Onondaga County Department of WATER ENVIRONMENT PROTECTION

Onondaga Lake Ambient Monitoring Program

2004 Annual Report
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Onondaga County, New York
Nicholas J. Pirro, County Executive

ONONDAGA LAKE AMBIENT MONITORING PROGRAM

2004 ANNUAL REPORT

REPORT AND APPENDICES 1-12

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LIST OF ACRONYMS

AMP-Ambient Monitoring Program
ACJ-Amended Consent Judgment
ASLF-Atlantic States Legal Foundation
AWQS-Ambient Water Quality Standards
BAF-Biological Aerated Filter
BAP-Biological Assessment Profiles
BMP-Best Management Practices
BOD-Biochemical Oxygen Demand
CERCLA-Comprehensive Environmental Response, Compensation, and Liability Act
CSO-Combined Sewer Overflows
DAIP-Data Analysis and Interpretation Plan
DO-Dissolved Oxygen
DVT-Data Visualization Tool
EPA-Environmental Protection Agency
GIS-Geographic Information System
HBI-Hilsenhoff Biotic Index
HRFS–High Rate Flocculated Settling
ISD-Impact Source Determination
METRO–Metropolitan Syracuse Wastewater Treatment Plant
MRL-Minimum Reporting Level
N-Nitrogen
NOAA–National Oceanic Administration Agency
NPL-National Priority List
NYSDEC-New York State Department of Environmental Conservation
OCDWEP–Onondaga County Department of Water Environment Protection
OLP-Onondaga Lake Partnership
OLTAC-Onondaga Lake Technical Advisory Committee
OLWQM-Onondaga Lake Water Quality Model
QEA-Quantitative Environmental Analysis, LLC
RCRA-Resource Conservation and Recovery Act
RI/FS-Remedial Investigation/Feasibility Study
RFP-Request For Proposal
RSE-Relative Standard Error
SPDES-State Pollution Discharge Elimination System
SRP-Soluble Reactive Phosphorus
SSO-Sanitary Sewer Overflow
TKN-Total Kjeldahl Nitrogen
TMDL-Total Maximum Daily Load
TP-Total Phosphorus
TSS-Total Suspended Solids
USGS-United States Geological Survey

2004 AMP ANNUAL REPORT SUMMARY

Onondaga County Department of Water Environment Protection (OCDWEP) is required to conduct an annual program to evaluate the water quality conditions of Onondaga Lake, the lake tributaries, and a portion of the Seneca River. An Amended Consent Judgment signed in 1998 requires Onondaga County to complete three major tasks: first, to upgrade the level of treatment at the Metropolitan Syracuse Wastewater Treatment Plant (Metro); second, to mitigate the Combined Sewer Overflows (CSOs); and third, to implement an Ambient Monitoring Program (AMP) that will track the effectiveness of these improvements to the wastewater collection and treatment infrastructure. Each year the County prepares an annual report of its findings.

The AMP is designed 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. In addition to the water quality-related program, the AMP examines many levels of the biological community of the lake and its watershed. The AMP includes an assessment of zebra mussels, benthic macroinvertebrates, aquatic plants, phytoplankton, zooplankton, and fish.

A rigorous Quality Assurance/Quality Control program is in place. Results of internal and external audits, blanks, and duplicates are presented in the Annual AMP report. Samples are collected by trained technicians and analyzed in a State-certified laboratory. The annual AMP workplan is subject to New York State Department of Environmental Conservation (NYSDEC) review and approval. A panel of technical experts (the Onondaga Lake Technical Advisory Committee) reviews the program findings and interpretive reports each year.

Technological advances now allow the County to monitor water quality conditions on a near-real time basis. Water quality buoys installed on the lake provide a window into variability in conditions in response to winds and waves. Acoustic Doppler devices installed at the lake's outflow by the U.S. Geological Survey provide data needed to assess water flux between the lake and the Seneca River.

As part of the AMP, OCDWEP tests over 20,000 water samples and examines several thousand biological samples each year. The 2004 data have been appended to the custom long-term database developed by Dr. William W. Walker Jr. The database, which merges the County's tributary and lake data from 1968 to the current year, has greatly improved data management and reporting tasks.

The AMP builds on Onondaga County's historical monitoring program, which provides a basis for evaluating trends over time. Overall, water quality is improving. Phosphorus and ammonia concentrations have decreased as wastewater treatment improved. In response, the levels of dissolved oxygen have increased throughout the lake's water column. Algal blooms are diminishing. Improved water clarity has allowed the beds of aquatic plants to expand; this has provided improved nesting and nursery habitat for the warmwater fish community.

The 2004 results are consistent with the trend of improving conditions. The Biological Aerated Filter (BAF) system at Metro that provides year-round nitrification came on-line in 2004. Metro has reduced its annual discharge of ammonia from about four metric tons (late 1990s) to one metric ton in 2004. Ammonia concentrations in Onondaga Lake in 2004 were the lowest ever measured, and remained at safe levels for even the most sensitive aquatic organisms.

Bacteria concentrations were monitored at a network of nearshore stations as well as at South Deep, the primary water quality monitoring site. These data are used to track progress towards water quality conditions that support recreational use. In 2004, despite the rainy weather, bacteria concentrations at the northern stations consistently met standards for water contact recreation. However, concentrations at the southern stations, near the major tributaries and Metro discharge, were elevated following storms. This result highlights the need for continued progress towards controlling CSOs, as well as the need for improved storm water management.

Dissolved oxygen (DO) levels also showed improvement in 2004. The volume-days of anoxia have declined and DO concentrations during the fall mixing period, a critical period in Onondaga Lake, were in compliance with regulatory standards.

Phosphorus concentrations in the lake have remained relatively stable since 2000. Algal abundance has been variable over this same time period, however. Chlorophyll-*a* concentration in the lake's upper waters averaged 16.5 µg/l during the summer of 2004. The spring bloom, which is characteristic of Onondaga Lake, was followed by moderate but variable concentrations through much of the summer recreational period. Bloom conditions developed again in the fall, with the highest concentration in mid-September. Average 2004 summer chlorophyll-*a* concentrations were much lower (about half) of the values measured during 2003.

The relative importance of cyanobacteria (blue-green algae) is of concern to lake managers because these organisms can proliferate, degrading water quality and the aesthetic environment. The percent contribution of cyanobacteria to the total phytoplankton community has been greatly reduced since the mid-1990s. Moreover, the intensity of the cyanobacterial blooms has been greatly reduced since 2000.

Onondaga Lake's water clarity is variable both within and between years. A spring clear-water phase was evident from the mid-1990s through the early years of this century, and was attributed to a seasonal peak in the abundance of larger zooplankton. However, larger zooplankton are now essentially absent from the community, and the spring clearing events have disappeared as well. Larger zooplankton, which are efficient grazers of phytoplankton, are the preferred food source of the alewife. This fish has recently become prolific in the lake, and its effects are seen throughout the food web.

Results of the 2004 fishery components of the AMP indicate that the lake is dominated by warmwater species that are tolerant of pollution. Largemouth and smallmouth bass are present, and are more common in the lake's northern basin. This abundance pattern is consistent with other indices (including macrophytes, macroinvertebrates, and substrate quality) showing that the southern basin 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 alewife was highly dominant in 2004, comprising more than 90% of the electrofishing catch.

Other biological programs were completed in 2004, including the biennial survey of the macroinvertebrate communities of the CSO-affected tributaries. Sites are located upstream and downstream of CSOs. Results at the majority of sites were consistent with surveys completed in 2000 and 2002. A notable exception was Onondaga Creek at Spencer St., where the macroinvertebrate community showed significant improvement in 2004.

Onondaga County completed a focused water quality monitoring effort at selected stations along the Seneca-Oneida-Oswego River system in 2004. The river program is designed to assess water quality conditions with respect to ambient water quality standards and support the Three Rivers Water Quality Model. High flows during the summer of 2004 helped maintain DO levels over the minimum standards during 2004. Ammonia concentrations were also in compliance. The river's water quality conditions continue to be strongly influenced by the effect of the zebra mussel metabolism.

The 2004 AMP report includes a series of metrics evaluating progress towards compliance with ambient water quality standards and attainment of designated uses. Several recommendations for additional investigations are included in the final section.

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CHAPTER 1:
OVERVIEW OF THE AMBIENT MONITORING PROGRAM (AMP)

1.1 HISTORY OF THE ONONDAGA COUNTY AMP

The 2004 Onondaga County Department of Water Environment Protection's (OCDWEP) Ambient Monitoring Program (AMP) represents the 35th consecutive year of Onondaga County's lake monitoring effort. The program began in 1970 as a baseline evaluation of the "state of the lake." Over time, the program evolved into an annual monitoring effort designed to track water quality conditions of the lake and its watershed.

In 1998, the County's existing lake monitoring program was modified to comply with the requirements of an Amended Consent Judgment (ACJ) between Onondaga County, New York State, and the Atlantic States Legal Foundation. The ACJ settled a suit between the parties regarding performance of the Onondaga County wastewater collection and treatment system. By signing the ACJ, Onondaga County committed to a 15-year program to design and implement three elements:

(1) Improvements to the wastewater and stormwater collection systems to abate Combined Sewer Overflows (CSOs).
(2) Improvements to the Metropolitan Syracuse Wastewater Treatment Plant (Metro) to reduce the concentration of ammonia N, phosphorus, BOD, solids, and bacteria in treated effluent prior to discharge.
(3) A comprehensive monitoring program of Onondaga Lake, the lake tributaries, and the Seneca River to track their response to the pollution abatement actions.

The ACJ included specific monitoring requirements for the lake, the tributaries, and the river to track their response to the pollution abatement actions. To meet these requirements, the existing lake monitoring program was modified and expanded. This process of evaluation and modification was a collaborative effort of six entities:

Onondaga County
Onondaga Lake Technical Advisory Committee (OLTAC)
U.S. Geological Survey (USGS)
New York State Department of Environmental Conservation (NYSDEC)
Environmental Protection Agency (EPA)
Atlantic States Legal Foundation (ASLF).

The modifications to the existing lake monitoring program focused on a series of hypotheses related to the effectiveness of the County's improvements to the wastewater collection and treatment system. The revised lake monitoring program, now known as the Ambient Monitoring Program, was initiated in August 1998.

1.2 OBJECTIVES OF THE AMP

The AMP is designed to provide data and information to evaluate the effectiveness of improvements to the County's wastewater collection and treatment system. The findings of the AMP, and the implications of these findings on water quality and ecological status of the lake and watershed, are reviewed by engineers and scientists associated with OLTAC, USGS, NYSDEC, EPA, ASLF, and the Onondaga Lake Partnership. The overall objectives and structure of the AMP are summarized in Table 1-1.

Table 1-1. Objectives and structure of the Ambient Monitoring Program.

AMP Program Objective	Monitoring and Assessment	Comments
Quantify external loading	Monitor streams and point sources for flow, nutrients, solids, indicator bacteria, metals, and salts. Calculate load.	Regular (biweekly) sampling supplemented with storm and high flow event monitoring.
Define compliance and trends in lake water quality	Physical characteristics: temperature, light penetration, water clarity Chemical characteristics: nutrients, salts, dissolved oxygen, ammonia, pH, metals. Biological characteristics: chlorophyll-*a*, phytoplankton, zooplankton, indicator bacteria. *Additional biological parameters are summarized below*. Trophic status: phosphorus, chlorophyll-a, Secchi disk transparency, deep water dissolved oxygen, phytoplankton community	Profiles through water column, supplemented by buoys at fixed depths. Water quality monitoring buoy at deepest location (profile sampling). Biweekly monitoring (open water season), monthly winter sampling, as possible. Water clarity and indicator bacteria monitoring at nearshore stations: suitability for water contact recreation.
Determine tributary water quality, biota, and habitat conditions	Water quality: Annual program for flow, nutrients, solids, bacteria, metals, salts, oxygen-demanding material, and carbon fractions. Habitat and biota: Every 2 years starting in 2000: monitor stream macroinvertebrate community. Stream mapping: based on the Natural Resources Conservation Service Visual Assessment Protocol (baseline assessment in 2000 and 2002, to be repeated in 2008 and 2012). Additional evaluation of stream segments possible following improvements and/or major hydrologic events.	Focus is on the CSO-affected tributaries.
Assess the biological community in Onondaga Lake	Fish community: annual assessment of nests, larval fishes, juveniles, adults using multiple sampling gears and techniques. Macrophytes: annual aerial photography for percent cover of littoral zone (limited ground truthing). Detailed field survey every 5 years starting in 2000. Littoral macroinvertebrates: every 5 years, community structure and abundance. Zebra mussels: habitat mapping and sampling at reference locations (lake and river)	Focus on metrics of community structure, food web dynamics. Biological sampling of littoral zone, sediment texture analysis.

1.3 2004 PROGRAM ELEMENTS

Improvements to Metro and the CSOs are being implemented in phases, with final completion dates in the year 2012. The ACJ includes specific milestone dates for assessment of progress and evaluation of the need for additional treatment or controls. The County's AMP includes both annual and special elements. Annual elements are designed to evaluate compliance and establish trends, and special elements are timed to follow ACJ-related milestones. Consequently, each year the AMP is slightly different. The structure of the 2004 monitoring program with respect to the ACJ-required objectives is summarized in Table 1-2.

Table 1-2. Elements of the 2004 AMP in relation to ACJ-required monitoring objectives.

ACJ Statement of Required Program Objective:	**2004 Program Elements**	**Data Used To**	**Location in 2004 Report**
Quantify external loading of phosphorus, nitrogen, suspended solids, indicator bacteria, and salts. Assess the reduction in loading achieved by the CSO improvements. Design program to evaluate the relative contribution of point and nonpoint sources of pollution to the lake.	(Annual program) Tributary monitoring: biweekly, and high flows - Includes locations upstream and downstream of CSOs, urban and rural segments of subwatersheds.	Estimate annual external loading to Onondaga Lake	• Loading tables (Chapter 2) • Executive summary (rev 1 July 2005) • Mass balance (estimates of point and nonpoint contribution) Section 2.2 • Appendix 7: Mass Balances
Assess the tributaries' physical habitat and macroinvertebrate community.	(Every 6 years following baseline evaluation) • Stream mapping using NRCS Visual Stream Assessment Protocol in CSO-subwatersheds: Onondaga Creek, Ley Creek and Harbor Brook (Every 2 years) • Macroinvertebrate surveys of CSO-affected subwatersheds	Quantify baseline conditions and provide basis to measure change. Quantify baseline conditions and provide basis to measure change	Not completed in 2004; most recent survey in 2002 report. Scheduled for 2008 and 2012 • Chapter 2: Results of the 2004 AMP • Appendix 5: Tributary Macroinvertebrates
Gather data on an adequate temporal and spatial scale to assess compliance with ambient water quality standards.	(Annual program) • Lake monitoring program: *South Deep Station, eight nearshore stations* • Tributary monitoring program • Seneca River monitoring program	Assess compliance with numerical and narrative standards	• Compliance tables (Chapter 2) • Executive summary (rev 1 July 2005)
Evaluate changes in the water quality and trophic state of Onondaga Lake in response to reductions in external loading achieved by the improvements to Metro and the CSOs.	(Annual program) • Lake monitoring • Tributary monitoring • River monitoring	Assess conditions in relation to inputs and trends	• Chapter 3: Progress Towards Improvement • Trend summary (Chapter 2) • Executive summary (rev 1 July 2005) • Trends (Section 3.2)

Table 1-2. Elements of the 2004 AMP in relation to ACJ-required monitoring objectives (continued).

ACJ Statement of Required Program Objective:	**2004 Program Elements**	**Data Used To**	**Location in 2004 Report**
Expand the chemical monitoring program to include other indices of ecological integrity: biological data, contaminant burden, and physical habitat.	(Annual biological program) • Fish: nesting, larvae, juveniles, and adult communities • Lower trophic levels: phytoplankton and zooplankton (NYSDEC) Contaminant data collected by NYSDEC	Assess current trophic state, abundance and diversity of species, importance of exotic species, reproductive success	• Chapter 2: Results of the 2004 AMP • Chapter 3: Progress Towards Improvement, • Appendix 2: Assessing Community Structure • Appendix 8: Fish Monitoring
Through interaction with NYSDEC and appropriate peer reviewers, coordinate data collection and analysis to provide data at an adequate spatial and temporal scale to use in existing or revised lake models.	Continued monitoring of lake water quality, progress with conceptual model, and mass-balance model.	Support new lake model (beginning in 2005)	Relevant text, tables, and figures
Define ambient water quality conditions in the Seneca River between Cross Lake and the Three Rivers junction.	(Annual program) Surveys at Seneca River Buoy 316 (target low flow conditions)	Assess current conditions, data set for model validation	• Chapter 2: Major findings • Appendix 1: Seneca River
Evaluate and quantify the assimilative capacity of the Seneca River and quantify effects of zebra mussels. *Note: The Three Rivers Water Quality Model (TRWQM) was completed by QEA, LLC for Onondaga County to support this assessment.*	(Annual program) Surveys during low flow conditions (depends on hydrologic conditions)	Assess current conditions, data set for model verification	• Chapter 2: Major findings • Appendix 1: Seneca River • TRWQM applications to estimate assimilative capacity will be reported separately
	Zebra mussel assessment (surveys completed in spring and summer 2004)	Assess current conditions, compile data for model verification	• Appendix 1: Seneca River • Appendix 6: Zebra mussels

1.4 DATA ANALYSIS AND INTERPRETATION PLAN

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. Also, program managers must be certain that the ACJ requirements are met. A Data Analysis and Interpretation Plan (DAIP) has been prepared to guide program managers in how the extensive data set collected under the AMP will be analyzed and interpreted. The document was prepared at the request of NYSDEC and will be updated periodically. The complete DAIP is included in this Annual Report as Appendix 9. Key features of the DAIP are summarized in this chapter in order to provide a context for interpreting the data summaries and discussion presented in subsequent chapters of the 2004 Annual AMP Report.

1.4.1 Key questions to be answered using AMP data

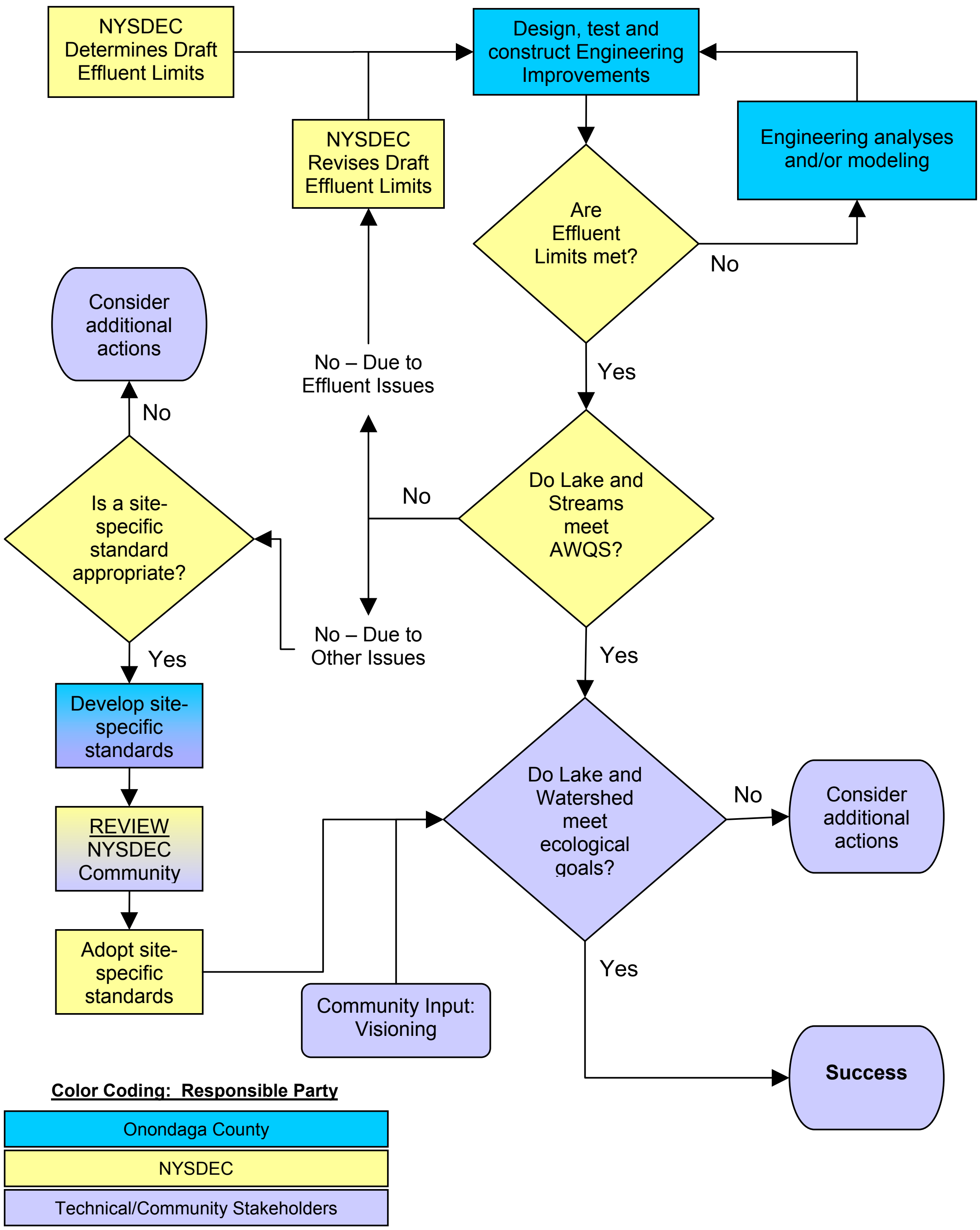
Onondaga County is required to conduct the AMP as the primary source of data to assess the effectiveness of the controls at Metro and the CSOs. AMP data will be used to:

- determine if additional remedial measures are required to bring the surface waters into compliance with applicable regulations, standards, guidance values, and criteria.
- evaluate the effectiveness of the engineering controls on meeting effluent limits.
- evaluate whether the effluent limits are appropriate for bringing the water bodies into compliance with applicable standards.
- provide information on whether the lake and its watershed meet community goals (which are still to be defined) for a rehabilitated ecosystem.

Figure 1-1 presents a flow chart of decision-makers and responsibilities for the AMP. The AMP will provide the data and information needed to support the following decisions:

Can Ambient Water Quality Standards (AWQS) be met with continued Metro discharge to Onondaga Lake? **Decision date: February 1, 2009**
Must Metro effluent meet the Stage III phosphorus and ammonia limits for discharge to Onondaga Lake or the Seneca River in order for the receiving water to comply with ambient water quality standards? **Decision date: February 1, 2009**
Can lake-wide oxygenation be used as an interim measure for meeting dissolved oxygen standards at fall mixing pending compliance with Stage III effluent limits? If Stage III effluent limits are not achievable, would lake-wide oxygenation bring the lake into compliance with dissolved oxygen at fall mixing? **Decision date: December 1, 2012**

Figure 1-1. Flow chart of decisions and responsibilities.



1.4.2 Overall approach: monitoring and modeling

Onondaga County and the other stakeholders rely on an integrated program of monitoring and modeling to determine whether the planned improvements to the Onondaga County wastewater collection and treatment infrastructure are effective in bringing the surface water system into compliance with state and federal requirements. Monitoring is used to measure conditions over the 15-year period of phased improvements. Monitoring data can describe current conditions, but mathematical water quality models are necessary to project future conditions under a range of management scenarios and environmental conditions. The NYSDEC will require mathematical models to complete their required Total Maximum Daily Load (TMDL) allocation.

Modeling is used to describe the interrelationships between physical, chemical, and biological characteristics of the lake and watershed. Models are valuable tools for interpreting data and elucidating underlying mechanisms. Once verified, models can be used to project future conditions. Several types of water quality models of Onondaga Lake, the lake watershed, and the Three Rivers system have been completed or initiated.

Both the monitoring and modeling efforts are closely reviewed. The Three Rivers Water Quality Model (TRWQM) went through an outside peer review. The Onondaga Lake Water Quality Model (OLWQM) will also be peer-reviewed. Development of the OLWQM began in mid-2005.

The interrelationship between the management questions, monitoring and modeling, and the spatial and temporal designation of compliance is summarized in Table 1-3.

Table 1-3. Summary of management questions and decision analysis.

Management Question	Decision Analysis Components and Regulatory References	Spatial and Temporal Scale of Assessment	Tools for Assessment
Can ambient water quality standards be achieved with continued Metro discharge to Onondaga Lake? **Decision date: February 1, 2009**	Dissolved Oxygen: 6NYCRR Sec. 703.3 Ammonia: 6 NYCRR Sec. 703.5 Turbidity: 6 NYCRR Sec. 703.2 Floatables: 6 NYCRR Sec. 703.2 Phosphorus: 6 NYCRR Sec. 703.2 TOG 1.1.1 Water Quality Standards & Guidelines Nitrogen: 6 NYCRR Sec. 703.2 Bacteria: 6 NYCRR Sec. 703.4	<u>Dissolved Oxygen:</u> Upper waters, fall mixing, South Deep <u>Ammonia and nitrite</u>: Upper waters; South Deep, year-round <u>Bacteria</u>: all Class B portions of lake	<u>Monitoring</u>: AMP data <u>Modeling</u> CSOs: use SWMM to confirm: system-wide annual average capture of 85% of combined sewage. <u>Modeling</u>: Onondaga Lake model (begin in 2005)

Table 1-3. Summary of management questions and decision analysis (continued).

Management Question	Decision Analysis Components and Regulatory References	Spatial and Temporal Scale of Assessment	Tools for Assessment
Must Metro effluent meet the Stage III phosphorus and ammonia limits for discharge to Onondaga Lake or the Seneca River in order for the receiving water to achieve compliance with ambient water quality standards? **Decision date: February 1, 2009**	Phosphorus: 6 NYCRR Sec. 703.2 (*possibly modified by site-specific guidance value)* Trophic state indicators: frequency, intensity and duration of algal blooms Ammonia: TOG 1.1.1 Water Quality Standards & Guidelines (*latest revision to NYS standards*) NYSDEC revised TMDL for phosphorus and ammonia: **January 1, 2009**	Phosphorus and other trophic state parameters: Summer average, upper waters, South Deep (per NYSDEC guidance). Dissolved Oxygen: Upper waters, fall mixing, South Deep Ammonia: Upper waters, South Deep, year-round	For lake discharge: • AMP data: Ammonia: effects of Stage III limits, met in 2004 TP: effects of Stage II limits, to be met in 2005 • Lake model, project compliance under critical conditions For Seneca River discharge: TRWQM
• Can lake-wide oxygenation be used as an interim measure pending compliance with Stage III effluent limits? • If Stage III effluent limits are not achievable, will lake-wide oxygenation bring the lake into compliance? **Decision date: December 1, 2012**	Feasibility analysis (ENSR 2004)	Focus of compliance for dissolved oxygen: fall mixing, upper waters	• AMP data • Mass-balance model • Onondaga Lake model (begin 2005) • In-lake test of hypolimnetic oxygenation (2006-2007)

1.4.3 Hypotheses

The elements of the monitoring program were distilled into a series of testable hypotheses. This work product was used as a basis for evaluating the AMP design, allowing the project team and the advisors to determine whether the correct parameters were being measured. A summary of the hypotheses for elements of the monitoring program is presented in Table 1-4.

Note that there are three types of hypothesis to be tested using data generated by the AMP. The first relates to whether Onondaga County is in compliance with the effluent limits required by the State Pollution Discharge Elimination System (SPDES) permit. The second type examines whether ambient water quality standards in the receiving water have been met. The third type of hypothesis, which is used for assessing the biological programs as well as the water quality programs, is whether there is a trend in the monitoring data.

Table 1-4. Summary of hypotheses underlying the AMP.

Monitoring Parameter	Hypothesis	Type of Hypothesis: Compliance with SPDES[1] permit	Compliance with AWQS[2] or guidance value	Significant Trend or Shift In Monitoring Data	Data Used for Assessment
Ammonia-N	Improvements at Metro enable the County to meet Stage III effluent limits (or as modified by TMDL) for ammonia N	*			Outfall 001 effluent concentrations, calculated for summer and winter (seasonal limits apply)
	Reduced ammonia load results in compliance with ambient water quality standards and federal criteria for ammonia in Onondaga Lake		*	*	South Deep station Biweekly monitoring, discrete samples collected at 3-m intervals, plus temperature and pH
Nitrite-N	Achievement of Stage III effluent limits for ammonia results in compliance with the NYS ambient water quality standard for nitrite (warm water fish community)		*	*	UML, LWL[3] composite samples, biweekly at South Deep

[1] SPDES = State Pollution Discharge
[2] AWQS = Ambient Water Quality Standards
[3] UML = Upper Mixed Layer; LWL = Lower Water Layer

Table 1-4. Summary of hypotheses underlying the AMP (continued).

Monitoring Parameter	Hypothesis	Type of Hypothesis			Data Used for Assessment
		Compliance with SPDES[1] permit	Compliance with AWQS[2] or guidance value	Significant Trend or Shift In Monitoring Data	
Phosphorus	Improvements at Metro will enable the County to meet final effluent limits (as modified by TMDL)	*			Outfall 001 effluent concentrations
	Reduced phosphorus load from Metro reduces concentration of phosphorus in Onondaga Lake		*	*	South Deep station Biweekly monitoring TP, SRP and TDP, discrete samples collected at 3-m intervals
	Reduced phosphorus load from Metro brings the lake into compliance with guidance value (or site-specific guidance value)		*	*	TP at South Deep, 1-m depth (weekly measurements, June –Sept)

Table 1-4. Summary of hypotheses underlying the AMP (continued).

Monitoring Parameter	Hypothesis	Type of Hypothesis: Compliance with SPDES[1] permit	Type of Hypothesis: Compliance with AWQS[2] or guidance value	Type of Hypothesis: Significant Trend or Shift In Monitoring Data	Data Used for Assessment
Dissolved Oxygen	Improvements at Metro enable the County to meet Stage III effluent limits (or as modified by TMDL) for BOD	*			Outfall 001 effluent concentrations
	Improvements at Metro and related load reductions bring the lake into compliance with AWQS for DO during fall mixing.		*	*	Weekly or biweekly measurements through water column and high-frequency measurements at buoy at South Deep station
	Improvements at Metro reduce the volume-days of anoxia.			*	Weekly or biweekly measurements through water column and high-frequency measurements at buoy at South Deep station
	Improvements at Metro reduce the areal hypolimnetic oxygen depletion rate.			*	Weekly or biweekly measurements through water column and high-frequency measurements at buoy at South Deep station

Table 1-4. Summary of hypotheses underlying the AMP (continued).

Monitoring Parameter	Hypothesis	Type of Hypothesis: Compliance with SPDES[1] permit	Compliance with AWQS[2] or guidance value	Significant Trend or Shift In Monitoring Data	Data Used for Assessment
Indicator bacteria	CSO remedial measures reduce the loading of fecal coliform bacteria entering the lake through Onondaga Creek, Ley Creek, and Harbor Brook during high flow conditions.	*		*	Storm event data: baseline and post-improvement rating curves for fecal coliform bacteria (load as a function of total precipitation, and total storm flow)
	Implementation of Stage 1 and 2 improvements to the wastewater collection and treatment system (including CSO projects) will reduce concentration of indicator organisms in Onondaga Lake	*	*	*	Indicator bacteria abundance at nearshore stations during summer and following storms. Annual average concentration at South Deep, 0m depth
Chlorophyll-*a*	Metro improvements and related nutrient load reductions result in lower chlorophyll concentrations in the lake.			*	Weekly or biweekly measurements at South Deep, photic zone and UML

Table 1-4. Summary of hypotheses underlying the AMP (continued).

Monitoring Parameter	Hypothesis	Type of Hypothesis			Data Used for Assessment
		Compliance with SPDES[1] permit	Compliance with AWQS[2] or guidance value	Significant Trend or Shift In Monitoring Data	
Secchi disk transparency	Metro improvements and related nutrient load reductions result in improved water clarity (as measured by Secchi disk transparency) in Onondaga Lake			*	Weekly or biweekly measurements at South Deep and nearshore stations
Phytoplankton community	Metro improvements and related nutrient load reductions result in lower biomass of phytoplankton in Onondaga Lake			*	Biweekly samples of UML phytoplankton community, numbers, size and identifications (PhycoTech)
	Metro improvements and related nutrient load reductions result in reduced importance of cyanobacteria to the Lake's phytoplankton biomass			*	Biweekly composite samples of UML phytoplankton abundance, biomass, and ID (PhycoTech)

Table 1-4. Summary of hypotheses underlying the AMP (continued).

Monitoring Parameter	Hypothesis	Type of Hypothesis: Compliance with SPDES[1] permit	Type of Hypothesis: Compliance with AWQS[2] or guidance value	Type of Hypothesis: Significant Trend or Shift In Monitoring Data	Data Used for Assessment
Zooplankton community	Metro improvements and related nutrient load reductions reduce the biomass of zooplankton in Onondaga Lake			*	Biweekly composite samples of UML and tow (0-15 m), zooplankton abundance, size, biomass, ID (Cornell Biological Field Station)
	Metro improvements and related nutrient load reductions (and DO improvements) increase the abundance of zooplankton deeper in the water column			*	Biweekly composite samples of UML and tow (0-12 m), zooplankton abundance, size, biomass, ID (Cornell Biological Field Station)
Macroalgae	Metro improvements and related nutrient load reductions result in reduced areal coverage of macroalgae in nearshore areas of Onondaga Lake			*	Weekly surveys during recreational period (June –Sept) at eight nearshore stations.

Table 1-4. Summary of hypotheses underlying the AMP (continued).

Monitoring Parameter	Hypothesis	Type of Hypothesis: Compliance with SPDES[1] permit	Compliance with AWQS[2] or guidance value	Significant Trend or Shift In Monitoring Data	Data Used for Assessment
Macrophytes	Metro improvements and related nutrient load reductions result in increased areal coverage of macrophytes in littoral zone of Onondaga Lake			*	Percent cover, biomass, and maximum depth of growth. Surveys: 2000, 2005, 2010 plus annual aerial photos (% cover)
	Metro improvements and related load reductions result in increased number of macrophyte species in Onondaga Lake			*	Macrophyte species richness Detailed surveys: 2000, 2005, 2010

Table 1-4. Summary of hypotheses underlying the AMP (continued).

Monitoring Parameter	Hypothesis	Type of Hypothesis: Compliance with SPDES[1] permit	Type of Hypothesis: Compliance with AWQS[2] or guidance value	Type of Hypothesis: Significant Trend or Shift In Monitoring Data	Data Used for Assessment
Littoral macroinvertebrates Note: effects may be in strata 2,3 and 4 (see Appendix 8 Figure A8-1 for strata locations)	Implementation of load reductions at Metro and CSO remediation will increase species richness of littoral benthic macroinvertebrates			*	Littoral macroinvertebrate species richness. Detailed surveys: 2000, 2005, 2010
	Implementation of load reductions at Metro and CSO remediation will increase the relative abundance of benthic macroinvertebrates that are not chironomids or oligochaetes			*	Littoral macroinvertebrate dominance, percent oligochaetes. Detailed surveys: 2000, 2005, 2010
	Implementation of load reductions at Metro and CSO remediation will improve the NYSDEC Biological Assessment Profile as compared to baseline conditions.			*	NYSDEC calculated index Detailed surveys: 2000, 2005, 2010
	Implementation of load reductions at Metro and CSO remediation will improve the littoral macroinvertebrate HBI as compared to baseline conditions (indicating increased importance of pollution sensitive organisms in the community)			*	Hilsenhoff Biotic Index (HBI) Detailed surveys: 2000, 2005, 2010

Table 1-4. Summary of hypotheses underlying the AMP (continued).

Monitoring Parameter	Hypothesis	Type of Hypothesis: Compliance with SPDES[1] permit	Type of Hypothesis: Compliance with AWQS[2] or guidance value	Type of Hypothesis: Significant Trend or Shift In Monitoring Data	Data Used for Assessment
Fish community	Implementation of load reductions at Metro and CSO remediation will increase the number of fish species present in Onondaga Lake			*	Annual monitoring program Species richness, electrofishing, gill nets,
	Implementation of load reductions at Metro and CSO remediation will increase the number of fish species that are sensitive to pollution present in Onondaga Lake			*	Annual monitoring program: Electrofishing Pollution tolerance index (Whittier and Hughes 1998)
	Implementation of load reductions at Metro and CSO remediation will increase the number of fish species reproducing in Onondaga Lake			*	Annual monitoring program Nesting survey Larval tows Larval light traps Littoral seines
	Implementation of load reductions at Metro and CSO remediation will improve the lake's IBI . Effects may be in strata 2,3, and 4 (see Appendix 8 Figure A8-1 for strata locations)			*	Annual monitoring program Electrofishing

Table 1-4. Summary of hypotheses underlying the AMP (continued).

Monitoring Parameter	Hypothesis	Type of Hypothesis			Data Used for Assessment
		Compliance with SPDES[1] permit	Compliance with AWQS[2] or guidance value	Significant Trend or Shift In Monitoring Data	
Fish community (continued)	Implementation of load reductions at Metro and CSO remediation will increase the habitat available for the coolwater fish community			*	Fish space metrics: dissolved oxygen and temperature profiles at South Deep station

Note: The potential impact of zebra mussels on the lake water quality will be assessed using the Onondaga Lake Water Quality Model under development by QEA, LLC for Onondaga County. While zebra mussels are not part of the ACJ-required monitoring program for the lake, their proliferation has the potential to affect water clarity and habitat for primary producers, as well as alter the cycling of energy and nutrients.

1.4.4 Metrics

A series of metrics have been developed to organize and report the extensive AMP dataset. As defined by EPA, metrics are attributes of the physical, chemical and/or biological ecosystem that respond to human disturbance. For the Onondaga Lake watershed, metrics are designed to indicate progress towards compliance with applicable standards and guidelines, and progress towards attaining a desired use.

Selected metrics may relate directly to an impairment of the lake or watershed; relate to a resource of interest; or correspond to a published standard that, in turn, reflects the requirements of public health or the aquatic biota. Candidate metrics can be measured and interpreted with relative ease to answer basic questions such as: "is the lake getting better?" and "is it safe for my family to swim here?"

Metrics selected to interpret and report on the AMP data are listed in Table 1-5. Note that the metrics are grouped into categories that address human uses and ecosystem function:

- water contact recreation;
- aesthetics;
- aquatic life protection; and
- sustainable recreational fishery

Metrics for water contact recreation are straightforward. New York State Department of Health and EPA have standards and guidance values for indicator bacteria and water clarity that are designed to be protective of human health and safety. Selecting metrics for aesthetics is slightly more judgmental, as they relate to perceived attributes such as water color and clarity, odors, and the visible extent of weed and algal growth. Water quality conditions needed to support aquatic life are fairly well defined in federal criteria and state standards. Onondaga County AMP metrics are designed to track water quality and habitat conditions during critical periods for reproduction and survival of young animals.

Table 1-5. Summary of Metrics: Measuring Progress towards Improvement in Onondaga Lake

Desired Use	Metrics	Measured By
Water contact recreation	Indicator Bacteria	Fecal coliform bacteria at nearshore and South Deep station
	Water Clarity	Secchi disk transparency at nearshore stations
Aesthetics	Water clarity	Secchi disk transparency at South Deep
	Bloom frequency and magnitude	Percent of chlorophyll-*a* measurements greater than 15 µg/l (threshold for public perception as impaired for recreational use) Percent of chlorophyll-*a* measurements greater than 30 µg/l (threshold for public perception of nuisance bloom).
	Algal community structure	Percent non-blue green taxa.
	Macroalgae proliferation	Percent cover of littoral zone, measured at eight nearshore stations June 1 – August 31 annually

Table 1-5. Summary of Metrics: Measuring Progress towards Improvement in Onondaga Lake (continued).

Desired Use	Metrics	Measured By
Aquatic Life Protection	Ammonia N	Percent of measurements in compliance with standards.
	Nitrite N	Percent of measurements in compliance with standards.
	Dissolved Oxygen	DO at fall mixing. Duration of DO concentrations < 4 mg/l (scale of hours, from high frequency buoy data)
	Integrated metrics	"Fish space" metrics, volume days with suitable conditions of DO and temperature for warm water, cool water, and cold water fish communities
	Species assemblage	Percent intolerant or moderately intolerant of pollution
Fish Reproduction	Number of species with documented reproduction and recruitment[1]	Nesting surveys, larval sampling (Miller tows and light traps), young-of-year sampling (littoral and pelagic) adult survey (electrofishing, gill netting), hydroacoustical survey (experimental)
	Habitat quality	Percent cover of macrophytes: scaled to optimal level for largemouth bass (40 - 60% cover is target).

[1]Sampling captures young-of-the-year (YOY) fish in the lake. It is assumed that the majority of these small fish originated in the lake, given their size and limited mobility of the early life stages. However, the presence of YOY fish that originated in the Seneca River or tributaries to Onondaga Lake cannot be ruled out.

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CHAPTER 2

RESULTS OF THE 2004 AMBIENT MONITORING PROGRAM

The results of the 2004 AMP are presented under these topic headings:

- External Loading
- Mass Balance
- Onondaga Lake Water Quality 2004 Findings
- Phytoplankton and Zooplankton Community
- Fish Community
- Seneca River Conditions
- Macroinvertebrates

2.1 EXTERNAL LOADING

2.1.1 Precipitation and Streamflow

According to the NOAA records, 43.14 inches of precipitation were recorded at Syracuse Hancock Field in 2004, well above the 30-year average of 38.91 inches. Below-average precipitation from January through April was followed by a very rainy May. Above-average rainfall continued through summer into the fall (Figure 2-1).

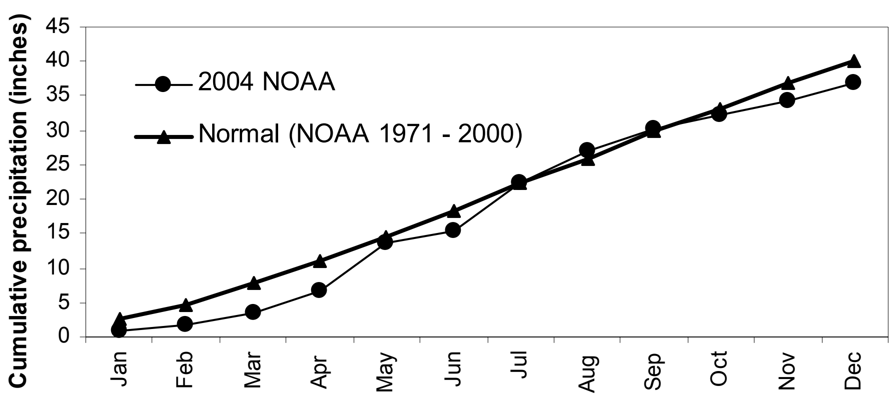


Figure 2-1. Cumulative precipitation in 2004 compared with the historical average for Syracuse, NY.
Source: National Climate Data Center, Ashveille NC

As expected, stream discharges were elevated in 2004 in response to the above-normal precipitation. Hydrographs of the major tributaries to Onondaga Lake are plotted in Figure 2-2.

