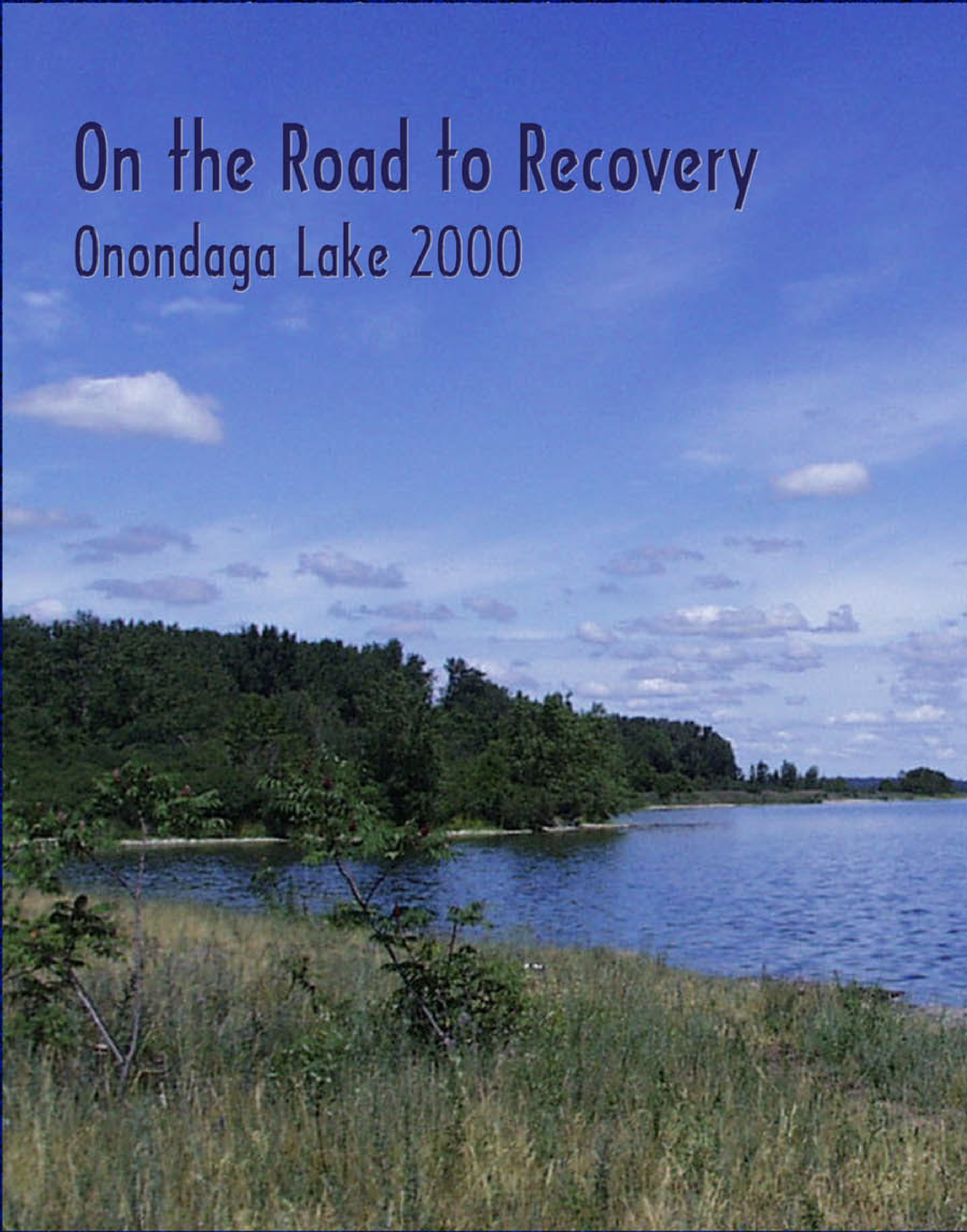
On the Road to Recovery

Onondaga Lake 2000



Onondaga Lake Monitoring Program Executive Summary ▸ 2000 Annual Report

Acknowledgments

The Onondaga County Department of Water Environment Protection (formerly, Onondaga County Department of Drainage and Sanitation) is responsible for implementing the Ambient Monitoring Program. Funds for the Ambient Monitoring Program (AMP) are provided primarily by Onondaga County. The Onondaga Lake Technical Advisory Committee (OLTAC) has been assembled to provide technical assistance to the County. OLTAC members include:

Dr. Raymond Canale (EnginComp Software, Inc.): modeling, Seneca River

Dr. Charles Driscoll (Syracuse University): water and sediment chemistry, mercury

Dr. Edward Mills (Cornell University): food web, phytoplankton and zooplankton

Dr. Elizabeth Moran (EcoLogic, LLC): monitoring program, limnology

Dr. Lars Rudstam (Cornell University): food web, fish community

Dr. Kenton Stewart (SUNY Buffalo): physical limnology

Dr. William Walker, Jr. (Environmental Engineer): statistical design, mass-balance modeling

In addition, many agencies provide oversight and technical assistance to the County, as listed below:

- New York State Department of Environmental Conservation
- United States Environmental Protection Agency
- New York State Attorney General, Environmental Protection Bureau
- United States Army Corps of Engineers and the Onondaga Lake Partnership
- Atlantic States Legal Foundation

Joseph J. Mastriano of Onondaga County Department of Water Environment Protection administers the AMP. Jeanne C. Powers oversees program implementation. Mr. Mastriano and Ms. Powers are supported by Nicholas Capozza (field program leader and biological program oversight), Michael Gena (director of Onondaga County's state-certified Environmental Laboratory), Janaki Suryadevara (water quality program oversight) and Antonio Deskins (data compilation, calculations, and plotting).

EcoLogic LLC, Quantitative Environmental Analysis (QEA) LLC, Dr. William Walker, Dr. Edward Mills, and Ichthyological Associates Inc., prepared chapters of the 2000 Annual Report. The Executive Summary was prepared by EcoLogic LLC with design and layout by Nichols Graphic Design of Lakeville, NY.

April 2002

The Onondaga County Department of Water Environment Protection is responsible for collecting and treating wastewater from homes and businesses throughout the County. As Commissioner, I am proud to lead our talented and dedicated staff under a name reflecting our strong commitment to protecting the water resources we all share.

The Department performs an intensive survey of water quality conditions in the Onondaga Lake watershed each year. This publication is a summary of the findings of the 2000 Onondaga Lake Ambient Monitoring Program, the 31st year of County monitoring of the lake and adjacent waters. Current conditions and trends in water quality and the lake's biological community are highlighted in this summary document. A complete report of the 2000 monitoring effort is available from the Department upon request.

Onondaga County is required by State and Federal regulations to monitor the lake and its tributary streams. The January 1998 Amended Consent Judgment (ACJ) required the development of an ambient monitoring program to measure water quality conditions and assess progress towards compliance with state and federal standards.

Employees of the Department sample Onondaga Lake, major streams flowing to the Lake, and the Seneca River. Water samples are analyzed in the County's state-certified environmental laboratory and results are used to calculate the input of sediment, chemicals, and bacteria to the lake. Results of the monitoring program are used to track how Onondaga Lake and the Seneca-Oneida-Oswego River system respond to pollution abatement activities. The data are also compared with applicable water quality standards developed to protect the aquatic ecosystem and ensure that the waters are safe for recreational uses.

In 1998, the County's annual monitoring program was redesigned to focus specifically on the water quality and ecological improvements brought about by the required improvements to the Syracuse Metropolitan Wastewater Treatment Plant (Metro) and Combined Sewer Overflows (CSOs) that are underway. Results of the monitoring program will help the New York State Department of Environmental Conservation (NYSDEC) and the federal Environmental Protection Agency (EPA) determine whether further actions are needed to meet community goals and standards.

Comments on this report are encouraged and may be directed to Joseph J. Mastriano, Operations Manager, at 315-435-2260.

Very truly yours,

Richard L. Elander, P.E.
Commissioner

Objectives Of The Ambient Monitoring Program

The main objective of the County's monitoring effort is to provide data and information needed to manage Onondaga Lake. A number of specific objectives are incorporated into the design of the lake, tributaries, and river components of the Ambient Monitoring Program (AMP).

