October 24, 2005

Executive Summary
Onondaga Lake 2004

Onondaga Lake Ambient Monitoring Program Executive Summary

2004 Annual Report

ACKNOWLEDGMENTS

The Onondaga County Department of Water Environment Protection (DWEP) is responsible for implementing the Ambient Monitoring Program (AMP), as required by the Onondaga Lake Amended Consent Judgment. Funds for the Ambient Monitoring Program 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. James Hassett (SUNY College of Environmental Science and Forestry): water resources engineering, hydrologic modeling
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 limnology, loading calculations, mass-balance, integrated data management

Many agencies provide oversight and technical assistance to the County, including:

- 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
- Onondaga Lake Partnership
- United States Geological Survey
- Atlantic States Legal Foundation

Joseph J. Mastriano of DWEP administers the AMP. Jeanne C. Powers oversees program implementation. In 2004, Mr. Mastriano and Ms. Powers were supported by DWEP staff members David Snyder (biological program oversight), Michael Gena (director of Onondaga County's state-certified Environmental Laboratory), Janaki Suryadevara (field program leader and water quality program oversight) and Antonio D. Deskins (data compilation, calculations, and plotting).

EcoLogic LLC, Quantitative Environmental Analysis LLC (QEA), Dr. William Walker, Jr., and Dr. Edward Mills prepared sections of the 2004 Annual Report. This Executive Summary was prepared by EcoLogic, LLC.

October 2005

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 a talented and dedicated staff under a name that reflects our strong commitment to protecting the water resources we all share.

The Department surveys water quality conditions in the Onondaga Lake watershed each year. This publication is a summary of the findings of the 2004 Onondaga Lake Ambient Monitoring Program (AMP), the 35th year of Onondaga 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 2004 monitoring effort will be posted on the Onondaga County web site and is available from the Department upon request.

Onondaga County is required by State and Federal regulations to monitor Onondaga Lake and its tributary streams. The January 1998 Amended Consent Judgment (ACJ) required the Department to develop and implement 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, streams flowing into the lake, and segments of the Seneca and Oneida Rivers. Water samples are analyzed in the County's state-certified environmental laboratory and results are used to calculate the annual input of sediment, chemicals, and bacteria. 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 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). 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

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INTRODUCTION TO THE AMBIENT MONITORING PROGRAM

Onondaga County and its federal and state partners are investing in the future of Onondaga Lake, a natural resource that has undergone years of abuse and neglect. Improvements to the wastewater collection and treatment system serving six towns, two villages, and the City of Syracuse are currently under construction. These improvements will result in improved water quality conditions in Onondaga Lake and its tributary streams. Projects to reduce the **Combined Sewer Overflows (CSOs)** and provide a higher level of treatment at the **Syracuse Metropolitan Wastewater Treatment Plant (Metro)** began in 1998 with the signing of the **Amended Consent Judgment (ACJ)**. The ACJ outlines a 15-year program with three major elements: CSO abatement projects, Metro treatment improvements, and the **Ambient Monitoring Program (AMP)** to track improvements in water quality.

The AMP is designed to provide data and information needed to assess the effectiveness of improvements to the wastewater collection and treatment infrastructure. The monitoring program includes field and laboratory components to identify sources of materials (nutrients, sediment, microorganisms, and chemicals) to the lake, evaluate in-lake water quality conditions, and examine the interactions between Onondaga Lake and the Seneca River. Biological programs encompass much of the food web of the lake and its watershed, including zebra mussels, macroinvertebrates, aquatic plants, phytoplankton, zooplankton, and fish.

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 to estimate the annual input of water and materials including nutrients, sediment, salts, and bacteria. Samples are collected upstream of the lake to help pinpoint sources of pollution. Accurate estimates of inflows are a critical component of the AMP, since they underlie many of the management decisions facing Onondaga County. Monitoring of Onondaga Lake and the Seneca River is conducted during the ice-free period and, when conditions allow, winter sampling is conducted as well. Unsafe ice conditions precluded winter sampling in 2004.

Sampling along the Onondaga Lake shoreline.

INDICATORS AND TRENDS

The AMP generates thousands of observations each year. It is challenging to organize and communicate these data in a way that retains integrity of the scientific information and makes it useful for all stakeholders. To help meet this challenge, a series of indicators are used to summarize water quality and habitat conditions with respect to specific uses. These indicators share several properties: they relate directly to an impairment of the lake or watershed; they relate to a resource of interest; they correspond to a published standard that, in turn, reflects the requirements of public health or the aquatic biota; and they can be measured and interpreted with relative ease. Indicators can help answer basic questions such as: "is the lake getting better?" and "is it safe for my family to swim here?"

Indicators are used to track progress towards lake improvement or compliance with ambient water quality standards. The major indicators are summarized in Table 1.

Table 1. Major indicators of water quality for Onondaga Lake.

Desired use	Measured by:
Water contact recreation	Bacteria concentrations
	Nearshore water clarity
Aesthetics	Phosphorus concentrations (narrative standard)
	Algal blooms: intensity, frequency, and duration
	Relative abundance of blue-green algae
	Nearshore macroalgae (algal mats)
Aquatic life protection	Dissolved oxygen concentrations
	Ammonia N concentrations
	Nitrite N concentrations
Recreational angling	Habitat quality: aquatic plant growth
	Nesting success
	Presence of early life stages of target species
	Presence of adult fish sensitive to pollution
	Mercury content of fish

The 2004 results provide a snapshot of "The State of the Lake" and help managers assess how conditions during this year met the goals for a swimmable, fishable lake. Throughout the community, there is deep interest in how the lake has changed over time. The County is closely tracking changes in water quality and relating these changes to the improvements in the wastewater collection and treatment system that are underway. As part of the AMP, water quality data collected each year are analyzed for trends. The trend analysis helps gauge how the lake is changing in response to the substantial public investment in improvements to the wastewater collection and treatment system. Trends in lake water quality conditions and the fish community are summarized in Table 2. Baseline fishery data from 2000—2004 are compared to historical data as available.

Table 2. Trends in water quality conditions and the biological community of Onondaga Lake

Indicator	Trend
Phosphorus concentration	Decreased through the 1990s, relatively unchanged since 2000.
Water clarity	Variable. In 2004, clear water was evident during most the summer.
Algal blooms	Variable. Improved conditions in 2004 (diminished duration, frequency and intensity of blooms)
Ammonia concentration	Decreased in response to improvements at Metro, lower (improving conditions) in 2004.
Nitrite concentration	Decreased with Metro improvements, lower (improving conditions) in 2004.
Chloride concentration	Declined with closure of AlliedSignal facility in mid-1980s, now stable.
Dissolved oxygen	Increased levels at fall mixing, shorter duration of anoxia.
Aquatic plant growth	Increased during the 1990s. This has improved aquatic habitat and helped stabilize shallow sediments.
Fish community structure	Increased number of species; increased number of species sensitive to pollution.
Fish reproduction	Evidence of more fish and better survival. Spawning smallmouth and largemouth bass.
Fish contaminant levels	Fish advisory remains in place based on mercury concentrations.
Bacteria concentration	Elevated levels persist in southern nearshore area following storms. Outlook good as controls on combined sewers are implemented.