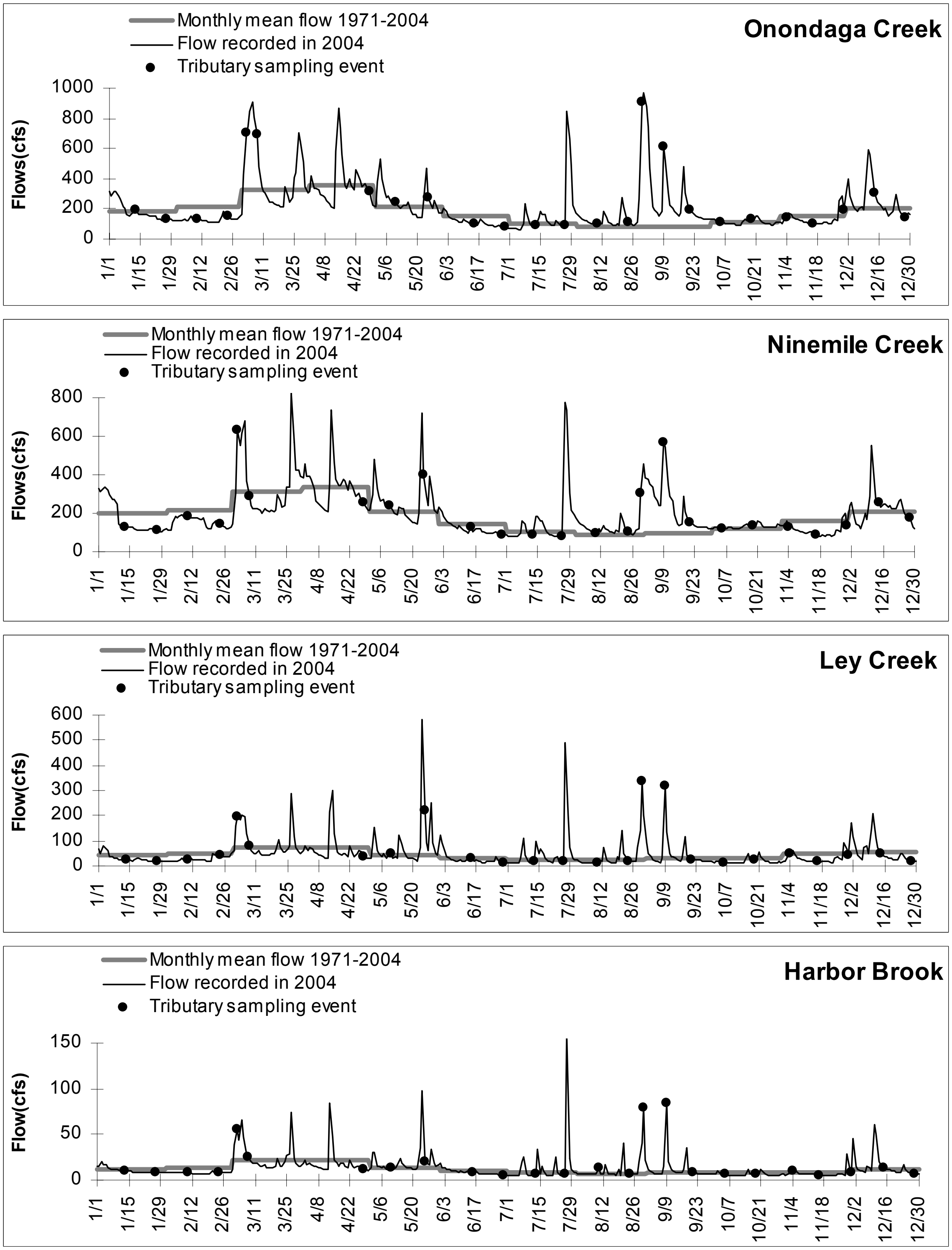


Figure 2-2. Observed tributary flows in 2004 compared with the long-term average flow record.

Sampling dates for the AMP tributary program are indicated on the hydrographs. The AMP is designed to sample the tributaries over a range of representative flow conditions, and targets inclusion of a minimum of five samples collected during high flow events (defined as one standard deviation above the monthly average flow for Onondaga Creek at Spencer Street). In 2004, a total of 26 tributary sampling events were completed and encompassed a range of discharge conditions. Seven of these were high flow events.

2.1.2 Metro Performance

The Metropolitan Syracuse Wastewater Treatment Plant (Metro) is a major source of nitrogen, phosphorus, bacteria, and organic (oxygen-demanding) material to the lake. Major projects to upgrade the Metro facility and increase removal of wastewater-related contaminants continued through 2004.

2.1.2.1 Ammonia Nitrogen Removal

Metro effluent is the largest external source of ammonia to the lake, contributing an estimated 69% of the external load in 2004, including discharges from both Outfalls 001 and 002. Significant reductions in the ammonia loading to Onondaga Lake were achieved between 1995 and 1999 (Figure 2-3) as the aeration system of Metro's secondary clarifiers was upgraded. From 1999 to 2003, the ammonia concentration in the Metro effluent was relatively consistent as an annual average although winter and summer concentrations varied each year due to the seasonal nitrification (Figures 2-4 and 2-5).

In January 2004, Onondaga County Department of Water Environment Protection (OCDWEP) put into service a new pump station to direct secondary-treated wastewater to the tertiary process. Up to 126 MGD of wastewater is now routed to the new state-of-the-art tertiary treatment process for year-round removal of ammonia. Ammonia is removed from wastewater using a process developed by I. Krüger, Inc. that uses a biological aerated filter (BAF). At Metro, the BAF process consists of eighteen individual cells, each with a capacity of about 273,000 gal. The cells are filled with billions of polystyrene beads that are 0.14 inch in diameter. The beads provide a huge surface area for nitrifying bacteria; these bacteria oxidize ammonia to nitrate and nitrite.

The BAF process has reduced the concentration of ammonia N discharged from Metro through outfall 001. As shown in Figure 2-4 (first panel), the ammonia load from Metro was reduced rapidly following start-up of the facility, even when wastewater temperatures were low, and remained low through the end of 2004.

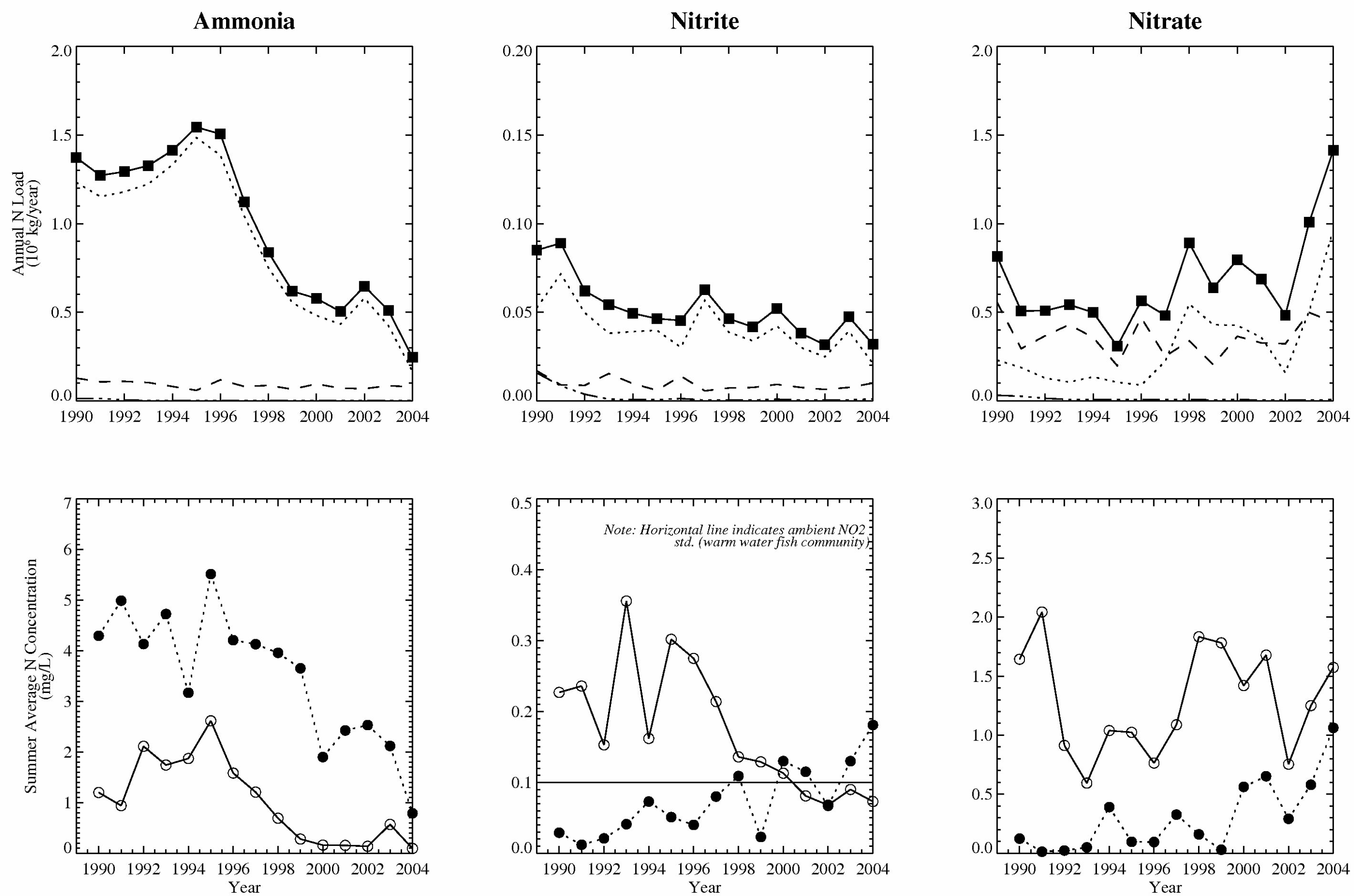
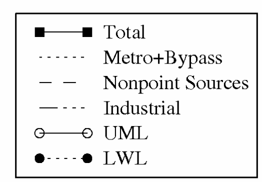


Figure 2-3. Annual trends of nitrogen load to Onondaga Lake and concentration at the South Deep station.



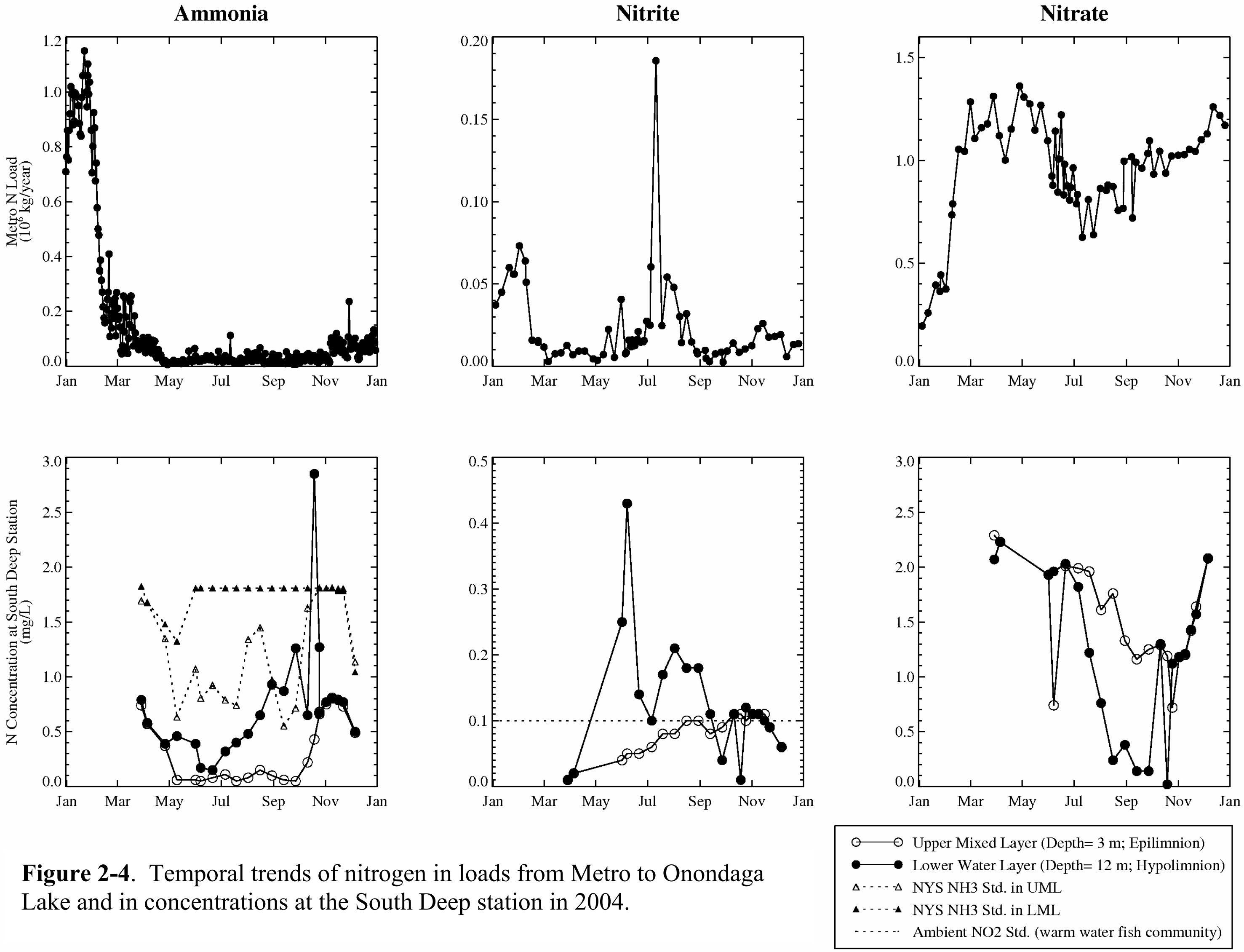


Figure 2-4. Temporal trends of nitrogen in loads from Metro to Onondaga Lake and in concentrations at the South Deep station in 2004.

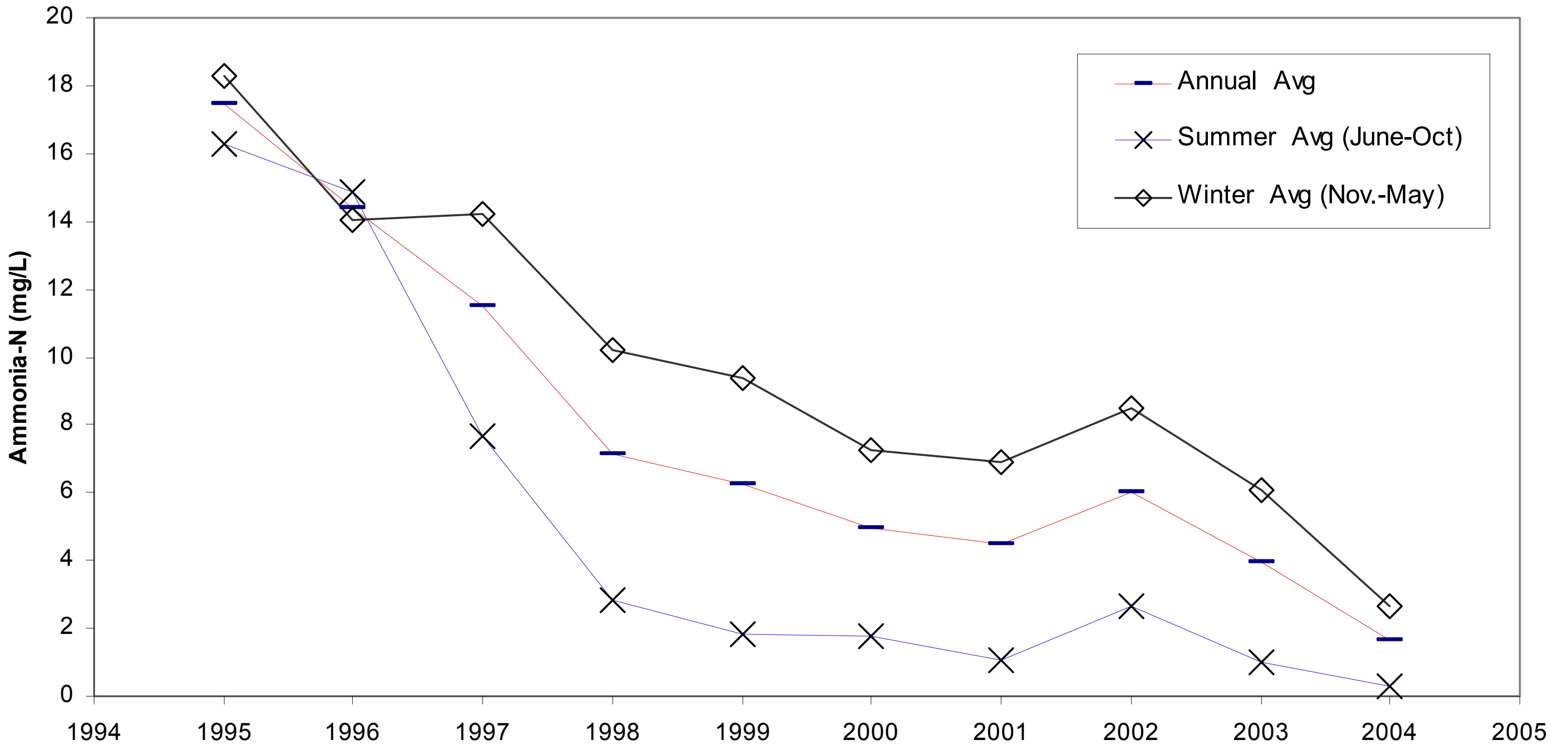


Figure 2-5. Average Ammonia-N concentration (mg/L) in Metro Outfall 001, 1995 to 2004.

2.1.2.2 Phosphorus Removal

Enhanced removal of phosphorus is the other major objective of the Metro improvements. A physical-chemical process designed to meet Stage II phosphorus limits was brought on line at Metro in early 2005. This process occurs after the BAF, which is a biological process. Following the BAF units, wastewater is directed through a phosphorus removal system that uses a High Rate Flocculated Settling (HRFS) process. This system was designed to bring Metro Outfall 001 effluent into compliance with the Stage II total phosphorus limit of 0.12 mg/l (12-month rolling average) by the ACJ-specified deadline of April 1, 2006. As of October 2005, Metro effluent was not consistently achieving the Stage II phosphorus limit.

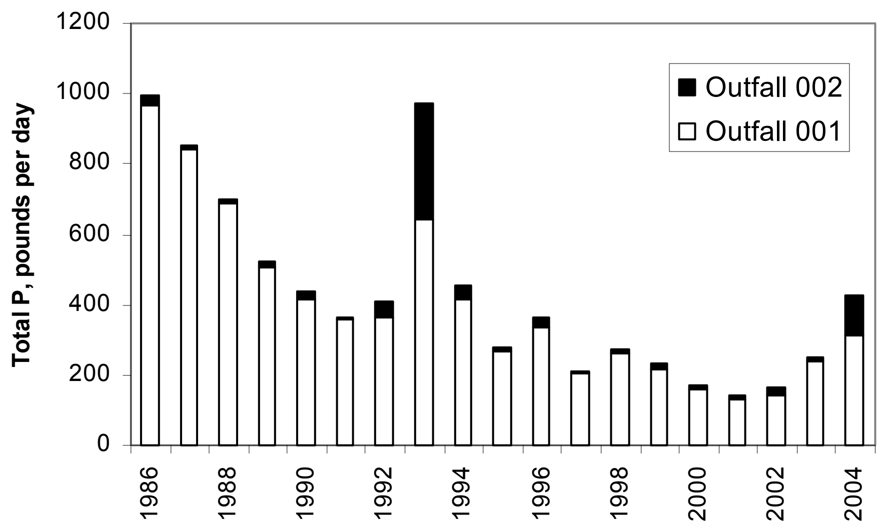


Figure 2-6. Annual phosphorus discharge from Metro outfalls 001 and 002, 1986 - 2004.

The phosphorus load from Metro (outfall 001) was estimated at 51,410 kg in 2004, averaging 310 pounds per day (Figure 2-6) which meets the Stage I effluent limit of 400 pounds per day. The secondary Metro discharge point (outfall 002, which is only operational during high flow periods, and discharges effluent after primary treatment and disinfection) contributed an additional 2,784 kg of phosphorus in 2004. The average total P concentration from Metro Outfall 001 in 2004 was 0.53 mg/l (Table 2-1). Effluent discharged through Outfall 002 in 2004 averaged 1.16 mg/l total phosphorus.

2.1.3 Collection System: Sanitary Sewer Overflows and Combined Sewer Overflows

OCDWEP tracks the occurrence of overflows from the separate sanitary sewer collection system each year, in addition to the Department's continued focus on the combined sewer system. A total of 21 events were reported to NYSDEC in 2004, as summarized in Table 2-2, with an estimated volume of 5.3 million gallons of sewage released from the separate collection area to Ley Creek, Bloody Brook, Harbor Brook, or to the direct drainage in nearshore Onondaga Lake areas. Approximately 65% of the total volume of sanitary sewer overflows during 2004 occurred on one date, July 27, 2004, and was associated with very heavy rainfall.

The quarterly submittals to NYSDEC detailing performance of the CSO control facilities were also reviewed for this Annual AMP report. As summarized in Table 2-3, various remedial measures have been installed to capture CSOs or remove floatable solids prior to discharge. The Amended Consent Judgment specifies completion of a number of other projects to control CSOs discharging to Onondaga Creek and Harbor Brook. A program of sewer separation in some service areas continues.

Table 2-1. Flow-Weighted average limnological parameters in Onondaga Lake tributaries and standard error of estimate, using Autoflux, 2004.

		Nine Mile Creek @ Rt 48		**Harbor Brook @ Hiawatha**		**Onondaga Creek @ Kirkpatrick Street**		**Ley Creek @ Park St**		**Trib. 5A @ Crucible**	
Parameter	**Units**	Concentration	***RSE***	Concentration	***RSE***	Concentration	***RSE***	Concentration	***RSE***	Concentration	***RSE***
5-day BOD	mg/l	2.2	*17.4%*	2.4	*41.9%*	2.3	*20.2%*	2.7	*24.4%*	3.3	*13.8%*
Total Alkalinity	mg/l	200	*1.9%*	245	*4.6%*	226	*2.6%*	187	*4.6%*	161	*2.4%*
Total Organic Carbon	mg/l	4.2	*23.8%*	4.4	*33.4%*	4.7	*28.2%*	8.4	*8.2%*	5.1	*5.1%*
TOC-filtered	mg/l	3.7	*16.8%*	3.8	*37.3%*	4.1	*31.1%*	7.4	*8.1%*	4.3	*5.0%*
Total Inorganic Carbon	mg/l	52.2	*2.7%*	64.3	*4.8%*	58.7	*3.1%*	51.0	*6.4%*	41.6	*3.5%*
Total Kjeldahl Nitrogen as N	mg/l	0.67	*10.9%*	0.49	*25.7%*	0.51	*12.0%*	0.95	*14.4%*	0.64	*30.2%*
Organic Nitrogen as N	mg/l	0.41	*15.8%*	0.43	*28.3%*	0.44	*15.5%*	0.66	*17.3%*	0.36	*14.4%*
Ammonia as N	mg/l	0.25	*24.1%*	0.07	*22.6%*	0.08	*13.7%*	0.27	*16.4%*	0.30	*73.8%*
Nitrate as N	mg/l	1.05	*7.9%*	1.65	*7.0%*	1.00	*6.6%*	0.41	*19.5%*	0.91	*12.6%*
Nitrite as N	mg/l	0.02	*12.3%*	0.01	*25.8%*	0.02	*33.1%*	0.02	*17.6%*	0.03	*20.8%*
Arsenic	ug/l	1.3	*4.8%*	1.3	*3.4%*	2.6	*19.6%*	1.4	*4.0%*	1.4	*10.1%*
Total Phosphorus	ug/l	56.9	*15.4%*	85.1	*31.5%*	64.9	*25.9%*	95.8	*26.2%*	120.8	*8.0%*
Soluble Reactive Phosphorus	ug/l	9.0	*31.4%*	27.3	*30.9%*	6.5	*31.8%*	16.3	*16.3%*	38.6	*13.1%*
Silica	mg/l	4.3	*6.3%*	5.1	*6.0%*	5.5	*8.8%*	5.8	*6.3%*	8.1	*5.3%*
Calcium	mg/l	189.0	*2.2%*	193.0	*4.7%*	105.1	*2.2%*	99.3	*6.1%*	143.0	*3.4%*
Sodium	mg/l	107.9	*4.7%*	135.9	*18.6%*	240.5	*4.1%*	172.0	*26.4%*	207.7	*4.5%*
Sulfate	mg/l	184.1	*3.9%*	336.0	*6.8%*	105.6	*3.4%*	98.0	*7.6%*	115.5	*9.9%*
Chloride	mg/l	308.9	*3.8%*	260.0	*16.5%*	403.6	*5.3%*	293.3	*26.1%*	442.3	*4.5%*
Total Suspended Solids	mg/l	25	*27.9%*	35	*53.2%*	45	*35.4%*	35	*68.5%*	12	*79.9%*
Total Dissolved Solids	mg/l	1088	*2.6%*	1177	*6.8%*	1023	*3.2%*	847	*14.5%*	1170	*4.0%*
Zinc	ug/l	11.3	*32.4%*	23.2	*30.4%*	21.8	*42.2%*	32.1	*21.0%*	8.0	*44.2%*
Copper	ug/l	9.4	*14.8%*	7.5	*32.4%*	8.8	*60.1%*	10.8	*22.3%*	10.5	*34.9%*
Chromium	ug/l	1.6	*46.2%*	3.3	*51.1%*	5.0	*74.9%*	6.6	*32.0%*	17.1	*39.5%*
Cadmium	ug/l	0.4	*19.7%*	0.4	*4.9%*	0.4	*11.8%*	0.4	*13.9%*	0.42	*48.5%*
Lead	ug/l	3.5	*17.5%*	6.9	*20.9%*	5.4	*31.3%*	8.0	*28.5%*	2.7	*24.0%*
Iron	mg/l	0.91	*16.9%*	0.85	*41.1%*	1.6	*64.9%*	1.4	*33.9%*	1.0	*48.6%*
Magnesium	mg/l	27.1	*1.6%*	36.4	*4.4%*	24.0	*2.1%*	19.4	*6.5%*	17.0	*2.5%*
Manganese	ug/l	72.2	*10.0%*	33.3	*35.7%*	75.4	*28.1%*	116.1	*10.9%*	97.0	*25.3%*
Nickel	ug/l	2.5	*22.9%*	5.1	*19.5%*	9.7	*39.4%*	3.7	*11.8%*	64.6	*19.4%*
Fecal Coliforms	cells/100ml	2,062	*141.2%*	4,888	*236.4%*	1,181	*65.3%*	1647	*55.8%*	169	*555.0%*

RSE = relative standard error of the concentration estimate. ** METRO BOD5, NH3-N, TP, TSS based on observations made daily,
METRO TKN based on observations made 5 times each 2 week period. Other values are based on data collected bi-weekly
Calculations use the laboratory limit of detection when observations were below that limit.

Table 2-1. Flow-Weighted average, continued.

Parameter	Units	METRO Effluent ** Concentration	METRO Effluent ** *RSE*	METRO By-Pass Concentration	METRO By-Pass *RSE*	East Flume Concentration	East Flume *RSE*
5-day BOD	mg/l	9.6	*2.8%*	49.3	*6.3%*	3.4	*15.8%*
Total Alkalinity	mg/l	200	*3.1%*	192	*11.0%*	170	*5.1%*
Total Organic Carbon	mg/l	10.2	*4.7%*	16.8	*16.9%*	6.2	*8.7%*
TOC-filtered	mg/l	8.5	*4.3%*	11.7	*17.2%*	5.5	*8.9%*
Total Inorganic Carbon	mg/l	55.9	*3.3%*	44.1	*13.0%*	40.5	*6.1%*
Total Kjeldahl Nitrogen as N	mg/l	3.0	*2.6%*	10.0	*7.9%*	1.4	*8.4%*
Organic Nitrogen as N	mg/l	1.2	*13.5%*	3.5	*25.6%*	0.83	*14.9%*
Ammonia as N	mg/l	1.6	*3.6%*	5.8	*11.9%*	0.52	*10.6%*
Nitrate as N	mg/l	9.9	*7.8%*	1.8	*30.8%*	3.8	*8.4%*
Nitrite as N	mg/l	0.21	*10.4%*	0.13	*60.1%*	0.81	*8.9%*
Arsenic	ug/l	1.7	*7.8%*	1.2	*6.6%*	2.6	*12.5%*
Total Phosphorus	ug/l	534.6	*2.3%*	1160.5	*7.3%*	153.5	*13.2%*
Soluble Reactive Phosphorus	ug/l	269.7	*13.7%*	255.7	*92.5%*	59.2	*21.9%*
Silica	mg/l	5.7	*4.0%*	7.4	*13.5%*	10.5	*7.5%*
Calcium	mg/l	129.8	*7.7%*	82.2	*27.8%*	127.4	*7.8%*
Sodium	mg/l	212.1	*13.6%*	159.8	*30.2%*	359.0	*8.4%*
Sulfate	mg/l	178.7	*3.6%*	96.4	*13.8%*	364.2	*10.7%*
Chloride	mg/l	374.9	*13.1%*	244.6	*33.8%*	481.5	*9.5%*
Total Suspended Solids	mg/l	8.6	*4.5%*	56	*10.8%*	15	*28.4%*
Total Dissolved Solids	mg/l	1219	*3.2%*	764	*23.9%*	1512	*7.7%*
Zinc	ug/l	17.0	*8.6%*	35.2	*16.7%*	31.7	*29.4%*
Copper	ug/l	8.0	*7.4%*	16.3	*11.5%*	4.5	*32.1%*
Chromium	ug/l	2.2	*9.6%*	3.5	*13.8%*	2.3	*38.4%*
Cadmium	ug/l	1.4	*11.2%*	1.4	*10.8%*	0.40	*70.5%*
Lead	ug/l	3.6	*7.3%*	6.1	*15.2%*	3.0	*34.5%*
Iron	mg/l	0.44	*6.9%*	2.5	*14.4%*	0.33	*25.2%*
Magnesium	mg/l	25.6	*2.9%*	17.0	*16.1%*	25.7	*8.3%*
Manganese	ug/l	35.7	*7.2%*	55.7	*14.8%*	20.4	*19.6%*
Nickel	ug/l	10.0	*6.4%*	11.3	*15.6%*	2.8	*19.7%*
Fecal Coliforms	cells/100ml	1,956	*75.3%*	471,512	*38.5%*	485	*66.2%*

RSE = relative standard error of the concentration estimate. ** METRO BOD5, NH3-N, TP, TSS based on observations made daily, METRO TKN based on observations made 5 times each 2 week period. Other values are based on data collected bi-weekly from Calculations use the laboratory limit of detection when observations were below that limit.

Table 2-2. 2004 Record of sanitary sewer overflows Onondaga Lake watershed.

Date	Estimated Volume (gallons)	Receiving Water	Disinfection
01/21/04	1,100	Ley Creek	N
02/12/04	15,000	Harbor Brook	N
03/02/04	47,250	Ley Creek	N
03/26/04	24,000	Ley Creek	N
03/26/04	48,000	Ley Creek	N
05/24/04	108,000	Ley Creek	N
05/24/04	900,000	Bloody Brook	N
05/24/04	156,000	Ley Creek	N
07/27/04	20,000	Onondaga Lake	N
07/27/04	22,000	Harbor Brook	Y
07/27/04	350,000	Ley Creek	Y
07/27/04	350,000	Ley Creek	Y
07/27/04	350,000	Ley Creek	Y
07/27/04	1,134,000	Ley Creek	N
07/27/04	1,230,000	Bloody Brook	N
08/30/04	288,000	Ley Creek	N
09/09/04	120,000	Ley Creek	N
09/17/04	3,000	Harbor Brook	N
09/19/04	5,000	Harbor Brook	N
10/25/04	96,000	Ley Creek	N
12/11/04	52,000	Ley Creek	Y

Total SSO releases in 2004		**5,319,350**	**(gal)**
	Ley Creek	3,124,350	(gal)
	Harbor Brook	45,000	(gal)
	Bloody Brook	2,130,000	(gal)
	Onondaga Lake (direct drainage)	20,000	(gal)

Source: Quarterly reports to NYSDEC

Table 2-3. Summary of CSO facility reports, 2004.

Facility	Comments from 2004 reports
Newell St. Regional Treatment Facility (RTF)	Designed for 90% storm event, design 23 cfs Vortex separator for CSO #067 Will be taken out of service when Midland is complete 18 inch under drain is monitored. second quarter 2004: 18 overflows, avg 26,671 gal third quarter 2004: 20 overflows, avg 29,017 gal
Burnet floatables control facility (FCF)	Uses bags to capture solids, 1-2 T per event average Changed vendors in 2004 (Fresh Creeks Technologies Inc.) Considered effective in reducing solids load to Onondaga Creek Flow estimates unreliable (probe damaged)
Teall Brook FCF	Bar screen activation: County reports FCF is successfully removing floatable solids. No flow monitoring.
Butternut FCF	FCF repeatedly overtops during wet weather. County will remediate in 2005, remove piles that appear to be restricting flow Discharges to Onondaga Creek First quarter 2004: 7 events, average 1.34 million gallons (mg) Second quarter 2004:3 5 events, average 3.48 mg Third quarter 2004: 23 events, average 5.32 mg Fourth quarter 2004: 10 events, average 4.16 mg
Maltbie St. RTF	First quarter 2004 24 events average 352 gal No subsequent data (Flow meter unreliable)
Spencer St. Bypass	Documented one overflow Sept 23, 2003; this storm was calculated at a return frequency of one year. Previous monitoring confirmed capacity of bypass gate to contain a one-yr storm
Harbor Brook FCF	First quarter 2004 report notes that original facility out of service. Pontoon (trash-trawler) removed because it caused streambank erosion. To be retrofit by Fresh Creek Technologies Inc. Second quarter 2004 new facility installed 6/23/04 performance testing Performance issues remain, per third and fourth quarter reports
Erie Blvd Storage System (EBSS)	This system has a capacity of 5 mg; designed to retain discharge from 9 CSOs, and bleed back to Metro. No releases from EBSS in 2004 (all flows captured and directed to Metro)
Hiawatha RTF	One release in 2004 to Ley Creek, from disinfection tanks (second quarter) 545,000 gal on May 24, 2004 (greater than 1-yr storm)

2.1.4 Tributary Loads

2.1.4.1 Methods

External loads of chemicals, solids, and microorganisms to Onondaga Lake are calculated using a software program developed for OCDWEP by OLTAC member Dr. William Walker Jr. Results of the tributary monitoring program are stratified by flow regime and by season using a multiple regression technique. Higher-frequency measurements collected during storm events are incorporated into the calculations when they are available. In 2004, no storm events were completed. Conditions during the unmonitored period are projected using a residual interpolation method that includes a flow derivative term. This term was included to account for the potential effect of differences in the flow: concentration relationship depending on whether data were taken during periods of rising vs. falling flows.

2.1.4.2 Loading Estimates for 2004 and Historical Comparisons

Flow-weighted average concentrations of the lake inflows (tributaries and point sources) are summarized in Table 2-1. This table also reports the relative standard error (RSE) of the annual means, a reflection of the variability in measurements. Note the high RSE associated with suspended sediment (TSS) measurements in the natural tributaries. Average concentrations of heavy metals are based on quarterly measurements. Bacterial concentrations were also extremely variable between sampling events, as expected in sources affected by combined sewer overflows and urban stormwater.

The 2004 external load of materials to Onondaga Lake is summarized in Table 2-4. Loading data from 1990 - 2004 are summarized in Table 2-5. Reductions in the loading of ammonia, nitrite, and TKN are evident, reflecting the effectiveness of the BAF process at Metro. Related to this change in technology is the increase in loading of nitrate.

The relative contribution of each source to the 2004 materials and water budget for Onondaga Lake is summarized in Table 2-6. Downstream sections of tributaries tend to have both higher loading

Table 2-4. Loading of major water quality parameters to Onondaga Lake.

Parameter	Units	Onondaga Creek	Nine Mile Creek	Metro Outfall 001	Metro Outfall 002	Ley Creek	Harbor Brook	East Flume	Trib 5A	Total Monitored
Water	10^6 m^3	193	178	97	2.40	43	12	1.1	1.87	528
Total P	10^3 kg	13	10.1	52	2.8	4.2	1.02	0.18	0.23	83
SRP	10^3 kg	1.2	1.6	26	0.61	0.71	0.33	0.07	0.07	31
TKN	10^3 kg	98	119	290	24	41	5.9	1.6	1.2	580
Nitrate-N	10^3 kg	193	187	951	4.2	18	20	4.4	1.7	1,379
Nitrite-N	10^3 kg	4.4	3.8	21	0.31	0.86	0.17	0.93	0.06	31
Ammonia-N	10^3 kg	15	45	152	13.8	11.8	0.9	0.59	0.55	240
Organic-N	10^3 kg	84	74	116	8.4	28.5	5.1	0.95	0.67	318
Ca	10^3 kg	20,274	33,657	12,529	197	4,312	2,316	146	267	73,697
Cl	10^3 kg	77,890	55,008	36,195	586	12,732	3,120	550	827	186,907
Na	10^3 kg	46,404	19,213	20,475	383	7,465	1,630	410	388	96,368
TSS	10^3 kg	8,755	4,459	832	135	1,520	417	17	23	16,157
Fecal Coli (annual)	10^{10} cells	227,868	367,229	188,834	1,129,660	71,519	58,645	554	315	2,044,624
Fecal Coli (May-Sept)	10^{10} cells	147,612	352,229	8,038	730,824	65,755	55,065	450	300	1,360,273
BOD -5 day	10^3 kg	451	396	931	118	119	29	4	6	2,054
T-Alk	10^3 kg	43,524	35,630	19,333	460	8,120	2,936	195	301	110,499
TOC	10^3 kg	911	754	981	40	366	53	7	10	3,121
TIC	10^3 kg	11,322	9,289	5,398	106	2,213	771	46	78	29,222

<u>Notes</u>

(1) Metro Outfall 001 calculated loads of BOD5, NH3-N, TP, TSS are based on daily measurements; METRO TKN 5 measurements/2 wks.
(2) Metro Outfall 002 estimates based on periodic grab samples when outfall is active (high flow events).
(3) Natural tributaries, East Flume and Tributary 5A calculations based on biweekly program, plus high flow events and storms.
(4) Tributary BOD samples include a large percentage of observations below the MRL.
(5) Data are reported for farthest downstream site on streams with multiple sampling points.

Table 2-5. Annual tributary loadings to Onondaga Lake 1990-2004, and comparison of 2004 load to longterm average conditions.

Parameter	Units	Annual Load 1990	Annual Load 1991	Annual Load 1992	Annual Load 1993	Annual Load 1994	Annual Load 1995	Annual Load 1996	Annual Load 1997	Annual Load 1998	Annual Load 1999
5-day BOD	10^3 kg	2,835	2,109	4,059	4,226	2,928	2,433	3,300	2,134	2,220	1,745
Total Alkalinity	10^3 kg	127,204	86,082	104,777	107,504	92,308	64,728	101,576	75,112	83,374	59,355
Total Organic Carbon	10^3 kg	5,836	4,531	3,324	4,344	2,558	2,369	3,867	2,269	2,072	1,682
Total Inorganic Carbon	10^3 kg	32,160	21,471	26,846	26,429	23,876	16,533	26,113	18,466	22,172	15,203
Total Kjeldahl N	10^3 kg	1,907	1,745	1,880	2,003	1,927	1,883	2,081	1,494	1,274	907
Ammonia-N	10^3 kg	1,364	1,265	1,287	1,321	1,408	1,541	1,498	1,118	833	614
Nitrate-N	10^3 kg	779	488	485	515	476	295	534	465	869	625
Nitrite-N	10^3 kg	84	88	61	53	49	46	44	62	46	41
Organic-N	10^3 kg	551	436	584	666	514	324	580	376	413	276
Total Phosphorus	10^3 kg	149	83	126	140	83	65	112	50	68	54
Soluble Reactive P	10^3 kg	29	24	22	30	20	19	24	12	12	9
Calcium	10^3 kg	98,242	72,741	77,957	76,011	67,176	50,443	72,581	57,271	61,175	49,142
Sodium	10^3 kg	88,765	75,504	76,862	91,093	82,787	58,656	77,378	65,721	76,469	76,776
Chloride	10^3 kg	220,065	182,969	180,697	196,525	164,121	119,322	156,452	138,290	156,969	144,908
Total Suspended Solids	10^3 kg	24,975	13,120	22,603	15,568	11,670	5,694	19,230	5,404	10,397	11,342
Fecal Coliform	10^{10} cells	1,120,878	1,099,838	3,040,649	5,519,621	1,103,861	9,182,161	3,254,615	1,833,174	2,849,618	3,957,407

Table 2-5. Annual tributary loadings to Onondaga Lake 1990-2004, and comparison of 2004 load to longterm average conditions.