The tributary monitoring program is designed to quantify the flow of water, chemicals, sediment, and microorganisms into Onondaga Lake. Accurate estimates are a critical component of the AMP since they underlie many of the management decisions facing Onondaga County.

- First, these estimates are needed to understand the relationships between pollutants entering the lake and the resulting water quality conditions. The New York State Department of Environmental Conservation (NYSDEC) and others will use these relationships to set an acceptable level of treatment for the Metropolitan Wastewater Treatment Plant (Metro) and the Combined Sewer Overflows (CSOs). CSOs discharge a mix of raw wastewater and storm water when flows exceed the capacity of the sewer system.
- Second, the tributary monitoring efforts can provide a basis for estimating the relative importance of point and nonpoint sources of phosphorus. Understanding the role of the watershed in contributing phosphorus to the lake will help clarify the need for additional treatment or relocation of the Metro effluent to meet community water quality and aesthetic goals for the lake.

Collecting stream samples during rainstorms and snowmelt is an important component of the tributary monitoring program. Monitoring has documented that most of the pollutants enter the lake during these infrequent high flow periods. Although challenging for the field and laboratory staff, the storm-event monitoring program is collecting valuable data to assess the effectiveness of the CSO remediation program. Storm event monitoring is designed around the construction schedule for the major CSO facilities that will collect and treat overflows on Onondaga Creek, Harbor Brook, and Ley Creek. Storm event monitoring on Nine Mile Creek will help managers understand the effects of urban stormwater (without CSOs) on stream quality.

Because physical features affect the distribution and abundance of life in streams, the County is evaluating habitat as well as water quality conditions in the Onondaga Lake watershed. Surveys of physical characteristics of the streams are underway along with periodic sampling of the macroinvertebrate community. As in all components of the AMP, Onondaga County is committed to evaluating the data as they are received. Sufficient flexibility is incorporated to re-allocate sampling and analytical resources as new information becomes available.

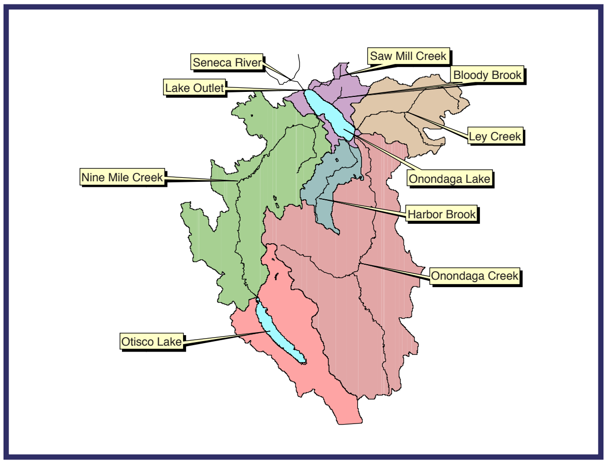
The lake components of the AMP are designed to measure the effectiveness of controls on Metro and the CSOs. Data are used to assess compliance with water quality standards and community goals. Experts in statistics have carefully reviewed the monitoring program design to ensure that managers will be able to draw firm conclusions regarding the effectiveness of the control measures.

An important feature of the AMP is the greatly enhanced program of biological monitoring. Monitoring of the macrophyte (rooted aquatic plants and algae) community is underway, along with assessment of other major components of the lake's food web: phytoplankton, zooplankton, and macroinvertebrates. Beginning in 2000, the County monitoring effort includes a comprehensive program to assess the status of the lake's fish community.

Water quality in the Seneca River is relevant to the AMP in two important areas. First, the river and lake are hydrologically connected. Water quality improvements in Onondaga Lake will be realized in the river as well, since the lake outflow affects the river. Second, if the improvements to Metro do not result in improved water quality conditions, future diversion of all or a portion of the Metro effluent to the Seneca River will be evaluated as an alternative. The assessment of this diversion alternative is to be made by February 1, 2009. Quantitative Environmental Analysis, LLC (QEA) is developing a mathematical water quality model of the Seneca River that will be used to help evaluate the environmental feasibility of diverting Metro discharge to the river.

Onondaga Lake and Its Watershed

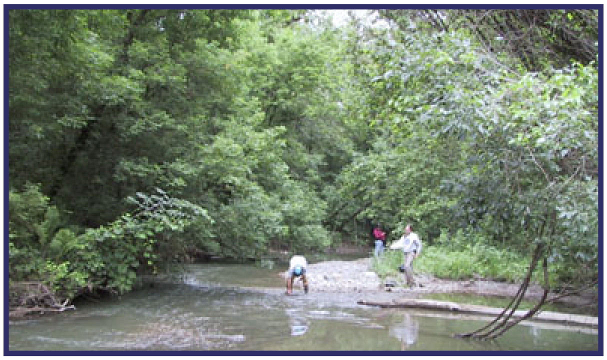
The Onondaga Lake drainage basin encompasses approximately 642 square kilometers (248 square miles) and lies almost entirely in Onondaga County. The drainage basin includes six natural sub-basins: Nine Mile Creek, Harbor Brook, Onondaga Creek, Ley Creek, Bloody Brook, and Saw Mill Creek. The outlet of Onondaga Lake flows north to the Seneca River and ultimately into Lake Ontario.



Land use in the watershed is a mixture of agriculture (32%), forests (43%), and urban areas (22%). Urban areas of Syracuse surround the lake. Sediment and pollutants from the entire drainage basin make their way to the lake.

The Metro wastewater treatment plant is a major source of nitrogen, phosphorus and organic (oxygen-demanding) material to the lake. Metro is an advanced secondary treatment plant, operated to enhance conversion of ammonia to nitrate during warm weather (in a process known as nitrification) and phosphorus removal. The plant is being upgraded to provide year-round nitrification and filtration to further reduce the outflow of ammonia, phosphorus and oxygen-demanding material. To avoid the use of chlorine, which is potentially harmful to aquatic life, ultra-violet (UV) disinfection is planned. This process will kill microorganisms without the use of chlorine. The UV disinfection system will allow Metro to meet NY State mandated chlorine residual limits.

Onondaga County's trained technicians collect water quality and biological samples at a number of key locations in the watershed. Streams flowing into Onondaga Lake are monitored close to the lake to estimate the annual input of water and materials including nutrients, sediment, salts, and bacteria. Samples are collected further upstream to help pinpoint sources of pollution. The lake's outlet to the Seneca River is monitored throughout the year, except when ice-bound. Periodically, the field teams sample over a 20-mile stretch of the Seneca River, upstream and downstream of the lake outlet.



Sampling in Onondaga Creek.

Onondaga Lake is relatively small, especially compared with the nearby Finger Lakes and Oneida Lake. The shoreline is highly regular, with few embayments. More than 75 percent of the shoreline is owned by Onondaga County and is maintained as part of a popular park and trail system. The lakeside park is currently used for recreational hiking, biking, jogging, roller-blading, fishing, and cultural entertainment. The lake is used for secondary water contact recreation such as boating and water skiing.

Fishing was banned in the lake in 1972 due to mercury contamination. The ban was lifted in 1986 and modified into a "catch and release fishery", that is, recreational fishing was permitted but possession of lake fishes was not. In 1999, the New York State Department of Health (NYSDOH) revised its advisory regarding consumption of gamefish from Onondaga Lake. The current recommendation is to eat no walleye from Onondaga Lake and restrict consumption of all other species to no more than one meal per month. The fish advisory continues to be based on mercury levels in fish flesh. As in all New York waters with health advisories, the Health Department advises that women of childbearing age, infants, and children under the age of 15 eat no fish from these waters.

Onondaga Lake Facts

Surface area:	11.7 km^2 (4.5 mi^2)
Average depth:	10.9 m (36 ft)
Maximum depth:	19.5 m (64 ft)
Volume:	131 million cubic meters (34,600 million gallons)
Average water residence time:	4 months
Largest tributaries:	Onondaga Creek and Nine Mile Creek
Fish:	Warmwater community

New York State Department of Environmental Conservation (NYSDEC) is responsible for managing the State's water resources. Lakes and streams are classified according to their designated best use (for example, water supply, swimming, fish propagation, aesthetic enjoyment, and fish survival). Water bodies that do not meet their designated best use are placed on a Priority Waterbodies List (PWL). The most problematic waterbodies are also included on a second list, the 303(d) list. These lakes and streams require a watershed approach to water quality protection or restoration. Onondaga Lake, one of the State's top priorities for water quality restoration, is on both lists.