As illustrated in Table 2, the water quality and habitat conditions of Onondaga Lake have improved over the past decade. Phosphorus and ammonia concentrations have decreased due to improved wastewater treatment. In response, the levels of dissolved oxygen have increased throughout the water column. Improved water clarity has allowed the beds of aquatic plants to expand; this has provided for improved nesting and nursery habitat for the lake's warmwater fish community.

The trend analysis examines changes in materials entering the lake (loading from tributaries and Metro), the quality of the lake's upper and lower waters, and materials flowing from the lake at the outflow to the Seneca River. A ten-year window has been identified as the appropriate time scale to track trends in Onondaga Lake's water quality. The lake has a relatively short water residence time and a dynamic history. With a longer period, results could be strongly influenced by historical data that are not representative of current conditions with respect to municipal and industrial wastewater inputs. With shorter time period, trends are more difficult to detect because of the influence of year-to-year variation in rainfall, stream flows, and temperature.

Metropolitan Syracuse Wastewater Treatment Plant (Metro) on Hiawatha Boulevard.

ONONDAGA LAKE AND ITS WATERSHED

The Onondaga Lake drainage basin encompasses approximately 738 square kilometers (285 square miles) and lies almost entirely in Onondaga County. The drainage basin includes six natural sub-basins: Ninemile Creek, Harbor Brook, Onondaga Creek, Ley Creek, Bloody Brook, and Sawmill Creek (Figure 1). 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 two towns, two villages, and the City of Syracuse border the lake. Sediment and pollutants from the large watershed make their way to the lake.

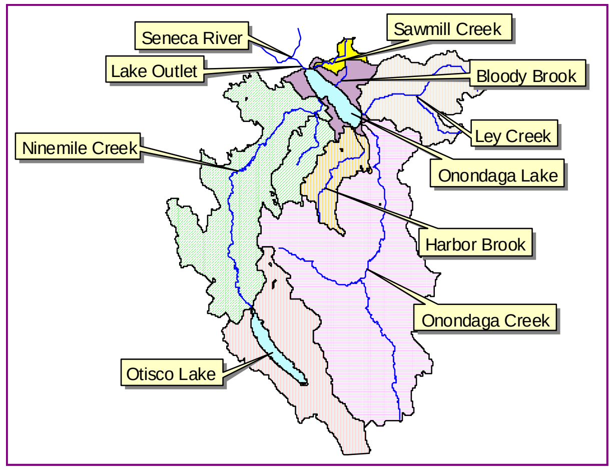

Figure 1. Onondaga Lake watershed.

Onondaga Lake is relatively small, especially compared with the nearby Finger Lakes and Oneida Lake. The shoreline is highly regular, with few bays. Much of the shoreline is owned by Onondaga County and is maintained as part of a popular park and trail system. The lakeside park is used for recreational activities such as jogging, biking, roller-blading, shoreline fishing, and cultural entertainment. The lake is used for secondary water contact recreation such as boating. Fishing derbies on Onondaga Lake attract thousands of anglers.

Fishing was banned in the lake in 1972 because of 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 the lake and restrict consumption of all other fish 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.

NYSDEC is responsible for managing water resources throughout the State. Lakes and streams are classified according to their designated best use (for example, water supply, swimming, recreational fishery, and/or aesthetic enjoyment). Monitoring results are evaluated regularly to determine if designated uses are supported. Because water quality and habitat conditions limit their use for swimming and ability to support aquatic life, Onondaga Lake and the Seneca River are among the State’s top priorities for water quality improvement.

Metro is a major source of nitrogen, phosphorus, bacteria, and organic (oxygen-demanding) material to Onondaga Lake. In early 2004 Metro was upgraded from an advanced secondary treatment plant, operated to enhance conversion of ammonia to nitrate during warm weather (in a process known as nitrification) and removal of phosphorus. The plant now provides year-round nitrification to increase removal of ammonia and oxygen-demanding material. Additional modifications were completed in early 2005 to enhance phosphorus removal as well. An ultra-violet disinfection system is used to kill microorganisms without using chlorine; this system is able to treat up to 126.3 million gallons per day (mgd). Metro can provide primary treatment to 240 mgd.

Nonpoint sources (such as runoff from agricultural, suburban, and urban areas) also contribute pollutants to Onondaga Lake. Nutrients, sediment, bacteria, metals, and pesticides reach surface water and groundwater from these diffuse sources. Industrial residuals in the watershed continue to enter the lake through surface runoff and infiltrating groundwater. Lake sediments contain elevated concentrations of mercury and organic chemicals.

AMP 2004 Results: Inflows (Tributaries and Metro)

Program Summary

Stream monitoring provides a basis for estimating the relative importance of sources of sediments, nutrients, bacteria and other potential pollutants. Understanding the contribution of various sources, such as urban stormwater and agriculture, will help managers determine effective strategies for meeting water quality and aesthetic goals for the lake.

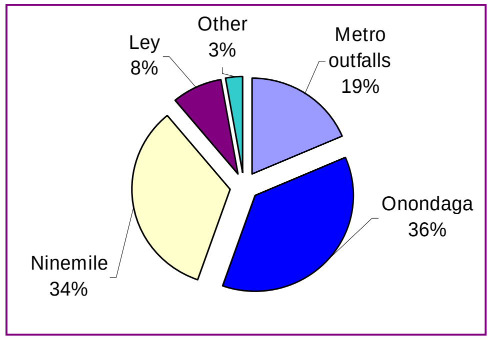

Figure 2. Annual flow contribution to Onondaga Lake, 2004 (gauged area) . *Note: "Other" consists of measured flow at Harbor Brook, Tributary 5A, and East Flume.*

Water Balance

Onondaga Lake receives water from two major tributaries (Onondaga and Ninemile Creeks) and several minor ones. The third largest contributor of water to Onondaga Lake is Metro (Figure 2). Metro treats wastewater from residential, commercial, and industrial sources within the service area. More than 90% of the flows entering the lake are measured (gauged).

In 2004, precipitation in Syracuse was 43.14 inches (109.6 cm), which was greater than the 30-year average of 38.91 inches.

Materials Balance

Results of the 2004 tributary monitoring program are summarized in Table 3. Note how the contributions of sediment, nutrients, bacteria, and chemicals vary by tributary. Onondaga Creek stands out as a major source of sediment and chloride. Treated effluent from Metro is a major source of nutrients, bacteria, and oxygen-demanding material.

Integrated Stream Assessments

Table 3. Percent contribution of gauged tributaries, and Metro to lake's water and material load, 2004.

