	32.21
1961	1,800	593	654,000	95.5	37.58
1962	1,750	580	639,000	77.8	30.64
1964	2,000	653	720,000	94.2	37.10
1965	2,250	662	730,000	72.1	28.39
1970	1,789	621	685,000	97.1	38.23
1971	1,541	644	710,000	99.5	39.18
1972	1,730	661	729,000	140.74	55.41

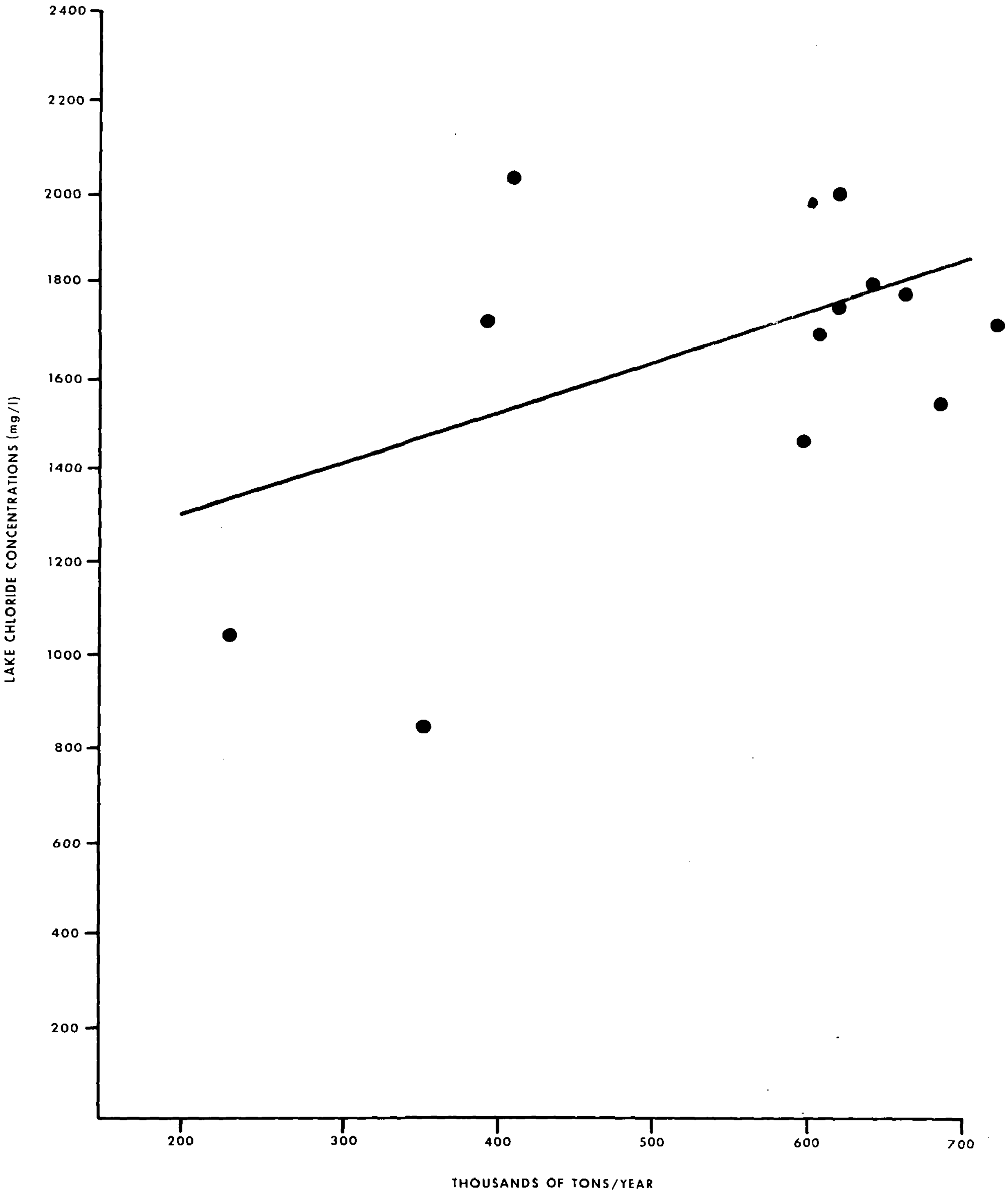
Source: O'Brien & Gere, 1973a.



Source: O'Brien & Gere, 1973a.

AVERAGE LAKE CHLORIDE CONCENTRATION VERSUS TIME

Figure C-1



Source: O'Brien & Gere, 1973a.

AVERAGE LAKE CHLORIDE CONCENTRATION VERSUS TONNAGE OF CHLORIDES FROM ALLIED CHEMICAL CORPORATION
Figure C-2

There are three factors which can account for the observed lack of correlation, namely:

1. The influences of non-point source contributions of chlorides may vary in an extreme manner and at times override the point source contribution from Allied Chemical.

2. The analytical data in determining the chloride composition of lake waters may not be uniform and self-consistent. The data was obtained from 6 sources over a span of 62 years reflecting the services of a large number of analysts. The sampling also suffers from the same lack of uniformity.

3. The rate of flushing of the lake may also be a contributing factor, responsible for differing fractions of Allied's flow to the total tributary contribution.

The effects of points (1) and (2) are largely indeterminate. There are little data available for non-point source contributions such as groundwater laden salt springs, sediment diffusion, air pollution, etc. The integrity and self-consistent nature of the analytical data cannot be verified, substantiated, or corrected for deficient analytical procedures and/or techniques. Both of these factors, because of their indeterminate nature cannot be checked for their contribution to the low correlation coefficient.