A watershed approach examines all point and nonpoint sources of pollution and develops an integrated strategy for improvement. Point source discharges to Onondaga Lake include effluent from Metro, treated industrial wastewater from Crucible Specialty Metals, and non-contact cooling water from several industries at the former AlliedSignal complex. Metro receives and treats wastewater from residential, commercial, and industrial sources. Certain industries such as Bristol-Myers Squibb pre-treat their wastewater before directing it to Metro where it mixes with the rest of the inflowing wastewater for treatment and discharge.

Nonpoint sources such as runoff from agricultural and urban areas also contribute contaminants. Nutrients, sediment, bacteria, metals and pesticides reach surface and ground water resources from these diffuse sources. Industrial residuals in the watersheds of individual tributaries, such as Polychlorinated Biphenyls (PCBs) in the Ley Creek basin and the AlliedSignal waste beds in the Nine Mile Creek basin, continue to enter the lake through surface runoff and infiltrating groundwater. Lake sediments contain elevated concentrations of mercury and organic chemicals.

2000 Water Quality Synopsis

Onondaga County monitors several common water quality indicators as part of the AMP. Water quality indicators are used to evaluate whether the lake can support its state-designated uses for water contact recreation (such as swimming and water skiing) and protection of the fish community. These designated uses, that the lake shall be suitable for swimming and fishing, reflect the national goal for all surface waters. The County monitors human health and safety indicators, such as sewage-related coliform bacteria and water transparency, along with ecological indicators, such as dissolved oxygen, ammonia, phosphorus, and the plant pigment chlorophyll-*a*, to assess the condition of the lake each year.

The Syracuse area experienced a wet early summer during 2000 but a relatively dry fall. The dry fall created favorable conditions for algal growth and blooms of algae persisted from August through October. Between May 15 and September 15, 2000 **chlorophyll-*a*** concentrations averaged 18.9 micrograms per liter (µg/l), a unit of measure equivalent to one part per billion. Lake users will perceive definite algal greenness that interferes with recreational uses when chlorophyll-*a* concentrations exceed about 13 µg/l.

Water transparency (as monitored with the Secchi disk) was high. Weekly **Secchi disk transparency** measurements from June through September averaged 2.2 meters (m); only one of 13 sampling dates did not meet the public bathing beach swimming safety guidance of 1.2 m. The 2000 chlorophyll-*a* concentrations were lower and Secchi disk transparency measurements were higher than in recent years. In spite of this apparent improvement, these two water quality indicators are consistent with a eutrophic (highly enriched) lake.

Summer average concentrations of **phosphorus**, the limiting nutrient for algal growth in Onondaga Lake, averaged 46 µg/l in the lake's upper waters. This concentration is also an indicator of a eutrophic lake. New York State's guidance value for summer average phosphorus in lakes is 20 µg/l.

Comparison of Onondaga and Oneida Lakes

	Onondaga Lake 2000	Oneida Lake 2000
Summer Phosphorus:	46 µg/l	16.8 µg/l
Secchi Disk Transparency:	2.2 m	2.9 m
Summer Chlorophyll-*a*:	19.7 µg/l	7.4 µg/l
Fall Oxygen:	Met standard	Met standard
Spring Ammonia:	Exceeded standard for brief period	Not measured
Summer Ammonia:	Met standard	Not measured

Nearby Oneida Lake is a large, shallow, productive lake renowned for its perch and walleye fishery. Comparing the results of the summer 2000 monitoring effort on the two lakes illustrates the higher concentrations of phosphorus and chlorophyll-a, and the diminished water clarity evident in Onondaga Lake.

Dissolved oxygen was absent from the lake's lower waters during the summer of 2000. This condition of anoxia, which is typical of eutrophic (highly productive) lakes, recurs each year. Without adequate oxygen in the cool deep waters, fish and other aquatic animals are restricted to the warmer upper waters where oxygen is present year-round. As a consequence, eutrophic lakes tend to have a fish community dominated by warm water species such as bass and sunfish.

As the lake cools each fall, temperature differences between the upper and lower waters begin to disappear and wind mixes the lake from top to bottom. Water from deep in Onondaga Lake contains hydrogen sulfide, iron, and methane that accumulate during summer anoxia. These chemicals are distributed throughout the lake during the fall mixing period and can cause a dramatic decline in lake-wide oxygen levels (a phenomenon known as an oxygen sag). In 2000 the fall oxygen sag continued to show improvement; daily average dissolved oxygen concentrations met state standards during the fall mixing period.

Ammonia nitrogen concentrations showed a significant improvement during 2000. Treated wastewater from the Syracuse Metro plant is the single largest source of ammonia to the lake, contributing more than 80% of the annual load. The water quality benefits of improved ammonia treatment at Metro and successful operation of a pretreatment facility at Bristol-Myers Squibb were evident in the lake in 2000. Concentrations of ammonia during spring slightly exceeded the state standard for a few weeks. Summer concentrations met the standards, falling well below critical levels for fish and other sensitive aquatic organisms.

Fecal coliform bacteria levels in the lake were generally within the state's standards for protecting public health. Fecal coliform bacteria, indicators of inadequately treated sewage, enter the lake during storms when the capacity of Syracuse's combined sewers is exceeded. At those times, a mixture of stormwater and untreated sewage overflows to relief points (combined sewer overflows or CSOs) within the wastewater collection system. Modifications to the CSOs are underway.

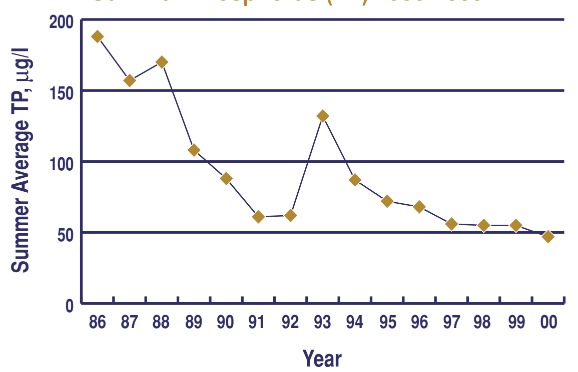
Phosphorus Concentrations Respond to Loading Reductions

Phosphorus is naturally present in all waters and is an essential nutrient for life. In most lakes, phosphorus is the limiting nutrient for algal growth; that is, phosphorus concentration is correlated with algal abundance. Until recently, phosphorus concentrations in the lake were so high that algal growth was limited by other factors such as light levels. Reductions in phosphorus loading achieved since the mid-1990s have shifted Onondaga Lake to a phosphorus- limited system. This is evidence of improving water quality conditions.

Excessive algae will make a lake appear turbid or green and diminish its attractiveness for recreational use. Decay of algae can reduce the concentration of dissolved oxygen in a lake's lower waters. Consequently, lake managers focus on controlling phosphorus concentrations.

Scientists and lake managers classify lakes according to their level of productivity (abundance of algae, plants, and other aquatic life forms) on a scale of trophic state. **Oligotrophic** lakes are low in productivity and are characterized by clear water. **Eutrophic** lakes are high in productivity and tend to appear green-tinged with cloudy water. **Mesotrophic** lakes are between the two extremes.

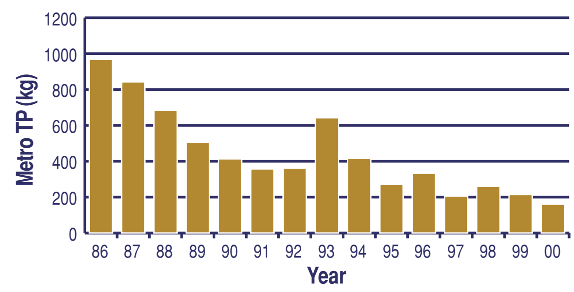
Figure 1. Onondaga Lake Summer Phosphorus (TP) 1986-2000



A fifteen-year record of summer average concentration of phosphorus in the upper waters of Onondaga Lake (the zone where plants and algae grow) is displayed in Figure 1. Improvements in phosphorus removal at Metro were implemented in the late 1980's and the lake responded quickly to this reduction in load. The high concentration in 1993 was caused by construction-related bypasses of wastewater from Metro during this extremely wet year. In recent years, summer concentrations range from 45 - 60 µg/l. Concentrations of phosphorus in this range are characteristic of a eutrophic (highly productive) lake. New York State uses 20 µg/l phosphorus as a guidance value to protect recreational uses. A site-specific standard may be appropriate for Onondaga Lake, since background loading from the urban watershed is high even without the discharge of treated wastewater.