(Note: gauged flow constitutes approx. 93% of all inputs)	**Onondaga Creek**	**Ninemile Creek**	**Metro Outfalls Discharge**	**Ley Creek, Harbor Brook, East Flume, Tributary 5A**
Water	36	34	19	11
Sediment	54	28	6.0	12
Total Phosphorus	15	12	66	6.8
Nitrate + Nitrite	14	14	69	3.3
TKN	17	21	54	8.6
Ammonia N	6.3	19	69	5.8
Bacteria	11	18	64	6.4
Chloride	42	29	20	9.2
Oxygen demanding materials	22	19	51	7.7

Because physical features affect the distribution and abundance of life in streams, the AMP examines habitat as well as water quality conditions in the Onondaga Lake watershed. Surveys of physical characteristics of the streams are conducted at regular intervals, along with periodic sampling of the macroinvertebrate community. **Macroinvertebrates** are aquatic insects, worms, clams, snails and other animals visible without the aid of a microscope. These animals spend at least part of their lives associated with the sediments and macrophytes of streams and lakes. Macroinvertebrates are included in the AMP because their numbers and types are closely linked to water quality and habitat conditions.

Results of the 2004 survey indicate that the macroinvertebrate communities of Onondaga Creek, Ley

Creek, and Harbor Brook are affected to various degrees by pollution and habitat degradation. 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, while urban runoff and CSOs influence the community in downstream segments.

Metro Phosphorus Loading

Because phosphorus is so important to lake ecology, its removal from wastewater has been a central focus of the improvements at Metro. Since 1987, the County has experimented with the amounts and types of chemicals added to the wastewater to maximize phosphorus removal. Phosphorus loading from Metro is plotted in Figure 3.

A phased limit for phosphorus discharged from Metro is included in the ACJ. The current (Stage I) maximum phosphorus discharge from Metro is 400 pounds per day; this limit has been consistently met since 1995. A Stage II limit of 0.12 mg/l (less than 90 pounds per day) is to be met by April 1, 2006.

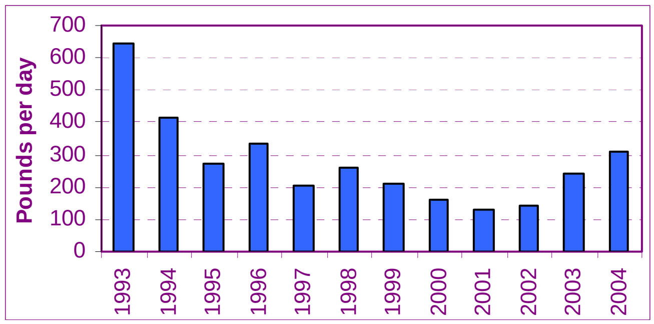

Figure 3. Annual phosphorus discharge from Metro, 1993 through 2004.

Meeting the proposed stage III limits of 0.02 mg/l (less than 15 pounds per day) will be challenging. Small-scale tests to determine how much additional phosphorus can be removed are underway to identify appropriate technology and performance limits. NYSDEC will set final Stage III limits using a Total Maximum Daily Load allocation for all sources of phosphorus.

Metro Nitrogen Loading

Metro is the major source of **ammonia nitrogen** to Onondaga Lake. Major improvements to Metro were completed in 2004 and the facility now successfully reduces ammonia concentration in wastewater throughout the year. Ammonia is converted to nitrate (a non-toxic form of nitrogen) in a biological process that takes place in 18 large cells filled with billions of tiny beads. The beads provide a huge surface area for the biological treatment. This upgrade to the treatment process was necessary to reduce the lake's ammonia nitrogen to safe levels for the aquatic community. Metro now meets the final effluent limits of 1-2 mg/l (less than 1000 pounds per day) eight years ahead of the scheduled date (December 1, 2012). Ammonia nitrogen discharge from Metro is plotted in Figure 4.

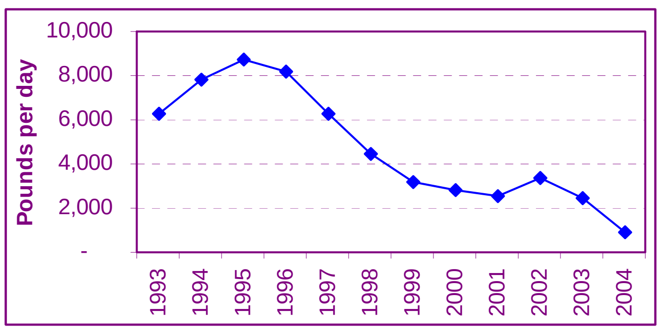

Figure 4. Annual ammonia nitrogen discharge from Metro, 1993 through 2004.

AMP 2004 RESULTS: ONONDAGA LAKE

PROGRAM SUMMARY

The County's comprehensive monitoring program of Onondaga Lake is designed to measure the effectiveness of controls on Metro and the CSOs. Samples are collected regularly throughout the ice-free season to characterize water quality conditions in the lake. Data are used to assess compliance with water quality standards and progress toward lake improvement. Experts in statistics have reviewed the monitoring program design to ensure that it will support firm conclusions regarding effectiveness of the control measures. Monitoring of the **macrophyte** community is conducted periodically, along with assessment of other major components of the lake's food web: **phytoplankton**, **zooplankton**, **macroinvertebrates**, and the **fish community**.

Indicators of Progress: Is the Lake Safe for Water Contact Recreation?

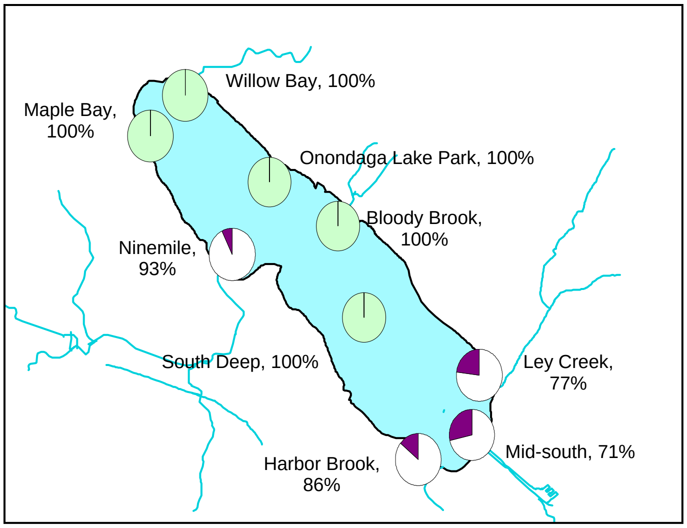

Figure 5. Percent compliance (white) with bacteria standards, summer 2004. (Green indicates 100% compliance. Purple indicates percent non-compliance.)

Bacteria Levels

Restoring recreational uses of the lake is a major goal of the improvements to the County's wastewater collection and treatment system. The AMP includes sampling for **fecal coliform bacteria** in nearshore areas. Sampling occurs during dry weather and following storms. Results of bacteria monitoring conducted from June—September 2004 are displayed in Figure 5. The southern end of the lake occasionally had high levels of fecal coliform bacteria following storms. This finding highlights the need for continued progress with the CSO projects.