In an effort to determine the effect of the third factor, the rate of flushing, on the observed lake average chloride concentrations, correlation analysis was conducted between the annual average level of precipitation and the lake average chloride concentrations. In addition, linear multiple correlation investigations were conducted between the annual lake average chloride concentrations and the product of the level of Allied's production activity and the average annual rainfall.

The correlation between the annual lake average chloride concentration and the product of the level of Allied's production activity and the average annual rainfall yielded a coefficient of 0.42. The correlation between the annual lake average chloride concentration and the product of Allied's production activity and the inverse of the average annual rainfall yielded a coefficient of 0.46. This would indicate that the latter linear multiple correlation is slightly stronger. However, a correlation coefficient of this nature would indicate that the chlorides in the lake respond to the change in the product of the production level and annual rainfall in a random manner. The correlation between the annual lake average chloride concentration and the average annual precipitation yielded a coefficient of 0.21. On the other hand, the correlation between the annual lake average chloride concentration and the inverse of the average annual precipitation yielded a coefficient of -0.14. As such the lake average chloride is only very weakly correlated to total average annual precipitation.

The (Cl/Na) ratio is an accurate trace of the effect of the Allied Chemical discharge on the entire drainage basin. Allied Chemical discharged both $CaCl_2$ and NaCl in 1972 at levels of approximately 758,000 tons/year and 401,000 tons/year respectively. The effect of the Allied Chemical Corporations's discharge on the chloride level of the entire basin can be assessed by comparing the (Cl/Na) ratio from the Allied Chemical discharge to that of the Seneca River. The (Cl/Na) ratio characteristic of the Allied industrial discharge in 1972 is approximately 4.61. All other point source discharges to Onondaga Lake have an average (Cl/Na) ratio of 1.16 which together with the Allied waste provide a (Cl/Na) average ratio within Onondaga Lake of 3.04, as measured during 1972. This in itself would imply that Allied Chemical contributes 54.5% of the total chloride contribution to Onondaga Lake under the assumption that the lake reflected a steady situation and that neither chlorides or sodium are subject to any appreciable sinks, or sources, within the lake.

In following the (Cl/Na) ratios further through the basin, the Seneca River Cl/Na ratio, upstream from the Onondaga Lake discharge, is 1.65, which together with the 3.04 ratio in Onondaga Lake contributes to the 2.26 (Cl/Na) ratio which was observed downstream from the Onondaga Lake outlet on the Seneca River. The balancing of these ratios indicate [sic] that the Onondaga Lake chloride contribution is approximately 43.2% of the total observed at the Belgium sampling station.

If one carries this line of discussion to its conclusion, one may determine from the above, that Allied Chemical Corp. contributes approxiamtely 23.5% of the chlorides to the Seneca River downstream from the point of intrusion of the Onondaga Lake Outlet.

The reason for determining Allied Chemical's contribution of chlorides on the basis of (Cl/Na) ratios is largely because of the difficulty in accurately determining the flows of the tributaries influent to the lake. Also, at the present time, no accurate flow data has [sic] been compiled for the bilaminar and bidirectional flow which is characteristic of the Onondaga Lake Outlet. The Seneca River flows to date are also not in a readily usable form.

One problem inherent to the use of the above approach is the problem of sodium cation discharges in the form other than sodium chloride (Na_2SO_4, $NaCH_3COO$, etc.). This is not generally encountered and may account for less than a 5-10% variation in the derived values.

Calculation of Allied's Effluent Cl/Na Ratio

Cl from $CaCl_2$ = 758,000 (71/111) = 485,000
Cl from NaCq [sic] = 401,000 (35.5/58.5) = 243,000
Na from NaCl = 401,000 (23/58.5) = 158,000
(Cl/Na) Ratio = 4.61

Calculation of Allied's Contribution to Onondaga Lake

(4.61)X + 1.6 (1-X) = 3.04
3.45 x = 1.88
x - 54.5

Calculation of Onondaga Lake's Contribution to the Seneca River

(3.04)y + 1.65 (1-y) = 2.26
1.39 y = .61
6 = 43.2%

The 1972 tributary discharge data and the lake monitoring data were also used to assess the impact of the Allied Chemical discharge on Onondaga Lake. Table C-2 contains the various loadings of chlorides, calcium and sodium used in the analysis along with the appropriate flows.

The total point source contribution of chlorides to the lake amounts to approximately 21.3×10^8 lbs/year. Of this Allied Chemical contributes approximately 18.8×10^8 lbs/year with point sources other than Allied accounting for 1.5×10^8 lbs/year. The lake occupies a volume of approximately 36×10^3 million gallons (MG) and has an average chloride concentration of 1750 mg/l. The lake thus holds approximately 5.2×10^8 lbs of chlorides. The total average tributary flow to Onondaga Lake in 1972 was measured to be approximately 600 MGD representing a lake residence time of 60 days. Assuming steady state conditions the 6.08 lake volumes flushed in 1972 represents [sic] 31.6×10^8 lbs of chlorides per year. Subtracting from this the 21.3×10^8 lbs of chlorides discharged from point sources results in a calculated non-point source contribution of 10.3×10^8 lbs/year. Based on the 1972 measured values Allied has been determined to contributed 59.5% of the total chloride loading (point and non-point sources).