Parameter	Units	Annual Load 2000	Annual Load 2001	Annual Load 2002	Annual Load 2003	Annual Load 2004	Average Load 1990-2003	% Change 2004 from Average
5-day BOD	10^3 kg	1,981	1,734	2,325	2,696	2,054	2,623	-21.7%
Total Alkalinity	10^3 kg	90,576	75,898	85,765	102,123	110,499	89,742	23.1%
Total Organic Carbon	10^3 kg	2,224	1,895	1,975	2,896	3,121	2,989	4.4%
Total Inorganic Carbon	10^3 kg	23,876	19,667	22,533	26,978	29,222	23,023	26.9%
Total Kjeldahl N	10^3 kg	982	824	1,018	932	580	1,490	-61.1%
Ammonia-N	10^3 kg	571	499	643	503	240	1,033	-76.8%
Nitrate-N	10^3 kg	772	667	463	977	1,379	601	129.6%
Nitrite-N	10^3 kg	52	38	31	47	31	53	-41.4%
Organic-N	10^3 kg	403	319	332	440	318	444	-28.3%
Total Phosphorus	10^3 kg	53	46	48	68	83	82	1.0%
Soluble Reactive P	10^3 kg	7	8	7	15	31	17	80.6%
Calcium	10^3 kg	64,406	55,498	60,308	68,945	73,697	66,564	10.7%
Sodium	10^3 kg	90,648	85,662	88,817	102,078	96,368	81,230	18.6%
Chloride	10^3 kg	171,897	167,643	168,405	193,596	186,907	168,704	10.8%
Total Suspended Solids	10^3 kg	14,034	9,567	9,109	10,368	16,157	13,077	23.6%
Fecal Coliform	10^{10} cells	1,629,608	1,957,691	2,635,930	1,196,515	2,044,624	2,884,398	-29.1%

Table 2-6. Percent contribution by gauged inflow in 2004.

	Onondaga Creek	Ninemile Creek	Metro *Outfall 001*	Metro *Outfall 002*	Ley Creek	Harbor Brook	East Flume	Trib 5A
Water	36.5%	33.7%	18.3%	0.5%	8.2%	2.3%	0.2%	0.4%
Total P	15.2%	12.3%	62.5%	3.4%	5.0%	1.2%	0.2%	0.3%
SRP	4.1%	5.2%	84.9%	2.0%	2.3%	1.1%	0.2%	0.2%
TKN	16.8%	20.5%	49.9%	4.1%	7.1%	1.0%	0.3%	0.2%
Nitrate-N	14.0%	13.6%	69.0%	0.3%	1.3%	1.4%	0.3%	0.1%
Nitrite-N	14.0%	12.1%	66.4%	1.0%	2.8%	0.5%	3.0%	0.2%
Ammonia-N	6.3%	18.9%	63.3%	5.8%	4.9%	0.4%	0.2%	0.2%
Organic-N	26.5%	23.2%	36.6%	2.7%	9.0%	1.6%	0.3%	0.2%
Ca	27.5%	45.7%	17.0%	0.3%	5.9%	3.1%	0.2%	0.4%
Cl	41.7%	29.4%	19.4%	0.3%	6.8%	1.7%	0.3%	0.4%
Na	48.2%	19.9%	21.2%	0.4%	7.7%	1.7%	0.4%	0.4%
TSS	54.2%	27.6%	5.1%	0.8%	9.4%	2.6%	0.1%	0.1%
Fecal Coli (annual)	11.1%	18.0%	9.2%	55.3%	3.5%	2.9%	0.03%	0.02%
Fecal Coli (May-Sept)	10.9%	25.9%	0.6%	53.7%	4.8%	4.0%	0.03%	0.02%
BOD -5 day	21.9%	19.3%	45.3%	5.7%	5.8%	1.4%	0.2%	0.3%
T-Alk	39.4%	32.2%	17.5%	0.4%	7.3%	2.7%	0.2%	0.3%
TOC	29.2%	24.2%	31.4%	1.3%	11.7%	1.7%	0.2%	0.3%
TIC	38.7%	31.8%	18.5%	0.4%	7.6%	2.6%	0.2%	0.3%

Note: Approximately 93.5% of flow to Onondaga lake is from gauged sources. The remainder of flow is attributed to non-point ungauged sources and precipitation.
Data are reported for farthest downstream site for streams with multiple sampling points

and concentration of important water quality variables because of the influence of urbanized areas in the downstream portion of most tributaries (See Appendix 10, Table 10-2).

2.1.4.3 Phosphorus Loading

Total phosphorus loadings to the lake declined from the early 1990s to the early 2000s, from about 150,000 kg/yr in 1990 to about 50,000 kg/yr in 2002 (Figure 2-7). From 1999 to 2002, total phosphorus loads remained relatively constant. The 2003 and 2004 data indicate a recent increase in TP and SRP loading (to 85,000 and 30,000 kg/yr, respectively, in 2004) to the lake, primarily due to an increase in loading from Metro. This is attributed to the County's decision to eliminate chemical (ferrous chloride) addition to the activated sludge system at METRO. This decision was based on concern about potential adverse impacts (nutrient deficiency) on the tertiary BAF system for ammonia removal which started up in early 2004. Now that the tertiary ACTIFLO system has been put into service (January 2005), the effluent SRP is much lower. This will be analyzed in detail in the 2005 Annual AMP Report.

Temporal trends in phosphorus species from Metro during 2004 are plotted in Figure 2-8 along with measured concentrations at South Deep. The annual SRP loading from Metro exhibited distinct seasonality in 2004, with an increase of SRP loading during fall. TP loading from Metro exhibited less seasonality, with a less pronounced increase in the fall.

As in past years, of the major tributaries, Onondaga Creek contributed the greatest amount of phosphorus to the lake on an annual basis, followed by Ninemile Creek, Ley Creek and Harbor Brook (Figure 2-9). This pattern has not changed appreciably since the late 1980s. The same order of importance has been observed during storm events in previous years. The consistency of this pattern implies that there have been no major changes in contributions from the various portions of the watershed over this period. This is likely due to the relatively stable land use patterns in the watershed over this period.

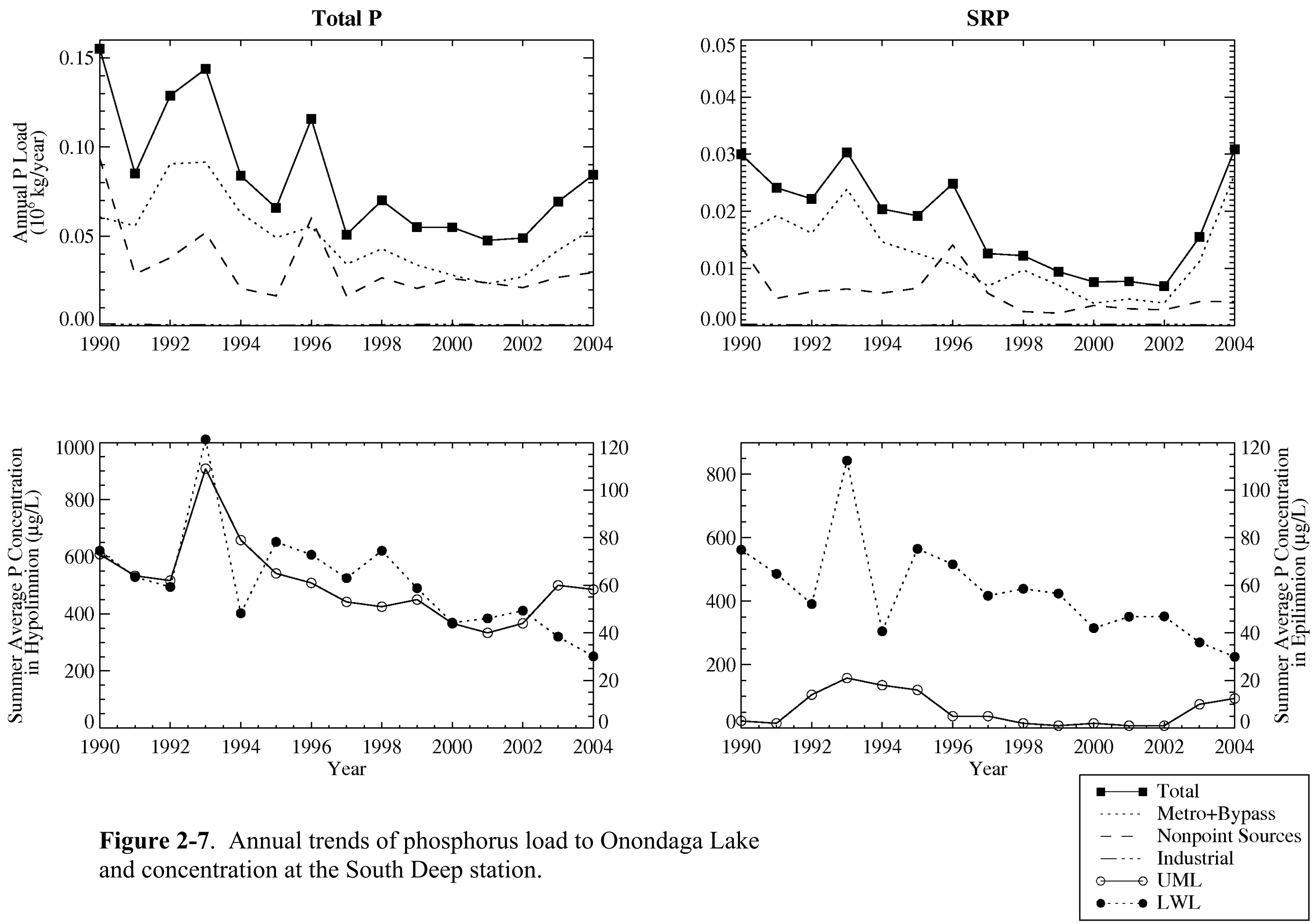


Figure 2-7. Annual trends of phosphorus load to Onondaga Lake and concentration at the South Deep station.

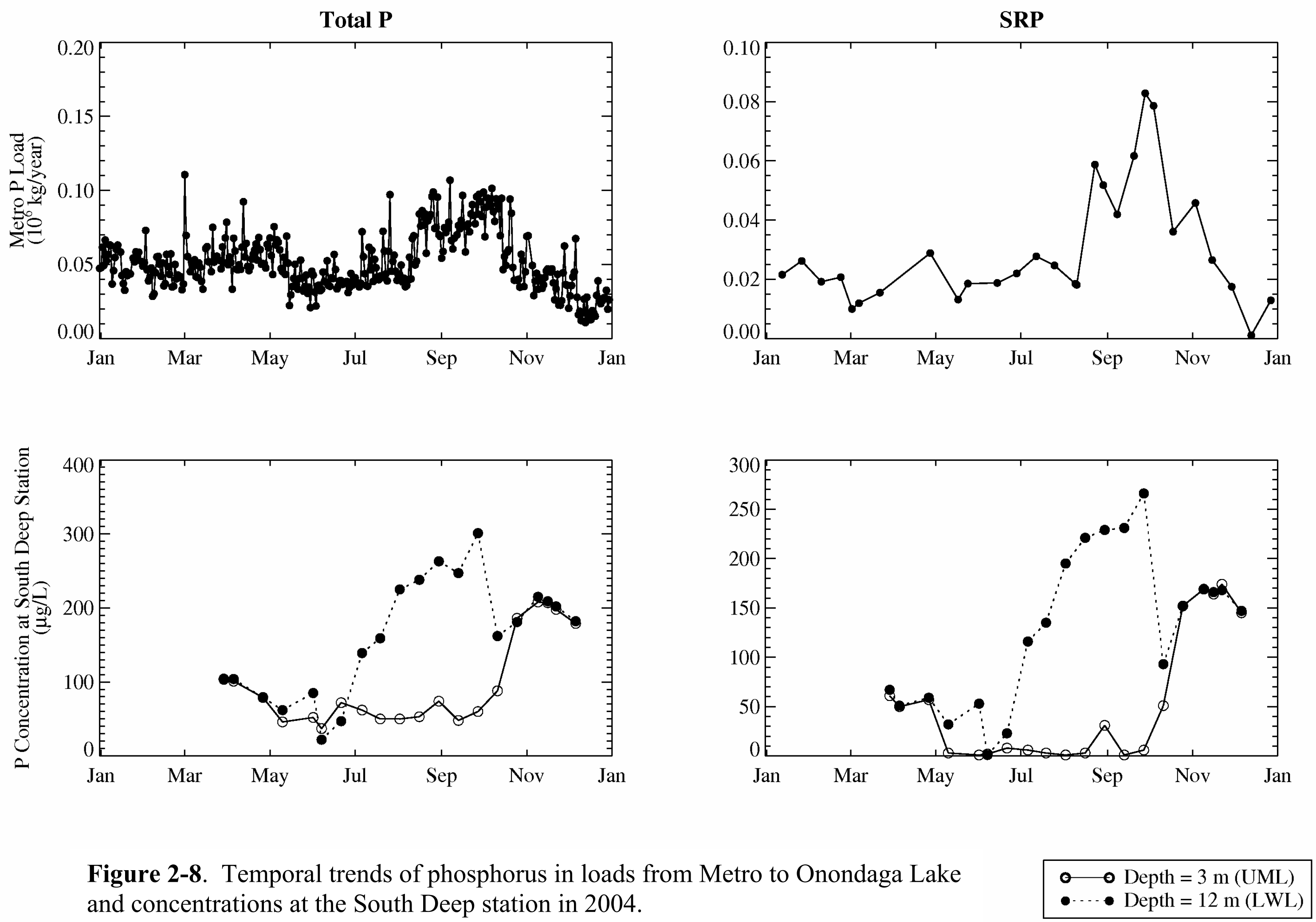


Figure 2-8. Temporal trends of phosphorus in loads from Metro to Onondaga Lake and concentrations at the South Deep station in 2004.

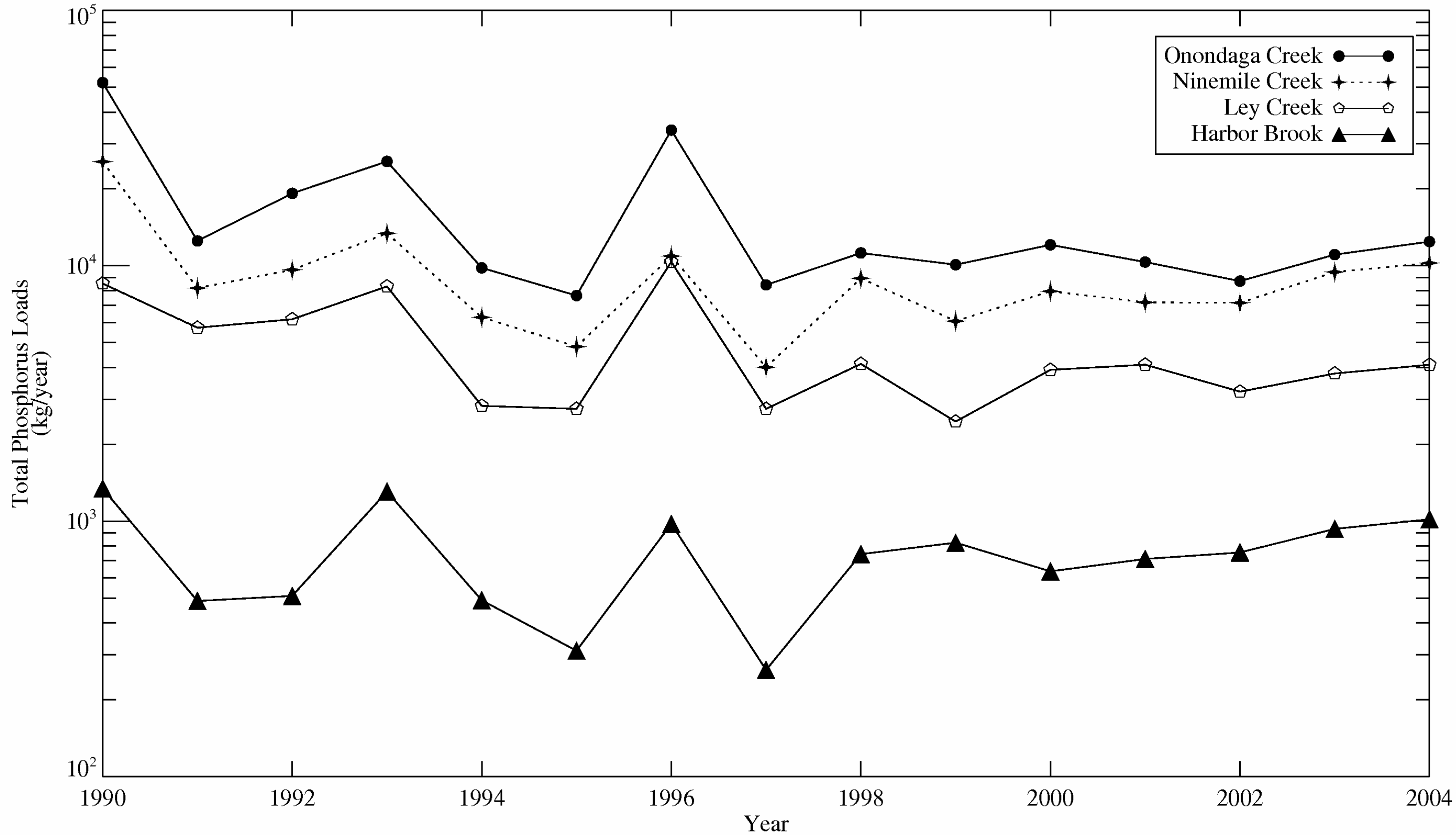


Figure 2-9. Total phosphorus loads to Onondaga Lake from the major tributaries.

2.1.4.4 Nitrogen Loading

Metro effluent represented the largest source of ammonia to the lake in 2004 (on an annual basis, refer to Table 2-6, Figure 2-3). As in previous years, Ninemile Creek and Onondaga Creek represented the largest non-Metro sources of ammonia to the lake (19% and 6%, respectively; see Table 2-6). Loading from all sources in 2004 was sufficiently low to bring the lake waters into compliance with ambient water quality standards for ammonia, as discussed in Chapter 3.

2.1.4.5 Bacterial Load

Disinfection of wastewater discharged to Onondaga Lake is required between May 15 and October 15 to protect the recreational uses. In 2004, OCDWEP utilized ultraviolet radiation to disinfect Metro Outfall 001; this represents a technology change from the previous use of chlorine followed by dechlorination. As summarized in Table 2-4, the estimates of annual bacterial load to the lake are associated with a high relative error from all the tributary steams (Table 2-1). This is due to the episodic nature of the CSO events. Seasonal loading estimates (May to September) for fecal coliform bacteria (Table 2-4) should be considered better estimates. Outfall 002, operational only during periods when high flows are reaching the treatment plant from the combined service area, is a source of bacteria far out of proportion to its annual flow contribution (Table 2-6). Flow was directed to the lake through Outfall 002 on 43 occasions in 2004. Under extremely rare conditions of high flows wastewater is bypassed at the head of the plant. This did not occur in 2004.

Abundance of fecal coliform bacteria in the Inner Harbor along Onondaga Creek has been monitored by OCDWEP personnel during the summer recreational period since 2002. This effort, while not part of the formal AMP, addresses the issue of suitability of this developing area of lower Onondaga Creek for water contact recreation. Results of the 2002 – 2004 monitoring effort are included in Appendix 10 (Special Studies). Concentrations of fecal coliform bacteria exceeded standards for water contact recreation on seven of nine sampling dates in 2004.

2.1.4.6 Upstream/Downstream Analyses

Onondaga Creek and Harbor Brook are sampled upstream and downstream of the CSO discharges. As summarized in Appendix 10, concentrations and loading of wastewater-related contaminants are tracked for the upstream and downstream sites. The increased loading at the downstream station reflects the inputs throughout the urban corridor, including stormwater runoff from the separate sewer areas as well as the CSOs.

2.1.4.7 Spencepatrick Spring Point

The USGS has established a groundwater sampling site between Spencer St and Kirkpatrick St along Onondaga Creek to track the concentration and discharge of saline groundwater into the stream bed. OCDWEP collects samples at this site four times per year and analyzes them for major anions and cations (see Appendix 10). Results in 2004 are consistent with those measured in 2003: the spring point is elevated in chloride, demonstrates relatively low seasonal variability, and sodium is the major cation.

2.2 MASS BALANCE ANALYSIS

Dr. William W. Walker Jr. has developed a mass-balance modeling framework for Onondaga Lake; the structure is described in previous AMP reports. As presented in Appendix 7, the mass-balance framework has been integrated with the AMP's long-term database and updated with 2003 and 2004 data.

The framework facilitates computation and analysis of mass balances for nutrients and other water-quality components using hydrologic and water quality data collected in the Lake and its tributaries since 1986. The input and output of water and materials are formulated on yearly and seasonal (May-September) time scales.

Ten-year trends in the concentration and load of inflows and outflows are tabulated in Appendix 7, as are five-year average mass balances for five constituents: chloride (which serves as a basis for testing the accuracy and completeness of the data set and the reasonableness of the mass-balance assumptions), total P, soluble reactive P, total N and ammonia N.

The input of several constituents to Onondaga Lake exceeds the output, demonstrating the extent to which the lake is a sink for materials. Among these constituents are total suspended solids and silica; Onondaga Lake, like most lakes, traps a portion of the particulate materials exported from its watershed. Total P input also exceeds the output, as does the input of Total N.

The extent to which Onondaga Lake retains dissolved constituents is more variable, and the patterns are shifting with changes in Metro treatment processes. For example, until 2003 the inflow of ammonia N and TKN exceeded the outflow, they are now about equal. Nitrate N input now exceeds output with the nitrified Metro effluent. Outflow concentrations of SRP, historically higher than inflows, are now about equal. The SRP load from Metro evidenced about a five-fold increase from 2002 – 2004. As discussed in Section 2.1.4.3, this is related to the reduced ferrous chloride additions in the activated sludge system during the start-up of the BAF system.

2.3 ONONDAGA LAKE WATER QUALITY: 2004 FINDINGS

As outlined in Chapter 1, the AMP is designed to support an assessment of whether Onondaga Lake meets its designated uses as Class B/Class C surface water. Compliance is assessed by monitoring a suite of water quality parameters. Some of the parameters are associated with ambient water quality standards or guidelines; others are measured to help elucidate how the lake functions. The focus of the Onondaga County monitoring effort is wastewater-related parameters. The County monitors indicators of human health and safety, such as sewage-related coliform bacteria and water clarity, along with ecological conditions, such as dissolved oxygen and nutrient levels, abundance of plant life, and the success of fish reproduction.

2.3.1 Stratification and Mixing

Selected physical and chemical characteristics of Onondaga Lake are recorded at frequent intervals using specialized water quality monitoring instrumentation deployed in the lake. Two monitoring buoys moored at the South Deep station provide near real-time measurements of lake water quality conditions. The Onondaga County buoy is designed to record water temperature, pH, specific conductance, dissolved oxygen, chlorophyll-*a*, and turbidity at frequent time intervals (every 15 minutes) at fixed depths of 3 m, 6 m, 12 m, and 15 m. Results are transmitted to a computer at the OCDWEP offices on Hiawatha Boulevard where they are uploaded to the County's web site. The buoy is in operation from early spring to late fall. Data can be viewed through http://www.ongov.net/WEP/we1510.html

An interactive Data Visualization Tool (DVT) has been developed by Quantitative Environmental Analysis, LLC (QEA) to display the Onondaga County buoy data. An example of the DVT output (2004 water temperature at South Deep) is displayed in Figure 2-10. A line plot displaying the same dataset (Figure 2-11) is included as well; this plot illustrates the dynamic nature of the lake's thermal structure. Note how the water temperature recorded by the 6-m buoy can oscillate by more than 5 degrees over short time intervals, on the scale of hours. This is interpreted to represent the effects of wind-induced internal seiche activity.

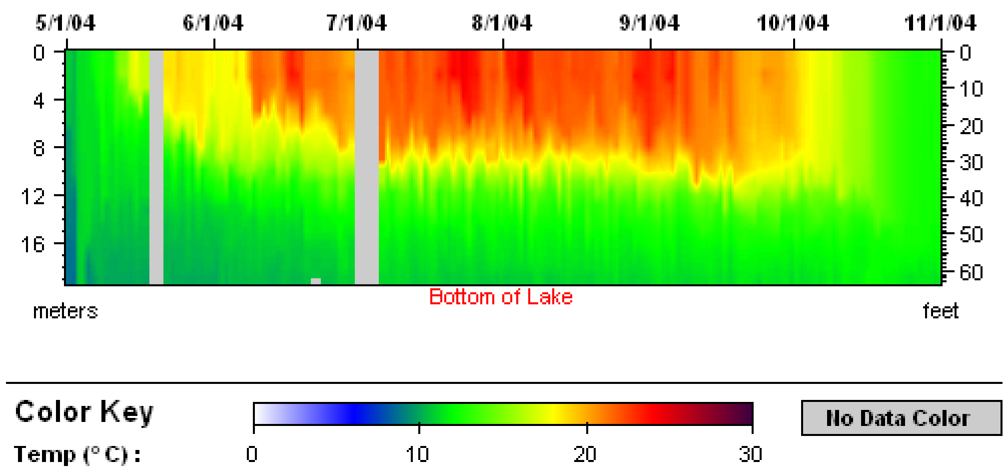


Figure 2-10. Contour plot of water temperature in Onondaga Lake, South Deep Station, 2004. Note: concentrations are daily averaged.

A second buoy moored at South Deep is operated by the Upstate Freshwater Institute of Syracuse NY with funding from the U.S. Environmental Protection Agency. This buoy collects data at multiple depths once or twice daily. Data plots are on-line at a web site maintained by the University of Minnesota http://www.waterontheweb.org/data/onondaga or at www.ourlake.org

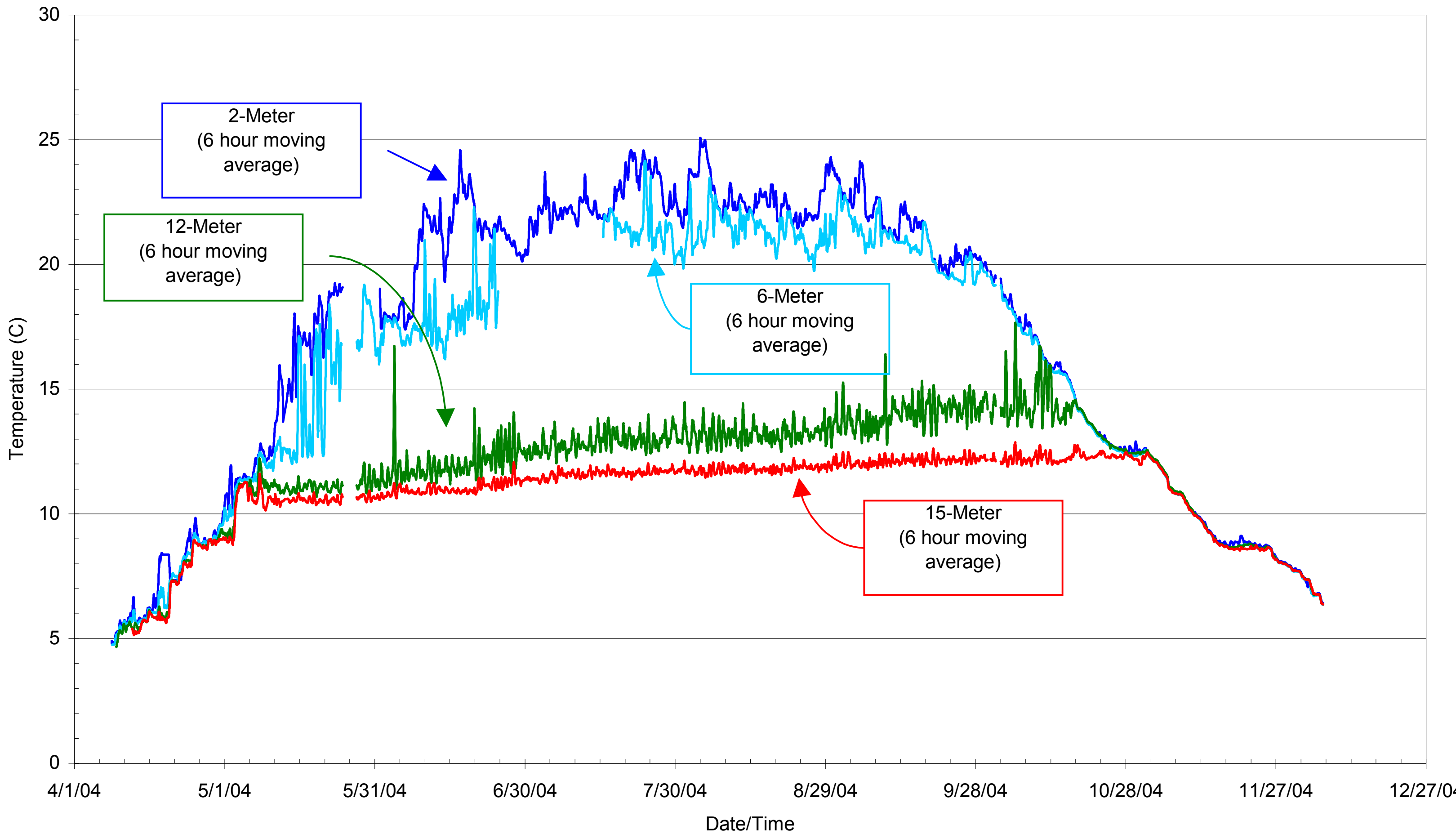


Figure 2-11. Metro South Deep YSI Monitoring Buoy 2004, Temperature (C).

Taken together, data from the buoys moored at South Deep enable lake managers to examine conditions at both frequent time intervals and multiple depths. OCDWEP routinely conducts side-by-side examinations of data reported by the two buoys, and compares the buoy data with results of samples collected in the field. To date, no systematic differences have been noted in temperature, DO, pH or specific conductance between the buoys or as compared with field measurements. However, total chlorophyll data collected by either buoy do not correlate well with laboratory analysis of the pigment, which measures chlorophyll-*a*.

Based on paired sampling results from the North Deep and South Deep stations on four dates, the lake is laterally well mixed. There is no systematic gradient in ambient water quality conditions from the south, where most of the inflows enter the lake, to the north. Results of the four paired sampling events during 2004 are included as Tables 2-7, 2-8, 2-9, and 2-10.

2.3.2 Phosphorus and Trophic State

In 2004, the total phosphorus (TP) concentration in the lake's upper waters averaged 60 µg/l during the summer recreational period, June – September. The time period for averaging and the sampling depth was selected to be consistent with the NYSDEC guidance value for phosphorus in lakes.

Average TP and SRP concentrations in the UML declined in the late 1990s and have been relatively stable since about 2000 (Figure 2-7). Summer average concentrations in the lake's upper waters have ranged from 35 - 70 µg/l since the late 1990's (Figure 2-12). Onondaga Lake remains a eutrophic system, as summarized in Table 2-11.

Similarly, the summer average concentrations of TP and SRP in the LWL generally declined in the late 1990s and have been relatively stable since about 2000. In contrast to the UML, 2004 values were the lowest since 1989. The decline in the late 1990s occurred concurrently with a decline in ammonia, an increase in nitrite and nitrate, and a decrease in the volume-days of anoxia. It is possible that these trends are linked to the availability of oxygen. The biomass of phytoplankton, which settle to the lower waters and exert oxygen demand as they are decomposed, exhibited a decreasing trend over this period (Figure 2-13). The total external loading of oxidizable material to Onondaga Lake, including both carbonaceous and nitrogenous material has also shown a declining trend since the late 1980s (Figure 2-14). The concomitant decrease in volume days of anoxia (Figure 2-15) implies a direct linkage between algal biomass and sediment oxygen demand. Note that all of these parameters have remained relatively constant since 2000.

Table 2-7. Comparison of South and North data, April 6, 2004.

PARAMETER	UNITS	UPPER MIXED LAYER SOUTH	UPPER MIXED LAYER NORTH	LOWER WATER LAYER SOUTH	LOWER WATER LAYER NORTH
Secchi Disc Depth	m	1.4	1.60	NA	NA
pH	Std. Units	7.82	7.82	7.84	7.72
Temperature	C	4.8	4.4	4.7	4.1
Specific conductance	umho/cm	1826	1931	1845	2064
Dissolved Oxygen	mg/l	12.18	11.5	12.02	10.08
5-day BOD	mg/l	< 2.0	< 2	< 2.0	< 2.0
Total Alkalinity	mg/l	191	198	197	198
Total Organic Carbon	mg/l	8.00	11.1	8.58	14.1
TOC-Filtered	mg/l	6.06	7.7	5.75	12.6
Total Inorganic Carbon	mg/l	51.2	50.7	50.1	54.7
Total Kjeldhal Nitrogen	mg/l	1.00	1.12	1.05	1.26
TKN-Filtered	mg/l	0.80	0.89	0.82	1.05
Organic Nitrogen	mg/l	0.436	0.42	0.482	0.38
Ammonia-N	mg/l	0.568	0.70	0.572	0.87
Nitrite-N	mg/l	0.020	0.020	0.020	0.02
Nitrate-N	mg/l	2.23	2.16	2.23	2.0
Total Phosphorus	mg/l	0.104	0.109	0.105	0.137
Soluble Reactive Phosphorus	mg/l	0.050	0.069	0.052	0.094
Silica	mg/l	4.50	4.80	4.7	4.88
Calcium	mg/l	119	128	114	134
Sodium	mg/l	217	224	215	260
Potassium	mg/l	3.78	4.0	3.88	4.2
Sulfate	mg/l	143	142	138	164
Chloride	mg/l	396	453	388	474
Total Solids	mg/l	1160	1131	1107	1210
Total Volatile Solids	mg/l	117	123	108	123
Total Suspended Solids	mg/l	6.00	4.0	5.8	3.6
Volatile Suspended Solids	mg/l	2.76	2.0	3.0	< 2.0
Total Dissolved Solids	mg/l	1081	1126	1085	1190
Arsenic	ug/l	< 1.0	1.0	< 1.0	< 1.0
Iron	mg/l	0.1360	0.102	0.140	0.203
Copper	ug/l	1.4	1.5	1.3	2.0
Chrominum	ug/l	< 0.50	< 0.50	0.60	0.50
Cadmium	ug/l	< 0.4	< 0.40	< 0.4	< 0.40
Lead	ug/l	4.3	4.2	3.8	4.8
Magnesium	mg/l	22.00	22.5	22.40	24.4
Manganese	mg/l	0.0273	0.048	0.032	0.193
Nickel	ug/l	< 2.5	< 2.5	< 2.5	< 2.5
Selenium	ug/l	< 2.0	< 2.0	< 2.0	< 2.0
Zinc	ug/l	8.9	6.6	8.7	7.8
Phaeophytin-*a* (1)	mg/m^3	< 0.20	0.37	NA	NA
Chlorophyll-a (1)	mg/m^3	14.42	7.5	NA	NA
Fecal Coliforms	cells/100ml	25	15	NA	NA
E.Coli	cells/100ml	40	< 5	NA	NA

Notes:

Data are volume-weighted when appropriate.

Calculations use the laboratory limit of detection when an observation is below that limit.

NA: Not Analyzed

(1) value represents a composite sample observation.

(2) sample taken from the photic zone.

Table 2-8. Comparison of South and North data, June 22, 2004.

		UPPER MIXED LAYER		LOWER WATER LAYER	
PARAMETER	**UNITS**	***SOUTH***	***NORTH***	***SOUTH***	***NORTH***
Secchi Disc Depth	m	2.0	1.40	NA	NA
pH	Std. Units	8.15	8.21	7.29	7.23
Temperature	C	21.4	21.3	10.9	11.4
Specific conductance	umho/cm	1774	1784	1784	1801
Dissolved Oxygen	mg/l	10.62	11.1	0.10	0.15
5-day BOD	mg/l	3.0	5	4.0	< 2.0
Total Alkalinity	mg/l	176	176	202	200
Total Organic Carbon	mg/l	6.79	6.3	4.53	4.3
TOC-Filtered	mg/l	4.90	4.5	2.84	2.8
Total Inorganic Carbon	mg/l	46.8	47.1	59.8	55.7
Total Kjeldhal Nitrogen	mg/l	0.76	0.88	0.66	0.51
TKN-Filtered	mg/l	0.38	0.44	0.54	0.38
Organic Nitrogen	mg/l	0.682	0.81	0.306	0.29
Ammonia-N	mg/l	0.080	0.07	0.352	0.22
Nitrite-N	mg/l	0.050	0.060	0.140	0.06
Nitrate-N	mg/l	2.01	1.86	2.03	2.3
Total Phosphorus	mg/l	0.072	0.062	0.235	0.167
Soluble Reactive Phosphorus	mg/l	0.030	0.004	0.179	0.141
Silica	mg/l	1.02	1.02	4.3	3.67
Calcium	mg/l	131	129	130	128
Sodium	mg/l	195	193	200	199
Potassium	mg/l	3.86	3.8	4.20	3.5
Sulfide	mg/l	NA	NA	< 0	< 0
Sulfate	mg/l	156	146	143	138
Chloride	mg/l	384	382	385	384
Total Solids	mg/l	1184	1136	1204	1164
Total Volatile Solids	mg/l	260.00	188.0	288.0	204.3
Total Suspended Solids	mg/l	2.00	3.0	< 2.0	< 2.0
Volatile Suspended Solids	mg/l	2	3	< 2	< 2
Total Dissolved Solids	mg/l	1144.0	1100.0	1078.0	1092.1
Arsenic	ug/l	< 1.0000	1.000	< 1.000	< 1.000
Iron	mg/l	0.1	0.0	0.0	0.0
Copper	ug/l	1.40	1.70	1.40	1.20
Chrominum	ug/l	< 0.5	0.60	< 0.5	< 0.50
Cadmium	ug/l	4.9	0.4	5.7	6.1
Lead	ug/l	5.40	< 1.2	3.80	6.7
Magnesium	mg/l	24.1000	24.100	23.200	23.000
Manganese	mg/l	0.0	0.0	0.5	0.2
Nickel	ug/l	< 2.5	< 2.5	4.8	< 2.5
Selenium	ug/l	< 2.0	< 2.0	< 2.0	< 2.0
Zinc	ug/l	3.80	3.30	4.1	3.2
Phaeophytin-*a* (1)	mg/m^3	0.80	< 0.2	NA	NA
Chlorophyll-a (1)	mg/m^3	31	57	NA	NA
Fecal Coliforms	cells/100ml	5	< 5	NA	NA
E.Coli	cells/100ml	5	< 5	NA	NA

Notes:

Data are volume-weighted when appropriate.

Calculations use the laboratory limit of detection when an observation is below that limit.

NA: Not Analyzed

(1) value represents a composite sample observation.

(2) sample taken from the photic zone.

Revision: 10/27/04

Table 2-9. Comparison of South and North data, September 14, 2004.

PARAMETER	UNITS	UPPER MIXED LAYER		LOWER WATER LAYER	
		SOUTH	*NORTH*	*SOUTH*	*NORTH*
Secchi Disc Depth	m	1.6	1.70	NA	NA
pH	Std. Units	8.16	8.12	7.22	7.26
Temperature	C	21.4	21.5	13.1	12.7
Specific conductance	umho/cm	1569	1561	1937	1905
Dissolved Oxygen	mg/l	11.40	10.4	0.31	0.18
5-day BOD	mg/l	3.0	3	5.0	6.0
Total Alkalinity	mg/l	146	150	224	226
Total Organic Carbon	mg/l	5.70	5.3	5.95	14.4
TOC-Filtered	mg/l	5.09	4.7	4.58	4.1
Total Inorganic Carbon	mg/l	39.5	39.1	59.0	59.1
Total Kjeldhal Nitrogen	mg/l	0.76	0.57	2.04	1.98
TKN-Filtered	mg/l	0.44	0.40	1.63	1.90
Organic Nitrogen	mg/l	0.669	0.48	0.505	0.23
Ammonia-N	mg/l	< 0.086	0.09	1.538	1.75
Nitrite-N	mg/l	0.080	0.080	0.110	0.56
Nitrate-N	mg/l	1.16	1.16	0.14	0.6
Total Phosphorus	mg/l	0.045	0.042	0.386	0.419
Soluble Reactive Phosphorus	mg/l	0.002	0.002	0.365	0.380
Silica	mg/l	1.69	1.17	4.9	4.86
Calcium	mg/l	108	111	129	130
Sodium	mg/l	172	171	217	220
Potassium	mg/l	4.30	4.3	4.39	4.4
Sulfide	mg/l	NA	NA	< 1	< 1
Sulfate	mg/l	103	101	103	105
Chloride	mg/l	338	338	421	421
Total Solids	mg/l	1060	1055	1285	1273
Total Volatile Solids	mg/l	247.81	235.3	236.2	224.8
Total Suspended Solids	mg/l	6.24	5.7	< 2.0	< 2.0
Volatile Suspended Solids	mg/l	3	< 3	< 2	< 2
Total Dissolved Solids	mg/l	1004.6	1014.9	1243.2	1202.8
Arsenic	ug/l	< 1.0000	1.000	< 1.000	1.100
Iron	mg/l	0.0	0.0	0.1	0.1
Copper	ug/l	2.30	1.10	0.80	1.00
Chrominum	ug/l	< 0.5	< 0.50	0.8	< 0.50
Cadmium	ug/l	< 0.4	< 0.4	< 0.4	< 0.4
Lead	ug/l	1.40	< 1.2	< 1.20	< 1.2
Magnesium	mg/l	21.7000	21.800	23.900	24.100
Manganese	mg/l	0.0	0.0	0.7	0.6
Nickel	ug/l	< 2.5	< 2.5	4.1	4.4
Selenium	ug/l	< 2.0	< 2.0	< 2.0	< 2.0
Zinc	ug/l	4.00	5.10	7.2	6.4
Phaeophytin-*a* [1]	mg/m^3	< 0.20	< 0.2	NA	NA
Chlorophyll-a [1]	mg/m^3	29	37	NA	NA
Fecal Coliforms	cells/100ml	5	4	NA	NA
E.Coli	cells/100ml	< 5	10	NA	NA

Notes:

Data are volume-weighted when appropriate.

Calculations use the laboratory limit of detection when an observation is below that limit.

NA: Not Analyzed

[1] value represents a composite sample observation.

[2] sample taken from the photic zone.

Revision: 10/27/04

Table 2-10. Comparison of South and North data, November 17, 2004.