However, microbiological quality improves greatly away from the southern tributaries. Water quality in Willow Bay, Maple Bay, and Onondaga Lake Park met bacteria standards of less than 200 cells per 100 milliliters for recreation during the summer of 2004. This finding is significant, given the relatively wet summer of 2004.

Nearshore Water Clarity

The NYS Department of Health recommends that water clarity in swimming areas be at least 4 ft (1.2 m) to maintain public safety. Onondaga County has monitored compliance with this guidance value at eight stations around the lake each summer since 1999. Figure 6 shows that nearshore water clarity was occasionally limited during the summer of 2004.

Nearshore transparency results are affected by wind, waves, precipitation, and algae. Results can be highly variable from day to day. No trends of increased or decreased water clarity have been detected.

Beginning in 2004, the AMP team is also tracking the development and extent of algal mats in nearshore areas.

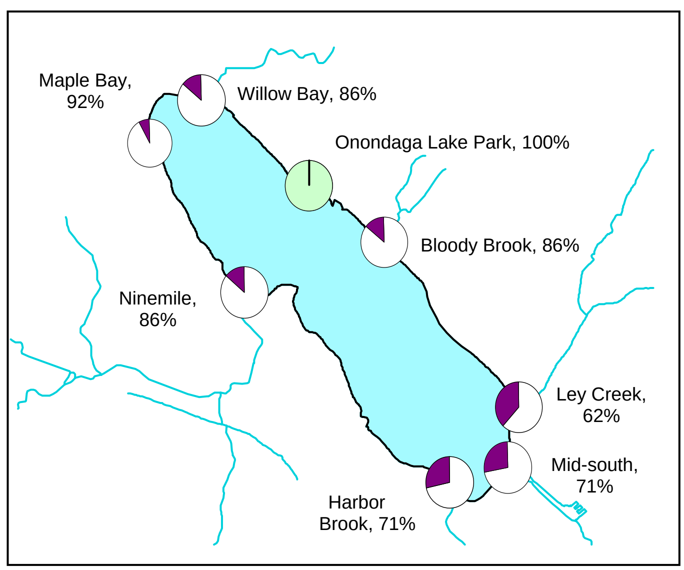

Figure 6. Percent compliance (white) with nearshore transparency guidance, summer 2004. (Green indicates 100% compliance; purple indicates percent non-compliance.)

Indicators of Progress: Is the Lake Visually Attractive?

The Importance of Phosphorus to the Lake's Aesthetic Quality

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 positively correlated with algal abundance. Excessive algae will make a lake appear turbid or green and diminish its attractiveness for recreational use. Decay of algae reduces the concentration of dissolved oxygen in a lake's deeper waters. Consequently, lake managers focus on controlling phosphorus inputs to protect recreational use and aquatic life. Trends in summer average concentration of phosphorus in the upper waters of the lake (the zone where plants and algae grow) are displayed in Figure 7.

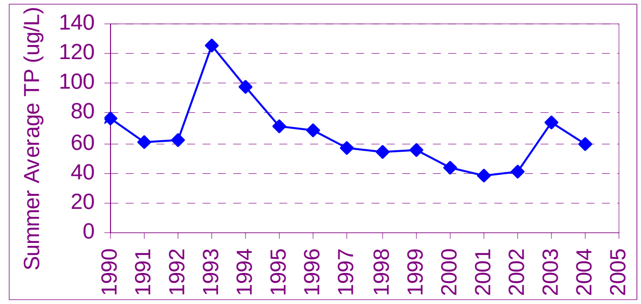

Figure 7. Summer (June-Sept) average total phosphorus, 0-3 meters, Onondaga Lake South Deep station.

Algae and Water Clarity

The concentration of **chlorophyll-a**, the major photosynthetic pigment in plants, is used as an index of algal abundance. Many water resources agencies have developed guidelines on chlorophyll-*a* to protect recreational uses in lakes. In New York, concentrations exceeding 13 µg/l are considered to impair recreational use.

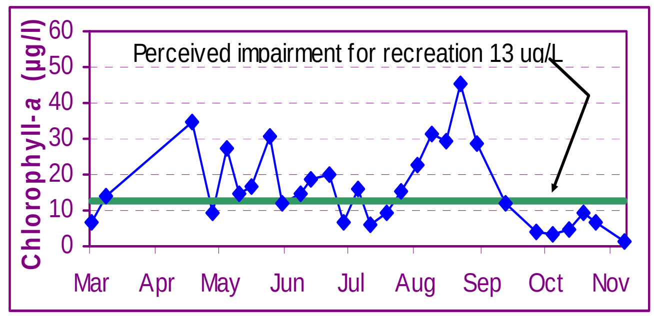

Figure 8. 2004 chlorophyll-a, upper mixed layer, South Deep station.

Chlorophyll-*a* concentration in the lake's upper mixed layer waters averaged 20 µg/l during the summer of 2004. The spring bloom, characteristic of Onondaga Lake, was followed by moderate but variable concentrations through much of the summer. Bloom conditions developed again in the fall, with the highest concentration in mid-September (Figure 8). The 2004 summer chlorophyll-*a* concentrations were lower than measured in 2003 (Figure 9).

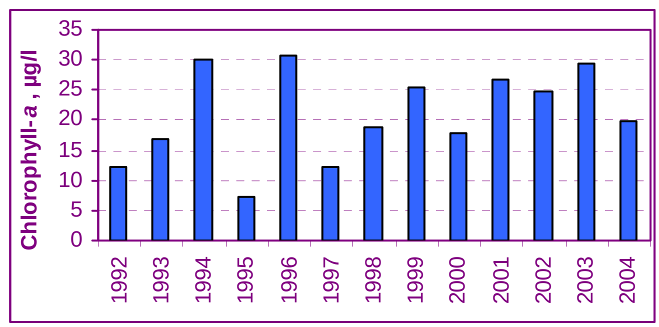

Figure 9. Summer average (June - Sept) chlorophyll-*a* concentration, Onondaga Lake South Deep Station (upper mixed layer), 1992-2004.

The 2004 **Secchi disk transparency** measurements in Onondaga Lake are plotted in Figure 10. Water clarity varied within a relatively small range during the summer and was improved from 2003. This finding is consistent with the chlorophyll-*a* measurements. Once again, the lake did not exhibit the springtime high water clarity (clearing event) that was typical during the 1990s. This is attributed to the loss of larger zooplankton, which are very efficient grazers of algae. An abundance of alewives appears to be causing the loss of the larger zooplankton; this fish preferentially feeds on larger zooplankton.