TABLE C-2

MAJOR SOURCES OF TOTAL DISSOLVED SOLIDS

Tributary	Chlorides		Calcium		Sodium		Average Flow	
	kg/day	lb/day	kg/day	lb/day	kg/day	lb/day	cu m/day	mgd
Onondaga Creek	86,797	191,184	55,671	122,625	77,303	170,272	518,000	137.0
Ley Creek	56,714	124,921	51,364	113,137	59,730	131,565	522,000	138.0
Nine Mile Creek	2,251,990	4,960,332	874,369	1,925,925	709,788	1,563,410	848,000	224.0
Harbor Brook	8,826	19,442	15,067	33,189	10,367	22,836	92,000	24.3
MSSTP	125,766	277,018	36,339	80,044	84,868	186,936	254,000	67.0
Steel Mill	2,826	6,225	766	1,688	2,000	4,405	25,000	6.5
East Flume	123,697	272,461	15,190	33,459	49,861	109,827	303,000	80.0

Source: O'Brien & Gere, 1972.

By two methods, Allied's contribution of chlorides to Onondaga Lake has been calculated to be 50.5% and 59.5% respectively in 1972. Within the confidence of both approaches, one may conclude that under present conditions, Allied Chemical contributes slightly over half of the chlorides currently observed in Onondaga Lake. Questions may rightly be directed to the source of the other 40.5% to 45.5% of the total chlorides in Onondaga Lake. Viewing figures C-1 and C-2, one may conclude that there should be a residual chloride level of 800-900 mg/l if extrapolated in 1883, a period prior to the initiation of Allied's operation. (O'Brien & Gere, 1973a).

The U. S. Environmental Protection Agency (Rooney, written communication, 1973) in its evaluation of the chlorides concluded that the instream chloride level due to discharges from Allied Chemical Corporation was 61.0 percent of the total chloride concentration of Onondaga Lake. The calculations are as follows:

Chloride Analysis of Onondaga Lake

Average Lake Conditions[2/]

average inflow = 278 mgd

total detention time = 159 days

epilimnion detention time = 102 days

total lake volume = 37.08×10^9 gallons

Chloride Conditions[2/]

total chloride load to lake = 3,232,736 lb/day

chloride load from Allied = 2,282,520 lb/day

chloride load from all natural tributaries to lake exluding Nine Mile Creek = 537,382 lb/day

2/ All data were taken from the 1971 Onondaga Lake Study (Onondaga County, 1971).

Chloride Analysis[2/]

average chloride levels in the lake:

epilimnion = 1404 mg/l

hypolimnion = 1950 mg/l

epilimnion volume $= \frac{102}{159} (37.08 \times 10^9)$

$= 23.2 \times 10^9$ gallons

hypolimnion volume $= (37.08 - 23.20) \times 10^9$

$= 13.88 \times 10^9$ gallons

true chloride average (summer 1969)

$$Cl = \frac{\text{vol. (epi.)} \times \text{Cl conc.} + \text{vol. (hypo.)} \times \text{Cl conc.}}{\text{vol. (epi.)} + \text{vol. (hypo.)}}$$

$$= \frac{(23.2\,[1404] + 13.88\,[1950])\,10^9}{37.08 \times 10^9}$$

$= 1610$ mg/l

The true chloride average in the lake is therefore 1610 mg/l

Instream chloride level attributable to all known sources

$$C_e^{3/} = \frac{3{,}232{,}736}{278\ (8.34)^{4/}} = 1390 \text{ mg/l}$$

2/ All data were taken from the 1971 Onondaga Lake Study (Onondaga County, 1971).

3/ C_e = equilibrium concentration of chloride.

4/ 8.34 = conversion factor from lb/day to mg/l

Assume the differential (1610 - 1390) of 220 mg/l is from unknown or unquantified sources such as sediment diffusion, geologic formation(s), road salt runoff, etc.

Instream chloride level due to Allied discharges

$$C_e = \frac{2,282,520}{278\ (8.34)} = 980\ \text{mg/l}$$

Therefore, if Allied discharges were removed from the lake, the instream chloride levels would be on the order of (1610 - 980) 630 mg/l, which is the probable average ambient level in the lake.

APPENDIX D

CALCIUM CARBONATE PRECIPITATION

One of the Onondaga Lake drainage basin's major water quality problems is the formation of a visible calcium carbonate ($CaCO_3$) precipitate in Geddes Brook and Nine Mile Creek. The precipitate is formed by the reaction of the calcium hydroxide ($Ca(OH)_2$, also called hydrated lime or slaked lime) that is present in the Allied Chemical Corporation's settling lagoon overflow with the carbonate (CO_3^{-2}) alkalinity that is naturally present in the receiving waters. Under the proposed project, the discharge of Allied's settling lagoon overflow into Geddes Brook will be terminated. The overflow will be transferred to the advanced waste treatment (AWT) units of the Metropolitan Syracuse sewage treatment plant (MSSTP).

In the AWT units, large amounts of $CaCO_3$ will be precipitated as the Ca^{2+} in Allied's settling lagoon overflow reacts with the available CO_3^{2-} alkalinity in the MSSTP wastewater flow. The reaction will take place at relatively high pH values (10.0 to 10.5) because of the $Ca(OH)_2$ in the settling lagoon overflow. Theoretically, $CaCO_3$ precipitation could also occur at the outfall when the MSSTP effluent, containing high Ca^{2+} concentrations, mixes with the waters of Onondaga Lake, naturally containing CO_3^{2-} alkalinity. However, the reaction would be limited by the relatively low pH (7.5 to 9.0) of the mixutre.

Both theoretical chemistry and empirical analyses suggest that there will be $CaCO_3$ precipitation at the plant outfall. The precipitation reaction is very complex and its behavior is difficult to accurately predict (see pp.156 to 163). Nevertheless, a simplified theoretical analysis can be performed. Empirically, the $CaCO_3$ precipitation reaction that now occurs in the Geddes Brook - Nine Mile Creek system can be compared to the precipitation reaction that is expected to occur in the AWT units of the MSSTP and at the outfall in Onondaga Lake.