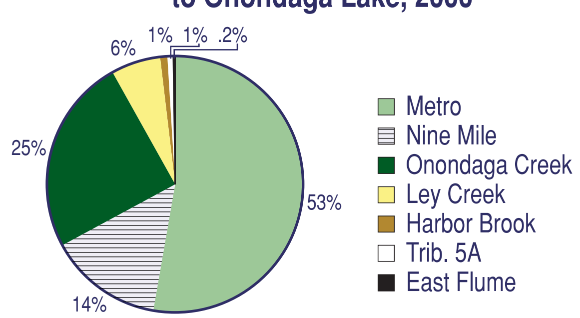
Phosphorus removal at Metro is achieved using chemicals such as iron salts and polymers to coagulate and precipitate the nutrient and enhance its settling from the wastewater. Because of the importance of phosphorus to lake ecology, its removal from wastewater has been a central focus of the engineering improvements at the Metro treatment plant. Beginning in 1987, the County has experimented with the amounts and types of chemicals added to the wastewater to maximize phosphorus removal. Note the decline in annual phosphorus loading from the treatment plant plotted in Figure 2. A phased limit for phosphorus discharged from Metro is included in the ACJ governing the lake cleanup projects.

Figure 2. Annual Phosphorus Discharge from Metro, 1986-2000



The current (Stage I) maximum phosphorus discharge from Metro is 400 pounds per day. A Stage II limit of 0.12 mg/l (less than 90 pounds per day) is to be met by April 1, 2006. The County's currently planned improvements at Metro will result in meeting the Stage II limits or better by mid- 2004, well ahead of schedule. Small-scale testing (pilot tests) to determine how much additional phosphorus can be removed from the wastewater has been conducted. Results of the pilot tests, which were conducted six years ahead of schedule, are very encouraging.

Figure 3. Phosphorus Load to Onondaga Lake, 2000

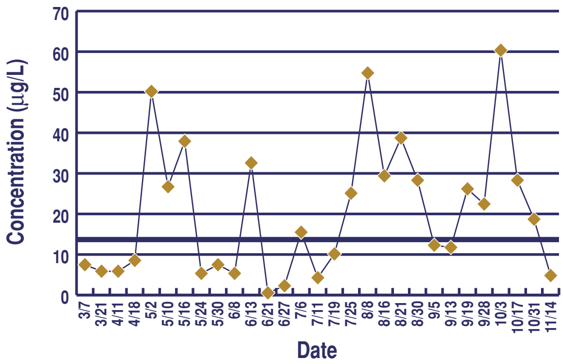


Phosphorus enters Onondaga Lake from both point and non-point sources. Treated effluent from Metro is the largest point source of phosphorus, contributing around 50 - 70% of the external phosphorus load to the lake each year. The relative contribution of major phosphorus sources during 2000 is plotted in Figure 3. In wet years like 2000, the Metro contribution is at the lower end of the range. Nonpoint sources of phosphorus include agricultural runoff and stormwater runoff from developed areas. Phosphorus is present in the mixture of stormwater and wastewater that enters receiving streams through the combined sewer overflows. Onondaga Creek is the second largest source of phosphorus to the lake, contributing 25% in 2000.

Algal Blooms Were Evident Late in the Cool Wet Summer of 2000

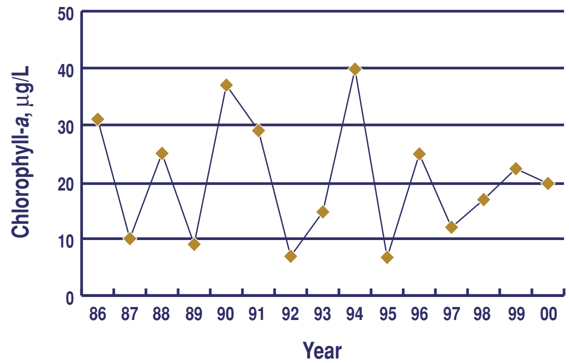
Figure 4. 2000 Chlorophyll in Surface Waters South Station Onondaga Lake

Chlorophyll-*a* perceived impairment at 13 µg/L



Chlorophyll-a is the major photosynthetic pigment in plants, both algae and macrophytes. The concentration of chlorophyll-a in a sample of water is frequently used to estimate algal biomass. Because of its ease of measurement, chlorophyll-*a* is used by water resource management agencies, including New York's Department of Environmental Conservation, to compare algal biomass between lakes and track changes over time in individual lakes. Some agencies have established guidelines on maximum concentrations of chlorophyll-*a* in an effort to protect recreational uses of lakes. As noted in Figure 4, 13 µg/l of chlorophyll-*a* is considered a threshold for a public perception that algal abundance is interfering with recreational uses of the water.

Figure 5. Summer Average Chlorophyll-*a* in Onondaga Lake, 1986-2000

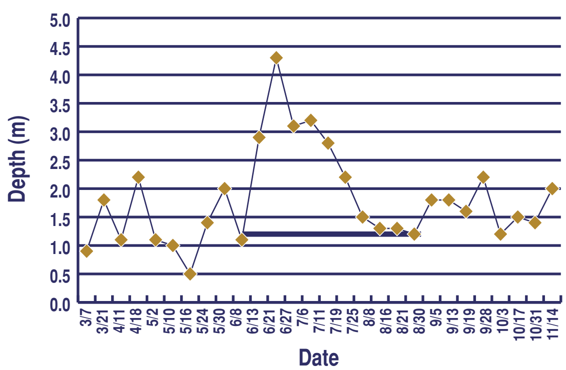


Chlorophyll-a concentrations in the upper waters of Onondaga Lake averaged 18.9 µg/l between mid-May and mid-September 2000. There is a tremendous amount of seasonal variability in this parameter as plotted in Figure 4. Weekly measurements were obtained to help characterize this short-term variability. The summer of 2000 was characterized by high algal abundance late July through October. The 2000 chlorophyll data were within the range of historical data, as evident from the data displayed in Figure 5. Note the high variability in chlorophyll concentrations from year-to-year.

Reduced Algal Blooms during the Cool Summer of 2000 Meant Higher Transparency during the Recreational Season

Figure 6. Onondaga Lake Secchi Disk Transparency, 2000

NYSDOH guidance value for bathing beaches: minimum of 1.2 meters during the recreational season (June-August)

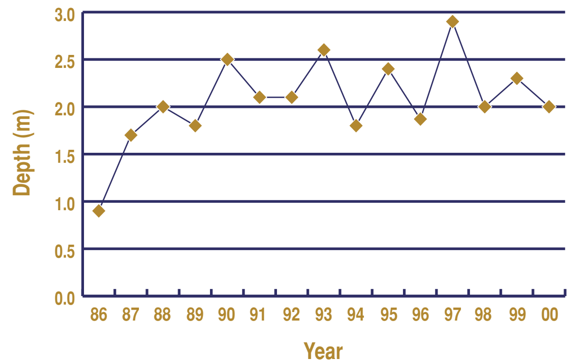


Secchi disk transparency is a measure of water clarity that is a standard feature of lake monitoring programs worldwide. The standard Secchi disk used in limnological investigations is a 20 cm disk with alternating black and white quadrants. The disk is lowered through the water column from a boat and the depth at which it disappears from view is recorded. Thus, higher measurements indicate clearer waters.

New York State Department of Health uses a Secchi disk transparency of 1.2 meters (4 ft) as a guideline of adequate water clarity for swimming safety. The 2000 Secchi disk transparency measurements in Onondaga Lake are plotted in Figure 6. Note the high water clarity during the summer period when algal density was low. This is a typical result for lakes where algal cells are causing the water to appear turbid or green. Comparing this graph to the 2000 chlorophyll results plotted in Figure 5 highlights the importance of algal biomass in limiting water clarity in Onondaga Lake.