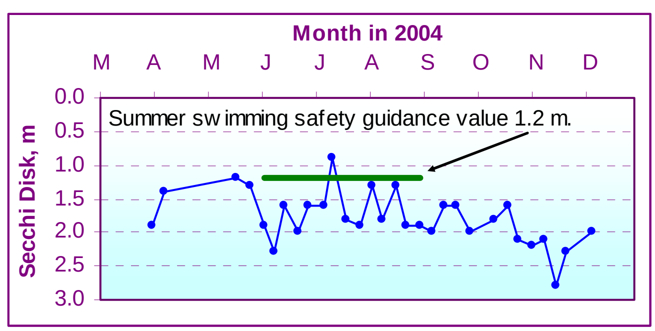

Figure 10. Secchi Disk transparency at South Deep Station.

Water clarity varies each year (Figure 11); Secchi disk transparency is affected primarily by algal abundance, although inorganic sediment particles and dissolved materials can affect the color and clarity of the water. The time period displayed in this graph encompasses many factors: changes in phosphorus loading, zebra mussels (first reported as abundant in 1999) and the loss of larger zooplankton noted since mid-2002.

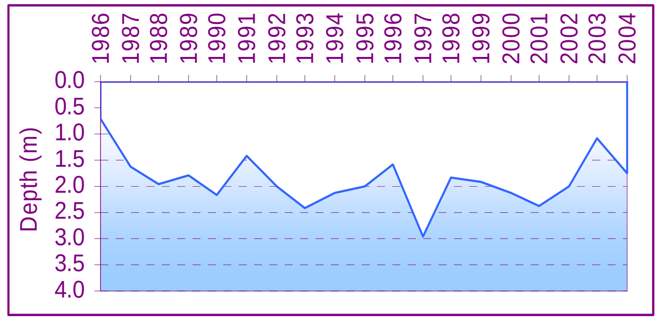

Figure 11. Summer average (June-Sept) Secchi Disk transparency, Onondaga Lake South Deep Station, 1986-2004.

Indicators of Progress: Can Onondaga Lake Water Quality Support a Balanced Community of Plants and Animals?

Ammonia and Nitrite Concentrations

Ammonia and nitrite concentrations are major factors affecting the type and abundance of aquatic life in Onondaga Lake. Reductions in concentration of these harmful forms of nitrogen are required to meet **water quality standards and criteria** and protect a diverse aquatic community. With improved Metro effluent quality, concentrations are decreasing (Figure 12) and habitat is improving for sensitive early life stages of fish and other aquatic animals.

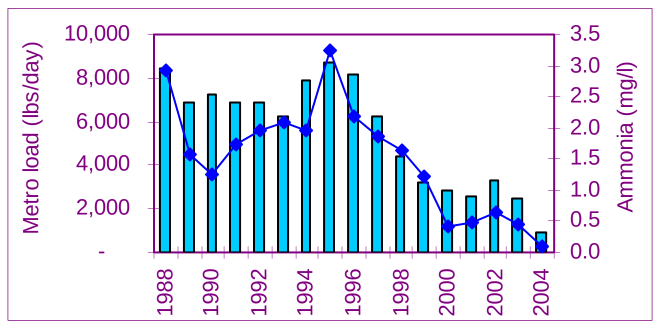

Figure 12. Summer average ammonia-N concentrations, in upper mixed layer of Onondaga Lake (line) , South Deep Station, 1988-2004, and Metro ammonia load (bars).

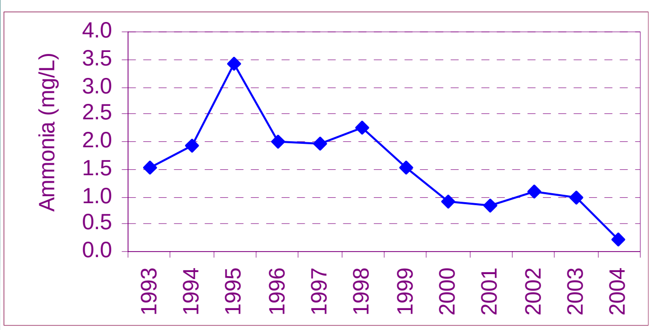

Figure 13. Average Ammonia at 3 m, Spring April 1—June 15 each year, South Deep.

In 2004, the lake's upper waters were in compliance with ambient water quality standards for ammonia N. Exceedances of the standard have historically occurred in the winter and spring as a result of Metro load. Completion of the Biological Aerated Filter (BAF) system at Metro in early 2004 ensured that spring ammonia levels were low (Figure 13).

The concentration of nitrite measured in the lake's upper waters during 2004 is displayed in Figure 14. The standard for nitrite is 0.1 mg/l, a level considered safe for a warmwater fish community. In 2004, the nitrite concentrations gradually increased over the monitoring period and peaked just above the standard during the fall when the lake waters cooled and mixed. This may represent incomplete transformation of the ammonia that accumulated in the lake's lower waters.

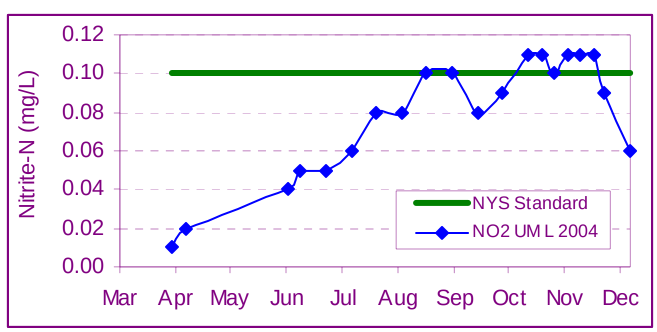

Figure 14. Average nitrite-N (NO2), upper mixed layer, South Deep during 2004.

Dissolved Oxygen

The **dissolved oxygen** (DO) status of Onondaga Lake is closely linked to its annual temperature cycle. During summer, the lake's deeper waters remain isolated from the atmosphere. Light to support photosynthesis by algae or aquatic plants cannot reach the deeper waters; thus no oxygen production occurs. DO in the lower waters is used during decomposition of organic material settling from the sunlit layers above. When DO is depleted, the waters become anoxic and chemicals such as iron, ammonia, hydrogen sulfide, and methane accumulate.

When the lake cools in the fall, temperature differences that keep the water layers isolated begin to break down. Gradually, the deep anoxic waters mix with the upper waters. As the iron, ammonia, hydrogen sulfide, and methane mix into the upper waters, DO is reduced. To comply with state and federal standards designed to protect aquatic life, DO should always remain above 4 - 5 mg/l in the upper waters, even during the fall mixing period.