THEORETICAL CHEMISTRY

A theoretical analysis of the AWT units of the MSSTP indicates that there will be 1) high Ca^{2+} concentrations, 2) relatively high CO_3^{2-} concentrations, and 3) substantial $CaCO_3$ precipitation. The high CO_3^{2-} concentrations will be attributable to the high pH caused by the presence of $Ca(OH)_2$. A theoretical analysis of the MSSTP discharge plume in Onondaga Lake indicates that there will be 1) high Ca^{2+} concentrations, 2) relatively low CO_3^{2-} concentrations, and 3) limited $CaCO_3$ precipitation. Both of these theoretical analyses are based on the comparison of the solubility-product constant (K_{sp}) of the $CaCO_3$ precipitation reaction with the molar concentrations of Ca^{2+} and CO_3^{2-} present in solution. Using the reaction

$A^+ + B^- \rightleftharpoons AB\downarrow$, Sawyer and McCarty (1967) note:

> There are two corollary statements related to the solubility-product principle, an understanding of which is basic to explaining the phenomena of precipitation and solution of precipitates. They may be expressed as follows:
>
> 1. In an unsaturated solution, the product of the molar concentration of the ions is less than the solubility-product constant, or $[A^+][B^-] < K_{sp}$.
> 2. In a supersaturated solution, the product of the molar concentration of the ions is greater than the solubility-product constant, or $[A^+][B^-] > K_{sp}$. In the former case, if undissolved AB is present, it will dissolve to the extent that $[A^+][B^-] = K_{sp}$, and a saturated solution results. In the the second case, nothing will happen until such time as crystals of AB are introduced into the solution or internal forces allow formation of crystal nuclei; then precipitation will occur until the ionic concentrations are reduced equal to those of a saturated solution.

A comparison of the concentrations of reactants actually present with the concentrations in a saturated solution gives some indication of the potential for precipitation. A small K_{sp} value indicates that the precipitate is relatively insoluble.

MSSTP AWT UNITS

The $CaCO_3$ precipitation reaction can be expressed as follows:

$$Ca^{2+} + CO_3^{2-} \rightleftharpoons CaCO_3\downarrow$$

As shown by Sawyer and McCarty (1967), if the product of the molar concentrations of Ca^{2+} and CO_3^{2-} is greater than the solubility-product constant (K_{sp}) of the $CaCO_3$ precipitation reaction, a supersaturated solution exists and precipitation is likely. In order to determine the likelihood of precipitation in the AWT units of the MSSTP, the molar concentrations of Ca^{2+} and CO_3^{2-} must be calculated.

The CO_3^{2-} concentration of any solution is directly related to the alkalinity and pH of that solution. If the solution's alkalinity and pH are known, the CO_3^{2-} concentration can be calculated according to the following equation:

$$CO_3^{2-}\ (mg/l) = \left[\frac{3.37 \times 10^{-6}}{[H^+]}\right] \left[\frac{\frac{Alk.}{50{,}000} + [H^+] \quad \frac{10^{-14}}{[H^+]}}{1 + \frac{11.22 \times 10^{-11}}{[H^+]}}\right]$$

This equation was derived from Sawyer and McCarty (1967) by Stamberg (written communication, 1973), using the value 5.61 x 10^{-11} as the solubility-product constant for the bicarbonate-carbonate conversion reaction. The pH of the AWT mixture is expected to range from 7 to 11 and the alkalinity from 100 to 200 mg/l (as $CaCO_3$). Once the CO_3^{2-} concentration is known, the Ca^{2+} saturation concentration can be calculated according to the following equation:

$$[Ca^{2+}] = \frac{K_{sp}}{[CO_3^{2-}]}$$

Using a K_{sp} of 4.7×10^{-9}, the Ca^{2+} saturation concentration was estimated for different alkalinity and pH conditions expected in the AWT units (see Table D-1). When the calcium levels exceed the saturation concentrations, precipitation of $CaCO_3$ can be expected.

The calcium concentration in the AWT units will exceed the saturation concentrations. At design flow, approximately 25,000 cu m/day (6.5 mgd) of Allied's settling lagoon overflow will mix with 300,000 cu m/day (80 mgd) of MSSTP secondary effluent in the AWT units. The Ca^{2+} concentration of the Allied flow will be approximately 20,000 mg/l. Excluding the slight amount of Ca^{2+} contained in the MSSTP secondary flow, the Ca^{2+} concentration of the AWT mixture will be approximately 1500 mg/l. O'Brien & Gere (1973b) estimate that the calcium concentration in the AWT units will range from 1250 to 3550 mg/l depending on flow conditions. Some of the calcium will be removed by precipitation reactions, slightly reducing the Ca^{2+} concentration of the MSSTP effluent.