PARAMETER	UNITS	UPPER MIXED LAYER		LOWER WATER LAYER	
		SOUTH	***NORTH***	***SOUTH***	***NORTH***
Secchi Disc Depth	m	2.8	2.90	NA	NA
pH	Std. Units	7.63	7.71	7.69	7.71
Temperature	C	8.7	8.7	8.6	8.6
Specific conductance	umho/cm	1849	1849	1855	1876
Dissolved Oxygen	mg/l	9.85	9.4	9.80	9.24
5-day BOD	mg/l	3.0	3	3.0	3.0
Total Alkalinity	mg/l	190	192	192	190
Total Organic Carbon	mg/l	4.07	3.9	4.05	3.8
TOC-Filtered	mg/l	3.64	3.4	3.53	3.4
Total Inorganic Carbon	mg/l	44.7	44.5	45.3	45.1
Total Kjeldhal Nitrogen	mg/l	1.17	1.12	1.15	1.14
TKN-Filtered	mg/l	1.07	1.04	1.02	1.03
Organic Nitrogen	mg/l	0.378	0.35	0.353	0.36
Ammonia-N	mg/l	0.790	0.78	0.792	0.78
Nitrite-N	mg/l	0.110	0.100	0.100	0.10
Nitrate-N	mg/l	1.42	1.27	1.43	1.2
Total Phosphorus	mg/l	0.206	0.201	0.205	0.198
Soluble Reactive Phosphorus	mg/l	0.165	0.167	0.167	0.163
Silica	mg/l	3.04	3.04	3.2	3.69
Calcium	mg/l	137	140	136	144
Sodium	mg/l	219	222	222	215
Potassium	mg/l	4.77	4.7	4.65	4.7
Sulfate	mg/l	155	156	150	163
Chloride	mg/l	418	412	411	405
Total Solids	mg/l	1183	1277	1251	1296
Total Volatile Solids	mg/l	205	266	272	262
Total Suspended Solids	mg/l	2.00	< 2.0	2.2	2.2
Volatile Suspended Solids	mg/l	< 2.00	< 2.0	< 2.0	< 2.0
Total Dissolved Solids	mg/l	1147	1194	1184	1204
Arsenic	ug/l	< 1.0	1.0	< 1.0	< 1.0
Iron	mg/l	0.0589	0.046	0.058	0.069
Copper	ug/l	0.9	0.8	1.3	< 0.5
Chrominum	ug/l	< 0.50	< 0.50	< 0.50	< 0.50
Cadmium	ug/l	< 0.4	< 0.40	< 0.4	< 0.40
Lead	ug/l	< 1.2	< 1.2	< 1.2	< 1.2
Magnesium	mg/l	25.70	26.0	25.70	26.4
Manganese	mg/l	0.0831	0.086	0.081	0.090
Nickel	ug/l	3.3	3.4	3.3	3.2
Selenium	ug/l	< 2.0	< 2.0	< 2.0	< 2.0
Zinc	ug/l	4.4	8.5	4.4	6.8
Phaeophytin-*a* [(1)]	mg/m^3	< 0.20	< 0.20	NA	NA
Chlorophyll-a [(1)]	mg/m^3	9.08	5.9	NA	NA
Fecal Coliforms	cells/100ml	56	105	NA	NA
E.Coli	cells/100ml	56	68	NA	NA

Notes:

Data are volume-weighted when appropriate.

Calculations use the laboratory limit of detection when an observation is below that limit.

NA: Not Analyzed

[(1)] value represents a composite sample observation.

[(2)] sample taken from the photic zone.

Revision: 10/27/04

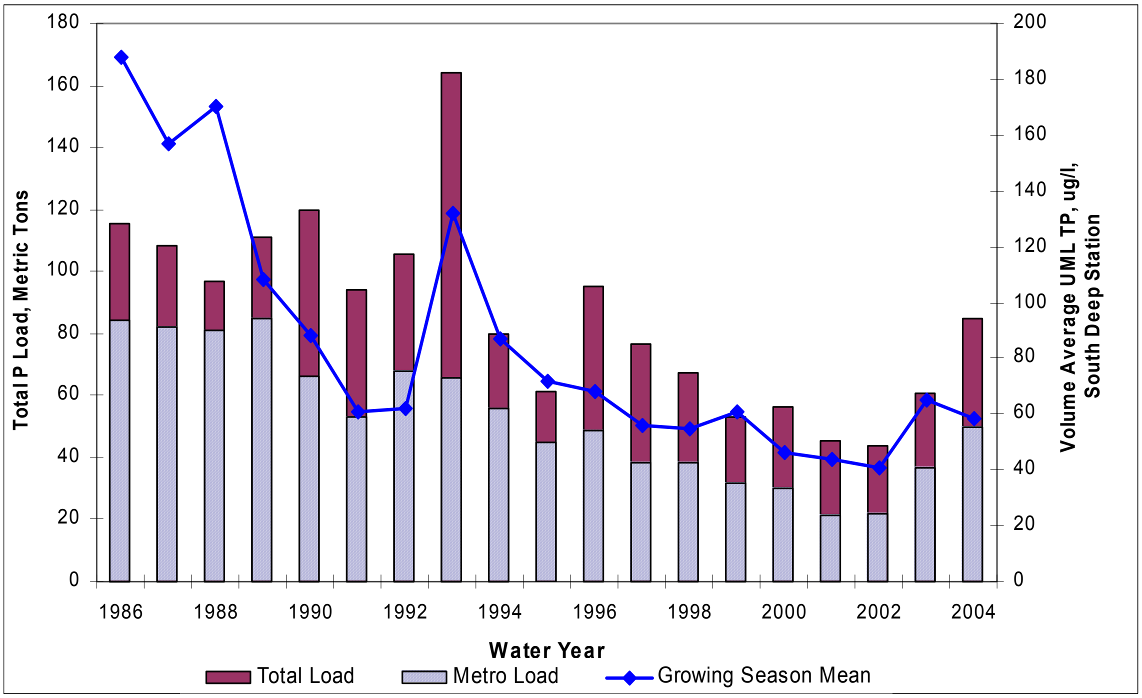


Figure 2-12. Annual external load of total phosphorus (for water year Oct. 1 to Sept. 30) and volume averaged UML TP (growing season mean) at South Deep station in Onondaga Lake, 1986-2004.

Table 2-11. Trophic State Indicator (TSI) parameters compared with Onondaga Lake 2004 water quality.

	Oligotrophic	Mesotrophic	Eutrophic	Onondaga Lake 2004
Summer average total phosphorus, upper waters (µg/l)	<10	10-35	35 -100	**60**
Summer average chlorophyll-*a*, upper waters (µg/l)	<2.5	2.5 – 8	8 – 25	**16.5 (Jun-Aug)**
Peak chlorophyll-*a* (µg/l)	<8	8-25	25-75	**48 (Sept. 14, 2004)**
Average Secchi disk transparency, m	>6	6-3	3-1.5	**1.7 (Jun-Sep)**
Minimum Secchi disk transparency, meters	>3	3-1.5	1.5-0.7	**0.9**
Dissolved oxygen in lower waters (% saturation)	80 – 100	10-80	Less than 10	**Zero**

Reference for TSI designations: Janus, L.L. and Vollenweider, R.A. 1981. *The OECD Cooperative Programme on Eutrophication: Summary Report - Canadian Contribution.* Inland Waters Directorate Scientific Series No. 131, Environment Canada, Burlington, Ontario, Canada.

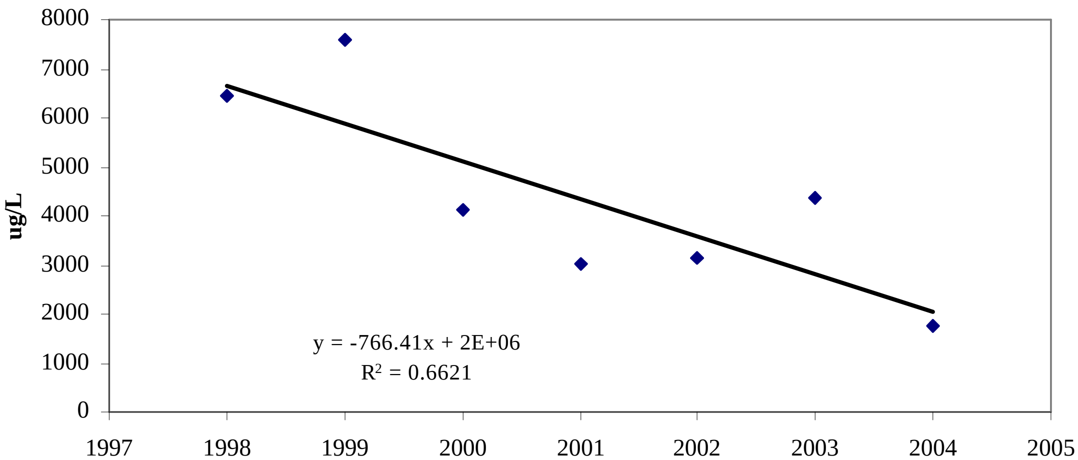


Figure 2-13. Annual average phytoplankton biomass in Onondaga Lake, South Deep Station, 1998-2004.

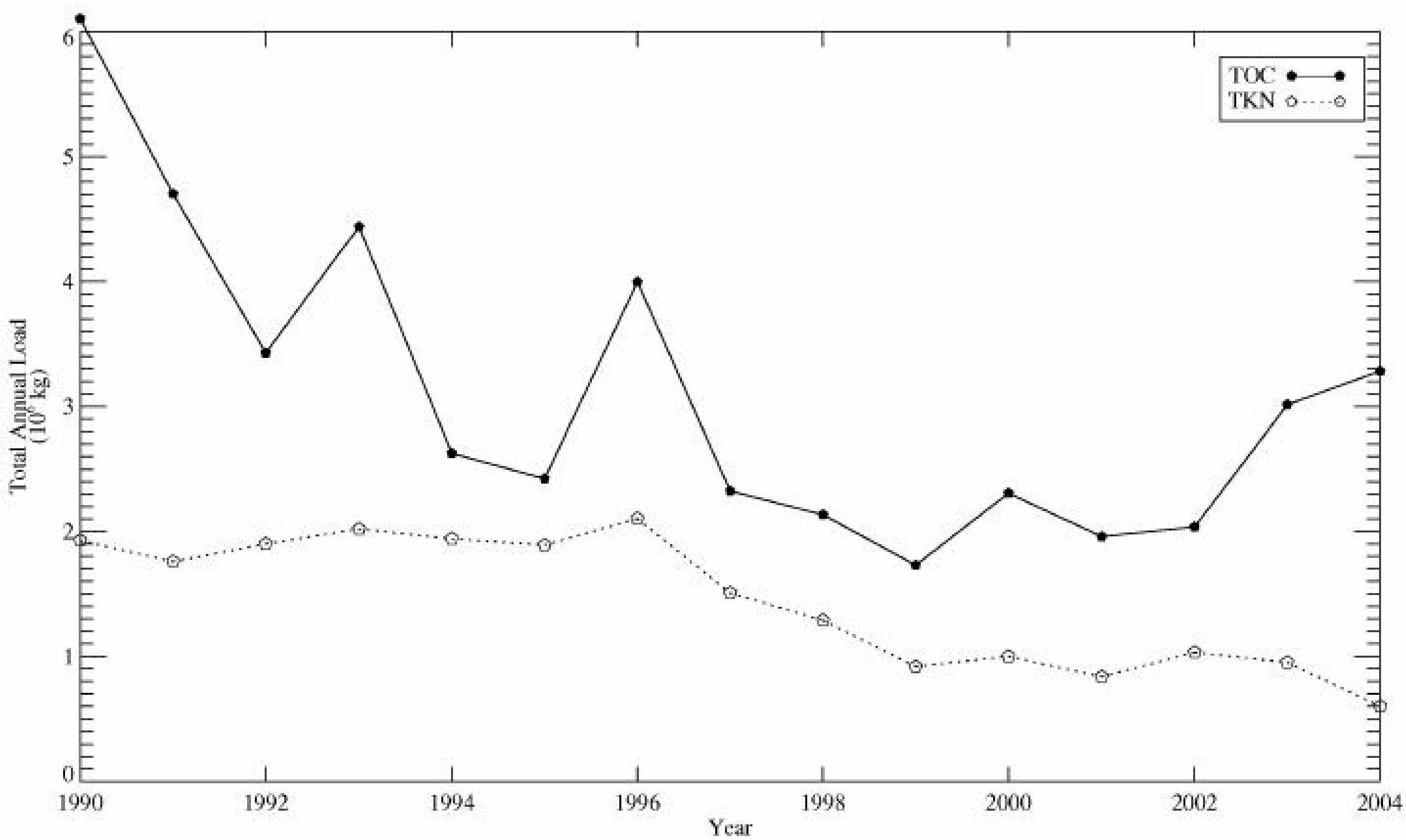


Figure 2-14. Historical total loading of oxidizable material to Onondaga Lake: organic carbon and total Kjeldahl nitrogen.

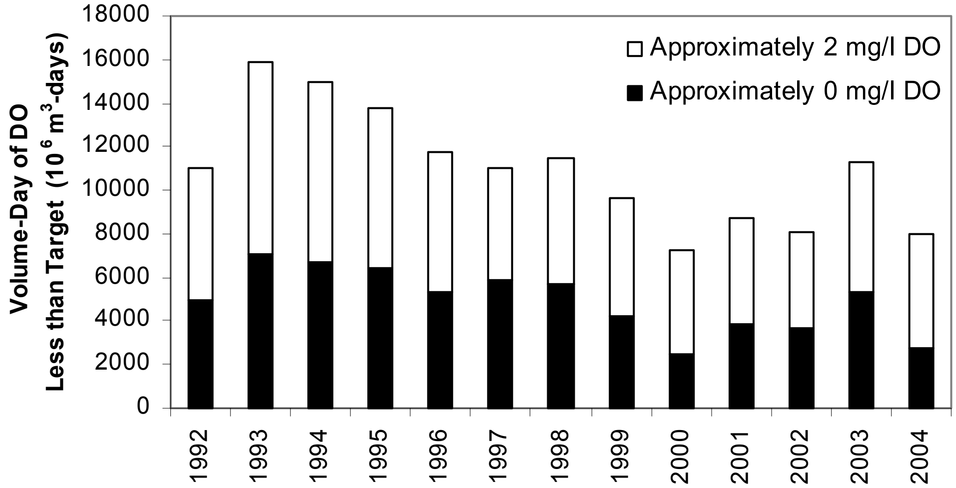


Figure 2-15. Volume-days of anoxia in Onondaga Lake, South Deep Station, 1992-2004.

2.3.3 Chlorophyll–*a*

Chlorophyll-*a* concentration in the upper mixed layer of Onondaga Lake averaged 20 µg/l during the period of June 1 – September 30, 2004. There was no prolonged clearing event in 2004, continuing the pattern first reported in 2002. As displayed in Figure 2-16, the spring algal bloom died off in late May. Algal standing crop biomass increased again through June and increased to bloom conditions by the end of the month. Chlorophyll-*a* concentrations were variable through

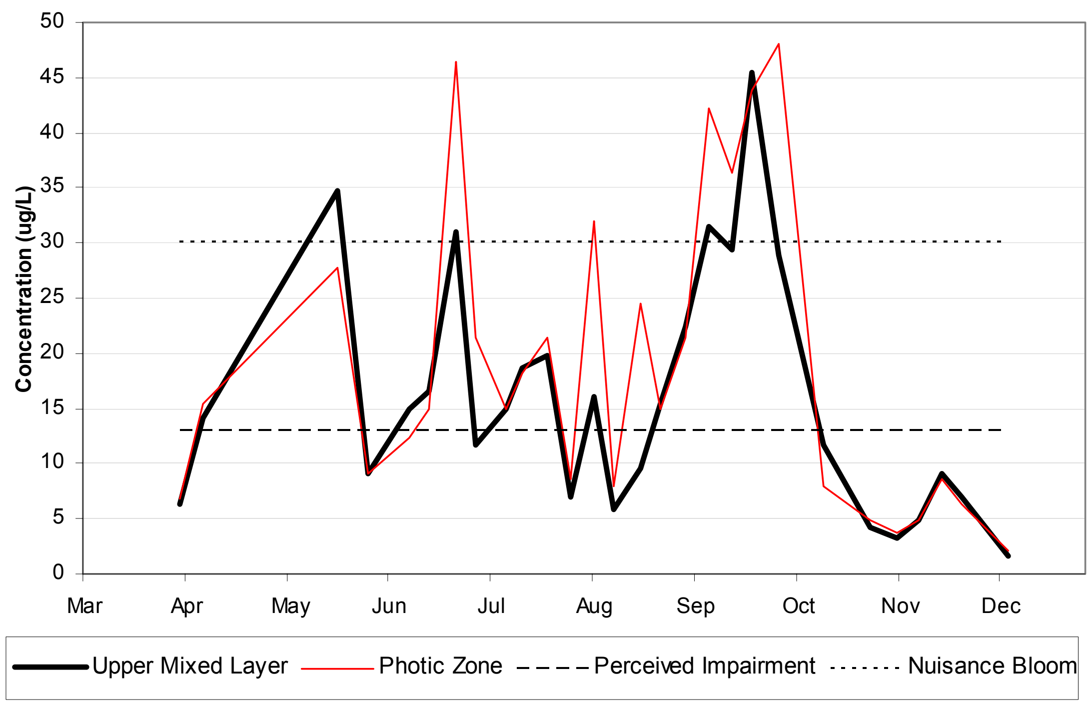


Figure 2-16. Chlorophyll-a concentration at South Deep, upper mixed layer and photic zone, in 2004. Perceived impairment and nuisance bloom guidance values based on surveys of the public by NYSDEC.

July and August. A late bloom occurred the second half of September, and the annual peak concentration was measured at 48 µg/l on September 28, 2004. Approximately 7% of the measurements obtained during the summer of 2004 were in excess of 30 µg/l; 57% of measurements were > 15 µg/l. The fall bloom persisted through mid-September when the algal biomass gradually declined through the remainder of the monitoring period. Although these chlorophyll-a concentrations are elevated compared with other regional lakes, they were reduced from the very high values of 2003, when 30% of the summer measurements were > 30 µg/l.

2.3.4 Water Clarity and Light Penetration

2.3.4.1 Secchi depth at South Deep

The 2004 Secchi disk transparency results measured at the deepest point in Onondaga Lake (South Deep station) are plotted in Figure 2-17. Note the seasonal changes in water clarity; Secchi disk transparency was low during the spring period of high algal abundance, increased somewhat in late May as the phytoplankton community declined (although not to the extent recorded in previous years) and fluctuated around 1.5 m during the summer and early fall. The annual minimum occurred on July 12, 2004 with a Secchi disk transparency of 0.9 m.

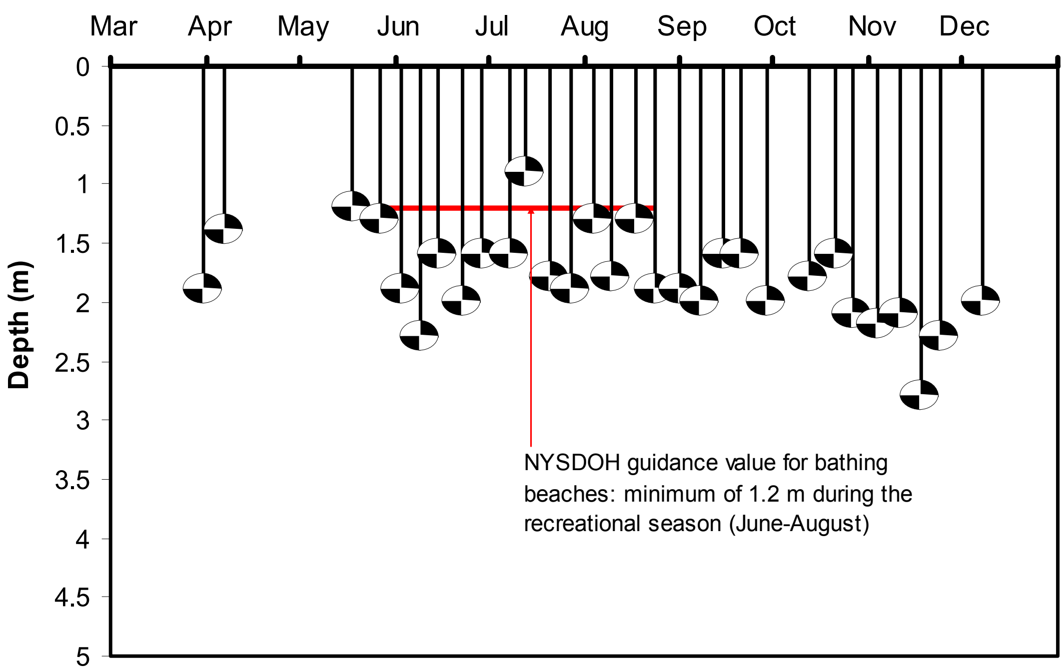


Figure 2-17. Secchi disk transparency in the upper mixed layer of Onondaga Lake, South Deep Station, 2004.

An interesting feature of the long-term Secchi disk data is the development and loss of the "clearing event" a period in the late spring when water clarity increased in response to zooplankton abundance. As displayed in Figure 2-18, high water clarity during the spring period was evident during the 1990s.

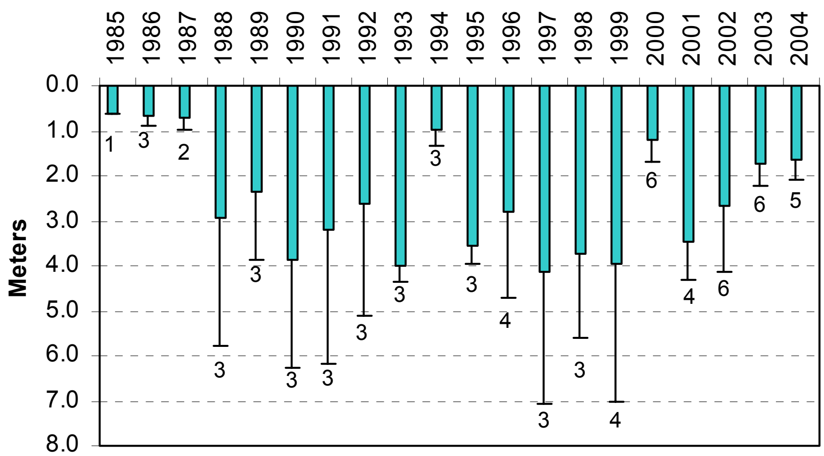


Figure 2-18. Mean Secchi Disk transparency from May 1 - June 15, South Deep Station, Onondaga Lake. Lines at the end of the bars represent one standard deviation. Number of observations included.

2.3.4.2 LiCor Data Analysis

While Secchi disk transparency is a widely-used measure of lake water clarity, light penetration through the water column can be measured directly using a transmissometer. OCDWEP collects these data in Onondaga Lake using a LiCor transmissometer (Model # LI-1400). This instrument measures the intensity of Photosynthetically Active Radiation (PAR, 400-700 nm) by lowering a light detector unit through the water column. Data are analyzed using the Beer-Lambert law to calculate the light extinction coefficient using the function:

$$I = I_0 \, e^{-kz}$$

where:

I = light intensity at depth, z
I_0= light intensity at surface
k = extinction coefficient

Higher values of k are associated with more turbid conditions; these conditions cause light to be scattered and/or absorbed by material in the water column and thus to limit the depth of penetration.

The temporal plot of light extinction measured in 2004 (Figure 2-19) illustrates the variability in this measurement. The concentration of chlorophyll-*a* in the photic zone is also plotted to indicate

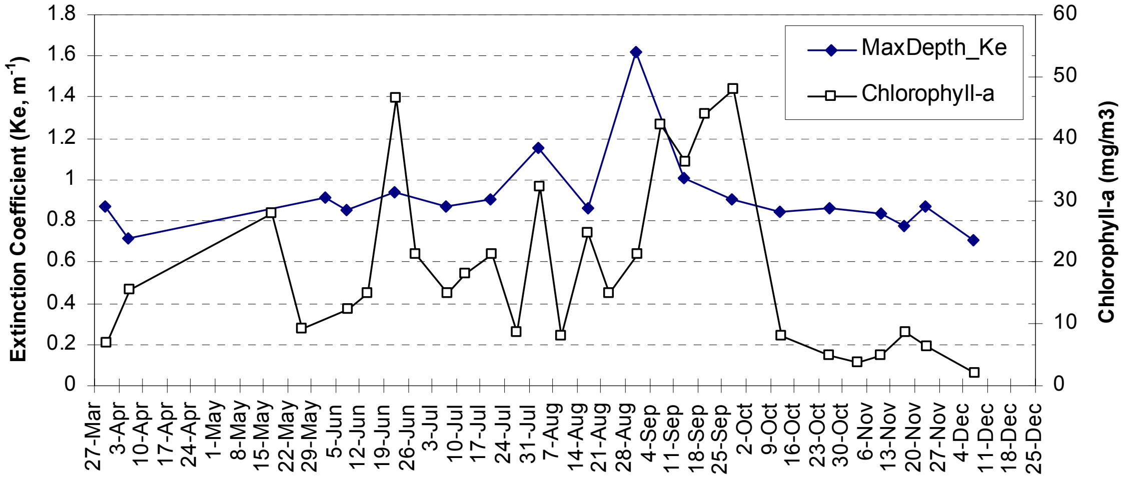


Figure 2-19. Temporal distribution of light extinction data with Chlorophyll-a data, Onondaga Lake South Deep, 2004.
Note:
Based on the Licor data reading at maximum depth for each sample date. The Extinction coefficient represents the slope of the line formed w hen the natural log of the ratio of light penetration at the surface to light penetration at depth is plotted against depth. The greater the number, the steeper the slope of the line, therefore the more rapidly light is extinguished w ith depth, indicating greater turbidity in the w ater column.

the extent to which algal abundance is correlated with the light extinction coefficients. Note that there are weekly measurements of chlorophyll-*a* during the summer which capture more of the variability; the LiCor measurements are obtained biweekly throughout the sampling season.

LiCor data from 1996 – 2004 have been compiled into a database and light extinction coefficients were calculated for each sampling date over this nine-year period. Summary statistics for the time period (Table 2-12) indicate that the minimum light extinction (clearest water) conditions are measured either early in the season (May and June) or in the late fall –winter period. This is consistent with the dynamics of the phytoplankton community. It is also evident from the data that there is no trend in light extinction over the period (Figure 2-20).

This finding is consistent with the trend analysis for Secchi disk transparency at South Deep. Secchi disk transparency can be considered a “low tech” estimator of light penetration which correlates reasonably well with the LiCor data (Figure 2-21); high Secchi disk transparency and low extinction coefficients indicate clear waters, while low Secchi depth and high extinction coefficients indicate turbid water. There is a lot of scatter at the extremes of the graph.

Table 2-12. Summary of light extinction data, Onondaga Lake South Deep, 1996-2004.

Year	Extinction Coefficient (m^{-1})							
	N	Minimum			Maximum			Average
		Ke	*On Date*	*At Depth (m)*	*Ke*	*On Date*	*At Depth (m)*	
1996	17	0.74	05/29/96	2.0	3.58	07/10/96	2.0	1.71
1997	12	0.74	06/30/97	2.0	1.92	04/10/97	2.0	1.32
1998	14	0.39	11/17/98	4.4	1.73	09/08/98	2.2	1.03
1999	17	0.39	06/29/99	4.2	2.56	07/27/99	1.8	1.11
2000	19	0.64	06/27/00	7.0	2.27	05/16/00	2.2	1.06
2001	17	0.32	11/27/01	9.0	2.35	09/18/01	2.0	0.94
2002	22	0.47	01/23/02	6.2	1.4	09/04/02	3.8	0.87
2003	16	0.36	01/07/03	6.0	1.89	10/14/03	2.6	1.13
2004	18	0.71	12/07/04	6.0	1.62	08/31/04	5.2	0.92

Notes:

Annual statistics for Extinction Coefficient are based on the maximum depth measured for each sample date.

The Extinction Coefficient represents the penetration of incoming solar radiation into the water column. By using the maximum reading for each sample date, rather than the readings at each depth for each sample date, a better sense of the relationship between depth and light penetration between different sample dates is achieved.

The Extinction coefficient represents the slope of the line formed when the natural log of the ratio of light penetration at the surface to light penetration at depth is plotted against depth. The greater the number, the steeper the slope of the line, therefore the more rapidly light is extinguished with depth, indicating greater turbidity in the water column.

The Extinction Coefficient was calculated using data collected with Licor technology.

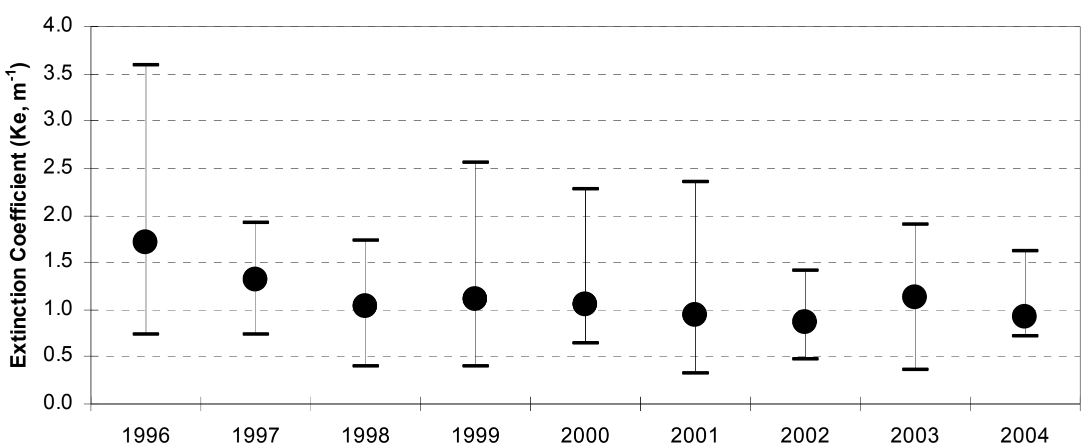


Figure 2-20. Maximum, minimum, and average of light extinction data, Onondaga Lake South Deep, 1996-2004.

Notes:
The Extinction coefficient represents the slope of the line formed w hen the natural log of the ratio of light penetration at the surface to light penetration at depth is plotted against depth. Annual statistics for Extinction Coefficient are based on the maximum depth measured for each sample date.

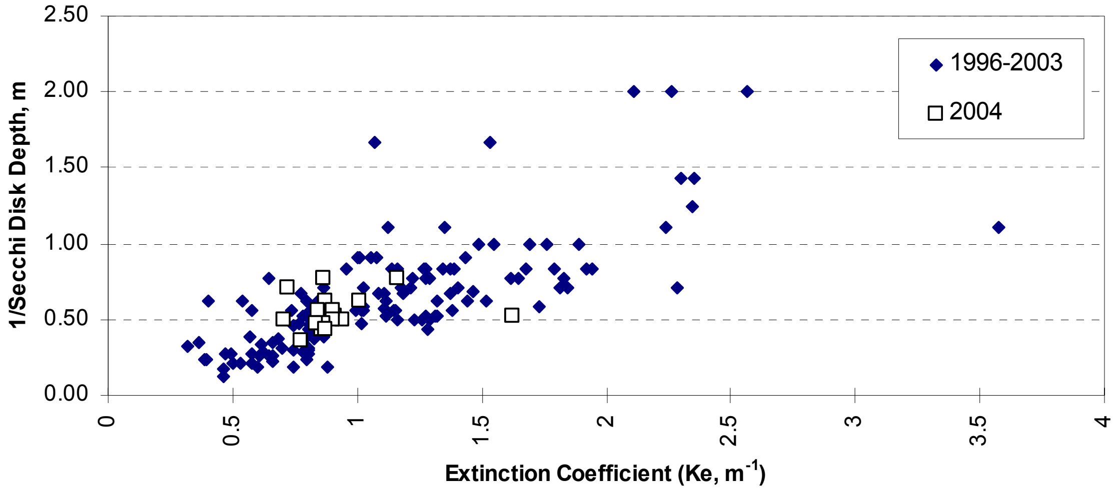


Figure 2-21. Correlation of light extinction data with inverse of Secchi depth, Onondaga Lake South Deep, 1996-2004.

Note:
The Extinction coefficient represents the slope of the line formed w hen the natural log of the ratio of light penetration at the surface to light penetration at depth is plotted against depth. The greater the number, the steeper the slope of the line, therefore the more rapidly light is extinguished w ith depth, indicating greater turbidity in the w ater column. Based on the Licor data reading at maximum depth for each sample date.

2.3.4.3 Nearshore Secchi Depth

As part of the AMP's focus on indicators of recreational use attainment in Onondaga Lake, Secchi disk transparency measurements are also obtained during weekly sampling at eight nearshore lake stations from June - August. The nearshore areas occasionally exhibited reduced water clarity during the 2004 monitoring period (Figure 2-22). This was more pronounced in the lake's southern basin which is more affected by inflows of the larger tributaries. Reduced water clarity in the nearshore areas may be caused by phytoplankton, sediments entrained in the water (either from plumes entering through the tributary streams or resuspended bottom material), and the presence of algal mats.

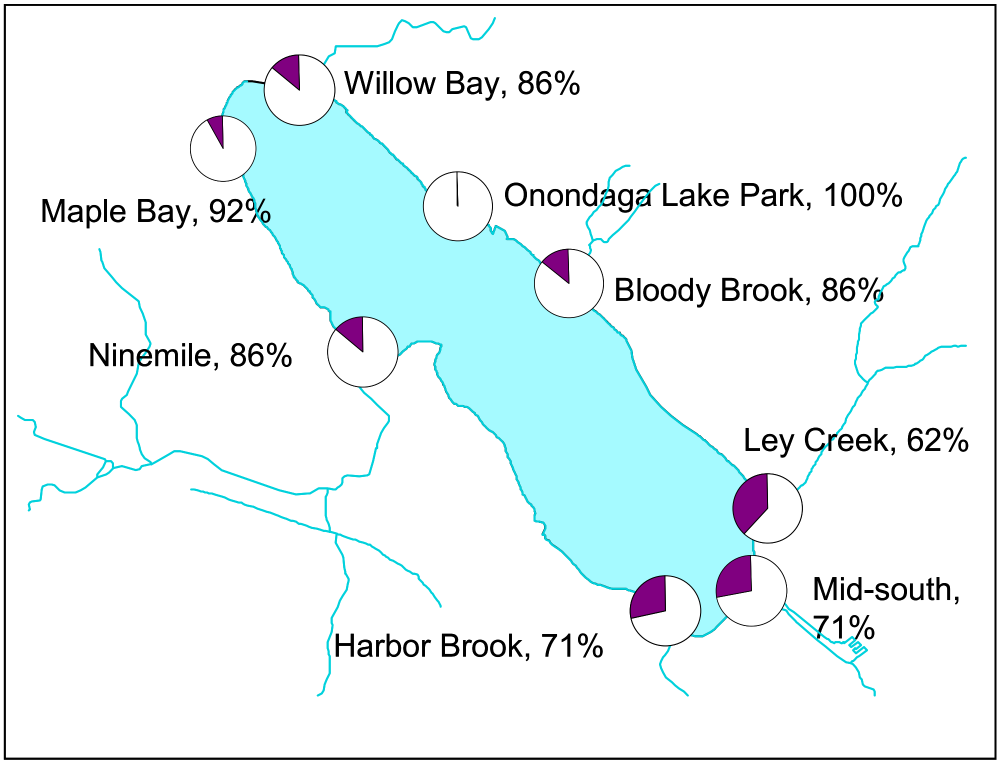


Figure 2-22. Nearshore Secchi violations in 2004. Percent shown in figure indicates compliance. Shaded area of pie charts indicates percent of samples where Secchi depth was less than 1.2 m (4 ft).

2.3.5 Dissolved Oxygen Concentrations

The DO content of the lake's upper and lower waters during 2004 is plotted in Figure 2-23. Note the rapid decline of DO in the lower waters at the onset of thermal stratification. The upper waters remained well-oxygenated until mid-October when the lake waters had cooled sufficiently to break down thermal gradients. Winds mixed the upper waters progressively deeper into the water column and complete mixing occurred around October 22, 2004. Concentrations of DO increased as the waters continued to mix and gain oxygen from the atmosphere.

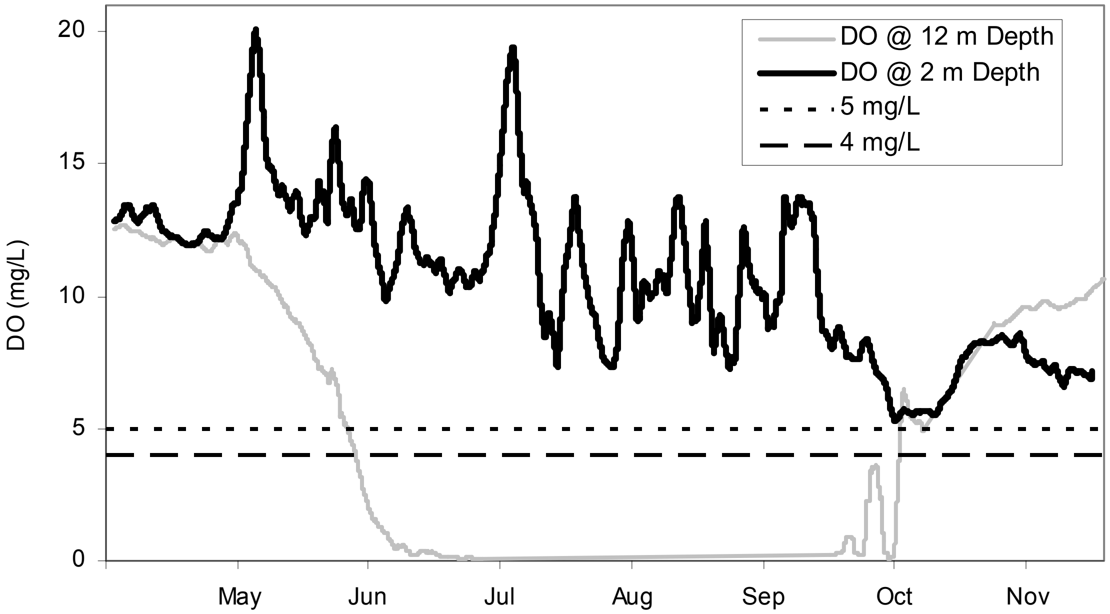


Figure 2-23. Temporal pattern of DO at 2 and 12 m depths in Onondaga Lake, South Deep Station in 2004. Data collected from OCDWEP high frequency monitoring buoy. Note: data were smoothed using a 192 point moving average which corresponds to two days of data collection. 5 and 4 mg/L lines designate NYS standards.

2.3.6 Ammonia Nitrogen

The water quality benefits of improved ammonia treatment at Metro were evident in the lake in 2004. As displayed in Figure 2-24, ammonia concentrations met the current NYS ambient water quality standard in the lake's upper waters (where oxygen levels are adequate for fish). NYSDEC is in the process of revising the state's ambient water quality standard for ammonia to be consistent with the federal criteria. Onondaga Lake was in full compliance with the federal criteria for ammonia throughout the 2004 sampling period.

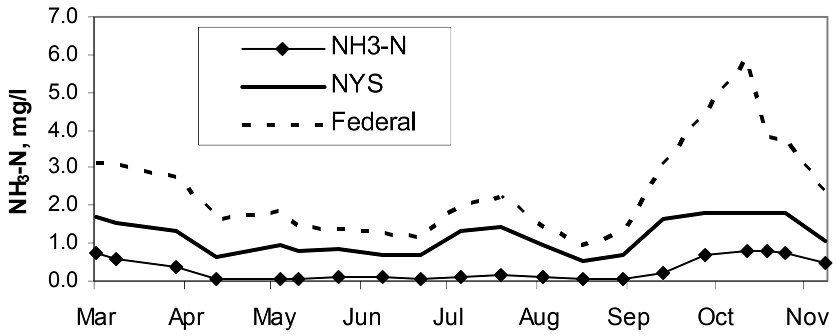


Figure 2-24. Ammonia concentrations at 3 meter depth, Onondaga Lake South Deep Station, 2004, compared with NYS standards and federal criteria.

Concentrations of ammonia in the lake waters and compliance with NYS standards and the federal criteria 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 Metro performance; recall that Metro Outfalls 001 and 002 have historically contributed more than 90% of the external ammonia load to the lake. In 2004 the Metro contribution was reduced to 69.1%. The reduction in external loading achieved with the BAF has improved water quality conditions in Onondaga Lake (Figure 2-25).

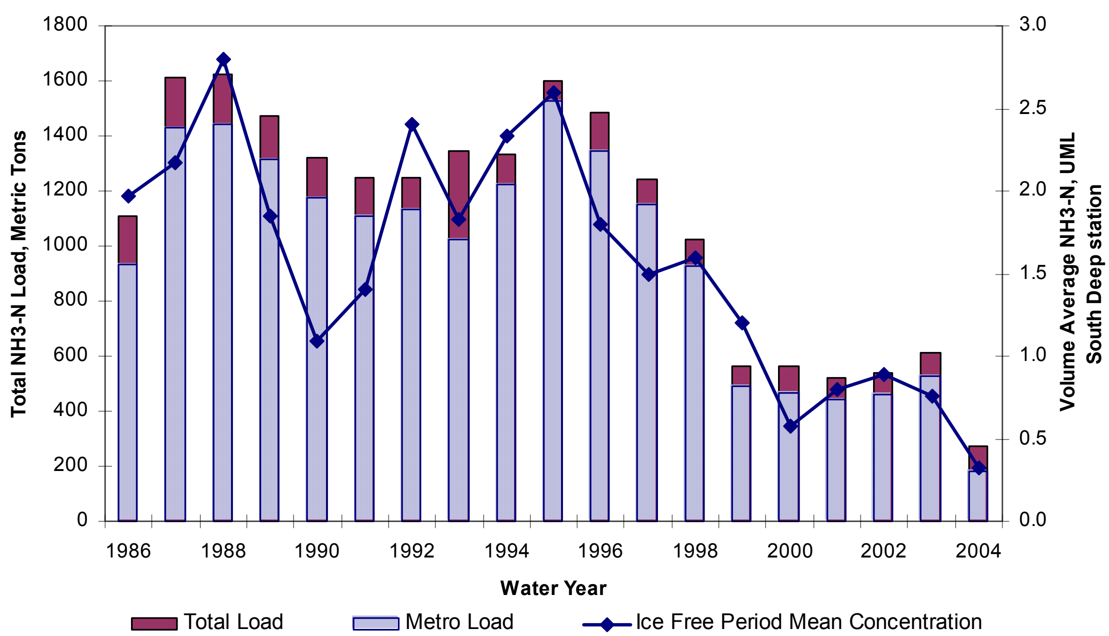


Figure 2-25. Annual external ammonia load (for water year Oct. 1 to Sept. 30) and volume-averaged UML average concentration (for ice free period) at South Deep station in Onondaga Lake,1986 - 2004. *Loads calculated with Method 5. See text for details.*

The decrease in loading produced a parallel decrease in the measured concentrations in the lake's UML during summer. The concentration of ammonia in the LWL increased during the summer as in previous years, generally responding independently of the changes in loading and reflecting the decay of settled organic matter (e.g., phytoplankton) into ammonia, the lack of nitrification due to lack of oxygen, and release of ammonia from the sediments, all of which serve to increase the concentration of ammonia in the LWL during the summer period of thermal stratification.