Similar to the chlorophyll results, year-to-year changes in Secchi disk transparency can be dramatic. Water clarity in Onondaga Lake has improved since 1986 as demonstrated by Figure 7. This improved water clarity is due in part to reduced phosphorus loading from Metro. However, changes to the lake's food web were triggered with the 1986 closure of the AlliedSignal facility and the dramatic reduction in chloride inputs that resulted. As chloride concentrations declined, different species of zooplankton (tiny aquatic animals that graze on algae) began to thrive in the lake. These zooplankton species were more efficient grazers of the lake's algal cells and contributed to the increased water clarity.

Figure 7. Average Summer Secchi Transparency in Onondaga Lake, 1986-2000

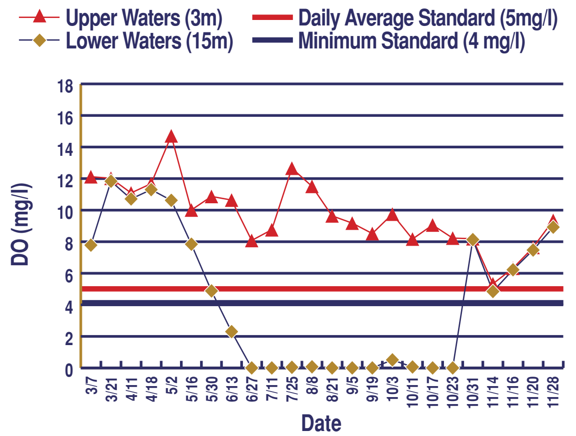


Dissolved Oxygen Concentrations in Onondaga Lake's Upper Waters Once Again Remained above Critical Levels in 2000

The dissolved oxygen (DO) status of Onondaga Lake is closely linked to the annual temperature cycle. During summer, the lake's deeper waters remain isolated from the atmosphere. Not enough light to support photosynthesis by algae or aquatic plants reaches those deeper waters. As a consequence, no new production of oxygen can take place. The existing DO in the lake's lower waters is used by bacteria and fungi that decompose the organic material settling to the lake bottom from the sunlit layers above. As algal abundance increases in the upper waters, activity of the decomposers increases and the DO is used up in the lower waters. When the supply of DO is depleted, the waters become anoxic. Other chemicals such as iron, ammonia, hydrogen sulfide, and methane accumulate in the anoxic lower waters as decomposition of algal biomass continues in the absence of oxygen.

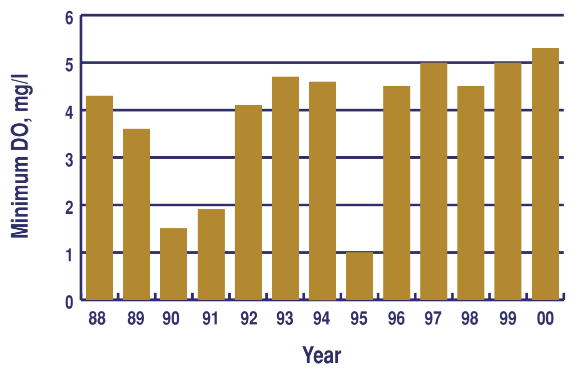
When the lake cools in the fall, these cooler anoxic waters gradually mix with the warmer upper waters. Chemical reactions with the iron, ammonia, hydrogen sulfide, and methane can quickly remove oxygen present in the upper waters as they begin to circulate with the anoxic lower layer. As a consequence, dissolved oxygen levels fall. There is a great deal of variability in minimum DO levels in the upper waters that depends on weather conditions and algal abundance during the fall. DO concentrations can reach critically low levels for survival of aquatic life. Fish may seek refuge in areas with higher oxygen levels such as the mouths of streams or the Seneca River. To comply with state and federal standards designed to protect aquatic life, DO should remain above 4 - 5 mg/l in the upper waters during this critical period of fall mixing.

Figure 8. 2000 Dissolved Oxygen, Onondaga Lake



Dissolved oxygen measurements obtained during the 2000 monitoring program are displayed in Figure 8. Note the rapid loss of DO in the lower waters that began in June, after thermal stratification had isolated the lower waters from the atmosphere. Note also the decline in DO in the upper waters during October. The upper waters lost about 2.0 mg/l as they cooled and began to mix with the anoxic lower waters. Complete mixing occurred by late October as seen by the

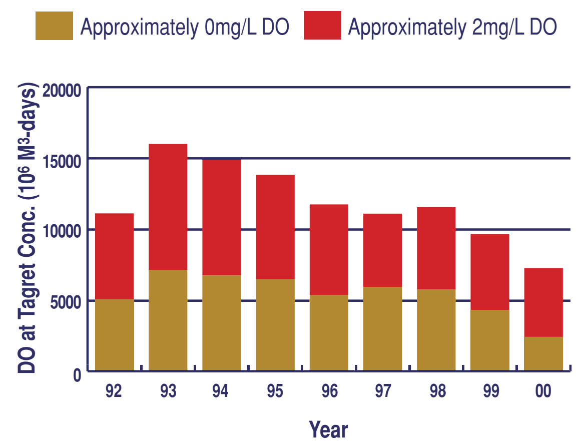
Figure 9. Minimum Dissolved Oxygen in Upper Waters of Onondaga Lake during Fall Mixing, 1988-2000



convergence of the lines for the upper and lower waters. Concentrations of DO increased lakewide during the fall as the waters continued to mix and gain oxygen from the atmosphere.

Minimum DO concentrations measured in the lake's upper waters during fall mixing since 1988 are plotted in Figure 9. Note the variability in this measurement. Some of the variability is random: minimum DO in the fall depends to a certain extent on how cool and windy the weather is. However, the pool of iron, hydrogen sulfide, ammonia, and methane that has accumulated over the summer period ultimately affects oxygen depletion in the fall. As algal biomass is reduced in response to decreased phosphorus inputs, the amount of decomposition in the lower waters will decline. This reduction in decomposition will, in turn, reduce the concentrations of these reduced chemicals in the lower waters. Improved oxygen levels will result.

Figure 10. Volume Days of Anoxia in Onondaga Lake, 1992-2000



Onondaga County has installed an in-lake water quality monitoring buoy at the lake's deepest point, the monitoring station known as "South Deep". Water quality conditions at this station have been demonstrated to be representative of conditions throughout the lake. Suspended from the buoy is an array of monitoring and recording instruments that measure water temperature, pH, dissolved oxygen, and specific conductance (a measure of dissolved salts). Results are transmitted back to a computer at the Water Environment Protection offices on Hiawatha Boulevard where they are uploaded to the County's web site. The buoy is in operation, approximately, from early spring to late fall. Buoy data for 2000 are available from April 16 – Dec. 12. Data can be viewed at **www.lake.onondaga.ny.us.** This near real-time water quality measurement system represents a critical advance in our ability to monitor and interpret lake conditions especially during critical periods such as fall mixing.

One measure of the lake's dissolved oxygen status is "volume-days of anoxia". This measurement has been used in Long Island Sound and other systems where low concentrations of dissolved oxygen (anoxia) are a significant water quality management issue. Both the volume of water affected by anoxia and the duration (days) of anoxia are calculated in a single measurement that can be tracked from year to year. As indicated by the data summarized in Figure 10, volume-days of anoxia in Onondaga Lake are declining, representing improved water quality conditions for the biological community.

Juvenile yellow perch.

Ammonia Nitrogen Concentrations Respond to Loading Reductions

Ammonia nitrogen can be harmful to aquatic life. Young stages of aquatic animals such as newly hatched fish are especially sensitive. Metro is the major source of ammonia to Onondaga Lake contributing about 85% of the annual load. The treatment plant was not designed to remove ammonia from wastewater and only recently have operational modifications been made to allow some nitrification to occur during warm weather. Improvements to the County's wastewater treatment facility are now underway to support biological conversion of ammonia in the wastewater to nitrate, a nontoxic form of nitrogen. This change in the treatment process is necessary to reduce the lake's ammonia nitrogen to safe levels for the aquatic community.

As part of the ACJ, the New York State Department of Environmental Conservation established a phased effluent limit for nitrogen in the Metro discharge. The County is making excellent progress on the ammonia removal projects and is projected to meet the final (Phase III) effluent limit by May 1, 2004, eight years ahead of schedule.