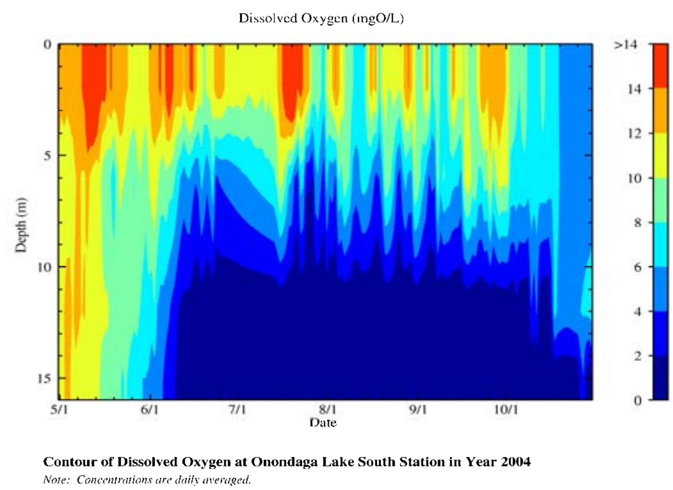

Figure 15. Dissolved oxygen (DO) in Onondaga Lake South Deep station, 2004, in milligrams of oxygen per liter (mgO_2/L)

DO measurements obtained during the 2004 monitoring season are displayed in Figure 15. Note the rapid depletion of DO in the lower waters in late 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 5 mg/l of DO as they cooled and began to mix with the anoxic lower waters. Complete mixing occurred by mid-October, and concentration of DO gradually increased as the waters mixed and gained oxygen from the atmosphere. In 2004, the upper waters were in compliance with the ambient water quality standard throughout this critical period.

Onondaga County has had a water quality monitoring buoy at South Deep station since 2001. Suspended from the buoy is an array of monitoring and recording instruments; the DO data plotted in Figure 15 were measured by the buoy. Results are transmitted back to a computer at the OCDWEP offices on Hiawatha Boulevard. The buoy is in operation from early spring to late fall. Data can be viewed through the County's website at ***www.ongov.net***. 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.

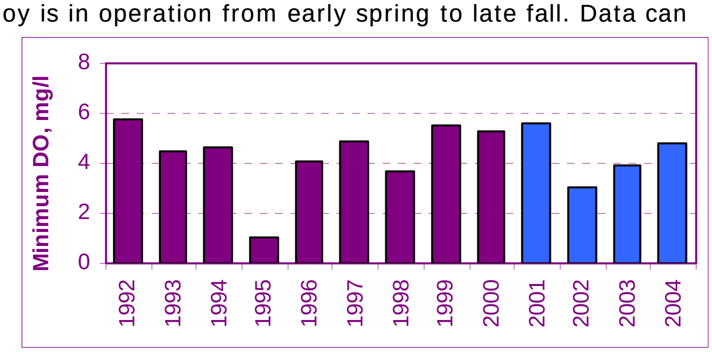

Figure 16. Minimum DO in upper waters during fall mixing, South Deep station, 1992-2004. Blue bars are high-frequency buoy data (15-minute intervals, 2 meters); purple bars are volume-averaged, low-frequency profile data (one per day, 3 meters). September to November.

Minimum DO concentrations measured in the lake's upper waters during fall mixing since 1992 are plotted in Figure 16. Note the variability in this measurement. Some of the variability depends on winds and air temperatures. However, the pool of iron, hydrogen sulfide, ammonia, and methane that accumulates over the summer period ultimately affects oxygen depletion in the fall. As algal biomass is reduced, decomposition in the lower waters will eventually decline.

Elements of a Balanced Biological Community

Monitoring the biological community of Onondaga Lake and its watershed is an important part of the AMP. The nearshore areas of Onondaga Lake are subject to different wave energy that has led to variation in the type and stability of nearshore sediments. To assess the importance of these different habitat conditions, the AMP uses a stratified sampling design. Biological data are collected, analyzed and reported in five distinct nearshore strata (Figure 17).

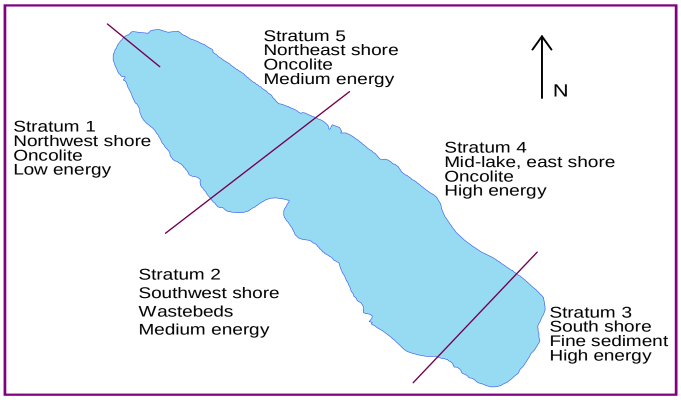

Figure 17. Strata used in Onondaga Lake biological programs.

Macroinvertebrates

Onondaga Lake's **littoral** (nearshore) macroinvertebrate community is sampled every five years. Results of the most recent event in 2000 reveal differences in the macroinvertebrate community between the lake's northern and southern ends (Figure 18). The macroinvertebrate community in the northern strata is less affected by the pollutant inputs that dominate the southern basin: wastewater, contaminated and/or saline groundwater, and sediment. The combined influences of eutrophication and habitat degradation are structuring elements of the littoral benthic community.

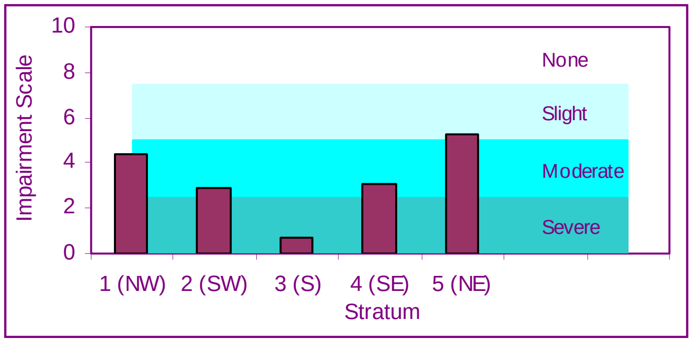

Figure 18 Status of the littoral macroinvertebrate community, assessed using standard indices of pollution tolerance, Onondaga Lake, 2000.

The impairment scale in Figure 18 was developed by NYSDEC; high numbers indicate better conditions. The 2005 sampling event may indicate whether conditions are improving, particularly in the southern strata where loading reductions from Metro and the CSO abatement projects could affect nearshore water quality and habitat conditions. However, the sediment remedial measures planned by Honeywell are more likely to directly affect the littoral habitat. The 2010 survey may show improvement following the remediation.

Macroinvertebrates collected in the lake tributaries. Photo includes common organisms such as snails, dragonfly, water beetle, mayfly, and caddisfly.

Macrophytes

Macrophytes stabilize the lake's bottom sediments, and provide food and shelter for young fish. Detailed surveys are completed every five years and aerial photographs are obtained each year as weather and water clarity allow.

A baseline survey in 2000 indicated a distribution among strata similar to that of the macroinvertebrates

(Figure 19). Both the number of plant species in the lake and the area covered with plants have increased. These surveys occur every five years, with the next survey scheduled for 2005. Aerial photos indicate that the abundance of macrophytes in the shoreline zone is increasing.