At fall turnover, the ammonia that had accumulated in the LWL mixed throughout the water column and came into contact with oxygen present in the upper waters (refer to Figure 2-4). Some of this material was probably nitrified prior to exiting the lake.

2.3.7 Nitrite Nitrogen

The summertime average nitrite concentrations in the LWL increased again in 2004, continuing the pattern noted in 2003 (refer to Figure 2-3). The cause of the increase is not clear but is likely related to changes in DO status and the pool of reduced ammonia species present in the lower waters. The water quality model of Onondaga Lake, initiated in 2005, will provide a tool for identifying and testing mechanistic hypotheses regarding changes in nitrogen cycles with shifts in external loading.

The UML concentration of nitrite increased gradually throughout the monitoring period. By mid October when stratification began to break down, the nitrite concentration measure in the upper waters were slightly over the ambient water quality standard of 0.1 mg/l (Figure 2-26). This is likely due to the mixing of oxygenated upper waters with bottom waters rich in ammonia, providing conditions suitable for nitrification.

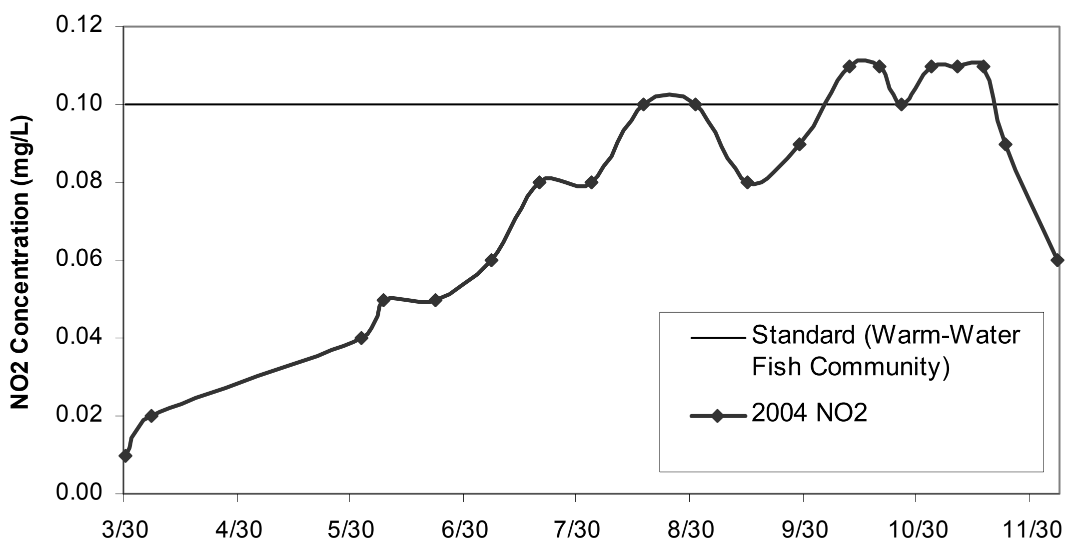


Figure 2-26. Volume-averaged UML nitrite-N concentrations, Onondaga Lake South Deep Station, 2004.

2.3.8 Nitrate Nitrogen

Concentrations of nitrate-N in the UML have exhibited considerable variability since the 1990s (refer to Figure 2-3). Until the recent improvements in ammonia treatment at Metro, with biological conversion of ammonia to nitrate N, nitrate concentrations in the lake's upper waters did not track external loads. However, recent improvements in year-round nitrification at Metro have yielded a closer tie between nitrate concentration in the UML and external loads.

LWL nitrate concentrations were variable through the 1990s but have exhibited an increasing trend since 2000. The cause of the increase is not clear, but may be associated with progress towards improved DO status of the lower waters.

The 2004 data are plotted in Figure 2-4. Concentrations were at the annual maximum at the first sampling event, likely due to the pool of nitrate from Metro. The concentration declined gradually over the summer as the nutrient became incorporated into algal biomass. The effect of fall mixing is evident in the October and November data.

The LWL concentration of nitrate decreased throughout the summer growing season in 2004. The decline occurred as oxygen was depleted in the lower waters. These are conditions under which nitrification is minimal and denitrification is favored. During and following fall turnover, nitrate concentrations increased in the LWL due to mixing with the upper waters (with its higher nitrate concentration), nitrification of the accumulated ammonia pool in the lower waters, and dispersion of the continuing Metro load throughout the entire isothermal water column.

2.3.9 Bacteria

Fecal coliform bacteria levels are measured at multiple sites in Onondaga Lake to assess whether the water is safe for contact recreation. Fecal coliform bacteria are used as indicators of the potential presence of pathogenic (disease-causing) microorganisms. This class of bacteria is currently used by NYSDEC as an indicator of microbiological purity. However, EPA is strongly encouraging states to change their ambient water quality standards to base their assessment of recreational suitability of freshwater on the presence and abundance of a second indicator organism, *E. coli*. Studies have shown that *E. coli* levels are more closely associated with human health impacts of contact recreation, particularly incidence of gastrointestinal illness (EPA 2002). Onondaga County is currently monitoring and reporting both classes of indicator organisms in Onondaga Lake.

The 2004 data indicate that indicator bacteria levels in the lake's southern basin, near the CSOs and major streams, are occasionally elevated in response to storms of sufficient intensity and duration to cause the combined sewer system to overflow. This finding highlights the need for continued progress with the CSO abatement projects. However, water quality improves in the northern basin. Water quality in Willow Bay, Maple Bay, and Onondaga Lake Park showed no violations of bacteria standards for safe swimming during 2004 (Figure 2-27).

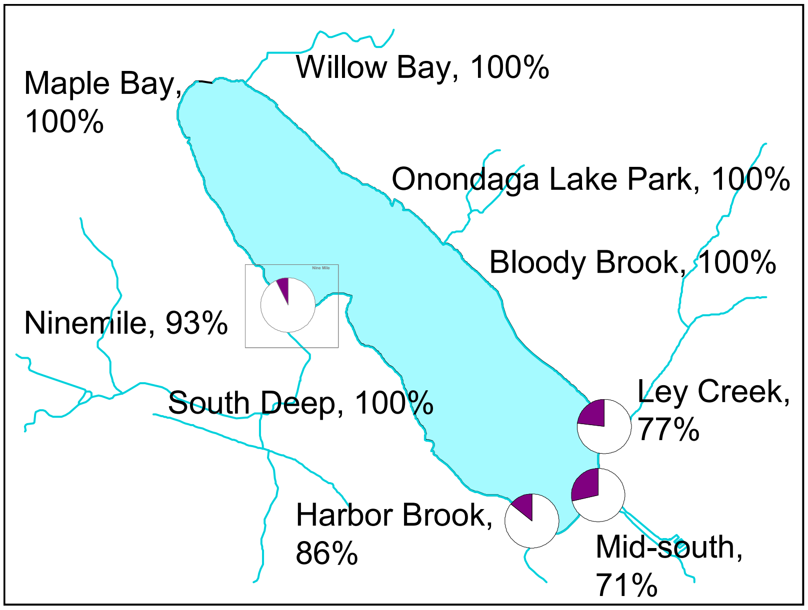


Figure 2-27. Nearshore F coli violations in 2004. Percent shown in figure indicates compliance. Shaded area of pie charts indicates percent of samples that exceeded 200 cells per 100 ml.

2.3.10 Mercury Concentrations

Results of the 2004 low-level mercury sampling program are summarized in Table 2-13. Samples were analyzed by Brooks Rand Laboratories. The first set of samples was collected on April 27, 2004 prior to development of thermal stratification. During the April 2004 sampling event, concentrations of total mercury were similar at the two stations and two sampling depths. This result was expected as the water column was fully mixed. Total mercury concentrations were in the range of 2.4 – 3.2 ng/l. Methyl mercury concentrations were less than 10% of the total concentrations (0.15 – 0.20 ng/l).

Table 2-13. Low-level mercury sampling, Onondaga Lake.

Sampling Event	Location and Depth	Total Hg (ng/l)	Methyl Hg (ng/l)
April 27, 2004	South Deep 3 m	2.40	0.19
Lake fully mixed	South Deep 18 m	2.62	0.15
	North Deep 3 m	2.44	0.20
	North Deep 18 m	3.19	0.18
September 16, 2004	South Deep 3 m	3.08	0.155
Stratified	South Deep 18 m	12.6	8.07
	North Deep 3 m	1.35	0.146
	North Deep 18 m	12.8	8.09
October 25, 2004	South Deep 3 m	5.34	1.87
Lake fully mixed	South Deep 18 m	8.41	6.43
	North Deep 3 m	4.81	1.49
	North Deep 18 m	6.72	3.44

A second set of samples was obtained on September 16, 2004 when Onondaga Lake was thermally stratified. In September, total mercury concentrations in the lower waters at both stations increased to approximately 12 ng/l. Methyl mercury concentrations were also at their seasonal peak at the 18 m during this event, with concentrations approximately 8 ng/l. This pattern of peak mercury levels in late summer and early fall is typical of data collected since 1999, and is consistent with the conceptual model of mercury cycling in productive lakes. The methyl mercury concentrations at 3 m were very similar to the April 2004 results.

Mercury concentrations were again essentially uniform through the water column during the fall event, which was completed on October 25, 2004. Consistent with results OCDWEP surveys since 2000, concentrations of methyl mercury are at their highest concentrations in the upper waters following fall mixing. Mercury concentrations throughout the water column in the October samples were higher than concentrations measured in April by a factor of about two. There is no trend evident in the data.

2.3.11 Macroalgae

In 2004, the scope of the AMP was expanded to include measurement of the proliferation of nearshore macroalgae. A semi-quantitative method was employed using visual observation and measurements at eight permanent locations along the lake shoreline. This semi-quantitative method was used for the first time in 2004 as an outcome of the Workgroup meeting. The field team measured the distance from shoreline to where algal mats were visible, and estimated percent cover. Beginning in 2005, observations at the eight stations will be made in triplicate to estimate variability and enable trend analysis.

The 2004 data are plotted in Figure 2-28. The units are in square meters of coverage, based on a 1-m wide transect at a measured distance from shoreline and the estimated percent cover. Macroalgal coverage was relatively low in 2004; presumably because the rainy weather and high streamflow prevented development of stagnant conditions within the observation areas.

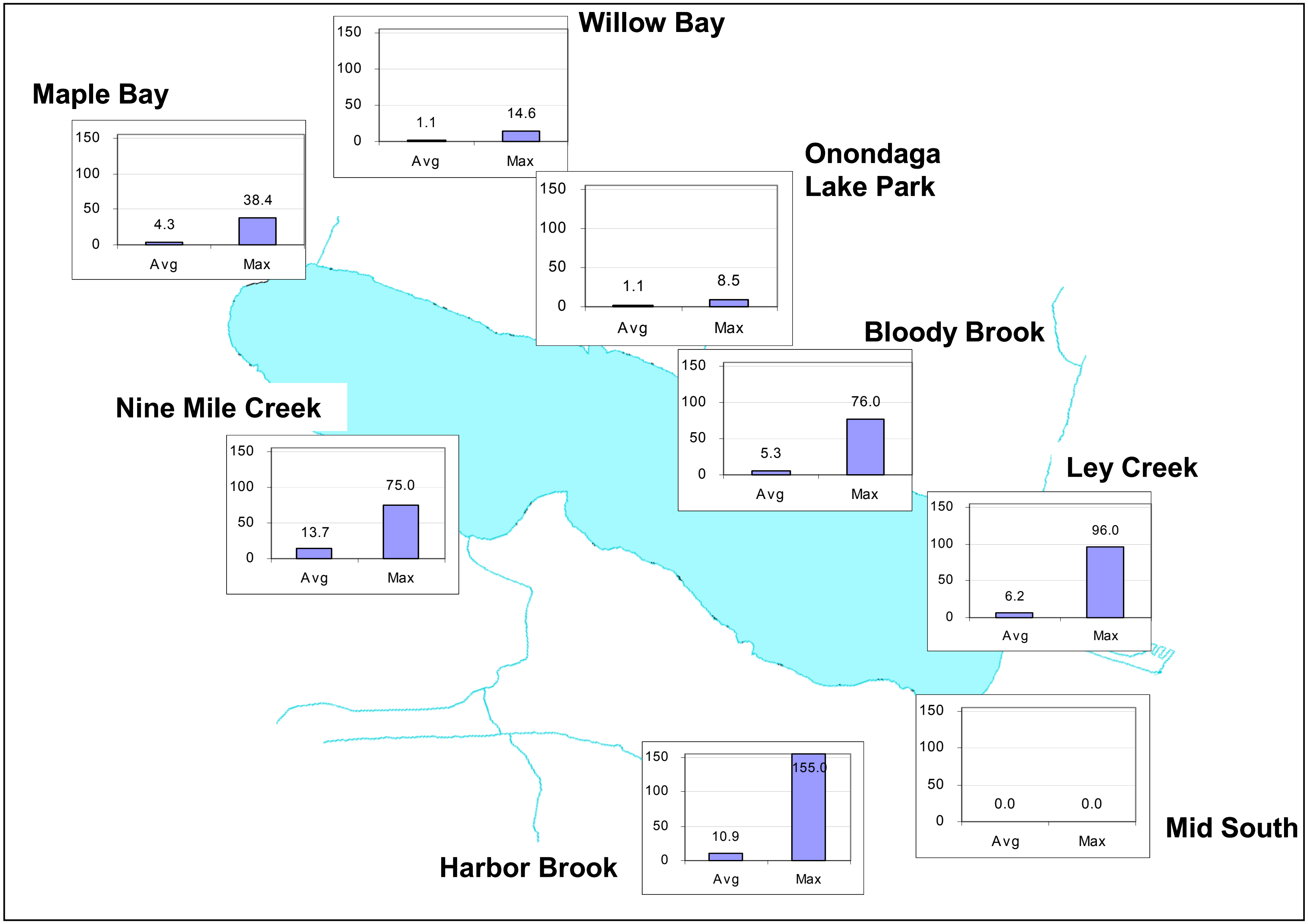


Figure 2-28. Estimated average and maximum observed areal coverage (m^2) of filamentous algae at nearshore stations in 2004. Data obtained from surveys conducted May through September 2004.

2.4 PHYTOPLANKTON AND ZOOPLANKTON COMMUNITY

Onondaga Lake remains a productive aquatic system as evidenced by its high levels of algal biomass. The AMP includes detailed examination of the phytoplankton and zooplankton community. The extensive dataset allows an examination of how the lower trophic levels are changing in response to reduced nutrient loading and shifts in the fish community.

The duration of the cyanobacterial blooms in Onondaga Lake declined from 1996-2000 (Figure 2-29). For example, cyanobacterial blooms (typically dominated by *Aphanizomenon flos-aquae*) that historically persisted from July through October (as evident in the 1996 dataset) decreased in duration (middle to late July through August) from 1997 to 2000. In 2001 there was no

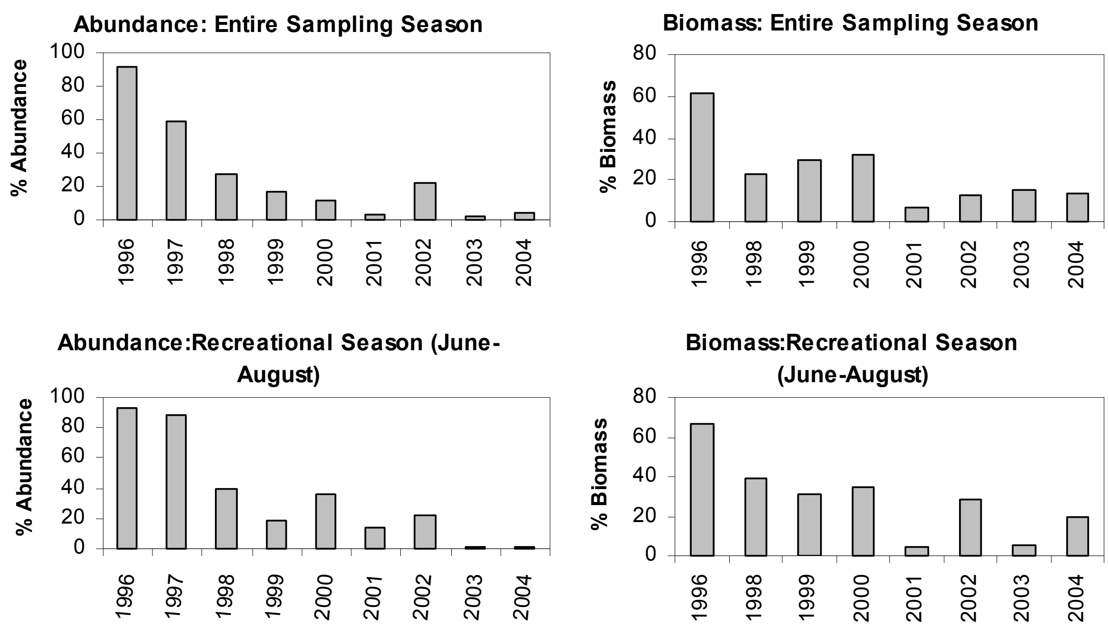


Figure 2-29. Percent contribution of Cyanobacteria (blue-green algae) to the phytoplankton community from 1996 to 2004, Onondaga Lake South Deep Station.
Note: 1997 data were not analyzed for biomass.

significant cyanobacterial bloom documented. The 2002 sampling season saw a reversal of this declining trend however, with cyanobacterial blooms of greater magnitude, lasting from late June through mid-September. A similar resurgence of cyanobacteria was again seen in 2003, but the onset of the bloom did not occur until mid-August, and remained in significant quantity through the end of October. The 2004 cyanobacterial blooms were significantly reduced compared to 2002 and 2003, dominated by a *Synechocystis* sp. (density) and *Anabaena crassa* (biomass). During the 2004 sampling season, only one minor peak was seen in early August (1741μg/L) with no lengthy period of late season dominance. The resurgence of cyanobacteria in 2002 and 2003 may still reflect changes in the food web that favors blooms of cyanobacteria, but the limited cyanobacterial productivity observed in 2004 could signal an overall improvement in water quality.

Average total zooplankton biomass in Onondaga Lake (March - November 2004) was 184 µg/L, while in nearby Oneida Lake it averaged 235 µg/L (Cornell Biological Field Station unpublished data; presented in Appendix 2, Figure A2-11). 2004 was the first year since 1996 that average total zooplankton biomass was greater in Oneida Lake than Onondaga Lake. This is due to a decline in biomass in Onondaga Lake in 2003 and 2004, not an increase in Oneida. This is a striking finding, considering the much higher levels of nutrients and primary production in Onondaga Lake. The decline in zooplankton biomass in Onondaga Lake in 2003 and 2004 is due to a dramatic decrease in large sized individuals. This loss of larger zooplankton was likely caused by the increase in alewives (a planktivorous fish species) in Onondaga Lake in 2003 and 2004 (see Section 2.5.1.2). Alewives are present in Oneida Lake but are not abundant enough to have significant effects on the lake's zooplankton community.

During both 1996 and 2004, small zooplankton dominated Onondaga Lake while larger species, especially *Daphnia pulicaria*, led to high average total zooplankton biomass in Oneida Lake. Onondaga Lake zooplankton biomass was moderate during most of the 2004 season (between 21 and 161 µg/L), but increased to 1508 µg/L in late June and 859 µg/L in early July. In contrast, Oneida Lake zooplankton biomass was more consistent, remaining above 100 µg/L on all sampling dates between May and November. Temporal patterns in average zooplankton size showed little similarity between the two lakes in 2004. The consistently small average size of the total zooplankton community in Onondaga Lake throughout the seasons in 2004 (0.35 mm year-round) is similar to 2003. In contrast, during 2002 average size showed more variation, changing from 0.92 mm in winter to 0.27 mm in fall. Associated with this change in size structure is the dominance of the small cladoceran *B. longirostris*, but also a much-reduced *Daphnia* sp. population and few mature calanoid copepods throughout the 2004 season. Like 2003, these findings suggest intense planktivory in 2004. Based on results of the fisheries investigations, this planktivory is attributed to the alewife.

Populations of *Daphnia* sp. have a tremendous capability to exert strong influence on the phytoplankton community (Mills *et al*. 1987). The low number of *Daphnia* sp. individuals in Onondaga Lake in 2004 was likely linked to the increased density/biomass and drastically different composition of the phytoplankton community in 2004 when compared to previous years other than 2003.

Cercopagis pengoi (an invasive predatory zooplankton) again appeared in the lake in the 2004 season. Interestingly, the periods of *C. pengoi* detection in the lake also represent periods of decreased dominance by *Bosmina longirostris* and a late-summer to early-fall season rise in average adjusted size, suggesting that, in addition to alewives, *C. pengoi* predation may be structuring the zooplankton community.

2.5 FISH COMMUNITY

The Onondaga Lake fish monitoring program evaluates the structure and function of the fish community by targeted sampling of various life stages and habitats. The number and locations of fish nests are surveyed; larval fishes are collected in the open waters (pelagic zone). Juvenile fish are collected in the littoral zone. Adult fish are captured by electrofishing along the shoreline, by gill nets set offshore and by anglers; some anglers provide data to OCDWEP in a diary program.

In late 2004, Dr. Lars Rudstam of the Cornell Biological Field Station conducted a special hydroacoustical survey on the lake to estimate abundance of the fish community. This survey was repeated in spring 2005; results will be presented in the 2005 Annual AMP report.

Significant findings of the 2004 results are presented in this section. Methods, data summaries and trends are included in Appendix 8. For additional information, a baseline analysis of the fish community completed in the 2002 Annual AMP Report is available on the Onondaga County web site (http://www.ongov.net/WEP/we1510.html).

2.5.1 Summary of Major Findings

2.5.1.1 Species Richness

A total of 21,661 fish representing 31 species were collected as part of the 2004 monitoring effort. Electrofishing captured 17,132, young-of-the-year seining captured 4248 fish, gill netting 260 and larval trawls 21. The total number of fish captured in 2004 is more than double the number of fish caught in 2003. The dramatic increase is due to an 11.5 fold increase in alewives in the electrofishing catch. Two species not previously documented in the AMP monitoring effort were collected in 2004; yellow bullhead (*Ameiurus natalis*) and lake sturgeon (*Acipenser fulvescens*). The lake sturgeon is the first documented occurrence in Onondaga Lake, yellow bullhead have been captured in the lake during other fish surveys. Also of note, a single small brown trout (*Salmo trutta*), likely originating in one of the lake tributaries, was captured during the July electrofishing event. The total number of species captured in Onondaga Lake since the inception of the AMP fish program in 2000 is now 38.

The spring electrofishing event in June was interrupted by an equipment failure before the event could be completed, only transects 13-19 were sampled. Sampling could not resume until early July. During the July event all transects were sampled, transects sampled in June were re-sampled. A comparison of catch rates from transects 13-19 for the June and July samples indicate that differences in catch per unit effort (CPUE) were not statistically significant for any of the species (See Appendix 8, Table A8-38). It was therefore concluded that the July sample in 2004 is comparable to data collected in June of past years.

The adult community in 2004 appeared much different than past years because of the dominance of alewives (Figure 2-30a). Alewives were much more abundant in 2004 than in previous years representing about 92% of the electrofishing catch in 2004 compared with 39% of the catch in 2003 and a maximum of 0.6% of the catch from 2000-2002.

2.5.1.2 Alewife Population Data and Diet Analysis

Aging of otoliths and analysis of the population's length-frequency histograms indicates that most (82%) of the alewives captured in both 2003 and 2004 were from a single cohort produced in 2002. Despite this finding, there were more alewives captured in 2004 than in 2003. We speculate that the increased alewife catch in 2004 was due to a greater proportion of alewives in the littoral zone (where they are susceptible to the electrofishing equipment). When clupeids (alewives and shad) are removed from the dataset, the 2004 adult fish community closely resembles that of past years. The same eight species dominate the catch (Figure 2-30b).

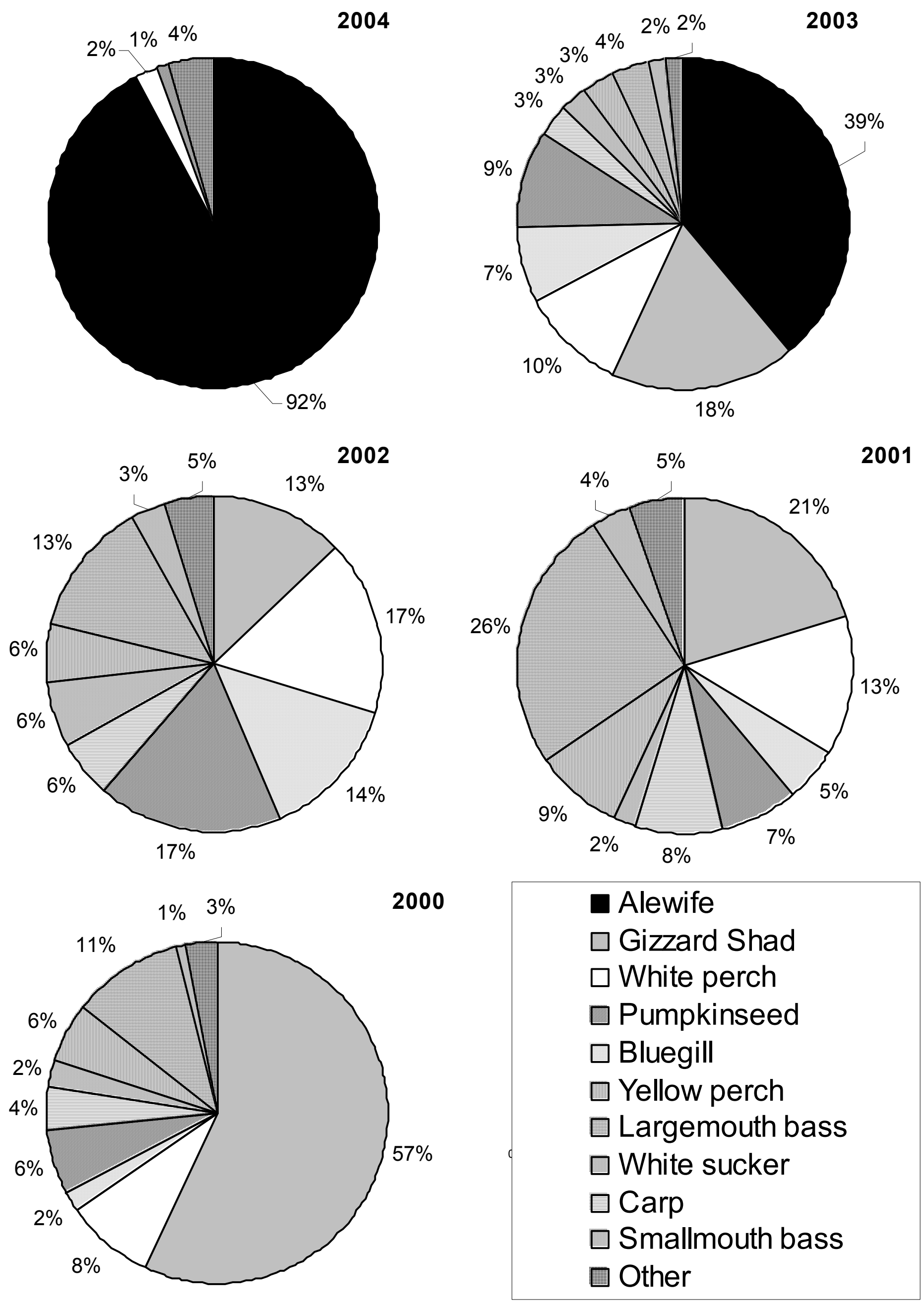


Figure 2-30a. Relative abundance based on CPUE of all fish captured during littoral zone electrofishing from 2000-2004 (spring and fall sampling combined). CPUE for gamefish is calculated from all 24 transects. CPUE for non-gamefish are calculated from only the one-half of the transects where all fish are collected (every other transect). Because of the difficulty in netting clupeids (shad and alewives), the CPUE for these species is calculated from a combination of fish that are boated and estimates of the number of fish missed. Because of their large size carp are not boated, instead carp within netting distance are counted while still in the water.

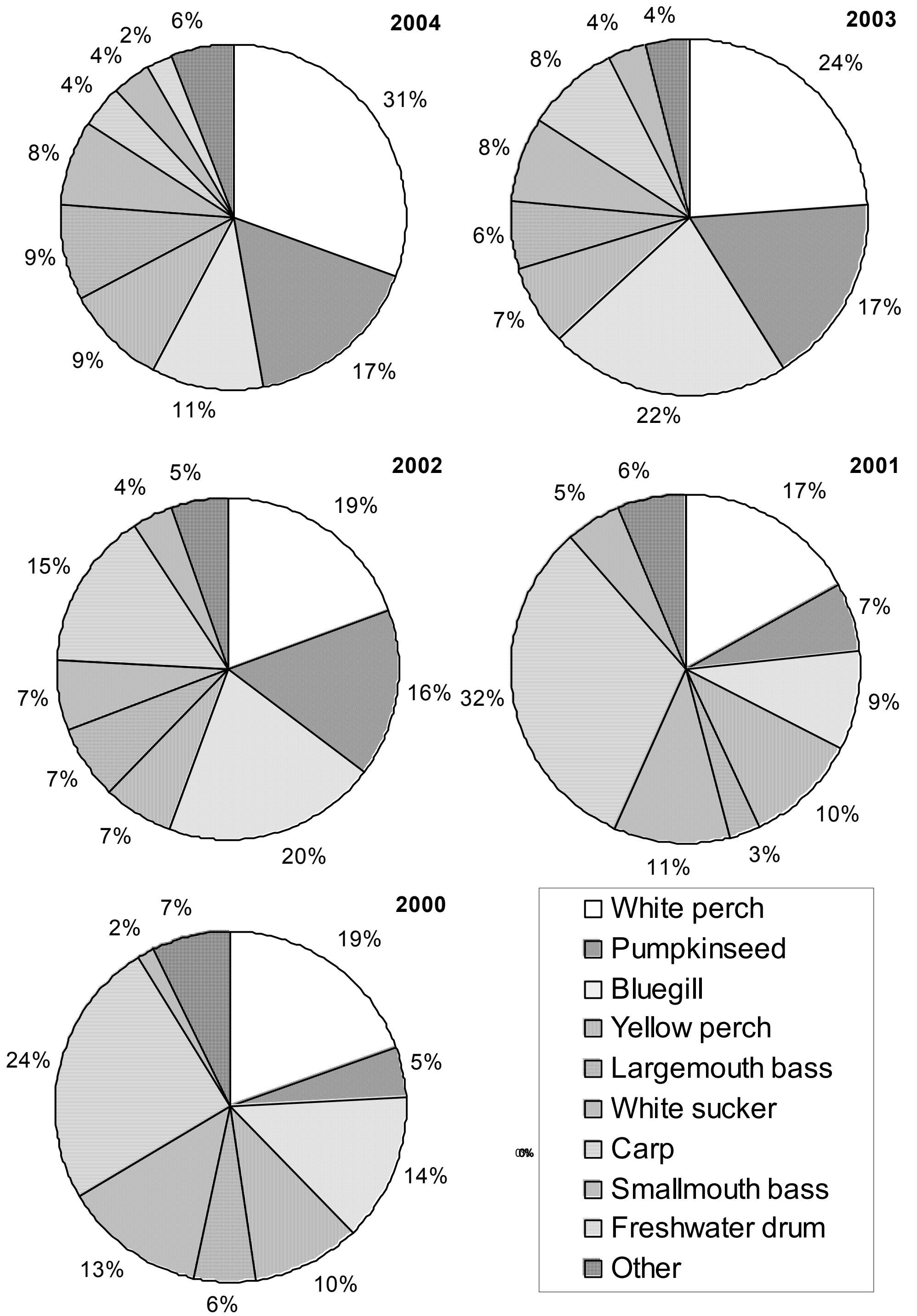


Figure 2-30b. Relative abundance based on CPUE of all non-clupeid fish captured during littoral zone electrofishing from 2000-2004 (spring and fall sampling combined). CPUE for gamefish is calculated from all 24 transects. CPUE for non-gamefish are calculated from only the one-half of the transects where all fish are collected (every other transect). Because of their large size carp are not boated, instead carp within netting distance are counted while still in the water.

Diet analysis of 30 alewives collected in the littoral zone of Onondaga Lake in 2004 demonstrated the opportunistic nature of alewives. Although numerically alewives fed primarily on zooplankton (66%) a substantial number of littoral macroinvertebrates were also consumed (43%). Most zooplankton consumed were either *Bosmina longirostris* (55%) or *Cercopagis pengoi* (45%), a much smaller percentage were *Diacyclops thomasi* and *Daphnia retrocurva* (combined 0.3%). The high proportion of *Cercopagis pengoi* is interesting as this species is not considered to be a desirable food source because of the elongated spines. It is possible that alewives have depleted preferred food sources (larger zooplankton) in the open water and have switched to less preferred zooplankton species and moved into the littoral zone in search of alternative food items. From a dry weight perspective, macroinvertebrates contributed the greatest amount to alewife diets (86%). The high proportion of macroinvertebrates in diets of the alewives may be a function of the fish having been collected from the littoral zone where macroinvertebrates are more abundant; sampling in open water would probably have resulted in different stomach content proportions.

2.5.1.3 Decline in Sunfish

Another notable result in 2004 was the decline of pumpkinseed (*Lepomis gibbosus*) and bluegill (*Lepomis macrochirus*) catch rates, bluegill more dramatically than pumpkinseeds (Figure 2-31). Prior to 2004, catch rates of both pumpkinseed and bluegill had been generally increasing since 2000. The increase in both bluegill and pumpkinseed catch rates from 2000-2003 was coincident with increases in year class strength from 2000 to 2002. The decline in these species in 2004 is coincident with a decline in year class strength in 2003 (which should have been captured as numerous one-year olds in 2004).

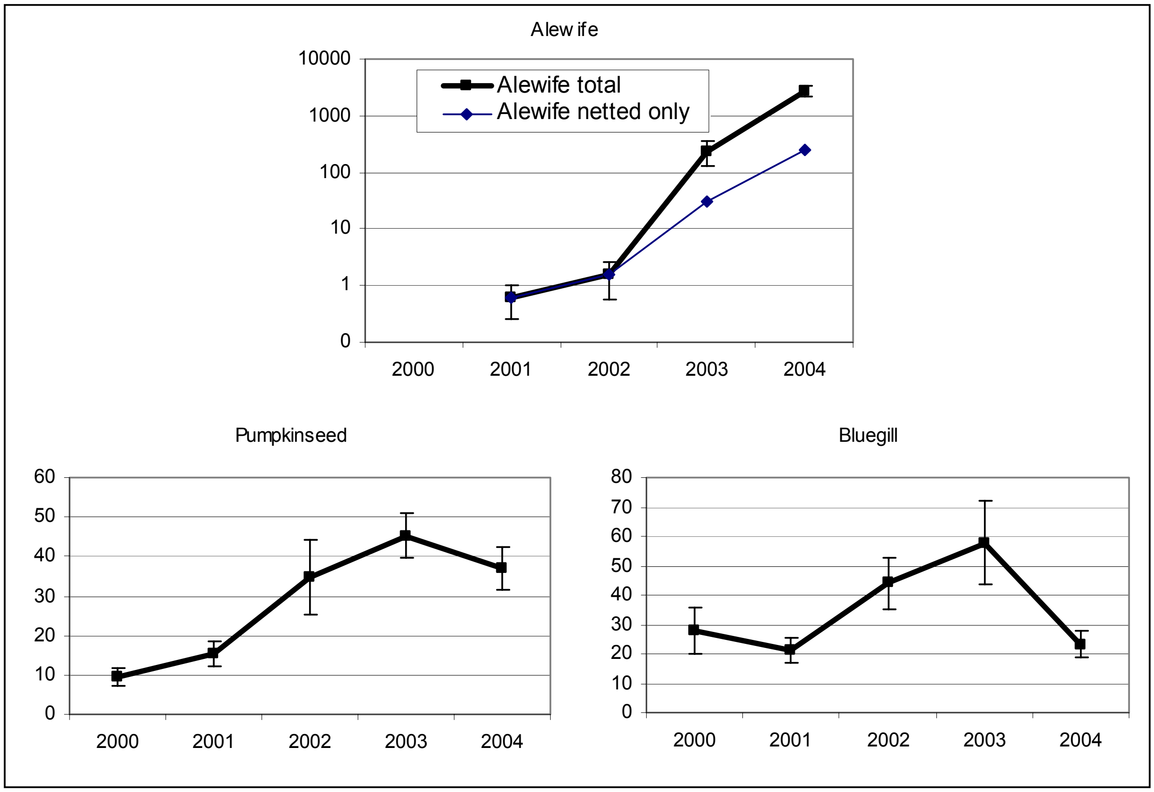


Figure 2-31. Catch per hour from littoral zone electrofishing from 2000-2004. Error bars are standard error. CPUE based on both "all-fish" and "gamefish-only" transects. Gamefish species have CPUE calculated for all 24 transects, all other species have their CPUE calculated from only the 12 "all fish" transects. Because of the difficulty in netting clupeids (shad and alewives), the CPUE for these species is calculated from a combination of fish that are boated and estimates of the number of fish missed. Note; Y-axis differs for each species, alewives are on a logarithmic Y-axis.

2.5.1.4 Shifts in Relative Weight of Major Species

Relative weight is the ratio of the actual weight of an individual fish to a “standard” fish of the same age and species from the same region. Fisheries scientists publish standard weights, which are used as a basis for comparing plumpness over time and between lakes. Changes in the relative weight (W_r) of largemouth bass (*Micropterus salmoides*), pumpkinseed, white perch (*Morone americana*), and to a lesser extent smallmouth bass (*Micropterus dolomieu*) were noted in 2004 (Figure 2-32). Largemouth bass and smallmouth bass W_r were generally consistent from 2000 through 2003 and diverged in 2004. Largemouth bass increased and smallmouth bass may have decreased (standard error for smallmouth bass was high in 2004 making interpretation difficult). The increase in largemouth bass W_r could be due to increased foraging opportunities due to the abundance of alewives in the littoral zone of the lake in 2004. The smaller gape (mouth) size of smallmouth bass may have prevented them from taking advantage of the increase in adult alewives in nearshore areas. Pumpkinseed W_r has increased steadily since 2001 and considerably in 2004, while white perch W_r declined considerably in 2004. The causes of these changes are not known at this time, but the decline in bluegill abundance in 2004 may have reduced interspecific competition for the pumpkinseed.

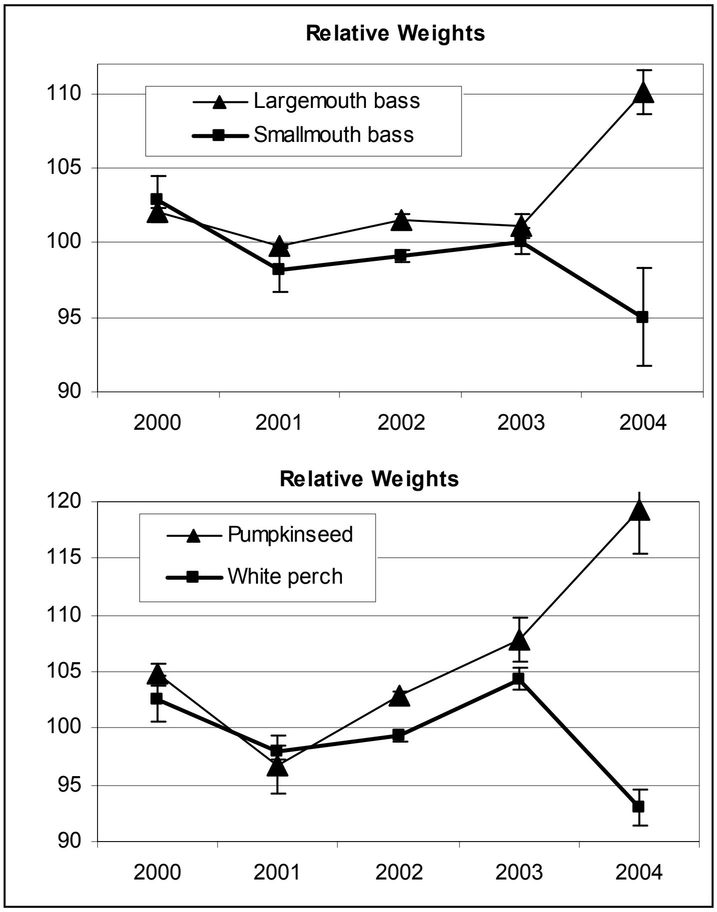


Figure 2-32. Relative weights of select species from 2000-2004. Error bars are standard error.

2.5.2 Age and Growth of Bass

OCDWEP routinely collects and ages scales of largemouth and smallmouth bass captured in Onondaga Lake for use in understanding growth rates, mortality, and related population statistics for these species. Age and growth data from 2000 – 2004 have been tallied and are reported in the sections that follow.

2.5.2.1 Smallmouth Bass

Statistical analysis of length at age of smallmouth bass collected as part of the AMP from 2000-2004 showed no significant difference between years. A comparable dataset collected by Chris Gandino from 1991-1993 showed no difference between those study years. After determining no significant difference between years, the data sets from the early 1990s were combined and compared to combined data sets from 2000 to 2004. This analysis did not detect any significant difference in length at age between the sample periods, indicating that growth of smallmouth bass has changed little from the 1990s (Figure 2-33).