The columns on Figure 11 display average ammonia nitrogen in Onondaga Lake's upper waters measured in recent years. Concentrations of this magnitude exceed the water quality standard for ammonia, designed to protect sensitive aquatic life. Results are variable from year to year, depending on factors such as weather and algal abundance. The single most important factor governing ammonia nitrogen in the lake is the performance of Metro. Recently, an enhanced aeration system has improved the treatment process, resulting in much less ammonia reaching the lake.

Ammonia nitrogen concentrations present in Metro effluent during 2000 are plotted in Figure 12. Note that the concentration was high in winter and spring and declined markedly in summer. The biological process of nitrification is extremely sensitive to temperature. It is much more difficult to achieve nitrification at the treatment plant when wastewater temperatures are cool. Metro effluent quality also depends on the quality of wastewater flowing into the treatment plant. Onondaga County is working with local industries, particularly Bristol-Myers Squibb, to reduce ammonia in wastewater before it reaches the treatment plant. Since the late 1990s, Bristol-Myers Squibb has operated a pretreatment facility that significantly lowers their ammonia loading to Metro.

Onondaga Lake responds very quickly to reduction in ammonia inputs. The ammonia concentrations measured in the lake during 2000 are plotted in Figure 13 and compared with state standards and federal criteria. Note that the ammonia concentrations at 3 meters depth met the federal criteria but exceeded the New York state standards through early spring. Both the state and federal limits vary with pH and temperature, which accounts for the variability of the lines on the graph.

Figure 11. Average Ammonia-N in Upper Waters of Onondaga Lake, 1988-2000

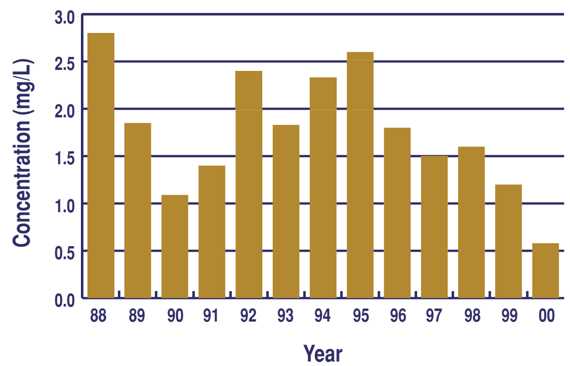


Figure 12. Ammonia-N Discharged from Metro during 2000

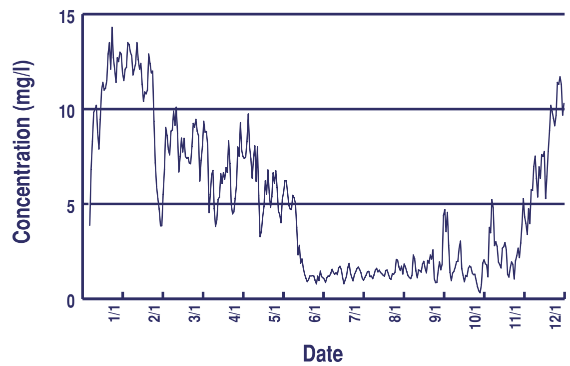
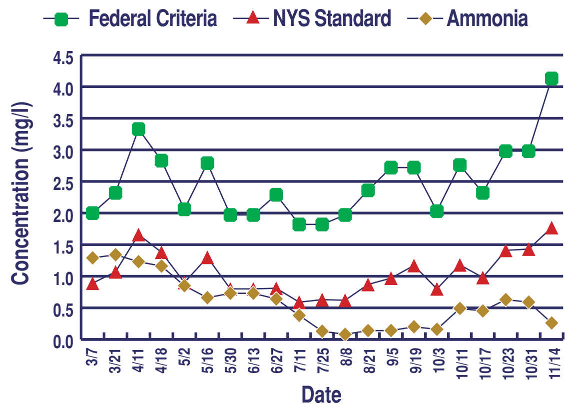


Figure 13. 2000 Onondaga Lake Ammonia-N, 3 meter depth



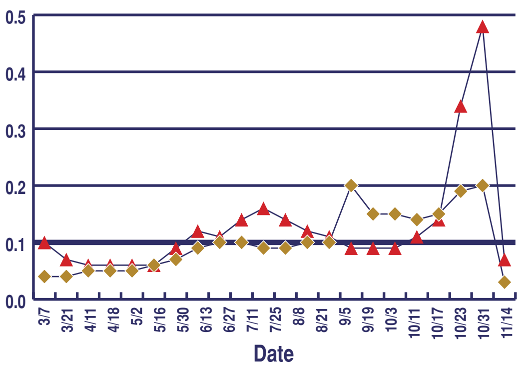


Figure 14. Surface Water Average Nitrite-N at South Station Onondaga Lake, 2000

The federal criteria for ammonia in water were revised in December 1999 and are now significantly less stringent, reflecting the latest scientific research. New York is currently evaluating their standards with respect to the new federal criteria to determine if revisions are warranted.

The concentration of nitrite, another harmful form of nitrogen, measured in the lake's upper waters during 2000 is displayed in Figure 14. The standard for nitrite is 0.1 mg/l, a level that scientists consider safe for a warmwater fish community. In 2000 the nitrite concentration was close to the standard in the upper waters until late fall. The November peak occurred after the lake had mixed. This may represent incomplete biological transformation of the pool of ammonia that accumulated in the lake's lower waters. Because of the linkage between ammonia and nitrite, improvements to the Metro treatment plant to reduce ammonia are expected to reduce nitrite levels in the lake as well.

Ammonia and nitrite concentrations are major factors affecting the type and abundance of aquatic life in the lake. Reductions in concentrations of these harmful forms of nitrogen are required to meet state and federal guidelines and protect a diverse aquatic community. As ammonia and nitrite levels are reduced, the aquatic community will begin to resemble that of other regional lakes. The recent proliferation of zebra mussels in Onondaga Lake suggests that a shift in community composition is underway.

Storm Monitoring for Bacteria Concentrations and Loading Continued During 2000

In 1999 Onondaga County began a storm event program designed to collect multiple samples in the tributaries at short time intervals during and after intense rainstorms. These data help engineers and scientists estimate the annual input of pollutants to the lake from the tributaries. Results also provide an indication of the relative importance of urban stormwater and CSOs.

Onondaga Creek is the primary focus of the storm event program. As of 2000, 43 CSOs discharged to this creek. Modifications to the wastewater collection system that will eliminate all untreated overflows (for the statistical 1-year storm or lesser intensity) have begun. The storm event program includes sampling during the three-year period from 1999 – 2001 to quantify baseline conditions. Sampling locations were selected to be upstream and downstream of major point and nonpoint sources. A particular focus is on the CSO points, sampling is conducted upstream and downstream of the overflows. Storm event monitoring is also planned for 2005, 2008, and 2012 based on the construction schedule for completing major projects along the creek.

The monitoring data will be used to verify mathematical models of the relationship between storm events (including both rainfall and snowmelt), stream and lake water quality. Water quality of streams and the lake is measured by the abundance of indicator bacteria such as fecal coliforms. Once tested and verified with site-specific data, the models can be used to project water quality conditions under a range of future conditions.

Figure 15 displays the concentration of fecal coliform bacteria, a type of organism associated with recent sewage contamination, measured in Onondaga Creek during an intense storm in November 2000. Fecal coliform bacteria are used as an indicator of the potential presence of pathogens (disease-causing organisms) in water. Two of the four sample locations in Onondaga Creek, Route

Figure 15. Mean Fecal Coliforms in Onondaga Creek during November, 2000

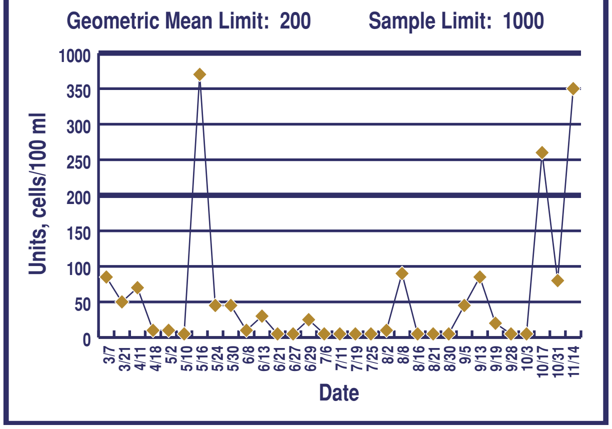
20 and Dorwin Avenue, are upstream of the City's urban corridor and CSO points. The remaining sampling locations, Spencer Street and the Inner Harbor, are affected by CSO discharges.