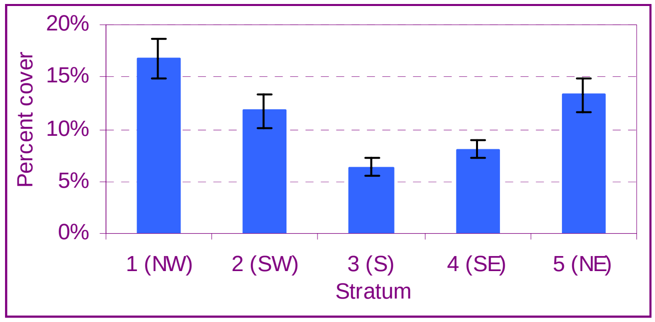

Figure 19. Average percent cover of macrophytes in littoral zone of Onondaga Lake, 2000. Error bars indicate plus/minus standard error.

Phytoplankton and Zooplankton

Researchers from the Cornell Biological Field Station evaluated the community of **phytoplankton** and **zooplankton** in 2004, as they have done each year since inception of the AMP. 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 is affected by the intensity of feeding by the fish community. In 2004 the average size of zooplankton was very small, presumably due to increases in alewife grazing pressure removing larger organisms from the community.

Invasive Species

Invasive (non-native) species are an important factor affecting ecosystems throughout the Great Lakes Basin, and Onondaga Lake is no exception. The 2004 field investigations documented the continued presence of a predatory cladoceran zooplankton *Cercopagis pengoi*. This organism was introduced to the Great Lakes from the Caspian Sea region in Eurasia and is rapidly making its way into adjacent waterways. Shipping and ballast waters are the presumed mechanism for transfer of organisms from remote areas.

Indicators of Progress: Does the Lake Have a Self-Sustaining Warmwater Fish Community?

Fish are among the most important elements of the food web of any lake and the AMP includes a major effort to track the types of fish present in the lake and their reproductive success. Onondaga Lake is part of a larger aquatic ecosystem, and it is clear that there is migration between Onondaga Lake, the Seneca River, and Oneida Lake. Therefore, the fish community in Onondaga Lake may be supplemented by fish moving in from other parts of the system.

The County uses a combination of classical and innovative techniques to count nests; sample larval, juvenile, and adult fish; and track changes in the fish community. Data are collected each year as improvements to wastewater collection and treatment are phased in. Cooperating anglers are recruited to keep annual diaries of their fishing efforts and successes, and report this information to the County. 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.

Since the program began in 2000, sampling of the juvenile and adult fish community has resulted in collection of approximately 43,000 fish representing 38 species. Smallmouth bass nests were documented for the first time in Onondaga Lake in 2000.

2004 fish survey results show that the lake is dominated by warmwater species that are tolerant of pollution. Gamefish are widespread in the lake but more common in the northern than the southern end of the lake (Figure 20). This abundance pattern is consistent with other indices (macrophytes, macroinvertebrates, substrate quality) showing that the southern end provides poorer habitat quality.

Other gamefish, such as walleye and northern pike, are present but much rarer than bass. Panfish, such as yellow perch, pumpkinseed, and bluegill, are common in nearshore areas.

The AMP calculates several indicators to evaluate the condition of the lake's fish community. Results indicate that Onondaga Lake supports a diverse assemblage of species, with planktivorous warmwater species, tolerant or moderately tolerant of pollution, most abundant. Fish appear to be in good condition with weights within expected ranges. Gamefish catch rates from electrofishing were typically on the low end of New York State averages for walleye and pike but close to average for bass.

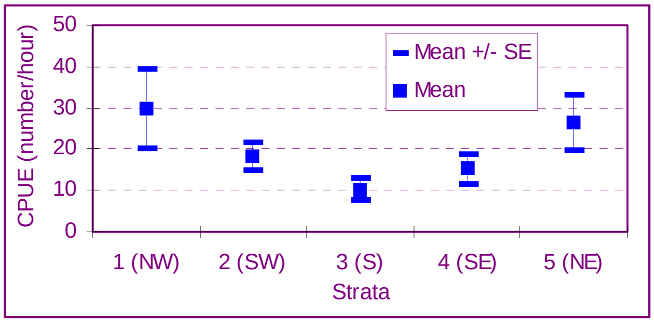

Figure 20. Adult smallmouth bass distribution, 2000—2004. Scale CPUE is "catch per unit effort", a standard calculation of abundance. SE is standard error, an estimate of variability.

AMP 2004 RESULTS: SENECA RIVER

PROGRAM SUMMARY

The Seneca River connects Onondaga Lake to the greater Oswego River-Great Lakes system (Figure 21). Fish and other organisms, including invasive species, can move in and out of the lake through the Seneca River. Water quality of the river is directly affected by the outflow of Onondaga Lake. The capacity of the river to handle additional treated wastewater will affect the final alternatives for discharge of the Metro effluent.

In 2004, OCDWEP completed two water quality surveys in the river to characterize water quality conditions, assess the impact of the zebra mussel on water quality, and support the Three Rivers Water Quality Model (TRWQM). The distribution and abundance of zebra mussels along a segment of the river extending from Jack's Reef to the Three Rivers junction were mapped in the spring and summer of 2004.

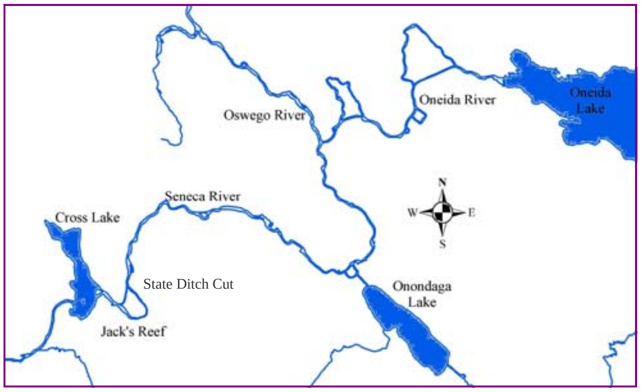

Figure 21. Onondaga Lake and the Seneca-Oneida-Oswego River System

2004 FINDINGS

Through the monitoring and modeling completed on the Seneca River, it is clear that zebra mussels have profoundly altered ecological conditions. In the early 1990s, the Seneca River was nutrient-rich and green with algae during the summer. Dissolved oxygen concentrations were variable, but remained at levels that could support a balanced aquatic community. Phosphorus was present primarily in the particulate form; that is, incorporated into algal biomass. Post zebra mussel conditions are different. Water clarity is high as phytoplankton are removed by active grazing. Dissolved oxygen levels are significantly lower due to the respiration of the benthic mussels. Phosphorus is now present primarily in the soluble form. Surveys along the river indicate that zebra mussel density is highest in the region of the State Ditch Cut, where the combination of hard substrate, moderate stream velocity, and abundant food source from Cross Lake provide ideal conditions for the mussels.