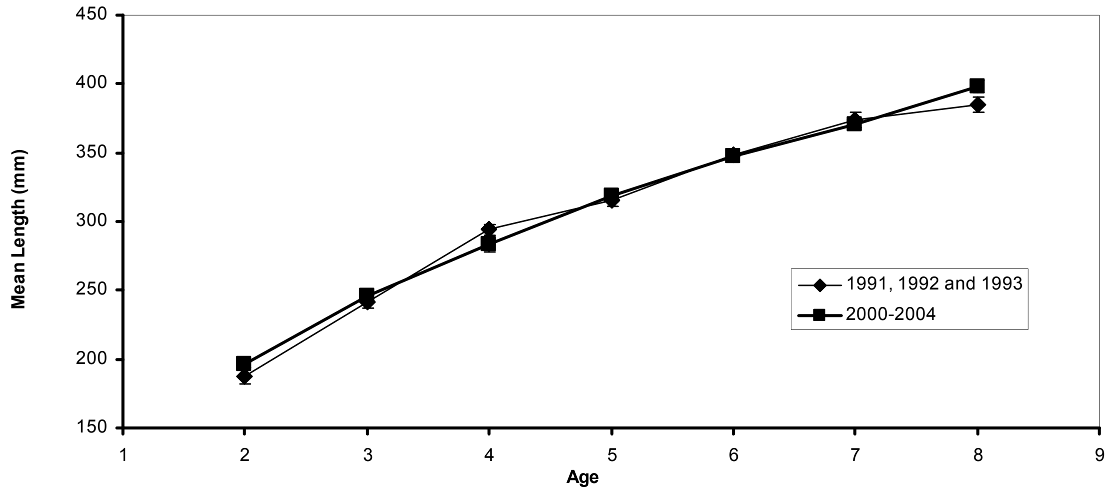


Figure 2-33. Length at age of smallmouth bass captured in Onondaga Lake in the 1990's (1991, 1992 and 1993) and during the current AMP (2000-2004). Ages interpreted from scale samples. Error bars are standard error. There was no statistcially significant differences between any of the length at ages.

2.5.2.2 Largemouth Bass

Data from the early 1990s for largemouth bass in Onondaga Lake are not as complete as smallmouth bass; only data from 1993 are comparable to the current program. Like smallmouth bass, length at age for largemouth bass collected from 2000-2003 closely resembled 1993 data, however a notable difference was evident at age 2 where bass collected in 1993 were significantly smaller than their counterparts from 2000-2003 ($P<0.05$) (Figure 2-34).

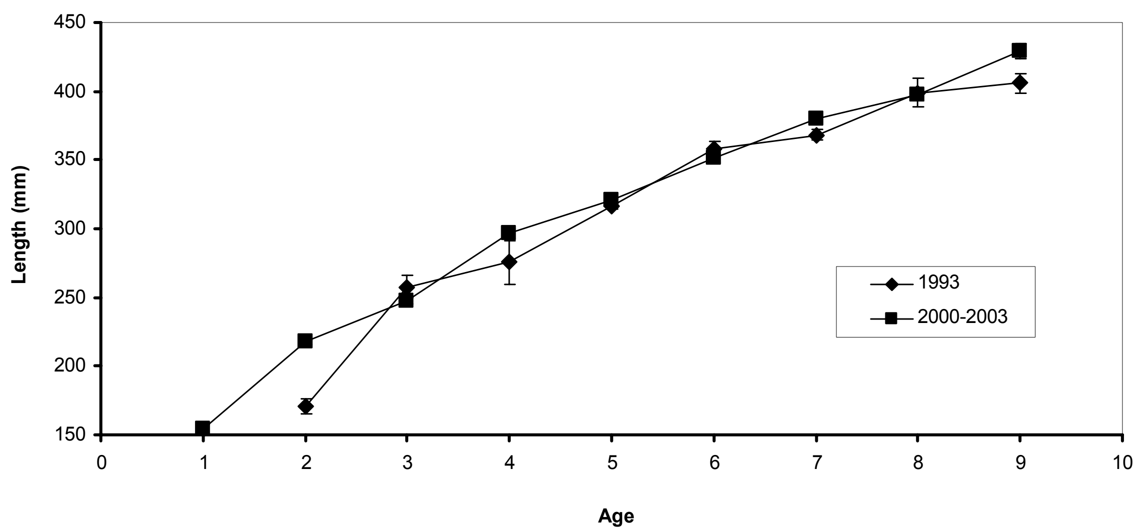


Figure 2-34. Length at age of largemouth bass captured in Onondaga Lake in 1993 and during the current AMP (2000-2003). Ages interpreted from scale samples. Error bars are standard error. Length at age 2 and 7 were signifcantly different between sample periods ($p<0.05$).

2.5.3 Reproduction

Of the 31 species captured in the lake in 2004, 17 (55%) showed some evidence of successful reproduction either through the catch of larvae or young-of-the-year (Table 2-14). Of the 14 species that did not show signs of reproduction in 2004, six (white sucker (*Catostomus*

Table 2-14. Life stages captured in Onondaga in 2004.

	Species	Life Stages Present
1	Bluegill	L/Y/A
2	Brook silverside*	L/Y/A
3	Gizzard shad	L/Y/A
4	Pumpkinseed	L/Y/A
5	Alewife	L/A
6	Banded killifish*	Y/A
7	Bluntnose minnow*	Y/A
8	Carp	Y/A
9	Fathead minow*	Y/A
10	Golden shiner*	Y/A
11	Johnny darter*	Y/A
12	Largemouth bass	Y/A
13	Logperch*	Y/A
14	Smallmouth bass	Y/A
15	Tessellated darter*	Y/A
16	White perch	Y/A
17	Longnose gar	Y
18	Yellow perch	A
19	Black crappie	A
20	Brown bullhead	A
21	Brown trout	A
22	Bowfin	A
23	Channel catfish	A
24	Lake sturgeon	A
25	Freshwater drum	A
26	Northern pike	A
27	Rock bass	A
28	Shorthead redhorse	A
29	Tiger muskellunge	A
30	Walleye	A
31	White sucker	A

Notes:
A= Adult stage present, L= Larvae present (captured during larvae sampling), Y= YOY present (captured during YOY seining).

* denotes species that are difficult to distinguish from adults due to their small size, these species are assumed to be reproducing in the lake if captured in the seines.

commersoni), redhorse sucker (*Moxostoma macrolepidotum*), freshwater drum (*Aplodinotus grunniens*), channel catfish, brown bullhead, yellow perch (*Perca flavescens*) have shown some evidence of reproduction in the lake from 2000 to 2004, one (brown trout) would not be expected to be present in a lake during early life history stages, and one (tiger muskellunge (*Esox lucius* x *Esox masquinongy*)) is a sterile hybrid.

The species captured as YOY and their relative abundance has remained largely unchanged since 2001. Like past years, *Lepomis spp*., probably a combination of pumpkinseed and bluegill, continued to dominate the YOY community in 2004 representing 60% percent of the catch (Figure 2-35). Largemouth bass (25%) were also a significant contributor in 2004. The catch of *Lepomis spp*. decreased for the second year in a row (Figure 2-36). Largemouth bass catch rates

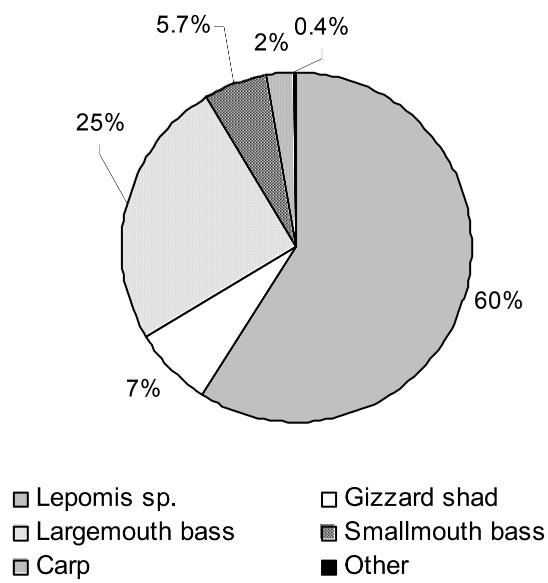


Figure 2-35. Relative abundance of YOY fish captured in littoral seining in 2004.

rose to their highest levels since the AMP was implemented. Gizzard shad and white perch YOY catch remained low in 2004. The YOY catch rate of smallmouth bass has remained largely unchanged. Yellow perch were not collected as either larvae or YOY in 2004.

The fluctuations in catch rates of YOY depicted in Figure 2-36 are not unexpected as fish reproduction is naturally variable. At least several more years of data will be needed before we can attempt to interpret patterns in the data.

Gizzard shad are particularly susceptible to population level fluctuations due to high mortality at low winter temperatures (Becker 1983). This species may be due for a rebound in Onondaga Lake after several years of low catch rates.

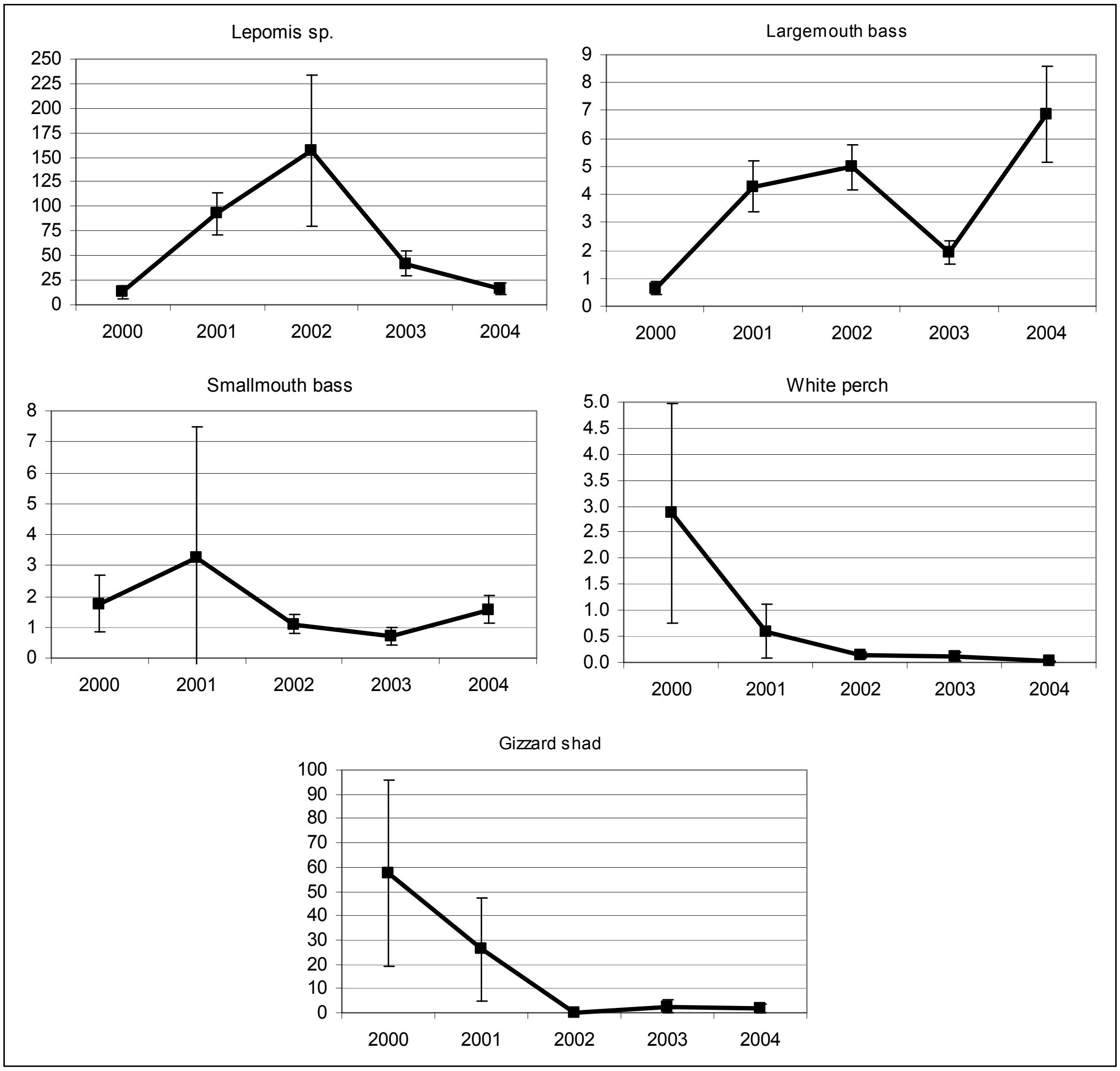


Figure 2-36. Catch per haul of select species from littoral seines from 2000-2004. Error bars are standard error.

2.5.4 Angler Diaries and Creel Survey

Smallmouth and largemouth bass continued to be the most frequently targeted species in the lake and river system, based on the angler diaries. The diaries also provide (semi-qualitative) estimates of catch rates, suggesting that angling success for smallmouth bass was relatively high in 2004 (Table 2-15). Over the course of the diary program, catch rates of largemouth bass have been typically lower than those of smallmouth bass in all segments and this continued to be the case in 2004. Largemouth bass were caught at a rate of 0.23 per hour in the lake compared to 0.73 per hour for smallmouth bass. Catches of largemouth bass were down in Onondaga Lake and the Seneca River downstream of the lake, but up in the Oneida River (Table 2-16).

Table 2-15. Angler catch rates of smallmouth bass from 2001 to 2004.

Year	Onondaga Lake	Seneca River Upstream	Seneca River Downstream	Oneida River
2001	2.8	0.41	1.5	ND
2002	0.38	0.39	1.1	0.12
2003	0.61	0.38	0.65	0.26
2004	0.73	1.2	2.0	1.5

Notes:
Angler catch rates in number of fish per hour.
ND indicates no data collected.

Table 2-16. Angler catch rates of largemouth bass from 2001 to 2004.

Year	Onondaga Lake	Seneca River Upstream	Seneca River Downstream	Oneida River
2001	0.28	0.61	0.69	ND
2002	0.31	0.46	0.32	0.57
2003	0.43	0.33	0.51	0.62
2004	0.23	0.40	0.25	0.76

Notes:
Angler catch rates in number of fish per hour.
ND indicates no data collected.

Another indicator of angling effort is the Creel Survey that was conducted during the August 7, 2004, "Fishing for Dollars" derby on Onondaga Lake. This event is primarily a largemouth and smallmouth bass event, however, several gamefish were targeted by the anglers for prizes and awards related to recaptured tagged fish. A total of 55 roving and access surveys were completed during this event, representing 133 anglers and approximately 10% of the total ticket sales. The roving or shoreline access surveys compiled records of 217 fish caught. The most frequently caught fish from the shoreline were pumpkinseeds and bluegills, which represented 71% of the catch, or 0.19 fish per hour. Largemouth and smallmouth bass represented 18% of the shoreline catch, or 0.047 fish per hour. The access or boating angler surveys compiled records of 84 fish. The most frequently-caught fish were largemouth and smallmouth bass, which represented 75% of the catch, or 0.49 fish per hour. Channel catfish and bullheads, and pumpkinseeds and bluegills were the next most frequently caught fish from a boat, representing 10% each of the access survey catch, or 0.06 fish per hour.

2.6 SENECA RIVER CONDITIONS

In 2004, OCDWEP completed two full water quality surveys of the Seneca River. The analyses were designed to assess current water quality status with respect to ambient water quality standards and support the river modeling effort being carried out by Quantitative Environmental Analysis, LLC (QEA). No July survey was completed in 2004 due to high flow conditions. The AMP calls for annual water quality monitoring at Buoy 316; this sampling and analysis was incorporated into the full river surveys. The study area for these water quality surveys is shown in Appendix 1, Figure A1-1.

Sampling events occurred on August 11th and September 29th 2004. During each survey, grab samples of upper and lower waters of the river (1m above the bottom and 1m below the surface) were collected and analyzed for a large number of water quality parameters. Grab samples of mid-depth waters (center location between the top and bottom of the water column) were also collected and analyzed at Buoy 269 (1 km downstream of Onondaga Lake outlet) to help characterize the extent of stratification of the water column and examine variations in water quality with depth. A depth profile of field parameters (DO, salinity, redox, pH, and temperature) was collected at each station.

The year 2004 was a relatively wet year, with high flow rates throughout the spring and few low-flow periods in the summer. The flow rates in the Seneca River on the two dates of the full water quality surveys were 2,790 and 6,160 cfs, respectively. The flow rates were high as compared to the survey days in previous years. The 2004 average flow rates in the rivers from July to September were 4,549 cfs in the Seneca River and 2,537 cfs in the Oneida River (Figure A1-2), as compared to 2,065 cfs and 1,162 cfs, respectively, in 2003. There were only 13 days in 2004 where the flow rates were below 1,000 cfs in the Seneca River. The minimum flow rate in the Seneca River in 2004 was 425 cfs, which is above the 7Q10* value of 350 cfs (See Appendix 1).

During both sampling events, DO concentrations were about 8-10 mg/L just downstream of Cross Lake. DO concentrations decreased as the water moved downstream to Baldwinsville, as a result of zebra mussel respiration and sediment oxygen demand. DO levels in the vicinity of Baldwinsville were lower in the August event, slightly above 6 mg/L, than the September event, around 8-9 mg/L. DO concentrations in 2004 were generally higher than those measured in 2003, likely as a result of the high flow rates observed during the 2004 sampling events.

As a result of the zebra mussel invasion, Seneca River water quality has shifted from a system in which nutrients such as phosphorus and nitrogen were largely tied up in phytoplankton standing crops to one in which dissolved forms are more prevalent (Figure 2-37). In 2004, the average ammonia–N concentration in the river upstream of the lake (0.1 mg/L) was less than the concentration in the lake's LWL (ranged from 0.5 to 1.0 mg/L), and was similar to the concentration in the UML. Thus, unlike previous years, the ammonia concentration in the UML was less likely in 2004 to be influenced by the river water during flow reversals in the outlet.

In 2004, as in previous years, SRP levels generally increased in the Seneca River from upstream to downstream. On the first sampling date (8/11/04; Figure 2-38), SRP concentrations increased from approximately 20 µg/L in the vicinity of Cross Lake to approximately 30 µg/L near the lake outlet. On the second sampling date (9/29/04; Figure 2-39), concentrations increased from approximately 10 µg/L to 20 µg/L over the same reach. These downstream increases are primarily caused by filtration and nutrient release by the zebra mussels. On both sampling dates, concentrations stayed relatively constant going further downstream, probably due to balancing of algal growth with filtration of the remaining algae. The SRP concentration in the Seneca River just upstream of the lake outlet (about 20 µg/L in the September 29th survey) was between the concentration of the lake UML (less than 10 µg/L) and the LWL (ranged from 100-300 µg/L). Thus, in mid-summer, the river may contribute some SRP to the lake's upper waters during periods of river inflow. These patterns are consistent with previous years.

* The 7Q10 refers to the lowest consecutive 7 day streamflow that is likely to occur in a ten year period.

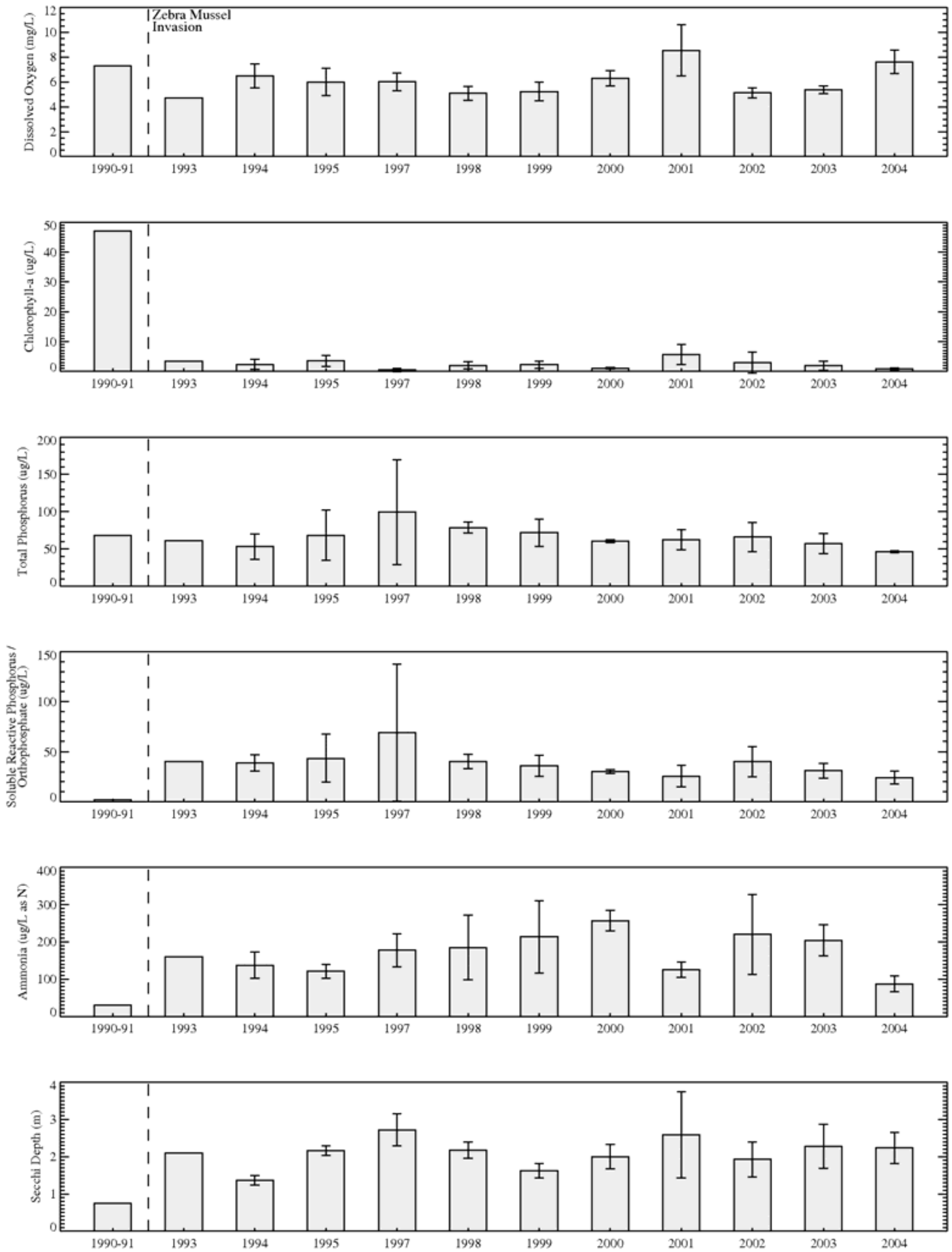


Figure 2-37. Water quality parameters measured near Baldwinsville before (1990-1991) and after the zebra mussel invasion of the Seneca River.

Note: 1990-91 & 93 data from Effler et al. (1996); 1994-04 data from County AMP; results are from 1 m below water surface at Buoy-316;plotted values represent yearly arithmetic mean +/- 2 standard errors of the mean

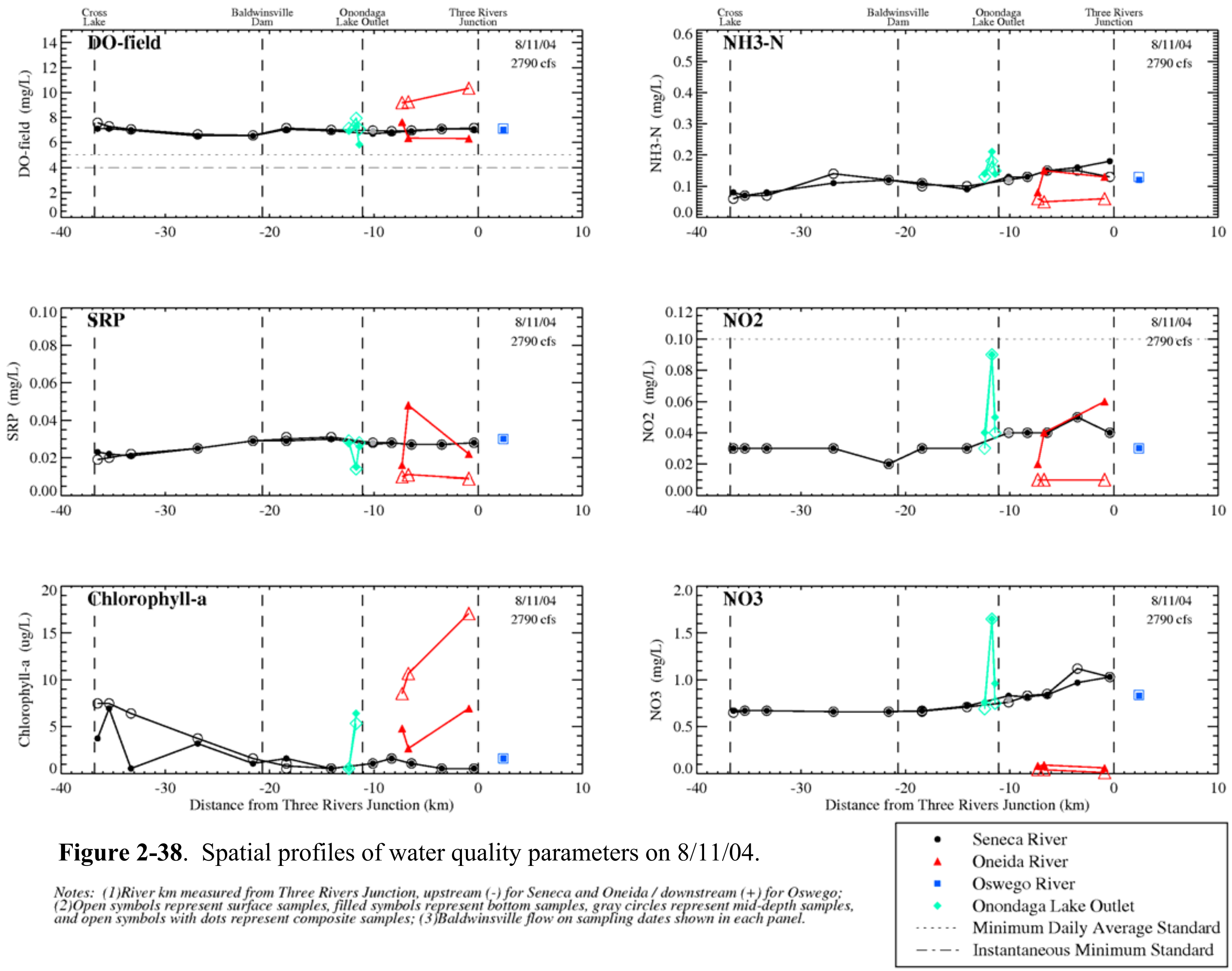


Figure 2-38. Spatial profiles of water quality parameters on 8/11/04.

Notes: (1)River km measured from Three Rivers Junction, upstream (-) for Seneca and Oneida / downstream (+) for Oswego; (2)Open symbols represent surface samples, filled symbols represent bottom samples, gray circles represent mid-depth samples, and open symbols with dots represent composite samples; (3)Baldwinsville flow on sampling dates shown in each panel.

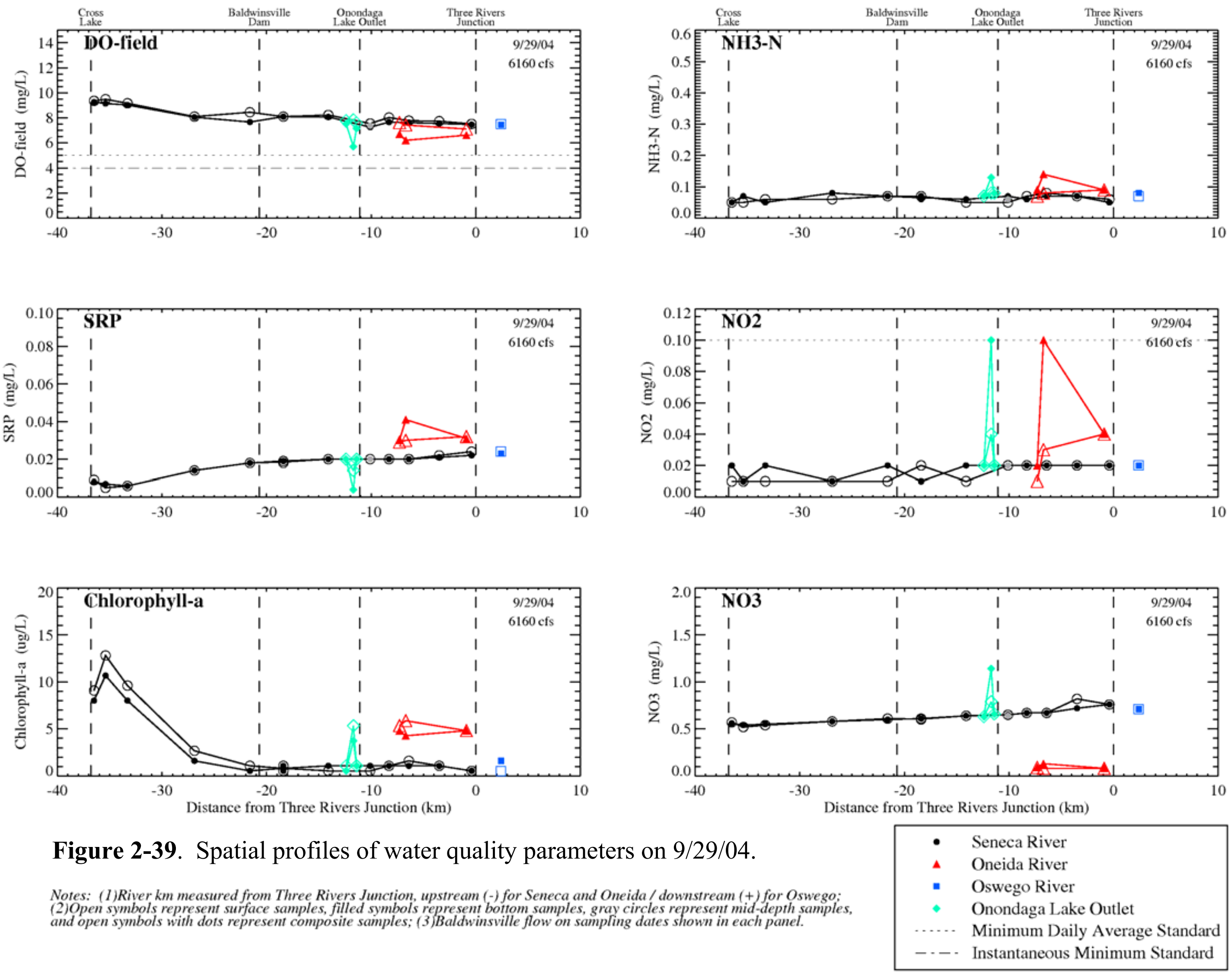


Figure 2-39. Spatial profiles of water quality parameters on 9/29/04.

Notes: (1)River km measured from Three Rivers Junction, upstream (-) for Seneca and Oneida / downstream (+) for Oswego; (2)Open symbols represent surface samples, filled symbols represent bottom samples, gray circles represent mid-depth samples, and open symbols with dots represent composite samples; (3)Baldwinsville flow on sampling dates shown in each panel.

Zebra mussel filtration led to a decrease in chlorophyll-*a*, with levels around 10 µg/L at Cross Lake, to levels below 2 µg/L at Baldwinsville. Nutrient release by the mussels led to the increases in NH_3-N and SRP concentrations in the river.

Elevated salinity and slightly lower temperature were observed downstream of the outlet, probably reflecting the influx of lake water: the salinity and temperature of the bottom waters of the river were similar to data collected in the bottom waters of the lake outlet. Dissolved oxygen levels in the bottom waters downstream of the outlet also appeared to be influenced by Onondaga Lake, where concentrations were lower than the Seneca River during the sampling events in 2004. However, the extent and magnitude of the concentration differences for salinity, temperature and dissolved oxygen between top and bottom waters was smaller and weaker in 2004, as compared to measurements from previous years. These patterns suggest that the high flow rates observed in 2004 led to increased mixing of Onondaga Lake waters with the Seneca River waters as well as less influence from groundwater recharge in the vicinity of the “deep hole” (downstream of the lake outlet; as noted in the OCDWEP 2003 AMP Annual Report). The coupled Onondaga Lake and Three Rivers Water Quality Models will provide a means for testing these hypotheses.

In summary, the river water quality in 2004 was comparable to data collected from 1994 to 2003, although the extent of stratifications was diminished due to the relatively high flow rates during 2004 sampling events. The introduction of zebra mussels in the early 1990s resulted in dramatic changes in water quality in the river; since then, the dominant patterns and mechanisms do not appear to have changed significantly.

2.7 MACROINVERTEBRATES

Macroinvertebrates are an important component of the aquatic food web. Because they have limited migration patterns or a sessile mode of life, they are well suited for assessing site-specific impacts of point and nonpoint discharges. Many state agencies, including NYSDEC, use macroinvertebrates as indicators of stream quality.

Sampling in the tributaries is conducted every two years and sampling in the lake's littoral zone is conducted every five years throughout the AMP. Macroinvertebrates were sampled in Onondaga Lake tributaries in 2000, 2002, and 2004. The objectives of monitoring this element of the aquatic ecosystem are to characterize the existence and severity of use impairment, and evaluate the effectiveness of improvements to the County’s wastewater collection and treatment infrastructure. The complete report of the 2004 macroinvertebrate investigations is in Appendix 5.

2.7.1 Methods

A total of ten sampling sites are located along the three CSO-affected tributaries: Onondaga Creek, Harbor Brook and Ley Creek. The macroinvertebrate community present at these sites is assessed every two years. Samples from the stream bottom are collected using either kick samples or jab samples. Data are analyzed using NYSDEC Biological Assessment Profiles (BAP), Hilsenhoff Biotic Index (HBI), and the percent oligochaetes in samples. In addition, the NYSDEC Impact Source Determination (ISD) is calculated at kick sample sites to determine the primary factor(s) influencing the macroinvertebrate community (see Appendix 5 for description of methods for sampling and analysis).

2.7.2 Significant Findings

The macroinvertebrate communities of Onondaga Creek, Ley Creek, and Harbor Brook showed varying levels of impact. Based on NYSDEC assessment scores, sites in Harbor Brook and Ley Creek tended to be more severely impacted than sites in Onondaga Creek. The combination of habitat degradation, non-point source pollution, and CSO discharges affects the streams' macroinvertebrate communities. Results at most sites were similar to observations made in 2000 and 2002. A notable exception was at Site 4, Onondaga Creek at Spencer Street, which showed significant improvement in the NYSDEC Water Quality Impact Assessment in 2004.

2.7.2.1 Onondaga Creek

Sites along Onondaga Creek showed a wide range of conditions in 2004, with a trend towards increasing adverse impacts downstream (Figure 2-40). Site 1 at Tully Farms Road was rated as a "Natural", slightly-impacted stream according to the NYSDEC criteria (Figure 2-40 and Table 2-17). This is a decline from the "no impact" designation in 2002; however the difference between 2002 and 2004 was not statistically significant. The decline in 2004 was apparently not related to any increase in oxygen-demanding wastes as judged from the lack of change in the HBI metric. The most common organisms collected at Site 1 in 2004 were midge larvae; this is a change from 2000 and 2002 when mayflies and stoneflies were most common (Figure 2-41). The combination of community structure change and decline in NYSDEC BAP may indicate increased disturbance at or immediately upstream of this site. The origin of this potential disturbance is not understood.

As in past years, Site 2 Webster Road was designated as slightly impacted and showed increased impacts of non-point source oxygen demanding waste compared to Site 1. This conclusion was based on a combination of the NYSDEC BAP metric, HBI scores and the percent of oligochaetes in the macroinvertebrate community. Mudboil associated discharges upstream of Site 2 may affect the macroinvertebrate community here, but differentiation of mudboil impacts from other sources is not possible with these data. The community at Site 2 in 2004 shifted from what was observed at Site 1 to one where midge larvae, oligochaetes, beetle larvae, caddisflies, aquatic fly larvae where almost all equally abundant. This community is similar to what has been observed at this site in past years. The NYSDEC ISD analysis indicated that the site was affected by "Impoundment". A similar result was observed in 2002, it is not understood why the community resembles those found in impounded areas as this section of stream is not impounded. Perhaps sedimentation from mudboils mimics impoundment conditions.

Site 3 at Dorwin Avenue showed the same level of impact in 2004 as the Webster Road site, being considered "slightly impacted" based on NYSDEC BAP. This site had a community that was similar to five of the seven ISD communities. This is likely indicative of the complex interactions that begin to occur as the stream enters the more urbanized areas of the watershed. Highest ISD similarities were to "Impoundment" and "Toxic: Industrial, or Urban Runoff". The dredged and straightened sections upstream of this site may have caused or contributed to the "Impoundment" ISD while the increase in urbanization likely is primarily responsible for the "Toxic: Industrial, or Urban Runoff" designation. Dominant organisms were aquatic beetle larvae, caddisflies and midge larvae. The increase in beetle larvae is a change from past years, the cause of the change is not known.

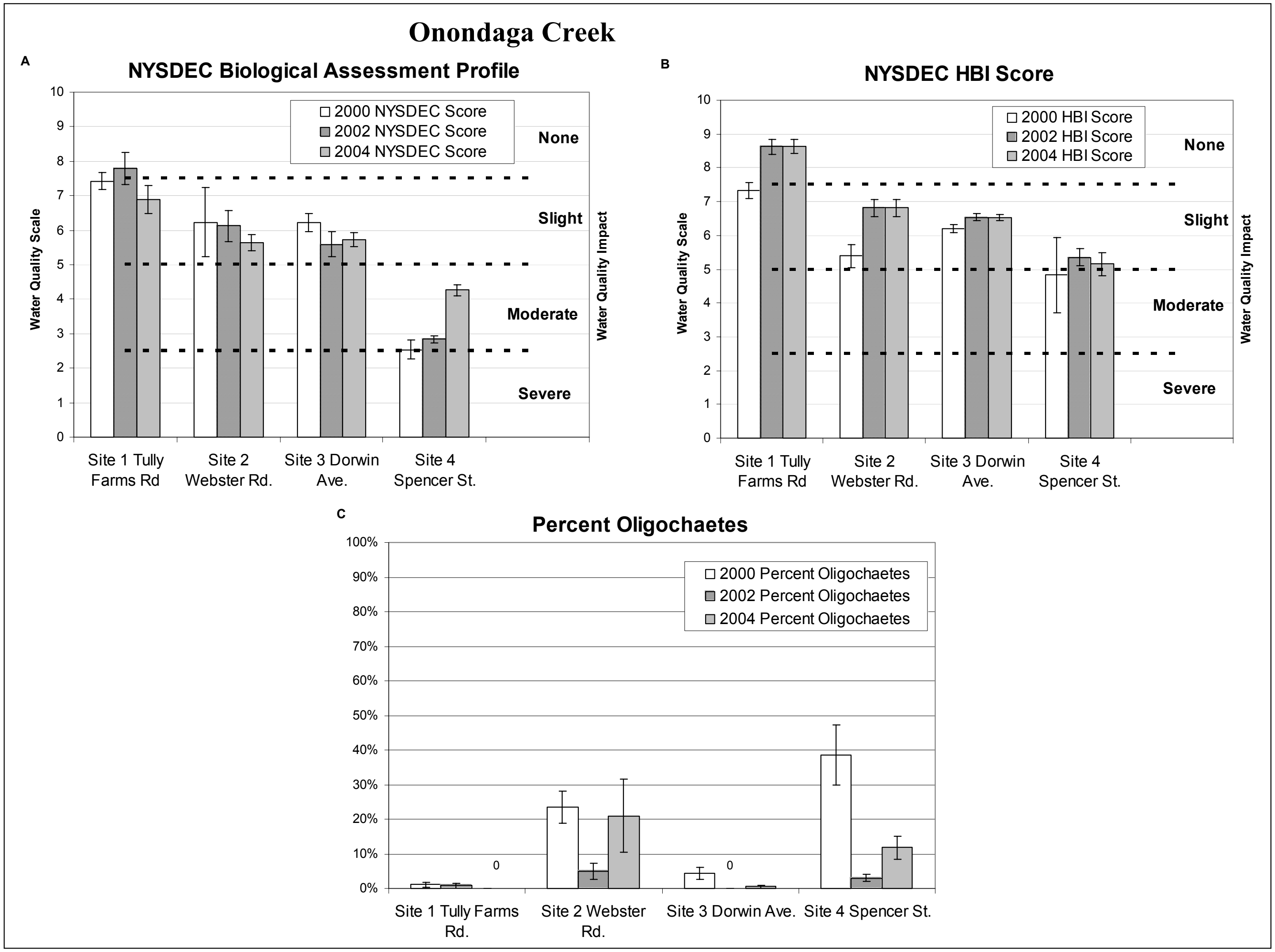


Figure 2-40. NYSDEC water quality scale scores (A), NYSDEC HBI scores (B), and percent oligochaetes (C)of sites in Onondaga Creek collected in 2000, 2002, and 2004 Error bars are standard error.

Table 2-17. Impact Source Determination, Onondaga Creek, 2000, 2002, 2004. Numbers represent similarity to macroinvertebrate community type models for each impact category. The highest similarities (within 5 percentage points of the highest) at each station are highlighted. Highest numbers represent probable type of impact. See Appendix 5 for further explanation. *Note: Similarities less than 50% are less conclusive.