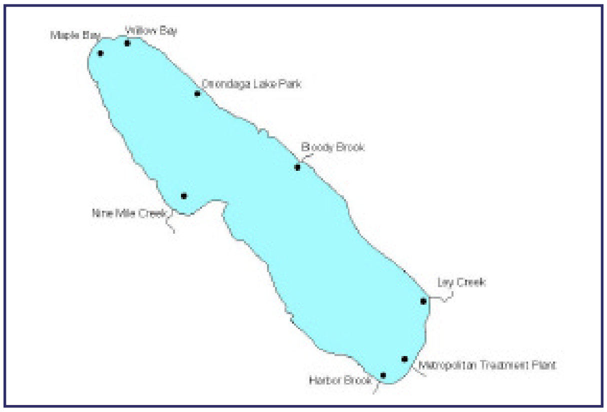
The indicator organisms most often used to indicate sanitary conditions at bathing beaches are fecal coliform bacteria and enterococcus bacteria. New York State uses the concentration of fecal coliform bacteria to indicate suitability for water contact recreation. Fecal coliforms are the part of the coliform group that is present in the waste of warm-blooded animals. Sources include untreated sewage and manure from agricultural operations.The concentration of fecal coliform bacteria measured in the surface waters at South Deep (a mid-lake station) during 2000 is displayed in Figure 16. Bacteriological quality at this station met the standards for water contact recreation during the summer 2000 recreational period.

The 1999 Federal Clean Water Action Plan encouraged the States to consider additional indicators of sanitary quality of waters used for swimming. Since 1999, the County has measured three classes of indicator bacteria in the near-shore waters of Onondaga Lake. This monitoring is in addition to the historical monitoring for fecal coliform bacteria at the South Deep station. Samples from near-shore areas are analyzed for fecal coliform bacteria, E. coli and Enterococcus.

Manure on riparian zone of Onondaga Creek.

Figure 16. Fecal Coliform Bacteria Concentrations in Upper Waters of Onondaga Lake, 2000





Nearshore bacteria monitoring stations.

Three popular shoreline areas (Maple Bay, Willow Bay, and Onondaga Lake Park near the marina) are monitored over the summer. These results will help managers evaluate whether the CSO controls have made the lake safe for swimming.

The 2000 results indicate that safe bacteria limits were exceeded following storms in regions of the lake close to the southern tributaries affected by CSO discharges. The frequency of violations decreased at sampling sites further north. Data collection will continue through the entire CSO control program.

Manure on riparian zone of Onondaga Creek.

Enhanced Biological Monitoring Continued in 2000

Electrofishing boat used by County personnel.

A restored Onondaga Lake will have a healthy community of plants and animals. Monitoring the biological community in and around the Lake is an important part of the AMP. Special organisms, known as biological indicators, are the focus of much of the monitoring program. The presence and abundance of these biological indicators can tell scientists a great deal about the overall health of the ecosystem.

Phytoplankton (tiny plants suspended in the water) and **zooplankton** (microscopic aquatic animals) have long been part of the County's annual monitoring program. Researchers from the Cornell Biological Field Station evaluate the community of phytoplankton and zooplankton each year. Abundance and species composition are evaluated from samples collected from early spring through the late fall. Zooplankton size is measured and tracked over the year, as this metric indicates the amount of grazing pressure exerted by the fish community. Results are compared with phytoplankton and zooplankton measurements from Oneida Lake.

Results of the 2000 monitoring effort indicate a shorter bloom period for cyanobacteria (blue-green algae). It is too early to tell if this is due to normal year-to-year variation or if it indicates improving lake water quality conditions.

Zooplankton density is high in Onondaga Lake, consistent with the eutrophic conditions of high nutrients and algal biomass. The average size of the lake's zooplankton declined from its maximum value in March through early summer, indicating a surge in zooplanktivory (consumption of zooplankton by fish and other organisms). A second decrease in average size of the zooplankton was evident in late summer, when the young-of-the-year fish begin to graze them in substantial numbers.

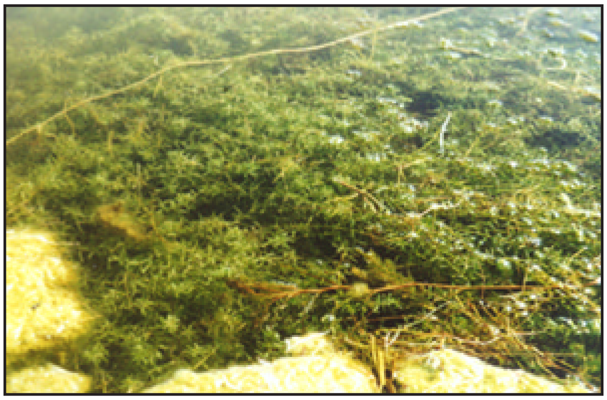
Non-native species are a visible feature of the Onondaga Lake ecosystem, as they are for lakes and streams throughout the Great Lakes Basin. The 2000 investigations documented an abundance of the larval stage of zebra mussels (called veligers) and the presence of a predatory cladoceran zooplankton *Cercopagis pengoi*, which has recently entered the Great Lakes from the Caspian Sea region in Asia. Ballast water from ships is the likely culprit in transporting these invasive species to North American lakes and streams.

Macroinvertebrates are small insects and worms that live in the bottom sediments of streams and lakes. They are included in the AMP because their numbers and types are closely linked to water quality and habitat conditions. A baseline survey was completed in 2000 to document existing conditions of the macroinvertebrate community and provide a benchmark against which change can be assessed.

Macroinvertebrates sampled in Onondaga Creek.

The macroinvertebrate communities of Onondaga Creek, Ley Creek and Harbor Brook are affected to various degrees by pollution and habitat degradation. The macroinvertebrate community of Harbor Brook is the most severely impacted based on standard indices calculated from the number and types of organisms present. Ley Creek and Onondaga Creek are affected to lesser degrees. It appears that a combination of habitat degradation, nonpoint source pollution, and oxygen-demanding material discharged by CSOs are affecting the macroinvertebrate communities of the three streams. Upstream segments of the tributaries are affected by nonpoint sources (including the mud boils along Onondaga Creek) while urban runoff and CSOs influence the community in downstream segments.

Results of the macroinvertebrate sampling of the lake's littoral (nearshore) area reveal differences in the macroinvertebrate community between the northern and southern ends of Onondaga Lake. As expected, the conditions of the macroinvertebrate community in the northern end of the lake are less affected by wastewater, contaminated and/or saline groundwater, and sedimentation. The combined influences of eutrophication and habitat degradation appear to be major structuring elements of the benthic (bottom-dwelling) community in the nearshore areas of Onondaga Lake.



Elodea spp. (Common waterweed)

Macrophytes will be monitored once every five years since they are important to stabilizing the lake bottom sediments and providing food and shelter for young fish. A baseline survey was conducted during 2000 so that future changes in community structure and composition can be documented. Compared with results of a survey conducted in 1991, the number of plant species in Onondaga Lake and the percent of the shoreline area covered by plants have increased.

Fish are a major focus of the biological monitoring program. The County is evaluating the reproductive success of the fish community using a combination of classical and innovative techniques to count nests, sample larval and adult fish, and track changes in the fish community. Data will be collected each year as improvements to wastewater collection and treatment are phased in. Cooperating anglers are recruited to keep diaries of their fishing efforts and successes. Extensive resources of both field time and equipment are dedicated to the fish program.

Data are used to evaluate which species are present, which are reproducing, what is their growth rate, and their migration patterns between the lake and river. Standard methods are used so that the fish community of Onondaga Lake can be compared with that of other lakes. Experts in fish ecology oversee program design and implementation.