The quantities of Ca^{2+} that will be removed can be estimated by reviewing the various precipitation reactions that will take place in the AWT units. One of the major reactions expected in the AWT units is the precipitation of calcium phosphate as hydroxyapatite ($Ca_5OH(PO_4)_3$):

$$5Ca^{2+} + 3PO_4^{3-} + OH^- \rightleftharpoons Ca_5OH(PO_4)_3 \downarrow$$

TABLE D-1

THEORETICAL CALCIUM SATURATION CONCENTRATIONS

Alkalinity (mg/l as $CaCO_3$)	Calcium Saturation Concentration At Ksp = 4.7×10^{-9} (mg/l)				
	pH=7	pH=8	pH=9	pH=10	pH=11
100	168	18	2	0.4	0.4
200	84	9	1	0.2	0.14

The amount of precipitate formed by this reaction will depend on the amount of phosphorus available in the AWT mixture. The MSSTP secondary effluent is assumed to contain a maximum phosphorus concentration of 4 mg/l as P (see Table 29). Phosphorus was not detected in Allied's settling lagoon overflow (see Table 27). Therefore, the maximum concentration of phosphorus in the AWT mixture will be 3.7 mg/l as P. This is equivalent to 1.2×10^{-4} moles/l as P. In the precipitation reaction, 5 moles of calcium will combine with 3 moles of phosphorus to form the calcium phosphate precipitate. Thus, the quantity of calcium that can combine with phosphorus in this reaction is $5/3 \times 1.2 \times 10^{-4}$, or 2.0×10^{-4} moles/l. This is equivalent to 8.0 mg/l of calcium. Thus, the maximum reduction in calcium concentration that can be effected by this precipitation reaction will be approximately 8.0 mg/l.

Another major reaction expected in the AWT units is the precipitation of $CaCO_3$. The quantity of $CaCO_3$ precipitate formed by this reaction will mainly depend on the pH of the AWT mixture. O'Brien & Gere (1973b) initially calculated that the Ca^{2+} concentration in the AWT units would be reduced by less than 1 percent, or approximately 2.0 mg/l. This calculation was based on a pH of 8.5 and an alkalinity of 215 mg/l (as $CaCO_3$). However, O'Brien & Gere (1974) revised this calculation subsequent to the publication of the draft environmental impact statement on the proposed projects. Both the NYSDEC (Pedersen, written communication, 1974) and the EPA agree with O'Brien & Gere's revised calculation. According to O'Brien & Gere (1974):

> The previously utilized tertiary clarifier pH of 8.5 to calculate the quantity of $CaCO_3$ precipitated within the tertiary units is to some degree not very realistic. This pH really reflects the status of the system after the reaction

has occurred and the alkalinity utilized. The pH of Allied's waste is generally 12.0 while Metro approaches 7.5. Upon mixing, the pH at the interface of both streams at the initiation of the $CaCO_3$ precipitation may be at a pH in the vicinity of 10.0.

The pH of the AWT mixture will greatly influence the $CaCO_3$ precipitation reaction. Both Ca^{2+} and CO_3^{2-} are needed for the $CaCO_3$ precipitation reaction. Since Ca^{2+} will be present in great quantity, the limiting factor will be the available quantity of CO_3^{2-} in the AWT clarifiers. As the pH increases, CO_3^{2-} concentrations increase exponentially. For instance, at a pH of 8.3, only about 1 percent of the alkalinity will be in the form of CO_3^{2-}; at a pH of 10.5, approximately 60 percent of the alkalinity will be in the form of CO_3^{2-}. The alkalinity form is especially important because only the carbonate form (CO_3^{2-}) of alkalinity will combine with Ca^{2+} to form $CaCO_3$.

According to O'Brien & Gere's (1974) calculations, if the AWT mixture has a pH of 10.0 and an alkalinity value of 215 mg/l, the CO_3^{2-} concentration will be approximately 1.1×10^{-3} moles/l. The quantity of $CaCO_3$ precipitate formed under these conditions is calculated as follows:

Revised Calculations of $CaCO_3$ Precipitation in the Tertiary (AWT) Clarifiers of the Proposed MSSTP

	Minimum	Maximum
Theoretical Characteristics of the Combined Tertiary Effluent	Ca=1250 mg/l Cl=2000 mg/l	3550 mg/l 6300 mg/l
$[Ca^{2+}]$ moles/l	31×10^{-3}	
$[CO_3^{2-}]$ moles/l Based on pH of 10.0 and alkalinity of 215 mg/l	1.1×10^{-3}	
$[Ca^{2+}]\ [CO_3^{2-}]$	34.1×10^{-6}	
K_{sp} of $CaCO_3$	4.7×10^{-9}	

Precipitation is expected because the product of the molar concentrations of Ca^{2+} and CO_3^{2-} is greater than the K_{sp} of the $CaCO_3$ precipitation reaction. The quantity of $CaCO_3$ precipitated will be limited by the quantity of CO_3^{2-} available in the AWT clarifiers. Since one mole of $CaCO_3$ will be formed for every mole of CO_3^{2-} used, and since 1.1×10^{-3} moles/l of CO_3^{2-} are readily available, approximately 1.1×10^{-3} moles/l of $CaCO_3$ will be formed. This is equivalent to 110 mg/l of $CaCO_3$.

Moles/liter of $CaCO_3$ that must precipitate to reach equilibrium	1.1×10^{-3}
kg/day (lb/day) of $CaCO_3$ precipitate expected in the MSSTP at 327,000 cu m/day (86.5 mgd)	36,000 (79,300)

The conclusion that approximately 36,000 kg/day (79,300 lb/day) of $CaCO_3$ will be precipitated in the AWT units is substantiated by the NYSDEC (Pedersen, written communication, 1974). The calculations made by the NYSDEC indicate that 35,600 kg/day (78,400 lb/day) of $CaCO_3$ will be precipitated.

In the $CaCO_3$ precipitation reaction, 1.1×10^{-3} moles/l of Ca^{2+} will be consumed. This is equivalent to 44 mg/l of Ca^{2+}. As discussed on page D-6, approximately 8 mg/l of Ca^{2+} will be precipitated as hydroxyapatite. Therefore, the total Ca^{2+} reduction will be 52 mg/l, or approximately 4 percent of the minimum Ca^{2+} concentration (1250 mg/l) or 1.5 percent of the maximum Ca^{2+} concentration (3550 mg/l).