Results of the 2004 water quality surveys were consistent with this overall description. However, river flows were high, in response to the high precipitation during the summer of 2004. DO concentrations remained above standards during the water quality surveys. There were no violations of the ammonia standard measured in 2004.

CONCLUSIONS

Onondaga County DWEP is responsible for a comprehensive monitoring program encompassing Onondaga Lake, the lake's tributary streams, and a segment of the Seneca River. In 2004, the County's state-certified environmental laboratory completed over 20,000 analyses to characterize the lake and its watershed. Trained technicians collected hundreds of samples of the biological community from microscopic algae to fish. This monitoring effort is designed to provide information needed to evaluate the effectiveness of improvements to the County's wastewater collection and treatment system.

Results of the 2004 AMP indicate improving water quality conditions. The effectiveness of the ammonia removal at Metro is evident. However, the ecological changes are also affecting the lake. Significant findings are summarized below.

- Summer total phosphorus concentrations in the lake's upper waters were approximately 60 ug/l in 2004, well above the NYSDEC guidance value of 20 ug/l. Algal abundance in 2004 was less than 2003 abundance and blooms were restricted to spring and fall.
- Dissolved oxygen (DO) was depleted from the lake's deep waters during the summer, thus restricting the habitat for most aquatic organisms to the warmer upper waters. This phenomenon is seen in many productive lakes. However, Onondaga Lake also has low DO concentrations in the fall, when oxygen-depleted waters from deep in the lake are mixed through the water column. Fall DO levels in 2004 were within acceptable ranges for aquatic life, a sign of improving water quality. Ammonia nitrogen concentrations have reached levels that protect even the most sensitive aquatic organisms. Nitrite concentrations were reduced in 2004, but fall levels remain slightly above standards.
- During the summer of 2004, bacteria concentrations along the lake's southern shoreline occasionally exceeded public health standards following rainstorms. Conditions were greatly improved in the northern areas. The County will continue to monitor bacteria concentrations to evaluate how the CSO abatement projects are improving lake quality.
- The biological programs are providing important information illustrating the linkages between improved water quality and the lake's community of plants and animals. Extensive monitoring indicates that the lake supports a balanced community of warmwater fish.
- Largemouth bass, smallmouth bass, and panfish are successfully reproducing in the lake; the growth rates of these warmwater fish are normal for New York lakes. As of 2004, the AMP has documented 38 species present in Onondaga Lake. This is likely a result of the open connection between Onondaga Lake and the Seneca River.
- Alewives are prolific; these fish preferentially graze on larger-bodied zooplankton, such as *Daphnia,* that have been helping to keep algae under control. Larger zooplankton remained absent from the 2004 samples. Loss of the larger zooplankton has resulted in a zooplankton community dominated by smaller organisms, which are much less efficient in grazing algae.

Onondaga County's 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 the restored lake and watershed.

A Final Note on the Fish Community

For most of the 1900s, many thought that Onondaga Lake was too polluted for fish to survive. However, recent studies have found that Onondaga Lake actually supports a productive fish community.

Over 21,000 fish representing 31 species were collected during 2004 as part of the County's Ambient Monitoring Program. The number of fish captured in 2004 was more than double that of 2003. This was due to a more than ten-fold increase in the catch of alewives (a small forage fish). Abundance of most other fish species in the lake has remained steady since at least the year 2000.

Two species not previously documented in the Ambient Monitoring Program were collected in 2004: lake sturgeon and yellow bullhead. The lake sturgeon, a threatened species in New York, was the first documented occurrence of that species in Onondaga Lake. A tag on the sturgeon indicated it was stocked in Oneida Lake in 1995 as part of ongoing restoration efforts. Yellow bullhead have been captured in the lake during other fish surveys in the 1990s.

This 51-inch long lake sturgeon was caught by the Ambient Monitoring Program sample crews in Onondaga Lake in 2004.

Another species documented in Onondaga Lake is brown trout. Brown trout prefer cooler water temperatures with enough dissolved oxygen in the water column to "breathe." It is likely that brown trout migrate between Onondaga Lake and its tributaries during the year, moving to where temperature and dissolved oxygen conditions are most suitable. Typically during the summer months, Onondaga Lake has unsuitable conditions for brown trout.

Large brown trout have been captured in Onondaga Lake since the early-1990s, usually in the springtime when temperatures and dissolved oxygen levels were suitable. In 2004, a brown trout was captured in the lake in July. This could point to improved summertime dissolved oxygen conditions in Onondaga Lake.

Fish Facts

What popular gamefish are commonly found in Onondaga Lake?	Largemouth bass, Smallmouth bass, Walleye, Northern pike, Tiger muskellunge, Yellow perch, Bluegill, Pumpkinseed, Bullheads, Catfish, Carp
How many species of fish have been captured in Onondaga Lake since 2000?	38 *(This compares favorably with the number of fish species found in other Finger Lakes.)*
Which fish species reproduce successfully in Onondaga Lake?	Examples include: Largemouth bass, Smallmouth bass, Pumpkinseed, Bluegill, White perch, Yellow perch
Which fish species do not reproduce successfully in Onondaga Lake?	Examples include: Walleye, Brown trout, Northern pike *(These fish rely on migration of adult fish from the Seneca River or lake tributaries to maintain the lake population.)*
What is the general condition of the fish caught in Onondaga Lake?	Good condition, healthy weight, and good growth. Low incidence of deformities, lesions, tumors, erosions or other abnormalities.

Six-year-old Timmy Gandino caught this 28-pound carp in the Onondaga Lake outlet. Photo courtesy of Chris Gandino.

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.

Biological Aerated Filter (BAF). Treatment process to biologically convert (oxidize) ammonia to nitrate; this treatment came on line at Metro in February 2004 and is effective year-round in ammonia removal.

Chlorophyll-a. The primary photosynthetic pigment in algal (phytoplankton) 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 intestinal tract of mammals. 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 sewage contamination.

Littoral zone. Shoreline habitat of a lake extending from the water's edge to the limit of light penetration to the sediment surface (often, the greatest depth occupied by rooted plants).

Macroinvertebrate. Aquatic insects, worms, clams, snails and other animals that spend at least part of their life cycle associated with sediments or macrophytes of streams and lakes. Numbers and types of these organisms are used to infer water quality and habitat conditions.

Macrophytes. Aquatic plants large enough to be seen without magnification. While most are rooted, some forms are free-floating. Macrophytes are an important component of the lake's food web.

Metro (Syracuse Metropolitan Wastewater Treatment Plant). Advanced secondary wastewater treatment plant on Hiawatha Boulevard being upgraded for enhanced removal of ammonia and phosphorus, and other improvements.

Nitrification. The biological conversion of ammonia to nitrate.

Nonpoint source pollution. Pollution sources which are diffuse and do not enter receiving waters from a specific outlet. The pollutants (such as sediment, nutrients, microorganisms etc) are generally carried off the land by stormwater runoff.

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
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