Juvenile and adult fish sampling in 2000 resulted in the collection of more than 13,000 fish representing 30 species. More than twice the number of nests documented in any previous survey were found during the 2000 fish nesting survey. Smallmouth bass nests were documented for the first time in Onondaga Lake. At the same time, yellow perch young-of-the-year were notably absent from the 2000 catch, suggesting limited or no reproduction of this fish in the lake.

Trap nets have been used to sample fish populations.

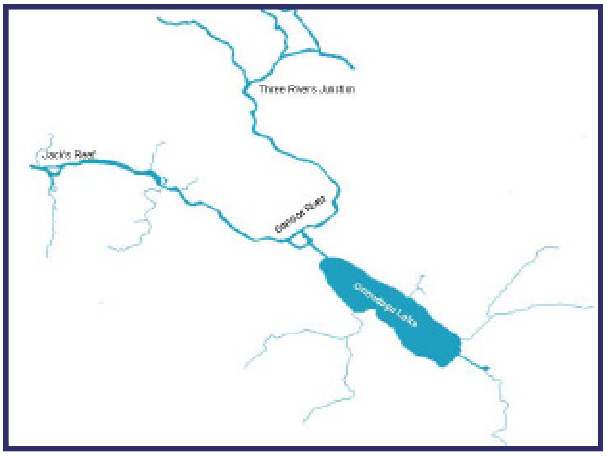
Monitoring Water Quality Conditions in the Seneca River is Also Required by the ACJ

Water quality of the Seneca River is relevant to the ambient water quality monitoring program in two important areas. First, the river and lake are hydrologically connected because water flows from the lake into the river. Water quality improvements in Onondaga Lake will, therefore, be evident in the river as well. Second, future diversion of all or some of the Metro effluent to the river is possible if the improvements to Metro do not bring the lake into compliance with standards and community goals. The assessment of the need to direct Metro effluent to the Seneca River is to be made by February

Seneca River at Onondaga Creek outlet.

2009. Under the current conditions, the Seneca River could not handle a new significant discharge of treated wastewater, because dissolved oxygen levels in the river do not meet state standards. Proliferation of zebra mussels has reduced the oxygen resources of the river. This situation has complicated what once appeared to be an acceptable management alternative for improving Onondaga Lake. Metro effluent can only be diverted to the river if water quality of both ecosystems would be protected.

Onondaga Lake is saltier (and thus denser) than the Seneca River, so water flowing out of the lake tends to remain near the bottom of the outlet channel and in the river. Because there is very little difference in elevation, river water can puddle over the lake water in the outlet and can actually flow into the lake during dry periods when stream flows are low.



Seneca River study area.

This unusual flow regime in the lake outlet affects water quality conditions in adjacent segments of the river. During average and low flow conditions, the difference in density isolates the lower waters from the upper waters in the river channel. Oxygen from the atmosphere does not mix deep into the river, as a consequence DO concentrations in the river's deeper waters are low upstream and downstream of where the outlet of Onondaga Lake joins the river. The DO concentrations in this stretch of the river fall below levels considered safe for aquatic life. When ammonia concentrations are high in the lake, they are high in the river as well.

The firm Quantitative Environmental Analysis, LLC (QEA) is developing a water quality model of the Seneca River that incorporates the effects of zebra mussels while projecting water quality conditions under a range of future scenarios. One objective of the river monitoring program is to collect the data needed to verify and test this model. Data collection efforts are targeted during late summer and early fall when water temperature is high and river flows tend to be lowest. Warm water and low flows represent critical conditions for dissolved oxygen resources in the Seneca River.

Beak Consultants have worked closely with the County on issues related to the Seneca River. Scientists from this firm have mapped the distribution and abundance of mussels along a stretch of river extending from Jacks Reef to the Three Rivers junction. These data are extremely valuable to the modeling team in assessing the importance of zebra mussel activity on water quality conditions.

Additional information about the Seneca River-Onondaga Lake system can be found at Onondaga County's web site **www.ongov.net**. From this site, follow the links to the Lake Improvement Project Office site where you can read monthly progress reports of the many activities underway to improve the lake and view near-real-time water quality data.

Summary and a Look Ahead

The Ambient Monitoring Program represents a significant commitment by Onondaga County to protect and restore our water resources. The program is designed to assess progress towards community goals and determine what else is needed. Experts from many areas provide guidance and review but we welcome input from all members of our community.

The 2000 data show us that Onondaga Lake is on the road to recovery. Levels of phosphorus and nitrogen, two important types of pollution affecting the use of the lake, are the lowest ever measured. Algal blooms are diminishing. Oxygen concentrations (essential for aquatic life) are the highest measured ever. These improvements are very encouraging, since a significant investment in the improvement of the wastewater collection and treatment system is well underway.

The biological programs are providing fascinating information illustrating the linkages between improved water quality and the number and types of plants and animals the lake can support. The County AMP is among the most comprehensive monitoring programs currently in place in any community. We look forward to bringing the highlights of the monitoring program to the public each year to build community appreciation and support for our restored lake and watershed.

Glossary

Amended Consent Judgment (ACJ). An agreement signed in January 1998 by New York State, Onondaga County, and Atlantic States Legal Foundation committing the County to a 15-year program of improvements to the wastewater collection and treatment system and associated monitoring.

Ambient Monitoring Program (AMP). Annual water quality and biological monitoring program conducted in Onondaga Lake, the lake tributaries, and the Seneca River.

Ammonia nitrogen. A form of ammonia that is toxic to aquatic life.

Bacteria. Single-cell or non-cellular organisms that lack chlorophyll and reproduce by fission. They are important as pathogens and for biochemical properties.

Chlorophyll-*a*. The primary photosynthetic pigment in algal cells, used as an index of algal abundance.

Combined Sewer Overflow (CSO). A relief point in the wastewater collection system that operates when the hydraulic capacity of the pipe is exceeded. CSOs direct a mixture of storm water and untreated sanitary wastewater to nearby water bodies.

Dissolved Oxygen (DO). The quantity of oxygen dissolved in water. DO concentrations vary with depth, season, and time of day in Onondaga Lake in response to photosynthesis and breakdown of organic matter (especially algal cells). DO levels are a major factor affecting the abundance and type of organisms living in the lake.

Eutrophic. A lake characterized by high levels of nutrients and biological productivity.

Fecal coliform. A type of bacteria whose natural habitat is the colon of warm-blooded mammals such as humans. While most fecal coliform bacteria are not harmful, they are used as an indicator of the potential presence of pathogenic (disease causing) microorganisms associated with recent fecal contamination.

Fish. Any of numerous cold-blooded aquatic vertebrates of the superclass Pisces, characteristically having fins, gills, and a streamlined body.

Macroinvertebrate. Aquatic insects and worms that spend at least part of their life cycle in sediments of streams and lakes. Numbers and types of these organisms are used to infer water quality and habitat conditions.

Macrophytes. Rooted aquatic plants and algae. Macrophytes are an important component of the lake food web.

Mesotrophic. A lake characterized by moderate levels of nutrients and biological productivity.

Metro (Metropolitan Syracuse Wastewater Treatment Plant). Treatment plant on Hiawatha Blvd., Syracuse, NY.

Nitrification. The biological conversion of ammonia to nitrate.

Nonpoint source pollution. Type of pollution involving complex transport and delivery mechanisms within the lake watershed.

Oligotrophic. A lake characterized by low levels of nutrients and biological productivity.

Phosphorus. An element that is an essential macronutrient for plant growth; the limiting nutrient for phytoplankton growth in Onondaga Lake.

Phytoplankton. Microscopic algae and certain bacteria found in lake water.

Secchi disk transparency. A standard measure of water clarity obtained by lowering a 20-cm disk through the water column and recording the depth at which it is no longer visible.

Water quality criteria. Best scientific judgment of the maximum contaminant level in water that will protect a designated use (such as water supply or swimming).

Water quality standard. An enforceable limit, usually numerical, of the maximum contaminant level in water that will protect a designated use. Standards may be the same as criteria.

Zooplankton. Microscopic animals found in lake water; primary consumers of phytoplankton.

A Publication of

Onondaga County

Department of Water Environment Protection

Syracuse, NY ▸ (315) 435-2260

Visit Our Website: www.ongov.net

Nicholas J. Pirro

Onondaga County Executive

Richard L. Elander, P.E.

Commissioner, Department of Water Environment Protection