In conclusion, the average Ca^{2+} concentration of the MSSTP effluent will be high. Depending upon the quality and the quantity of the Allied settling lagoon overflow, the Ca^{2+} concentration in the MSSTP effluent will range from 1200 mg/l to 3500 mg/l. Substantial quantities of $CaCO_3$, approximately 36,000 kg/day (79,300 lb/day), are expected to precipitate in the AWT units.

MSSTP Discharge Plume

When the MSSTP effluent is discharged into Onondaga Lake, it will begin to mix with the lake waters. The effluent is expected to have a high Ca^{2+} concentration and to have essentially no free CO_3^{2-}. The Ca^{2+} in the effluent is expected to combine with the CO_3^{2-} naturally existing in the waters of Onondaga Lake, forming $CaCO_3$. The amount of CO_3^{2-} naturally present in the lake waters will depend on the pH of the lake waters.

The applicant's calculations for $CaCO_3$ precipitation in the MSSTP discharge plume that were presented in the draft environmental impact statement for the proposed projects assumed a lake pH of 8.3 and an alkalinity value of 170 mg/l (as $CaCO_3$). These calculations indicated that approximately 1.1 mg/l of $CaCO_3$ would be precipitated in the epilimnetic waters of Onondaga Lake. The applicant revised its calculations, assuming a pH of 8.5 and an alkalinity value of 215 mg/l (O'Brien & Gere, 1974). Under these conditions, approximately 3.4 mg/l of $CaCO_3$ would be precipitated in the discharge plume. In neither case would the quantity of $CaCO_3$ formed be expected to cause a visible discharge plume.

The applicant's calculations do not take into account two factors which could radically increase the amount of $CaCO_3$ precipitated. As discussed on pages D-6-D-8 , the $CaCO_3$ precipitation reaction is largely pH dependent. High pH conditions (in the 9.0 to 9.5 range) naturally occur in Onondaga Lake during the summer months when algal activity is high. In addition, there is the possibility of an operational upset at the MSSTP. As discussed previously, lime ($Ca(OH)_2$) will be added to the AWT mixture if the lime content of Allied's settling lagoon overflow is insufficient to effect adequate phosphorus removal. Operational upsets could result in high pH values for both the MSSTP effluent and the MSSTP discharge plume. High pH values would substantially increase the quantity of $CaCO_3$ formed in the discharge plume. The $CaCO_3$ concentrations that would result at different MSSTP effluent and lake pH values are summarized in Figure D-1.

The following calculation is based on information provided by the NYSDEC (Pedersen, written communication, 1974). It was used to determine the discharge plume $CaCO_3$ concentrations shown in Figure D-1:

<u>Sample Calculation of $CaCO_3$ Precipitation in the Discharge Plume of the Proposed MSSTP</u>

Assume pH of lake epilimnion = 9.0; $(H^+) = 1.0 \times 10^{-9}$ moles/l
Assume pH of MSSTP effluent = 8.0; $(H^+) = 1.0 \times 10^{-8}$ moles/l
Assume 1:1 dilution of MSSTP effluent in Onondaga Lake
Assume Onondaga Lake alkalinity = 205 mg/l (as $CaCO_3$)
Assume minimum calcium concentration in discharge plume = 860 mg/l = 2.15×10^{-2} moles/l

$$
\begin{aligned}
(H^+) \text{ in discharge plume} &= 1/2(1.0 \times 10^{-9}) + 1/2(1.0 \times 10^{-8}) \\
&= 0.5 \times 10^{-9} + 0.5 \times 10^{-8} \\
&= 5.5 \times 10^{-9} = 10^{0.74} \times 10^{-9} = 10^{-8.26}
\end{aligned}
$$

Average pH in discharge plume = 8.26

Since $HCO_3^- \rightleftharpoons CO_3^{2-} + H^+$; $K_e = 5.61 \times 10^{-11}$

$$\frac{(CO_3^{2-})(H^+)}{(HCO_3^-)} = 5.61 \times 10^{-11}$$

At pH = 8.26, $[H^+] = 5.5 \times 10^{-9}$ moles/l

So
$$\frac{(CO_3^{2-})}{(HCO_3^-)} = \frac{5.61 \times 10^{-11}}{5.5 \times 10^{-9}} = 1.02 \times 10^{-2}$$