Onondaga Creek	**STATION**											
	Site 1 Tully Farms Road			**Site 2 Webster Road**			**Site 3 Dorwin Avenue**			**Site 4 Spencer Street**		
Community Type	**2000**	**2002**	**2004**	**2000**	**2002**	**2004**	**2000**	**2002**	**2004**	**2000**	**2002**	**2004**
Natural: minimal human impacts	**51**	**73**	**45***	47	70	**52**	41	48	39	12	23	24
Nutrient additions: mostly nonpoint, agricultural	36	60	39	50	74	50	**57**	**75**	**60**	12	35	29
Toxic: industrial, municipal, or urban run-off	27	48	**43***	45	63	41	51	**76**	**62**	21	44	**46***
Organic: sewage effluent, animal wastes	31	50	32	**64**	**80**	43	43	**72**	47	**41***	**66**	**48***
Complex: municipal/industrial	18	40	35	51	**81**	41	45	**72**	**58**	**42***	34	**49***
Siltation	30	57	33	49	70	45	**59**	**76**	**61**	24	32	33
Impoundment	21	49	29	50	**81**	**57**	**54**	**73**	**63**	**46***	59	**46***

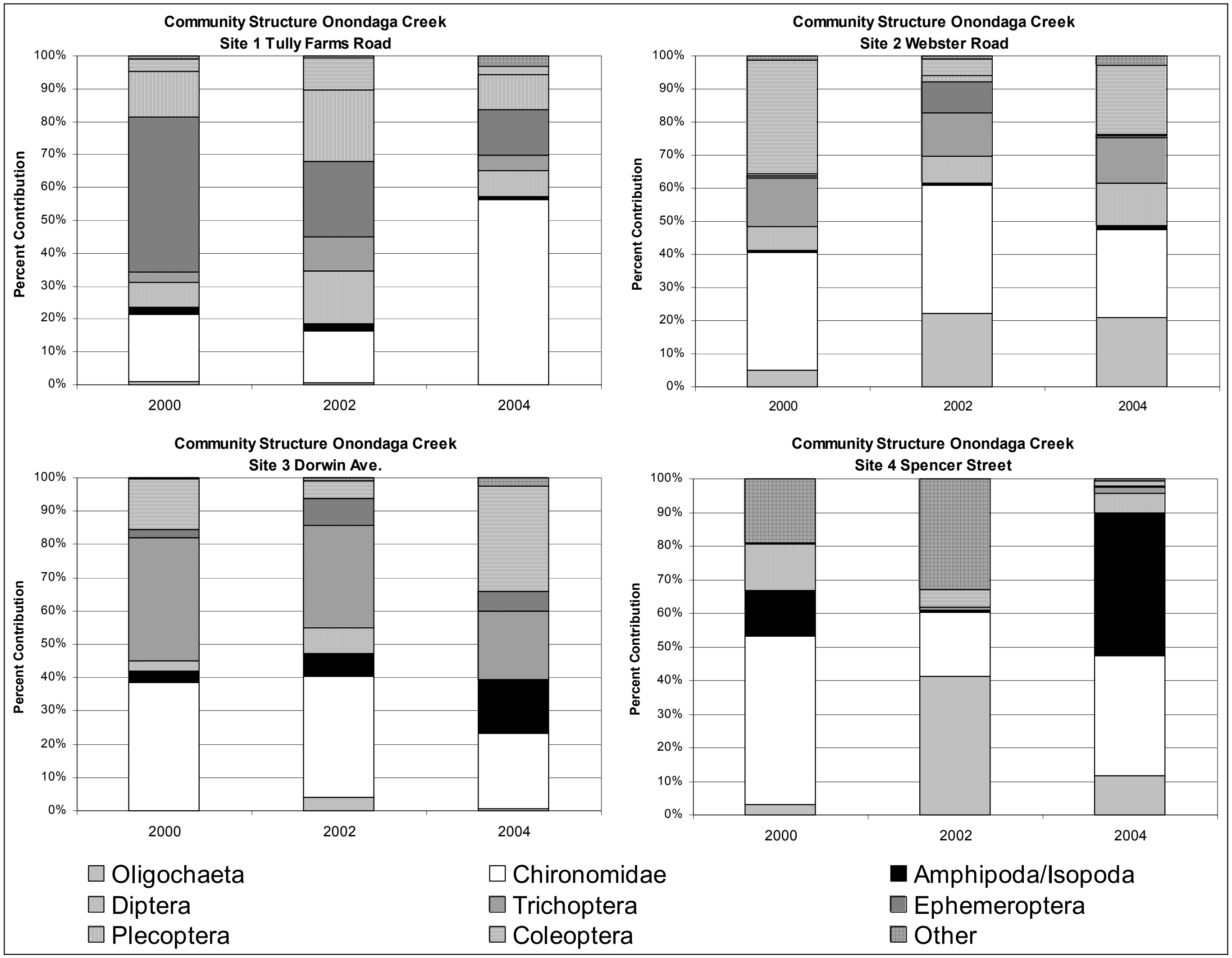


Figure 2-41. Community structure of macroinvertebrate communities at Onondaga Creek sites in 2000, 2002, and 2004.

The most downstream site on Onondaga Creek is Site 4 at Spencer Street, which is downstream of most CSOs. As in past years, this site was calculated as “moderately impacted.” However, there was a significant improvement in the NYSDEC BAP score from previous years 2000 and 2002 ($p<0.05$). The HBI score has not changed from past years indicating that the improvement at this site is probably not associated with decreases in oxygen demanding wastes. Although this site showed significant improvement from past years it is still the most impacted of the Onondaga Creek sites. A statistically significant ($p<0.05$) drop in HBI score progressing downstream from the Dorwin Avenue site indicates that some of the increased impact is due to oxygen-demanding wastes, probably from a combination of urban runoff and CSO discharges. However, severe habitat degradation upstream of this site likely influences the macroinvertebrate community here. The macroinvertebrate community at this site was dominated by a combination of amphipods, isopods, and midge larvae. The increase in amphipods/isopods and decrease in oligochaetes is a change from past years.

2.7.2.2 Ley Creek

Ley Creek was considered severely impacted at its two most upstream sites in 2004 (Site 1 and Site 2) with aquatic worms (oligochaetes) dominating at both sites (Figure 2-42). HBI scores and the percent of oligochaetes indicated that oxygen demanding wastes are the likely source of impairment at these sites. NYSDEC BAP and HBI score results at these two sites are consistent with 2002 but worse than the year 2000. The cause of the decline from 2000 is not known but conditions appear to have stabilized. NYSDEC ISD was only completed at Site 1 because ISD is dependant on kick samples and other sites were sampled with jab nets. The ISD indicate the most probable source of impact was from “Organic: Sewage Effluent/Animal Waste” (Table 2-18).

The most downstream site, Site 3 Park Street, showed an substantial improvement in 2004. However, because replicates had to be combined into a single sample at this site in 2004 to compensate for low organism numbers, there is no measure of statistical significance between the 2004 results and past years. Therefore, these results should be viewed with caution. Amphipods, isopods and midge larvae were the most dominate organisms at this site in 2004, a change from past years when oligochaetes dominated the community (Figure 2-43).

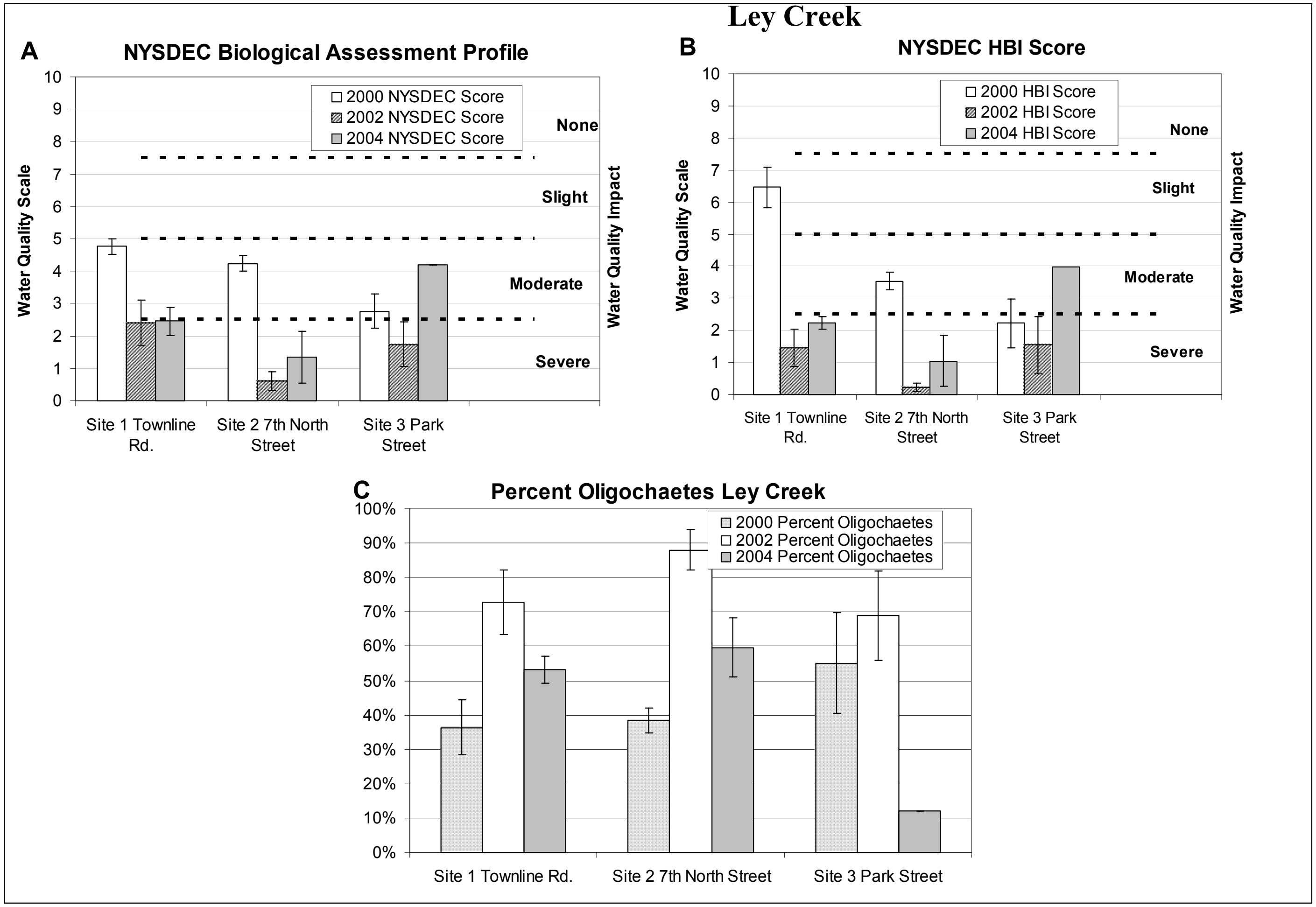


Figure 2-42. NYSDEC water quality scale scores (A), NYSDEC HBI scores (B), and percent oligochaetes (C) of sites in Ley Creek collected in 2000, 2002, and 2004 Error bars are standard error.

Note: Site 3 (Park Street) in 2004 had very few organisms sampled (average 21 organism per replicate) as a result replicates were combined into a single sample to approach 100 organisms; no standard error was calculated. One replicate at Site 2 (7th North Street) also had few organsism, results of this replicate sample were not used in the calculations.

Table 2-18. Impact Source Determination, Harbor Brook, 2000, 2002, and 2004. No data from Site 3 Rt. 690 because ISD is only applicable to kick samples in riffle habitats and this site is sampled with jab nets. Numbers represent similarity to macroinvertebrate community type models for each impact category. The highest similarities (within 5 percentage points of the maximum) at each station are highlighted. Highest numbers represent probable type of impact. See Appendix 5 for further explanation.

Harbor Brook	STATION								
Community Type	Site 1 Velasko Road			Site 2 Hiawatha Boulevard			Site 3 Route 690		
	2000	2002	2004	2000	2002	2004	2000	2002	2004
Natural: minimal human impacts	12	50	28	5	26	7	-	-	-
Nutrient additions; mostly nonpoint, agricultural	18	46	26	5	31	22	-	-	-
Toxic: industrial, municipal, or urban run-off	23	42	28	20	45	25	-	-	-
Organic: sewage effluent, animal wastes	47	45	19	53	56	49	-	-	-
Complex: municipal/industrial	**69**	**67**	**53**	**70**	**76**	**74**	-	-	-
Siltation	25	42	23	20	36	22	-	-	-
Impoundment	53	**64**	**57**	40	57	54	-	-	-

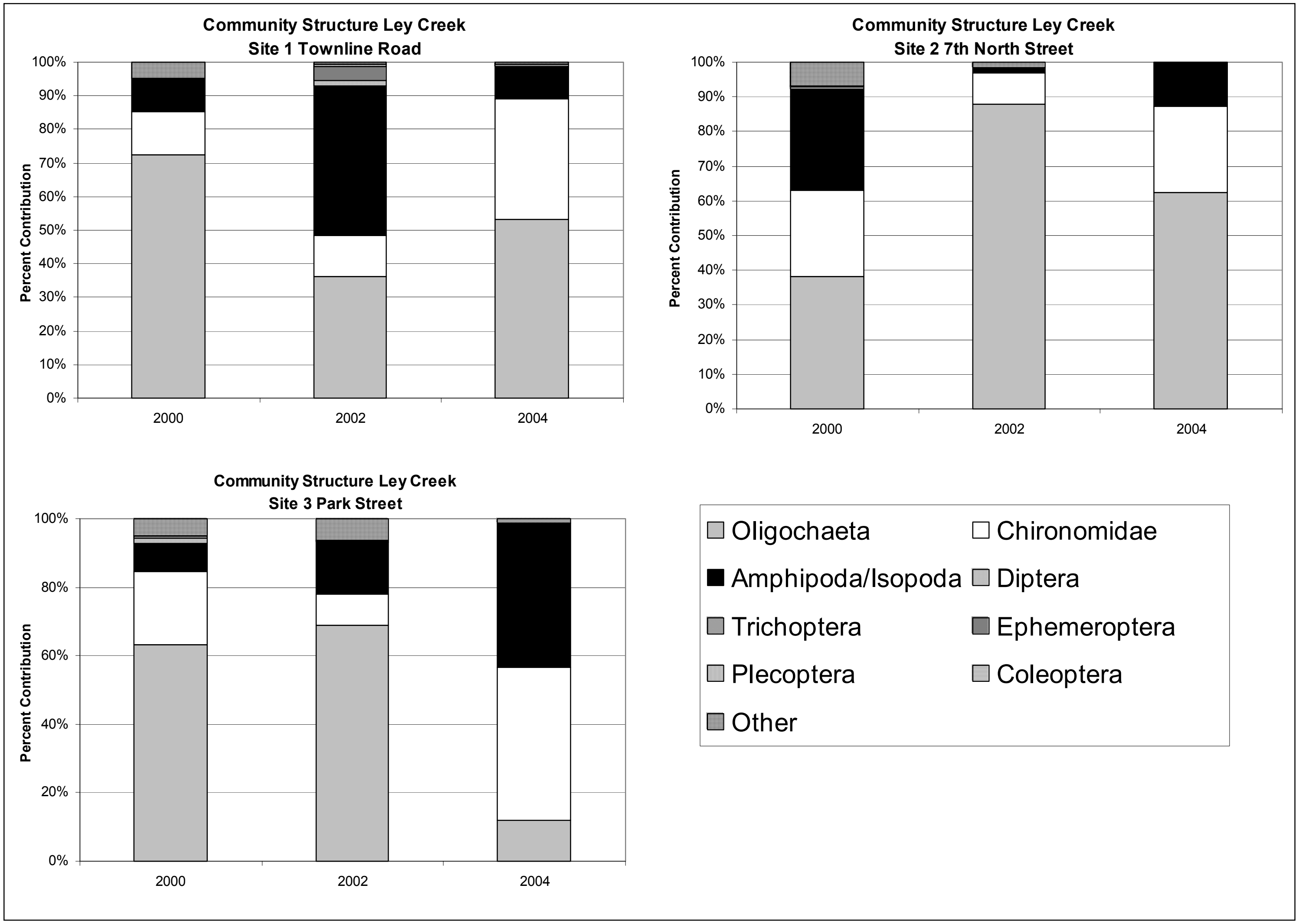


Figure 2-43. Community structure of the macroinvertebrate communities at Ley Creek sites in 2000, 2002, and 2004.

2.7.2.3 Harbor Brook

Harbor Brook was ranked as moderately impacted at its most upstream site at Velasko Road, and borderline moderately/severely impacted at its two downstream locations at Hiawatha Boulevard and Route 690 (Figure 2-44). HBI scores and the percent of oligochaetes indicated increasing impact from organic pollution at the two downstream locations compared to Velasko Road. The significant improvement ($p<0.05$) in all metrics observed at Site 1 Velasko Road from 2000 to 2002 is still evident in 2004. The cause of the improvements at this site appears to be due to substantial declines in oxygen demanding wastes as indicated by the dramatic increase in HBI scores and decrease in percent oligochaetes since 2000. Why these improvements occurred is not well understood as this location is upstream of CSOs.

NYSDEC ISD was completed at Sites 1 and 2. The ISD results have been very consistent across years (Table 2-19), indicating that Sites 1 and 2 are most likely impacted from combinations of "Impoundment" affects and "Complex: Municipal/Industrial". This finding does not imply that there is an impoundment on Harbor Brook that is structuring the macroinvertebrate community, only that the existing community most closely resembles those affected by impoundments. Recall that the NYSDEC ISD is an empirical model based on assessment of multiple sites throughout the state. Oligochaetes were the most common taxa at downstream Sites 2 and 3 while amphipods/isopods were most common at Site 1 (Figure 2-45). Also notable is the increase in mayflies at Site 1 in 2004 compared to past years.

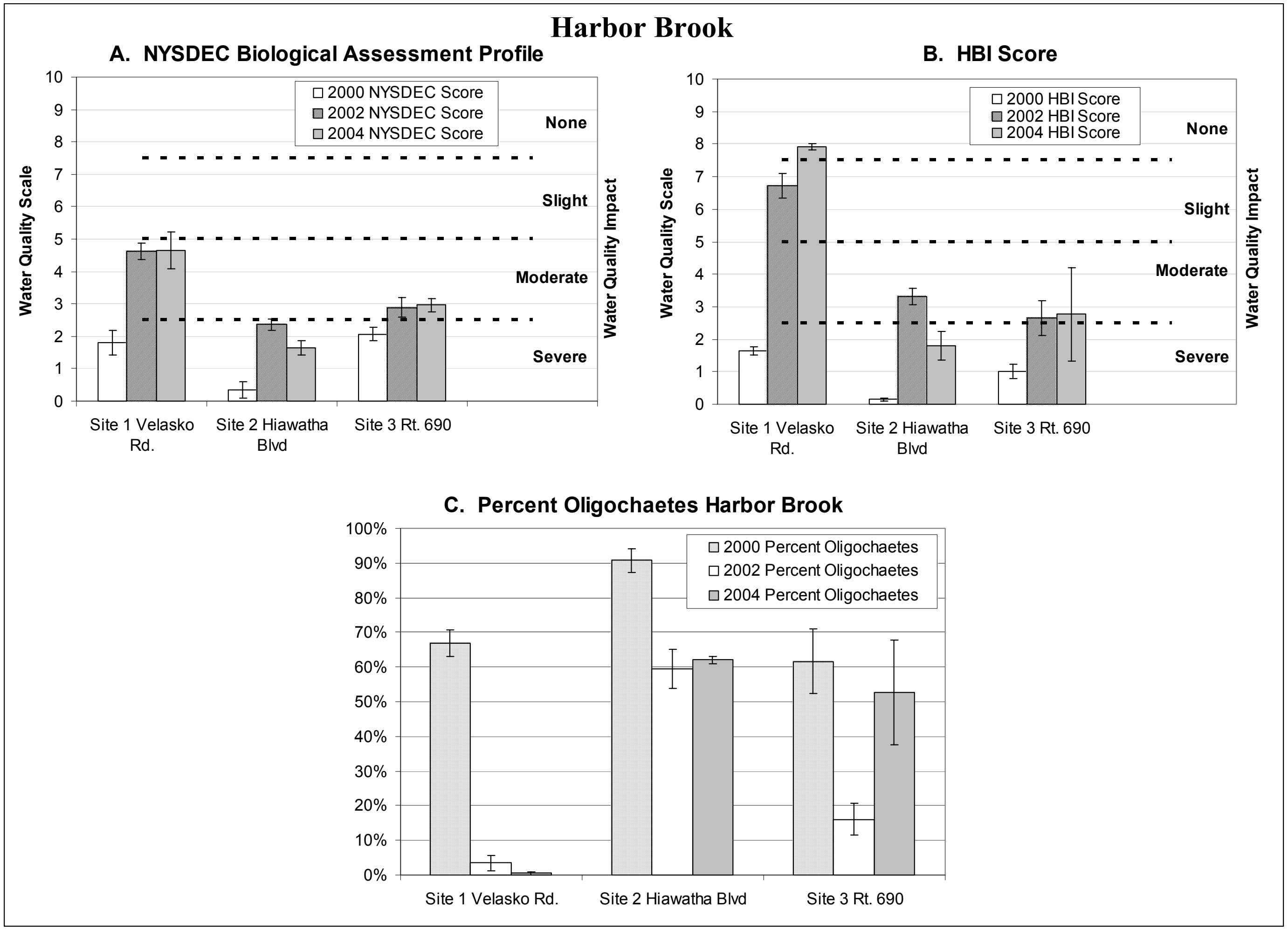


Figure 2-44. NYSDEC water quality scale scores (A), NYSDEC HBI scores (B), and percent oligochaetes (C)of sites in Harbor Brook collected in 2000, 2002, and 2004 Error bars are standard error. Note: Site 3 Rt 690 in 2004 had very few organisms sampled (average 21 organism per replicate) as a result replicates were combined into a single sample therefore no standard error was calculated.

Table 2-19. Impact Source Determination, Ley Creek in 2000, 2002, and 2004. No data for Site 2 and Site 3 because ISD is only applicable to kick samples in riffle habitats and this site is sampled with jab nets. No data for Site 1 in 2000 and 2002 because this site was sampled with jab nets in those years, subsequent changes in sediment composition allowed for kick sampling in 2004. Numbers represent similarity to macroinvertebrate community type models for each impact category. The highest similarities (within 5 percentage points of the maximum) at each station are highlighted. Highest numbers represent probable type of impact. See Appendix 5 for further explanation.

Ley Creek	**STATION**								
	Site 1 Townline Road			**Site 2 7th North Street**			**Site 3 Park Street**		
Community Type	**2000**	**2002**	**2004**	**2000**	**2002**	**2004**	**2000**	**2002**	**2004**
Natural: minimal human impacts	-	-	13	-	-	-	-	-	-
Nutrient additions; mostly nonpoint, agricultural	-	-	37	-	-	-	-	-	-
Toxic: industrial, municipal, or urban run-off	-	-	34	-	-	-	-	-	-
Organic: sewage effluent, animal wastes	-	-	**67**	-	-	-	-	-	-
Complex: municipal/industrial	-	-	57	-	-	-	-	-	-
Siltation	-	-	32	-	-	-	-	-	-
Impoundment	-	-	53	-	-	-	-	-	-

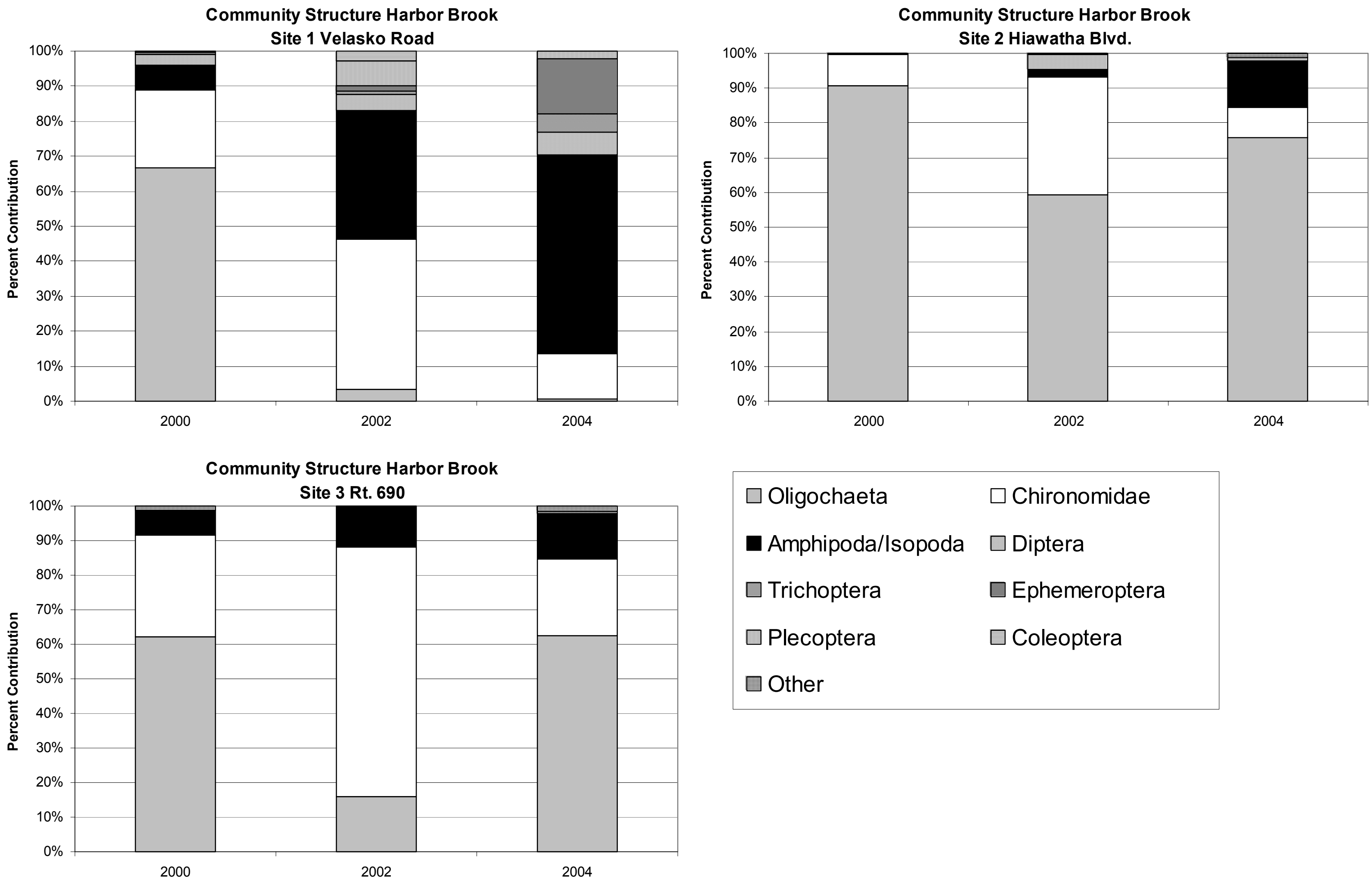


Figure 2-45 . Community structure of the macroinvertebrate communities at Harbor Brook sites in 2000, 2002, and 2004.

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CHAPTER 3:
PROGRESS TOWARDS IMPROVEMENT

3.1 Regulatory Compliance

3.1.1 Tributaries

The monitored segments of the Onondaga Lake tributaries are classified C (suitable for fish propagation and secondary water contact recreation). Compliance with the ambient water quality standards is summarized in Table 3-1. Overall, the tributaries were in compliance except for the following:

- As in previous years, the natural tributaries were not in compliance with the current state ambient water quality standard for iron, which is 300 µg/l. Following an evaluation of the scientific basis for the standard, NYSDEC has announced its intention to propose a revision to 1000 µg/l as a guidance value. This change would be consistent with the 1976 federal criterion for iron. Between 69% and 100% of the tributary iron measurements were below 1000 µg/l during the 2004 monitoring period.

- With the exception of one measurement on Ley Creek, concentrations of heavy metals (excluding mercury) in the streams were in compliance with regulatory standards. The ambient water quality standard for mercury (0.0007 µg/l) is below the minimum reporting level (MRL) of the OCDWEP laboratory (0.02 µg/l). At least one of the four samples collected in Ley Creek, Harbor Brook and the East Flume during 2004 had mercury over the MRL and thus over the ambient water quality standard.

- The East Flume occasionally exceeded standards for cyanide, ammonia and pH during 2004. Nitrite-N concentrations in this stream consistently exceeded the ambient water quality standard (0.1 mg/l to protect a warmwater fish community).

- The average DO concentration in Tributary 5A was low in 2004 but the concentrations were within the range of historical values.

- Cyanide concentrations in Ley Creek exceeded the ambient water quality standards on three of the four samples collected in 2004.

- Fecal coliform/bacterial levels were elevated in many of the streams during 2004, presumably due to the wet weather. Streams with CSOs were most affected.

Table 3-1. Regulatory compliance in Onondaga Lake tributaries, 2004.

Parameter (units)	**NYSDEC Standard (Class C)**[1]			**Average of 2004 measured concentrations**	**Measurements in Compliance**
pH (standard units)	Shall not be less than 6.5 nor more than 8.5	NM :		7.79	100%
		OC :		7.80	100%
		LC :		7.46	100%
		HB :		7.68	100%
		5A :		7.79	100%
		EF :		8.30	59%
		BB :		7.68	100%
		SM :		7.41	100%
Dissolved Oxygen (mg/l)	Minimum daily average 5.0 mg/l, at no time shall DO be < 4.0 mg/l	NM :		11.52	100%>4, 100%>5
		OC :		11.79	100%>4, 100%>5
		LC :		9.01	100%>4, 96%>5
		HB :		11.24	100%>4, 100%>5
		5A :		5.81	81%>4, 58%>5
		EF :		9.71	100%>4, 92%>5
		BB :		11.16	100%>4, 100%>5
		SM :		8.84	100%>4, 100%>5
Fecal Coliform [2] (cells/100 ml)	Percent individual observations < 200 cells.	NM :		1503	61%
		OC :		1012	42%
		LC :		1378	36%
		HB:		2292	44%
		5A :		301	92%
		EF :		711	56%
		BB :		1621	50%
		SM :		1756	50%
Ammonia-N (mg/l)	Varies with pH and temperature.	NM :		0.30	70%
		OC :		0.07	93%
		LC :		0.29	71%
		HB :		0.06	94%
		5A :		0.67	33%
		EF :		0.52	48%
		BB :		0.07	93%
		SM :		0.06	94%
Arsenic [3,4] (µg/l)	190 µg/l	NM :		1.3	100%
		OC :		2.1	100%
		LC :		1.4	100%
		HB :		1.3	100%
		5A :		1.4	100%
		EF :		2.6	100%
		BB :	<	1.3	100%
		SM :	<	1.3	100%
Cyanide [4] (µg/l)	5.2 µg/l (Free CN)	NM :	<	2.0	100%
		OC :	<	2.0	100%
		LC :		5.5	25%
		HB :		2.1	100%
		5A :	<	2.0	100%
		EF :		4.0	75%
		BB :		2.3	100%
		SM :		3.0	75%

Table 3-1. Regulatory compliance in Onondaga Lake tributaries, 2004 (continued).

Parameter (units)	**NYSDEC Standard (Class C)**[1]	**Average of 2004 measured concentrations**		**Measurements in Compliance**
Nitrite-N	100 µg/l (Warm water fishery)	NM :	24.8	100%
(µg/l)		OC :	24.8	91%
		LC :	18.8	100%
		HB :	13.5	98%
		5A :	26.9	100%
		EF :	788.4	0%
		BB :	15.0	100%
		SM :	15.0	100%
Copper [4]	0.96 exp (0.8545 [ln (ppm hardness)] - 1.702)			
(µg/l)	Standard Range (µg/l):			
	NM: 24.0-26.1	NM :	8.475	100%
	OC: 22.2-26.1	OC :	7.06	100%
	LC: 10.8-26.1	LC :	8.05	75%
	HB: 20.8-26.1	HB :	2.97	100%
	5A: 26.1	5A :	10.575	100%
	EF: 10.6-26.1	EF :	4.455	100%
	BB : 11.3-26.1	BB :	5.0625	100%
	SM : 9.9-26.1	SM :	2.7375	100%
Mercury * [4]	0.0007 µg/l	NM :	0.02	*See note*
(µg/l)		OC :	0.02	
		LC :	0.04	
		HB :	0.04	
		5A :	< 0.02	
		EF :	0.06	
		BB :	< 0.02	
		SM :	< 0.02	
Lead [4]	(1.46203 - [ln (hardness) 0.145712]) exp (1.273 [ln (hardness)] - 4.297)			
(µg/l)	Standard Range (µg/l):			
	NM: 12.9-14.3	NM :	2.7	100%
	OC: 11.8-14.3	OC :	3.9	100%
	LC: 4.8-14.3	LC :	5.1	75%
	HB: 10.9-14.3	HB :	3.1	100%
	5A: 14.3	5A :	2.9	100%
	EF: 4.7-14.3	EF :	3.0	100%
	BB : 5.1-14.3	BB :	2.1	100%
	SM : 4.3-14.3	SM :	2.5	100%
Cadmium [4]	0.85 exp (0.7852 [ln (ppm hardness)] - 2.715)			
(µg/l)	Standard Range (µg/l):			
	NM: 5.2-5.6	NM :	< 0.4	100%
	OC: 4.8-5.6	OC :	0.4	100%
	LC: 2.5-5.6	LC :	< 0.4	100%
	HB: 4.5-5.6	HB :	< 0.8	100%
	5A: 5.6	5A :	0.4	100%
	EF: 2.4-5.6	EF :	< 0.4	100%
	BB : 2.6-5.6	BB :	0.9	100%
	SM : 2.3-5.6	SM :	< 0.4	100%

Table 3-1. Regulatory compliance in Onondaga Lake tributaries, 2004 (continued).

Parameter (units)	**NYSDEC Standard (Class C)**[1]	**Average of 2004 measured concentrations**		**Measurements in Compliance**
Zinc [4] (µg/l)	exp (0.85 [ln (ppm hardness)] + 0.50)			
	Standard Range (µg/l):			
	NM: 220-40	NM :	8.3	100%
	OC: 204-240	OC :	13.6	100%
	LC: 99-240	LC :	20.6	100%
	HB: 191-240	HB :	8.7	100%
	5A: 240-240	5A :	8.0	100%
	EF: 98-240	EF :	30.9	100%
	BB : 104-240	BB :	16.4	100%
	SM : 92-240	SM :	10.2	100%
Chromium [4] (µg/l)	0.86 exp (0.819 [ln (ppm hardness)] + 1.561)			
	Standard Range (µg/l):			
	NM: 458-497	NM :	1.0	100%
	OC: 425-497	OC :	3.0	100%
	LC: 212-497	LC :	4.9	100%
	HB: 399-497	HB :	1.0	100%
	5A: 497	5A :	16.5	100%
	EF: 210-497	EF :	2.2	100%
	BB : 222-497	BB :	1.0	100%
	SM : 197-497	SM :	0.7	100%
Iron (µg/l)	300 µg/l (current) ; 1000 µg/l (proposed)	NM :	798	19% ; 81%
		OC :	1800	34% ; 76%
		LC :	1009	0% ; 69%
		HB :	514	76% ; 93%
		5A :	945	4% ; 78%
		EF :	328	67% ; 96%
		BB :	479	25% ; 100%
		SM :	642	25% ; 75%
Nickel [4]	0.997 exp (0.846 [ln (ppm hardness)] + 0.0584)			
(µg/l)	Standard Range (µg/l):			
	NM: 138-150	NM :	< 2.5	100%
	OC: 128-150	OC :	6.7	100%
	LC: 62-150	LC :	3.3	100%
	HB: 120-150	HB :	3.3	100%
	5A: 150	5A :	59.9	100%
	EF: 62-150	EF :	2.8	100%
	BB : 65-150	BB :	2.6	100%
	SM : 58-150	SM :	3.6	100%

Notes:

All 2004 data are reported for each tributary. Samples were obtained at several sites on certain streams. Tributary abbreviations:

NM=Ninemile Creek @ Lakeland Rt48, OC=Onondaga Creek @ Kirkpatrick St and Dorwin Ave; LC=Ley Creek @ Park St.; HB=Harbor Brook @ Velasko Rd and Hiawatha Blvd; 5A=Trib 5A; EF=East Flume; BB = Bloody Brk @ Onondaga Lake Parkway; SM = Sawmill Crk @ Onondaga Lake Rec. Trail

* Mercury limit of detection 0.02 µg/l. Most observations during 2004 are less than the limit of detection. Compliance cannot be evaluated.

(1) Standard values are derived from NYSDEC Ambient Water Quality Standards and Guidance Values, 1993, for Class B and C surface waters and 6NYCRR Part 703, with Jan. 1994 updates for bacteria and zinc; and 1998 updates for metals.

Table 3-1. Regulatory compliance in Onondaga Lake tributaries, 2004 (notes continued).

(2) The bacteria data presented compare individual measurements to the standard of 200 cells/100mL. Compliance is assessed as the geometric mean of a minimum of 5 samples a month. Therefore, the table represents the worst case. Compliance would always be greater than or equal to percentages noted.

(3) Standard value applies to dissolved fraction, though currently only acid soluble, total recoverable fraction is measured within the monitoring program. Standard values for all other metals apply to acid soluble, total recoverable fraction.

(4) Averages derived from observations made during quarterly sampling. All other averages derived from observations made during the bi-weekly sampling program supplemented with high flow and storm samples. Calculations use the laboratory limit of detection when observations are below that limit .

Compliance calculations are made using a maximum hardness value of 350 ppm, which is the maximum value allowed by NYSDEC for these calculations.

2004 Average Hardness for tributaries (from lab) is as follows (units ppm).

NM-692	OC-364	LC-371	HB-735
5A-426	EF-414	BB-382	SM-358

3.1.2 Metro Effluent

Metro compliance with its SPDES permit limits is summarized in Table 3-2. During 2004 there were a total of 65 permit violations; of these, 28 were related to suspended solids and 28 to the seven-day rolling average concentration and load of $CBOD_5$.

Table 3-2. Metro SPDES limit exceedances 2004*.

SPDES Permit Parameter	Number of Exceedances
Flow	0
$CBOD_5$ (30 Day Avg Concentration)	0
$CBOD_5$ (30 Day Avg) Loading	0
$CBOD_5$ (7 Day Avg) Concentration	14
$CBOD_5$ (7 Day Avg) Loading	14
$CBOD_5$ Percent Removal)	0
Suspended Solids (30 Day Avg) Concentration	0
Suspended Solids (30 Day Avg) Loading	0
Suspended Solids (7 Day Avg) Concentration	14
Suspended Solids (7 Day Avg) Loading	14
Suspended Solids Percent Removal	0
Fecal Coliform (30 Day Avg)	0
Fecal Coliform (7 Day Avg)	7
pH	0
Settleable Solids	2

Table 3-2. Metro SPDES limit exceedances 2004* (continued).

SPDES Permit Parameter	Number of Exceedances
Total Phosphorus	0
Cyanide	0
Total residual chlorine	0
Bypass settleable solids	0
Cadmium	0
Lead	0
Zinc	0
CBOD (5 Day)	0
Total	**65**

Notes:
* Exceedances based on effluent limits.

3.1.3 Onondaga Lake

Compliance of Onondaga Lake's upper and lower waters with applicable ambient water quality standards is summarized in Table 3-3. Onondaga Lake is classified as B and C waters (for a map of the Class B and C segments refer to Appendix 9 DAIP Figure A9-1) The Class B segment encompasses the northern basin; the Class C segments include much of the southern basin and a small area around the mouth of Ninemile Creek. Both B and C waters must exhibit water quality conditions suitable for fish survival and propagation. Class B waters are to be suitable for primary water contact recreation (e.g. swimming) and secondary water contact recreation (e.g. boating) Class C waters shall be suitable for primary and secondary water contact recreation, although other factors may limit their use for these purposes.

Table 3-3. Regulatory compliance in Onondaga Lake waters, 2004.

Parameter (units)	NYSDEC Standard (Class B,C)[1]	2004 Average		2004 Measurements in Compliance
pH (standard units)	Shall not be less than 6.5 nor more than 8.5	UML: LWL:	7.9 7.4	100% 98%
Dissolved Oxygen (mg/l)	Minimum daily average 5.0 mg/l, at no time shall DO be less than 4.0 mg/l	UML: LWL:	10.4 5.1	98%>4; 98%>5 50%>4; 48%>5

Table 3-3. Regulatory compliance in Onondaga Lake waters, 2004 (continued).

Parameter (units)	NYSDEC Standard (Class B,C)[1]		2004 Average	2004 Measurements in Compliance
Dissolved Solids (mg/l)	Shall be kept as low as practicable to maintain the best usage of waters but in no case shall it exceed 500 mg/l.	UML:	1102	0%
		LWL:	1163	0%
Fecal Coliform [2] (cells/100 ml)	Percent individual observations < 200 cells.	0 m:	78.2	93%
		Nearshore (eight stations):	116.0	89%
Ammonia-N (mg/l)	Varies with pH and temperature.	0 m	0.30	100%
		3 m	0.31	100%
		6 m	0.35	100%
		9 m	0.42	100%
		12 m	0.60	100%
		15 m	0.96	80%
		18 m	1.15	75%
Arsenic [3,4] (mg/l)	190 mg/l	UML:	<1.0	100%
		LWL:	<1.0	100%
Nitrite-N (mg/l)	100 mg/l (Warm water fishery)	UML:	77	77%
		LWL:	128	40%
Copper [4,5] (mg/l)	0.96 exp (0.8545 [ln (ppm hardness)] - 1.702) Standard: 26.1 mg/l	UML:	1.61	100%
		LWL:	1.20	100%
Lead [4,5] (mg/l)	{1.46203 -[(ln hardness) 0.145712)]} exp (1.273 [ln hardness)] - 4.297 Standard: 14.34 mg/l	UML:	3.1	100%
		LWL:	2.5	100%
Cadmium [4,5] (mg/l)	0.85 exp (0.7852 [ln (ppm hardness)] - 2.715) Standard: 5.60 mg/l	UML:	1.66	88%
		LWL:	1.73	75%
Zinc [4,5] (mg/l)	exp (0.85 [ln (ppm hardness)] + 0.50) Standard: 240 mg/l	UML:	5.2	100%
		LWL:	6.1	100%
Chromium [4,5] (mg/l)	0.86 exp (0.819 [ln (ppm hardness)] + 0.6848) Standard: 497 mg/l	UML:	0.51	100%
		LWL:	0.60	100%

Table 3-3. Regulatory compliance in Onondaga Lake waters, 2004 (continued).

Parameter (units)	NYSDEC Standard (Class B,C)[1]	2004 Average		2004 Measurements in Compliance
Iron (mg/l)	300 mg/l (current) ; 1000 mg/l (proposed)	UML:	79	100% ; 100%
		LWL:	58	100% ; 100%
Nickel [4,5] (mg/l)	0.997 exp (0.846 [ln (ppm hardness)] + 0.0584) Standard: 248 mg/l	UML:	3.0	100%
		LWL:	3.7	100%
Total Phosphorus (mg/l)	None in amounts that will result in growths of algae, weeds, and slimes that will impair the waters for their best usages. Guidance value of 20 ug/l *UML summer (June - Sept.) average.*	UML:	59.9	0%
Secchi Disk Transparency (m)	NYSDOH guidance for bathing beaches 1.2 m June - Aug. (South Deep)	UML:	1.7	92%

Notes:
UML = upper mixed layer; LWL = lower water layer (field determined).

(1) Standard values are derived NYSDEC Ambient Water Quality Standards and Guidance Values, 1993, and 6NYCRR Part 703, with January 1994 updates for bacteria and zinc, and 1998 updates for metals.

(2) Bacteria compliance reported by comparing individual measurements to the standard of 200 cells/100 ml. Since the standard is a geometric mean of at least 5 samples, compliance will always be equal or greater than the percent listed.

(3) Standard value applies to dissolved fraction, though currently only acid soluble total recoverable fraction is measured within the monitoring program. Standard values for all other metals apply to acid soluble total recoverable fraction.

(4) Averages derived from observations made during quarterly sampling. All other averages derived from observations made during the bi-weekly sampling program from March 30 to December 7, 2004. Calculations use the laboratory limit of detection when observations are below that limit.

(5) Compliance calculations were made using a hardness value of 350 ppm, which is the maximum value allowed by NYSDEC for these calculations. Average hardness for Onondaga Lake South Basin waters was 420 ppm in 2004.