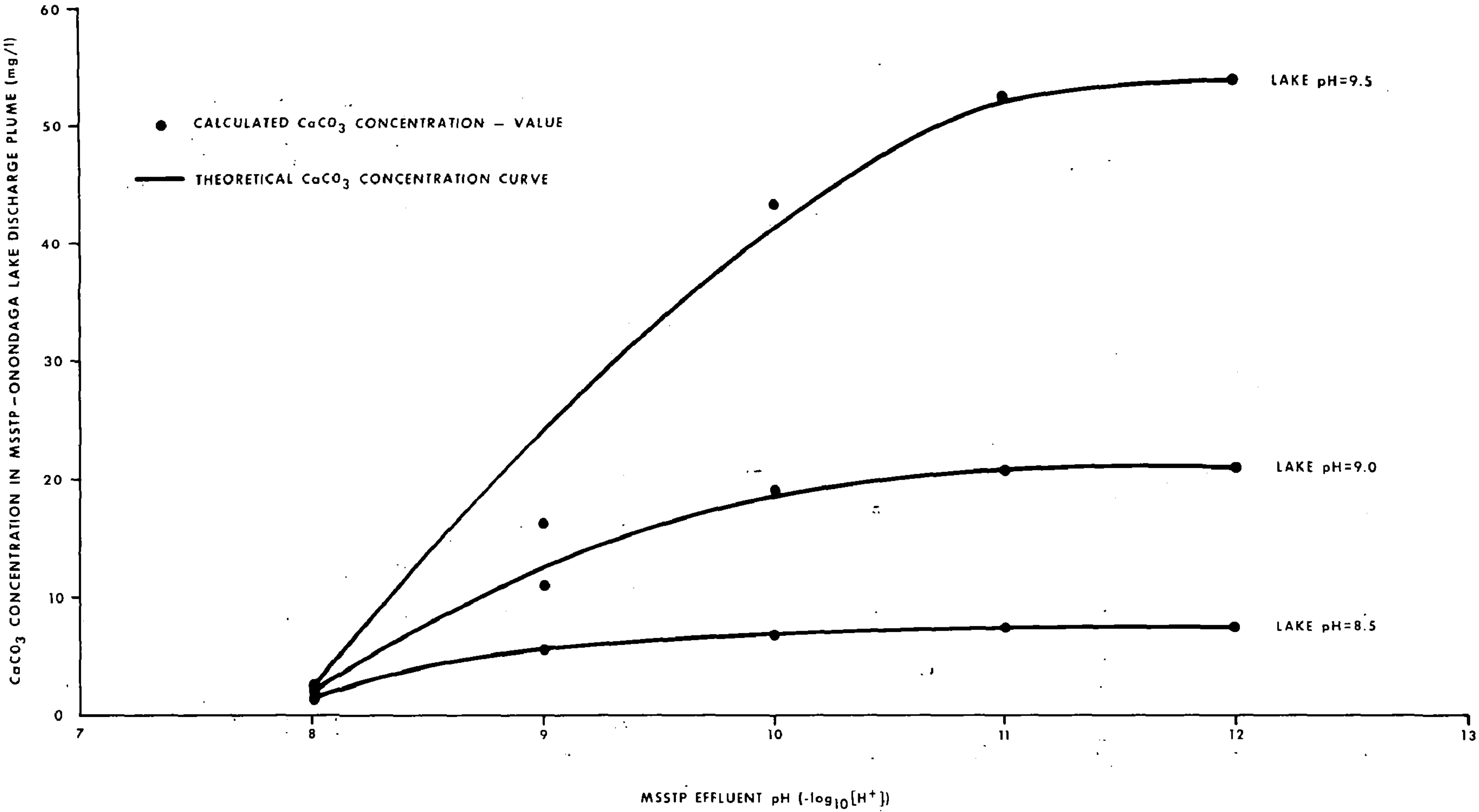


Figure D–1

CALCIUM CARBONATE CONCENTRATION IN PROPOSED MSSTP– ONONDAGA LAKE DISCHARGE PLUME

For alkalinity = 205 mg/l (as $CaCO_3$), $(CO_3^{2-}) + (HCO_3^-) = (205)(60/100) =$ 123 mg/l

Solving simultaneously,

$$CO_3^{2-} = (1.02 \times 10^{-2})(123 - CO_3^{2-})$$

or $$CO_3^{2-} = \frac{(1.02 \times 10^{-2})(123)}{(1 + 1.02 \times 10^{-2})} = 1.24 \text{ mg/l} = 2.1 \times 10^{-5} \text{ mole/l}$$

Converting to $CaCO_3$: 1.24 mg/l (100/60) = 2.07 mg/l of $CaCO_3$

The calculation assumes a 1:1 dilution of MSSTP effluent in Onondaga Lake. The 1:1 dilution is expected in the immediate vicinity of the proposed MSSTP surface outfall; greater dilution will occur farther out in the lake. Precipitation of $CaCO_3$ is expected at this dilution because the product of the molar concentrations of Ca^{2+} and CO_3^{2-} ($2.15 \times 10^{-2} \times 2.1 \times 10^{-5} = 4.5 \times 10^{-7}$) is greater than the K_{sp} of the $CaCO_3$ precipitation reaction (4.7×10^{-9}).

As shown in Figure D-1, substantial $CaCO_3$ precipitation will occur in Onondaga Lake when the pH of the lake water is in the range of 9.0 to 9.5 and the pH of the MSSTP effluent is above 9.0. In order to minimize $CaCO_3$ precipitation in the discharge plume and to insure that the discharge plume will not be visible, the pH of the MSSTP effluent should not exceed 9.0. The applicant has agreed to provide adequate controls to fulfill this requirement:

> Owing to the possibility of upsets in the system, it is agreed that provision will be made to maintain an average effluent pH of 8.5 to 9 via the addition of acid. Although this high pH condition would be an occasional occurrence, the use of tank car volumes of either H_2SO_4 or HCl to effect pH reduction to acceptable levels would be the most economical approach. The capital expenditure required would be $10,000. Based on one tank car per year, the annual chemical costs would be in the order of $2,400. (O'Brien & Gere, 1974).

As noted by O'Brien & Gere (1974), the MSSTP effluent's pH is expected to be normally less than 9.0. Therefore, acid control of the MSSTP effluent pH will be an emergency procedure only. Under normal circumstances, both the MSSTP effluent and Onondaga Lake should have pH values of less than 9.0. The pH of the effluent will be monitored by two sensors in the effluent/outfall line. One of these pH sensors will be used to control acid feed into the MSSTP effluent. This system will assure maintenance of the MSSTP effluent pH at or below 9.0.

EMPIRICAL ANALYSES

As discussed in the text, a visible calcium carbonate precipitate now occurs in Geddes Brook and Nine Mile Creek, the receiving waters of Allied Chemical Corporation's settling lagoon overflow. In 1972, the average flow in Nine Mile Creek was 850,000 cu m/day (224 mgd). Thus, for an average settling lagoon overflow rate of 25,000 cu m/day (6.5 mgd), the creek provided a dilution ratio of approximately 34:1.

The NYSDEC calculated that a minimum of 70 mg/l of $CaCO_3$ precipitate is currently formed in the Geddes Brook - Nine Mile Creek system (Pedersen, written communication, 1974). This concentration results in a visible discharge plume. The occurrence of this plume was analyzed by the NYSDEC:

> From the data contained in Table 12, on page 33 [of the draft environmental impact statement], it is possible to make a calculation of the calcium carbonate precipitation that is currently occurring in the Geddes Brook - Nine Mile Creek system.
>
> Since the Geddes Brook - Nine Mile Creek system provides about 34:1 dilution of the waste bed overflow and, since the pH of the overflow is 11.5, the pH, after complete mixing, would be approximately 10.0. Next, it is necessary to assume a figure for the alkalinity of Nine Mile Creek - Geddes Brook prior to the introduction of the waste bed overflow. This can be done, since the data

on the three other tributaries of Onondaga Lake, presented in Table 12, offer a suggested range of 200-225 mg/l and since it is possible to back-check the assumption after completing the calculations. Without presenting the trial and error solution, suffice to say that the figure ultimately arrived at is 205 mg/l of alkalinity. At the pH conditions specified, about 42 mg/l of the alkalinity will be present as free carbonate, which is virtually all precipitated, due to the low solubility product constant for calcium carbonate. Converting the free carbonate figure to calcium carbonate yields 70.0 mg/l of calcium carbonate, formed in the Geddes Brook - Nine Mile Creek system.

The figure of 70.0 mg/l is based on average flow conditions in the Geddes Brook - Nine Mile Creek system. Under low flow conditions, similar calculations show that the calcium carbonate concentration would be on the order of 200 mg/l. Consequently, the concentrations of calcium carbonate precipitated in the Geddes Brook - Nine Mile Creek system are greater by approximately two orders of magnitude and the potential concentration that might be generated where the municipal treatment plant effluent enters Onondaga Lake is almost negligible by comparison.

Furthermore, this calculation is conservative in that the figure of 70.0 mg/l is actually a minimum figure. The simplifying assumptions which indicate why this figure is a minimum are as follows:

1. It is assumed that the 42 mg/l of free carbonate initially produced at the calculated mix-point pH are used up without being regenerated.

2. It is assumed that no further reaction takes place in Nine Mile Creek and that the 135.6 mg/l of alkalinity, shown in Table 12, persists to the point of discharge into Onondaga Lake.

3. Complete mixing is assumed in the Geddes Brook - Nine Mile Creek system.

4. It is believed that the waste bed overflow is a much stronger lime solution then pH measurements indicate. The waste bed overflow is reported to contain about 550 mg/l of lime. In the absence of common ion effects, due to the presence of high concentrations of calcium chloride, the pH of such a lime solution would be 12.1. The excess calcium ions, however, drive the dissociation reaction of lime backwards so that the free hydroxide present, upon which the pH depends, is significantly reduced. Nevertheless, in terms of lime content, the waste bed overflow is equivalent to a lime solution having a pH of 12.1. Taking this equivalence into account we find that the concentration of calcium carbonate, precipitated in the Geddes Brook - Nine Mile Creek system, under average flow conditions, might actually be as high as 110 mg/l. (Pedersen, written communication, 1974).

The dilution provided in the Geddes Brook - Nine Mile Creek system (34:1) is nearly the same as that which will be provided in the proposed MSSTP - Onondaga Lake system (40:1). The pH and alkalinity characteristics of the Geddes Brook - Nine Mile Creek system are essentially the same as those of Onondaga Lake. The major differences between the two systems will be the lime content and the pH of the flows discharged into them. At present, visible $CaCO_3$ precipitation occurs in the Geddes Brook - Nine Mile Creek system because of the relatively high lime content and consequent high pH of Allied's settling lagoon overflow. In the proposed MSSTP - Onondaga Lake system, limited quantities of $CaCO_3$ will be precipitated in the lake because of the relatively low lime content and consequent low pH of the MSSTP discharge plume.

The applicant performed a series of jar tests to determine whether the quantity of $CaCO_3$ that is likely to precipitate when the MSSTP effluent mixes with the waters of Onondaga Lake will be visible. In the tests, volumes of Allied's settling lagoon overflow were mixed with volumes of effluent from the existing MSSTP at different ratios (1:3, 1:5, 1:7, and 1:10). The overflow-effluent mixtures were then mixed with samples of Onondaga Lake water at a ratio of 1:2. O'Brien & Gere (1974) reported that there was "...no visible $CaCO_3$ formation at any of the volume ratios investigated." This is not unexpected since the reported data indicate that the pH of the effluent-lake water mixture ranged from 7.4 to 8.1. A second series of jar tests was performed in which the pH of the Onondaga Lake water samples was artificially raised by the addition of Na_2CO_3 and/or NaOH. When the lake water reached a pH range of 9.9 to 10.2, significant increases in turbidity were noted. The jar tests performed at an average dilution ratio of 1:2 do not take into account either the dynamics of an operating treatment plant discharging into the lake or the transport phenomenon at the interface of the discharge plume and the lake water in a continuous flow system. They do, however, support the assumption that "...the major factor regulating the formation of $CaCO_3$ and hence to the creation of a visible plume is the availability of sufficient hydroxyl activity at the lake water interface." (O'Brien & Gere, 1974).