Similar to previous years, Onondaga Lake waters were not in full compliance with ambient water quality standards for dissolved oxygen, nitrite-N, and total dissolved solids. Fecal coliform bacteria occasionally exceeded the NYSDEC standard of 200-cells/100 ml at South Deep and at the southern nearshore stations. However, the standard is for a geometric mean value of a minimum of five samples collected over a 30-day period; comparing each measurement to the geometric mean standard results in a conservative assessment of compliance. The NYSDEC narrative guidance value for phosphorus (20 µg/l at 1 m depth, mid-lake sample, biweekly average from June 1 – Sept. 30) was not met, nor was the NYSDEC narrative standard for phosphorus. In addition, the Department of Health's swimming safety guidance value requiring a minimum of 1.2-meter (4 ft) visibility in swimming areas was not consistently met during the recreational period.

3.1.4 Seneca River

Violations of ambient water quality standards for nitrite were detected at two locations on September 29th during the 2004 program. Nitrite concentrations equaled the regulatory limit (0.1 mg/L) at sampling locations LO1 and Buoy 182. There were no violations of dissolved oxygen ambient water quality standards (4.0 mg/L for instantaneous standard; 5.0 mg/L for daily average standard) detected during the 2004 program.

3.2 Trends

3.2.1 Trends in Loading

Trends in external loads over the ten-year period from 1995-2004 are presented in Appendix 7, the mass-balance framework. As summarized in Table 3-4, the total inflow of nitrogen species has changed over the ten-year period, and the detailed analysis demonstrates the effect of the modifications at Metro in altering nitrogen loading. The total inflow of ammonia N to the lake has decreased by 16% per year; TKN load has decreased by 12% per year. Nitrate N loading has increased by 10% per year. Interestingly, the total N load to the lake has decreased by 3% each year over the last decade. This is due to a decrease in the municipal portion of the total loading.

There has been no trend in the phosphorus loading to Onondaga Lake over this time period. Nonpoint sources of alkalinity, total inorganic carbon, sodium, and chloride have increased. The municipal loading of sodium and chloride is also trending upward, while the loading of organic carbon from the wastewater treatment plant is decreasing.

Table 3-4. Annual trends in tributary loads, 1995 – 2004 (percent annual change in load).

Source	ALK	BOD_5	Ca	Cl	Na	NH_3.N	NO_2-N	NO_3-N	TKN	TN	SiO_2	TIC	TOC	TOC_F	SRP	TP	TSS
Metro		-5.4		3.3	2.6	-19.3		22.1	-15.6		-1.3		-5.3	-6.6		-5.4	
Bypass		-5.0				-8	10	23.3	-8				-15.9	-15.4		-7.0	
East Flume		-1.8	-3.7			-18.3	-9.3		-11.9		-5.3		-5.0	-4.8	-7.6	-5.9	15.5
Trib 5A	2.8		2.8	4.6		2.8	-11.8	-11.2	2.4		5.1	3.3			24.5	12.5	
Harbor Br, @ Velasko			-2.8		1.3	-8.3	0.0	3.3			-2.0					-5.6	
Harbor Br. @ Hiawatha			-1.6		2.3	-8.1		3.1								3.5	
Onondaga Cr. @ Dorwin			-1.2			-9.2			4.4						-13.0		
Onondaga Cr. @ Kirkpatrick															-16.7	-5.7	
Ley Cr						-4.3	-9.4		-3.1						-7.3	-3.4	
Ninemile Cr			-5.5	-6.9	-5.5	-4.3	-4.1	2.5	-2.1					4.1			
Total Gauged				4	5	-17	-4	11	-12	-4		4					
Nonpoint Gauged	5			4	6							5					
Ungauged	5			4	6							5					
Total nonpoint	5			4	6							5					
Total industrial								-5								7	
Total municipal				4	3	-18		16	-15	-6			-6	-7			
Total inflow				4	5	-16	-4	10	-12	-3		4					
Total outflow						-12	-5	6	-8								
Retention	5		-14	-21	-25		28	-18	-5		5		-20	-11			
Outlet @ 2 m						-10.6	-5.6		-6.9							-3.4	9.4
Outlet @ 12m			-1.9	-1.8		-14.6	-7.9		-11.5							-5.2	

Note: Cells without a number do not exhibit a statistically significant trend in load

3.2.2 Trends in Concentration

As part of the AMP, water quality data collected each year are analyzed for trends over a ten-year period. With a longer period, results would be strongly influenced by historical data that are not representative of current conditions with respect to municipal and industrial wastewater inputs. With a shorter period, results would be increasingly influenced by short-term variations in hydrology and other random factors. Trends are analyzed using the seasonal Kendall test accounting for serial correlation.

Trends in concentration of inflows to the lake vary by tributary (Table 3-5). The results of the 2004 trend analysis in the natural tributaries are similar to those reported in 2003, indicating relatively stable conditions for nonpoint sources over the past several years.

Table 3-5. Ten Year Trends in concentration (1995-2004) – Summary.

Symbol	Description
I	increasing trend (p2 < 0.1)
D	decreasing trend (p2 > 0.1)
blank	no trend indicated (p2 >= 0.1)
p2	significance level, two-tailed, seasonal Kendall test accounting for serial correlation.

VARIABLE	SOUTH_U	SOUTH_L	NORTH_U	NORTH_L	OUTLET12	OUTLET2	METRO	BYPASS	DORWIN	SPENCER	KIRKPAT	VELASKO	HIAWATHA	PARK	RT48	TRIB5A	EFLUME
ALK																I	
BOD5							D	D									D
CA	D	D	D	D	D				D			D	D		D	I	D
CHLA																	
CL	D		D	D	D		I								D	I	
COND	D	D	D	D	D		I					D			D	I	
DO_F	I				I	I			I		I	I	I	I	I	D	I
FCOLI			D			D								D			D
FE	D	D	D		D	D					D	D		D	D		
MG						I	I					D			D	I	
MN				I	D	D									D	I	D
NA			D				I					I	I		D		
NH3N	D	D	D	D	D	D	D	D	D			D	D	D	D	I	D
NO2N	D		D		D	D		I						D	D	D	D
NO3N		I					I	I				I	I		I	D	
ORGN	D	D	D	D	D	D	D	D	I		I		I				D
PH_F	I								D		I	I			I	D	I
SECCHI																	
SIO2							D					D				I	D
SO4								D				D	D			D	
SRP		D							D		D			D		I	D
TEMP									D								
TIC																I	

Table 3-5. Ten Year Trends in concentration (1995-2004) – Summary (continued).

VARIABLE	SOUTH_U	SOUTH_L	NORTH_U	NORTH_L	OUTLET12	OUTLET2	METRO	BYPASS	DORWIN	SPENCER	KIRKPAT	VELASKO	HIAWATHA	PARK	RT48	TRIB5A	EFLUME
TKN	D	D	D	D	D	D	D	D	I					D	D	I	D
TOC							D	D									D
TOC_F							D	D							I		D
TP		D		D	D	D		D			D	D	I	D		I	D
TSS						I											I

NOTE: Tributary data are flow-weighted average concentration; lake data are UML and LWL average concentration.

There is evidence of a decreasing trend in ammonia and SRP at the Dorwin Avenue station on Onondaga Creek. However, the organic N concentration is increasing. Ninemile Creek at Rt. 48 continued to show a decreasing trend in dissolved salts (Ca, Mg, Na, Cl, and specific conductance), iron and manganese, ammonia, nitrite, and TKN. This tributary also showed an increasing trend in pH, nitrate, and dissolved oxygen. Tributary 5A, which includes treated effluent from Crucible Specialty Metals, showed increasing trends in several water quality parameters including total alkalinity, Ca, Cl, and specific conductance. Concentrations of ammonia, TKN, nitrite, and organic N in the East Flume decreased, but suspended solids increased. Decreases in the concentrations of ammonia, TKN, and organic carbon (including BOD) from Metro outfall 001 and Metro bypass (outfall 002) continued to be significant.

The trend analysis also examines water quality conditions in the lake's upper and lower waters at North Deep and South Deep stations. From 1995 to 2004 both the upper and lower waters of North Deep and South Deep exhibited decreasing trends in concentration of Ca, specific conductance, ammonia N, organic N and TKN. The upper waters of both stations showed a decreasing trend in concentration of nitrite, chloride, and iron. At South Deep, the upper waters showed an increasing trend in DO and pH; however, the trend was not statistically significant at the North Deep station. Recall that North Deep has only four observations each year compared with more than 20 at South Deep; the sample size influences the power to detect change. The trend to decreasing concentrations of TP and SRP in the lower waters was significant at the south station.

3.2.3 Effectiveness of Improvements at Metro on Lake Ammonia Levels

As discussed in Section 2.1.2.1, completion of the Biological Aerated Filters (BAF) at Metro in early 2004 enabled the facility to greatly reduce the concentration of ammonia N in the effluent from Outfall 001. This reduced the concentration of ammonia in the lake waters. Similar to the 2003 results, the lake's upper waters were in compliance with the state ambient water quality standard for ammonia (Figure 3-1).

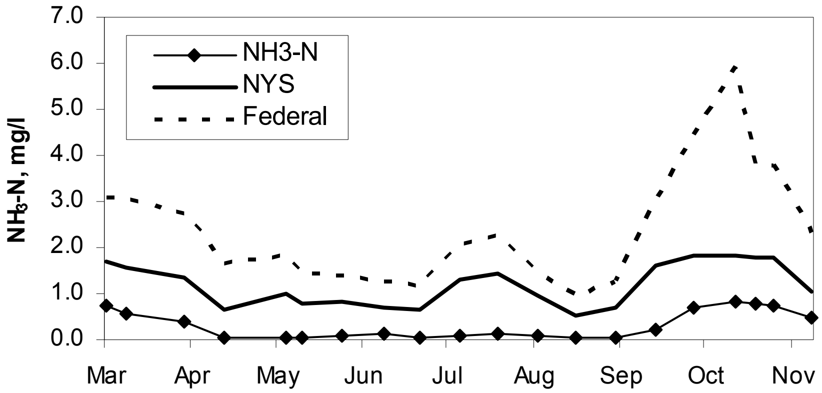


Figure 3-1. Ammonia concentrations at 3 meter depth, Onondaga Lake South Deep Station, 2004, compared with NYS standards and federal criteria.

Reducing the lake's ammonia levels has been a major objective of the Metro improvements. The temporal scale of ammonia excursions is also significant; historically, ammonia concentrations were high in the spring as winter effluent quality affected the lake's upper waters and temperatures and pH began to rise. Ammonia concentrations were high at the same time when the most sensitive life stages of aquatic life were present in the lake. Historical data for the ammonia-N concentration at 3 m from April 1st – June 15th is plotted in Figure 3-2. An interesting feature of this analysis is the role of precipitation. In winters with exceptionally high precipitation, spring ammonia concentrations tended to be lower as the inflow from the natural tributaries diluted the Metro effluent.

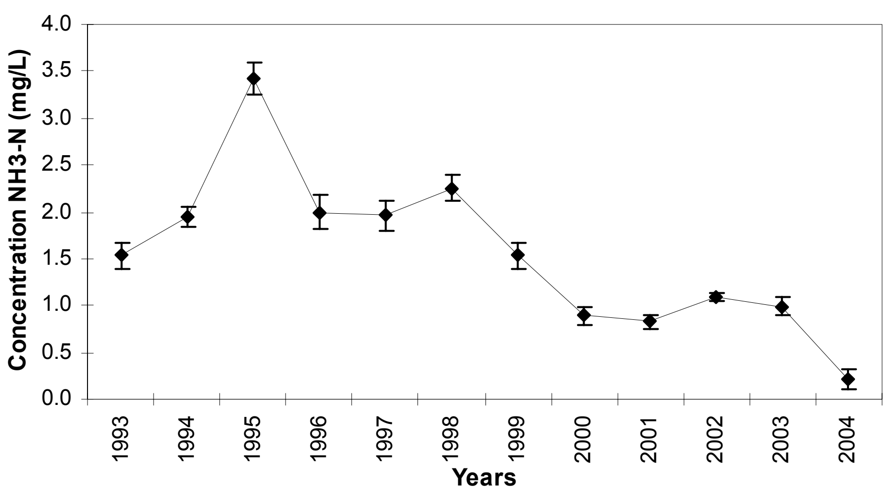


Figure 3-2. Annual trend in mean spring ammonia-N at 3 meters depth from 1993 to 2004. *Note:* Spring average from April 1 to June 15, error bars are standard error.

3.3 Summary Tables and Metrics

The primary objective of the County's monitoring effort is to provide the data and information needed to assess the effectiveness of the improvements to the wastewater collection and treatment system that are underway. Each year, water quality and habitat conditions are reviewed in context of compliance with ambient water quality standards and progress towards use attainment. A series of metrics or indicators are used to summarize current conditions related to specific uses (Table 3-6). These metrics share several specific properties: they relate directly to an impairment of the lake and watershed; they relate to a resource of interest; they correspond to a regulatory limit that, in turn, reflects the requirements of public health or the aquatic biota; and they can be measured and interpreted with relative ease. Indicators that help answer basic questions of the community: is the lake getting better, is it safe for my family to swim here, can we eat the fish, provides perspective on the benefits realized by the huge investment of time and dollars.

Quantitative metrics are proposed for four categories of use attainment:

(1) water contact recreation;
(2) aesthetics;
(3) aquatic life protection; and
(4) sustainable recreational fishery

Note that these categories describe human use of the resource as well as attributes of the ecosystem itself. These categories were defined to be consistent with public perception and regulatory determinations of use attainment.

Table 3-6. Summary of metrics: Onondaga Lake Report Card.

Desired Use	Metrics	Measured By
Water contact recreation	Indicator Bacteria	Fecal coliform bacteria at nearshore and South Deep station
	Water Clarity	Secchi disk transparency at nearshore stations
Aesthetics	Water Clarity	Secchi disk transparency at South Deep
	Bloom frequency and magnitude	Percent of chlorophyll-*a* measurements greater than 15 µg/l (moderate bloom)
		Percent of chlorophyll-*a* measurements greater than 30 µg/l (intense/nuisance bloom)
	Algal community structure	Percent non-blue green taxa.

Table 3-6. Summary of metrics: Onondaga Lake Report Card. (continued).

Desired Use	Metrics	Measured By
Aquatic Life Protection	Ammonia N	Percent of measurements in compliance with standards.
	Nitrite N	Percent of measurements in compliance with standards.
	Dissolved Oxygen	DO at fall mixing.
Fish Reproduction	Indicator species with documented successful reproduction	Compare with list developed by Onondaga Lake Technical Advisory Committee and other experts based on habitat and nature of open system.
	Species found in the lake	Percent intolerant or moderately intolerant
	Habitat quality	Percent cover of macrophytes: scaled to optimal level for largemouth bass (40 - 60% cover is target).

Metrics for water contact recreation are straightforward: New York State Dept. of Health and EPA have standards and guidance values for indicator bacteria and water clarity that are designed to be protective of human health and safety. Selecting metrics for aesthetics is slightly more judgmental, as they relate to perceived attributes such as water color and clarity, odors, and the visible extent of weed and algal growth.

Scientific information regarding how water quality conditions affect aquatic life is embodied in federal criteria and state standards. The metrics consider water quality conditions both throughout the year, and during critical periods for reproduction and early life stages. Also included are indices related to habitat quality for reproductive success of a warmwater fish community. Other indices related to the recreational fishery include the number of nests, and the presence and abundance of various life stages of warmwater fish. Calculations of these metrics using the 2004 AMP data are presented in Table 3-7 (for a map of the Class B and C segments refer to Appendix 9 DAIP Figure A9-1).

Table 3-7. 2004 Results Onondaga Lake water quality and habitat metrics.

Issue: Water Contact Recreation (*Note*: For a map of the Class B and C segments refer to Appendix 9 DAIP Figure A9-1.)		
Metric (using summer data: June, July, August)	**Target**	**2004**
Percent of water clarity measurements > 4 ft (1.2 m); Segment B nearshore stations	100%	93%
Percent of water clarity measurements > 4 ft (1.2 m); Segment C nearshore stations	100%	75%
Percent of *E. coli* bacteria samples in compliance; Segment B nearshore stations	100%	95%
Percent of *E. coli* bacteria samples in compliance; Segment C nearshore stations	100%	80%
Percent of F. coli bacteria samples in compliance; Segment B nearshore stations	100%	100%
Percent of F. coli bacteria samples in compliance; Segment C nearshore stations	100%	88%
Metric (using all data)		
Percent of *E. coli* bacteria samples in compliance; Segment B nearshore stations	100%	97%
Percent of *E. coli* bacteria samples in compliance; Segment C nearshore stations	100%	86%
Percent of F. coli bacteria samples in compliance; Segment B nearshore stations	100%	98%
Percent of F. coli bacteria samples in compliance; Segment C nearshore stations	100%	86%
Issue: Aesthetics		
Metric	**Target**	**2004**
Water clarity > 5 ft (1.5 m) at mid-lake station (South Deep)	100 %	80%
Algal abundance low in summer (chlorophyll-*a* < 15 µg/l in 85% of measurements)	>85%	36%
Lake is free of nuisance algal blooms 90% of time (nuisance algal bloom = chlorophyll-*a* > 30 µg/l)	>90 %	86%
Blue-green algal abundance is low (< 10% of community biomass)	<10%	13%
Issue: Aquatic Life Protection		
Metric	**Target**	**2004**
Dissolved oxygen > 5 mg/l during turnover; (daily average) >4 mg/l (minimum)	>5 mg/L; >4mg/L	5.21mg/L, 4.76mg/L
NH_3-N meets standards in 100% of measurements throughout the year	100%	100%
Nitrite meets standards in 100% of measurements throughout the year	100%	75%
Issue: Fish Reproduction		
Metric	**Target**	**2004**
Reproduction of target species in the lake:		
• largemouth bass, smallmouth bass, and sunfish	• Occurring	• Occurring
• yellow perch	• Occurring	• No evidence
• black crappie and rock bass	• Occurring	• No evidence
• walleye and northern pike	• Occurring	• No evidence
Percent intolerant or moderately intolerant species in Lake	>25%	4%
Percent macrophyte cover of littoral zone, based on optimal habitat for largemouth bass {note: most recent survey data are from 2000}	40%	10%

In addition to these summary tables, detailed tables are prepared each year to specific hypotheses to be tested using AMP data with recent results, trends, and tools used for analysis. Detailed tables (Tables 3-8 through 3-19) summarize water quality conditions and the lake's biological response, including trophic status indicators, compliance with standards, and structure of the biological communities.

3.4 Summary of Other Projects in the Onondaga Lake Watershed

Onondaga County is one of the many agencies working towards rehabilitation of the lake and its watershed. The Onondaga Lake Partnership (OLP), which includes representatives of Onondaga County, New York State DEC and Attorney General, EPA, the Army Corps of Engineers and the City of Syracuse, was established in 2000. According to the OLP website, their mission is to "promote cooperation among government agencies and other parties involved in managing the environmental issues of Onondaga Lake and the Onondaga Lake watershed. The Partnership coordinates development and implementation of improvement projects in accordance with the Onondaga Lake Management Plan and the Amended Consent Judgment (ACJ) to restore, conserve and manage the lake." http://www.onlakepartners.org/olp/index.cfm.

The OLP has prepared a summary of improvement projects aimed to restore, conserve, and manage Onondaga Lake and its watershed. These projects are summarized in Table 3-20. One project not yet included in the OLP compilation is the Onondaga Lake Water Quality Model (OLWQM) to be developed by QEA, LLC. Phase I of the OLWQM project, which includes development of a conceptual model, completion of a detailed workplan and a workshop for technical stakeholders, and a peer review is underway as of the date of this report. Phase 1 will be completed by the end of 2005 or early 2006, depending on the peer review schedule.

Table 3-8. Progress towards water quality improvement: Ammonia-N. AMP 2004 Annual Report. ***(Water Quality Standard).***

AMP PROGRAM OBJECTIVE

Compliance with the applicable ambient water quality standard in the upper waters and/or removal of ammonia toxicity as impairment to designated best use for survival and propagation of a warmwater fish community.

Current Conditions	
Major Sources	Metro effluent. 1988-2004 mean contribution: 88.7% (S.D. 6.2) 2004 contribution: 69.1%
Upper Waters Concentration	Annual mean 1988-2004: 1.5 mg/l (S.D. 0.73) 2004: 0.32 mg/l Decreasing trend through 2004
Compliance with NYS AWQS in Upper Waters (April 1 – December 1)	Annual mean 1992 – 2004: 98 days of non-compliance (S.D. 78) 2004: 0 days of non-compliance during sampling period *(no winter sampling in 2004)*
Factors Affecting Compliance	Hydrology, Metro performance, pH, and water temperature
Planned Load Reductions (1998 – 2012)	
Metro SPDES Permit Requirement ***NOTE: The County met Stage III effluent limits in March 2004, 8 years ahead of schedule.***	Stage I Limit: Cap on Loading (effective Jan. 1998) • July 1 – Sept. 30: 8700 ppd (as NH_3) • Oct. 1 – June 30: 13,100 ppd (as NH_3) Stage II (effective May 1, 2004): • June 1 – Oct. 31: 2.0 mg/l (as NH_3) • Nov. 1 – May 31: 4.0 mg/l (as NH_3) Stage III: (effective Dec. 2012) • June 1 – Oct. 31: 1.2 mg/l (as NH_3) • Nov. 1 – May 31: 2.4 mg/l (as NH_3) Or as required by a revised TMDL (anticipated in 2009)
Monitoring and Assessment Program	
Hypotheses to be tested	Improvements at Metro enables the County to meet Stage III effluent limits (or as modified by TMDL) for ammonia N Reduced ammonia load results in compliance with ambient water quality standards and federal criteria for ammonia in Onondaga Lake
Lake Monitoring	Annual County monitoring program • Biweekly profiles in Lake, April –Nov • Winter sampling as weather allows
Related Biological Monitoring	• Assessment of fish community began in 2000 • Annual zooplankton monitoring
Tools for Decision Making	
Models	New lake water quality model (under development 2005)
TMDL Allocations	NYSDEC Phase I TMDL 8/27/97 Phase II TMDL by January 2009
NYS AWQS and Federal Criteria	NYSDEC aims to complete its review and revision of NYS ammonia standards in 2005.

Table 3-9. Progress towards water quality improvement: Nitrite-Nitrogen. AMP 2004 Annual Report. ***(Water Quality Standard).***

AMP PROGRAM OBJECTIVE

Compliance with the applicable ambient water quality standard in the upper waters and/or removal of toxicity as an impairment to designated best use for survival and propagation of a warmwater fish community.

Current Conditions	
Major Sources (NO2-N)	
Upper Waters Concentration	Annual mean 1992-2004: 0.127 mg/l (S.D. 0.049) 2004: 0.078 mg/l Decreasing trend through 2004
Compliance with NYS AWQS in Upper Waters	Percent of observations in violation of standard 1992 – 2004: 48.8% 2003: 25% (peak in fall)
Factors Affecting Compliance	Hydrology, METRO performance, pH and temperature of receiving water
Planned Load Reductions (1998 – 2012)	
METRO SPDES Permit Requirement	No numerical limit for nitrite in SPDES permit Monitor Only (one sample per week)
Monitoring and Assessment Program	
Hypothesis to be tested	Achievement of Stage III effluent limits for ammonia results in compliance with the NYS ambient water quality standard for nitrite (warmwater fish community)
Loading Estimates	Annual County monitoring program • Biweekly tributary monitoring, supplemented with samples collected during high flow conditions • Daily measurements of Metro effluent
Lake Monitoring	Annual County monitoring program • Biweekly profiles in Lake, April –Nov • Additional sampling during fall mixing • Winter sampling as weather allows
Related Biological Monitoring	• Assessment of fish community, beginning in 2000 • Annual zooplankton monitoring
Tools for Decision Making	
Models	New lake water quality model (under development 2005)
TMDL Allocations	None planned
NYS AWQS	Standard is 100 μg/l.

Table 3-10. Progress towards water quality improvement: Total Phosphorus. AMP 2004 Annual Report. ***(Guidance Value).***

AMP PROGRAM OBJECTIVE

Reduction in phosphorus sufficient to reduce the frequency and duration of nuisance algal blooms. Eliminate turbidity as an impairment to use of the lake for secondary water contact recreation (Class C segment) and primary water contact recreation (Class B segment). Compliance with narrative standard and site-specific guidance value appropriate for this urban lake considering all watershed sources of phosphorus.

Current Conditions

Major Sources	Metro effluent: 1988-2004 average contribution: 62.8% (S.D.11); 2004:68.3% (outfalls 001 and 002). Nonpoint sources
UML concentration (summer average)	1986 – 2004: 0.084 mg/l (S.D. 0.046) 2000-2004: 0.048 mg/l (S.D. 0013) 2004: 0.060 mg/l
Compliance with NYS AWQS and Guidance Value	Narrative standard for phosphorus not met Guidance value (0.020 mg/l summer average upper waters) not met
Factors Affecting Compliance	Hydrology, Metro performance, land use in watershed, CSO performance

Planned Load Reductions (1998 – 2012)

Metro SPDES Permit Requirement	Stage I Limit: Cap on Loading (effective Jan. 1998) • 400 pounds TP per day (ppd) 12 month rolling average Stage II (effective April 2006): • Metro effluent TP 0.12 mg/l Stage III: (effective Dec. 2012 or as modified based on TMDL) • Metro effluent TP at 0.020 mg/l • Watershed nonpoint source reduction of approximately 50% (includes CSO)

Monitoring and Assessment Program

Hypothesis to be tested	• Improvements at Metro will enable the County to meet final effluent limits (as set forth in TMDL on or before Jan 1, 2009) • Reduced phosphorus load from Metro reduces concentration of phosphorus in Onondaga Lake • Reduced phosphorus load from Metro brings the lake into compliance with TP guidance value 20 ug/l summer average, (or site-specific guidance value)
Loading Estimates	Annual County monitoring program • Biweekly tributary monitoring, supplemented with samples collected during high flow conditions • Daily measurements of Metro effluent • Storm event monitoring in tributaries
Lake Monitoring	Annual County monitoring program • Biweekly profiles of P fractions (TP, SRP, TDP), plus N species, DO and carbon species, April – Nov • Chlorophyll *a* and Secchi disk transparency, LiCor measurements • Winter sampling as weather allows
Related Biological Monitoring	• Annual phytoplankton and zooplankton monitoring • Macrophyte survey every five years (begin in 2000)

Table 3-10. Progress towards water quality improvement: Total Phosphorus. AMP 2004 Annual Report. ***(Guidance Value)*- ** continued.

Tools for Decision Making	
Models	• USGS watershed model for Onondaga Lake Partnership • New lake water quality model (under development 2005)
TMDL Allocations	NYSDEC Phase I TMDL 8/27/97, Phase II TMDL by January 2009
NYS AWQS and Guidance Value; Federal Criteria	Possible site-specific guidance value for TP

Table 3-11. Progress towards water quality improvement: Dissolved Oxygen. AMP 2004 Annual Report. ***(Water Quality Standard).***

AMP PROGRAM OBJECTIVE

- Reduce volume-days of anoxia and volume-days of dissolved oxygen (DO) less than 2 mg/l.
- Maintain daily average DO > 5 mg/l throughout the water column during fall mixing.
- Maintain DO > 3.0 mg/l above the LWL at least 80% of the time to provide suitable habitat for coolwater fish such as walleye and tiger musky.

Current Conditions

Major Sources	Oxygen depletion in the LWL is primarily due to decomposing algal biomass (excess algae is caused by phosphorus load). Other sources include ultimate oxygen demand from organic material and reduced nitrogen species (primarily ammonia from Metro)
UML concentration during fall mixing	Average minimum concentration (1988 – 2004 data) 3.9 mg/l (S.D. 1.3) 2004 minimum: 4.1 mg/l
Volume-days of anoxia	**Anoxia**: Average 1992 – 2004: 4950 10^6 m^3-days (S.D.1460) **Less than 2 mg/l**: Average 1992 – 2004: 6039 10^6 m^3-days (S.D.1356) **2004 conditions**: 2748 10^6 m^3-days anoxia; 5239 10^6 m^3-days $\leq$ 2 mg/l
Factors Affecting Compliance	• Meteorology, algal abundance (related to phosphorus load) • NH3-N concentration and dynamics

Planned Load Reductions (1998 – 2012)

METRO SPDES Permit Requirement	See staged effluent limits for TP BOD limit through 2001: 21 mg/l (30 day average)

Monitoring and Assessment Program

Hypothesis to be tested	Improvements at Metro enable the County to meet Stage III effluent limits (or as modified by TMDL) for BOD Improvements at Metro and related load reductions bring the lake into compliance with AWQS for DO during fall mixing. Improvements at Metro reduce the volume-days of anoxia. Improvements at Metro reduce the areal hypolimnetic oxygen depletion rate.
Loading Estimates	Annual County monitoring program • Biweekly tributary monitoring, supplemented with samples collected during high flow conditions to estimate TP, N and BOD inputs • Daily measurements of Metro effluent • Storm event monitoring in tributaries
Lake Monitoring	Annual County monitoring program • Biweekly DO profiles in Lake, April – Nov • Intensive sampling during fall, including tributary mouths • Monitoring buoy installed at South Deep for near-continuous measurements and transmittal of water quality data including DO • Winter sampling as weather allows
Related Biological Monitoring	• Annual phytoplankton monitoring • Annual zooplankton monitoring • Limited tracking of fish movement during fall mixing • Fish tagging program
LWL Oxygenation Demonstration Project	• Begin summer 2003 with detailed workplan preparation • RFP for pilot tests (Summer 2005)

Table 3-11. Progress towards water quality improvement: Dissolved Oxygen. AMP 2004 Annual Report. ***(Water Quality Standard)*** - continued.

Tools for Decision Making	
Models	New lake water quality model (under development 2005)
TMDL Allocations	NYSDEC Phase I TMDL for phosphorus 8/27/97 Phase II TMDL for phosphorus by January 2009

Table 3-12. _Progress towards water quality improvement: Bacteria. AMP 2004 Annual Report. ***(Water Quality Standard).***

AMP PROGRAM OBJECTIVE

Compliance with the standards for water contact recreation in the Class B segment and for secondary water contact recreation in Class C segment of Onondaga Lake.

Current Conditions	
Major Sources	Combined sewer overflows (major) sanitary sewer overflows (rare) Urban runoff (stormwater) Metro effluent (chlorination period April 1– Oct 15) and by-pass Other sources (wildlife, birds, etc.)
Upper Waters Concentration	Fecal coliform: 1988 – 2004 annual average: 91 cells/100 ml (S.D. 52) (Measured in surface waters, South Deep) 2004 average: 101 cells/100 ml No trend
Near Shore Stations (2004 F. coli average)	Maple Bay 37 cells/100 ml (S.D.78); summer compliance: 100% Willow Bay 56 cells/100 ml (S.D.137); summer compliance: 100% Nine Mile Cr. 50 cells/100 ml (S.D. 97); summer compliance: 93% Eastside 61 cells/100 ml (S.D. 191); summer compliance: 100% Bloody Brook 29 cells/100 ml (S.D.48); summer compliance: 100% Mid-south: 285 cells/100 ml (S.D. 543); summer compliance: 71% Ley Creek: 284 cells/100 ml (S.D. 632); summer compliance: 77% Harbor Brook : 133 cells/100 ml (S.D. 261); summer compliance: 86%
Compliance with NYS AWQS	South Deep Station: 2004 results: 100% compliance during summer; 97% compliance overall
Factors Affecting Compliance	Metro disinfection, extent of CSO and Sanitary Sewer Overflow (SSO) Meteorological conditions (rainfall, temperature, sunlight, winds) Lake water quality (turbidity); Abundance of waterfowl
Planned Load Reductions (1998 – 2012)	
METRO SPDES Permit Requirement Staged CSO Remediation	Seasonal disinfection (4/1 – 10/15) of Metro effluent required CSO phased plan to capture combined sewage and stormwater: • Stage I captures 62% of volume through best management practices • Stage II eliminates and/or captures 85% of volume and provides equivalent of primary treatment.
Monitoring and Assessment Program	
Hypothesis to be tested	CSO remedial measures reduce the loading of fecal coliform bacteria entering the lake through Onondaga Creek, Ley Creek, and Harbor Brook during high flow conditions. Implementation of Stage I and II improvements to the wastewater collection and treatment system (including CSO projects) will reduce concentration of indicator organisms in Onondaga Lake
Loading Estimates	Annual County monitoring program • Biweekly tributary monitoring supplemented with samples collected during high flow conditions. (Fecal coliform) • Daily measurements of Metro (001 and 002 if active) for Fecal coliform • Storm event monitoring in tributaries, (Fecal coliform)
Lake Monitoring	Annual County monitoring program (Fecal coliform, E. coli) • Weekly monitoring at South Deep, Class C segment (May – Sept.) • Eight nearshore stations weekly (summer) and following storms

Table 3-12. Progress towards water quality improvement: Bacteria. AMP 2004 Annual Report. ***(Water Quality Standard)*** – continued.

Tools for Decision Making	
Models	• UFI/Canale bacteria model • Storm Water Management Model (simulates bacteria loads in tributaries from collection system given rainfall conditions)
TMDL Allocations	Based on presumptive approach: percent capture of combined storm and wastewater. Must account for urban stormwater.
NYS AWQS and Federal Criteria	NYS indicator bacteria standards include total and fecal coliform. EPA criteria now use *E. coli* (freshwater) and *Enterococcus* (marine water) as indicators; states encouraged to adopt *E. coli*

Table 3-13. Progress towards water quality improvement: *Chlorophyll-a.* AMP 2004 Annual Report. ***(Narrative Standard, Assessment Measure).***

AMP PROGRAM OBJECTIVE

- Reduction in average and peak algal biomass and frequency and duration of bloom conditions.
- Less than 10% chlorophyll *a* measurements exceed 30 μg/l (threshold for nuisance blooms) and
- Less than 25% chlorophyll *a* measurements exceed 15 μg/l

Current Conditions	
Major Sources	Internal algal production based on nutrients (P is limiting as of late 1990s), light, temperature
Upper Waters Concentration Summer average (mid-May through mid-September) 1992 – 2004 data	1992 – 2004 22% observations >30 μg/l; 51% observations >15 μg/l Mean 18.1 μg/l (S.D. 17.7) Peak 114 μg/l (August 2003) Increasing trend 1993 – 2003 at South Deep; decrease in 2004 2004: 7 % observations >30 μg/l; 57 % observations >15 μg/l 2004 summer mean 16.5 μg/l; summer peak 31 μg/l (6/22/04) Annual peak 45 μg/l (9/20/04)
Compliance with NYS AWQS and Guidance Value	No NY State standard or guidance value for chlorophyll *a.* Narrative P standard references algal abundance at nuisance levels Federal guidance based on ecoregion and reference lakes.
Factors Affecting Compliance	Nutrients, light, temperature, grazing pressure
Planned Load Reductions (1998 – 2012)	
METRO SPDES Permit Requirement	• See planned reduction in TP from METRO • Staged reductions in CSO
Monitoring and Assessment Program	
Hypothesis to be tested	Metro improvements and related nutrient load reductions result in lower chlorophyll concentrations in the lake.
Lake Monitoring	• Weekly measurements at South Deep Station, April–November
Related Biological Monitoring	• Phytoplankton community measurements biweekly April-November • Zooplankton community measurements biweekly April-November
Tools for Decision Making	
Models	• New lake water quality model (under development 2005)
TMDL Allocations	See discussion of TP

Table 3-14. Progress towards water quality improvement: Secchi Disk Transparency. AMP 2004 Annual Report. ***(Guidance Value).***

AMP PROGRAM OBJECTIVE

Summer average Secchi disk transparency at South Deep at least 1.5 m (for aesthetic quality); transparency at nearshore stations at least 1.2 m daily during recreational season (bathing beach swimming safety guidance value).

Current Conditions	
South Deep Station (June 1 – Sept 30 average)	Mean 1.9 m (1990 – 2004, N=239) Standard deviation 1.06 m Increasing trend.
Compliance with NYS AWQS and Guidance Value	**<u>South Deep Station</u>** 81% of observations during this 12-year period met or exceeded swimming safety guidance value of 1.2 m ; 64 % met or exceeded 1.5 m (associated with NYSDEC aesthetic guidance of 20 ug/l TP) 2004 conditions: 1.7 m June – Sept. average (S.D. 0.33 m) 97 % $\geq$ 1.2 m 80 % $\geq$ 1.5 m **<u>Nearshore Stations</u>**: track compliance with 1.2 m (swimming) Bloody Brook: summer compliance: 86% Eastside: summer compliance: 100% Harbor Brook : summer compliance: 71% Ley Creek: summer compliance: 62% Maple Bay: summer compliance: 92% Nine Mile Creek: summer compliance: 86% Mid-south: summer compliance: 71% Willow Bay summer compliance: 86%
Factors Affecting Compliance	• Algal abundance (depends on light, temperature, nutrients and grazing pressure) • External loading of suspended solids • Resuspension of bottom sediments • Precipitation of calcite
Planned Load Reductions (1998 – 2012)	
METRO SPDES Permit Requirement	• Staged reduction in TP load from Metro • Staged implementation of CSO projects
Monitoring and Assessment Program	
Hypothesis to be tested	Metro improvements and related nutrient load reductions result in improved water clarity (as measured by Secchi disk transparency) in Onondaga Lake
Lake Monitoring	• Biweekly measurements of Secchi disk at South Deep (increased to weekly between 6/1 and 9/30) • Nearshore Secchi disk measurements: weekly (summer). and following storm events
Related Biological Monitoring	Phytoplankton and zooplankton abundance and community composition
Tools for Decision Making	
Models	• Dr. William Walker's mass balance TP framework and linked empirical eutrophication model. • New lake water quality model (under development 2005)

Table 3-15. Progress towards water quality improvement: Phytoplankton. AMP 2004 Annual Report. ***(Assessment Measure).***

AMP PROGRAM OBJECTIVE

Abundance and composition of the algal community typical of a eutrophic lake in the same geologic and climatic setting. Decreased importance of cyanobacteria (blue-green algae).

Current Conditions	
Biomass and Community composition	1968 – 1996 data set (Dr. Philip Sze, Georgetown University) Abundance of major groups 1997 – present data set (Dr. Edward Mills, Cornell Biological Field Station and Dr. Anne St. Armand, PhycoTech Inc.), Biomass and biovolume Qualitative discussion of trends in annual lake reports, also in Effler (ed.) 1996
Forcing Functions	Nutrients, light, temperature, grazing pressure
Monitoring and Assessment Program	
Hypothesis to be tested	Metro improvements and related nutrient load reductions result in lower biomass of phytoplankton in Onondaga Lake Metro improvements and related nutrient load reductions result in reduced importance of cyanobacteria to the lake's phytoplankton biomass
Lake Monitoring	Biweekly sampling events: • Phytoplankton abundance (number per liter) • Biomass (μg/l) • Composition of the algal community (7 major groups) • Cell size divisions (nannoplankton and netplankton) Metrics to track over time: • Percent of major taxa • Blue-green algae dynamics and shifts in N:P ratio of lake water • Number of taxa (1995 and later) • Diversity (1995 and later) • Percent dominance (1995 and later)
Tools for Decision Making	
Models	New lake water quality model (under development 2005)

Table 3-16. Progress towards water quality improvement: Zooplankton. AMP 2004 Annual Report. ***(Assessment Measure).***

AMP PROGRAM OBJECTIVE

Abundance and composition of the zooplankton community are comparable to reference eutrophic lake in same geologic and climatic setting.

Current Conditions	
Biomass and Community Composition	Density (numbers per ml for major types) documented since late 1960's Qualitative discussion in annual reports, also in Effler (ed.) 1996 Since 1995, biomass of organisms reported
Forcing Functions	Food supply (algal abundance) grazing pressure (fish community structure), water quality (ammonia, chlorides, extent of aerobic habitat)
Monitoring and Assessment Program	
Hypothesis to be tested	Metro improvements and related nutrient load reductions reduce the biomass of zooplankton in Onondaga Lake Metro improvements and related nutrient load reductions (and DO improvements) increase the abundance of zooplankton deeper in the water column
Lake Monitoring	Biweekly monitoring for density (organisms per ml) and biomass (μg/l), March – November/December *Metrics to track over time* • Average size in spring (June 1 – 15) and fall (Sept. 1 – 15) • Relative biomass of major cladoceran types • Relative biomass of major copepod types • Number of crustacean taxa (1995 on)
Tools for Decision Making	
Models	None developed. Zooplankton grazing rate will be specified in new lake water quality model (under development 2005)

Table 3-17. Progress towards water quality improvement: Macrophytes. AMP 2004 Annual Report. ***(Assessment Measure).***

AMP PROGRAM OBJECTIVE

Expansion of the areal coverage and increase in diversity of macrophyte community. Number of species and biomass of macrophytes in the littoral zone comparable to other regional lakes. Increase percent cover of littoral zone to optimal levels for smallmouth bass (40 – 60%).

Current Conditions	
Biomass	1991 survey (John Madsen, Army Corps of Engineers) reported number of transects with macrophytes present, no biomass or percent littoral zone coverage noted. 2000 survey (Onondaga County), species richness, percent cover, biomass, diversity
Community Composition	Five species present in 1991 survey. In comparison, New York lakes average 18, Oneida has approx 16 species. Cross Lake has 5. No emergent or floating leaf species were present in Onondaga in 1991. In 2000, species richness doubled (to 10 species) but community dominated by only 3 plants. Percent cover about 12% of littoral zone. Distinct habitat zones present.
Forcing Functions	• Sediment texture (oncolites are nutrient-poor and unstable, shifting with wind-driven waves in nearshore area) • Light penetration • Salinity levels
Monitoring and Assessment Program	
Hypothesis to be tested	Metro improvements and related nutrient load reductions result in increased areal coverage of macrophytes in littoral zone of Onondaga Lake Metro improvements and related load reductions result in increased number of macrophyte species in Onondaga Lake
Lake Monitoring	• Survey species composition and biomass every 5 years, beginning in 2000. • Annual aerial photographs of littoral zone to estimate percent cover *Metrics to track over time* • Number of species (richness) • Percent cover • Biomass
Tools for Decision Making	
Qualitative and Quantitative Analysis	• Compare to baseline survey in 2000 • Macrophytes will be included in sensitivity analysis of new lake water quality model (under development 2005)

Table 3-18. Progress towards water quality improvement: Macroinvertebrates. AMP 2004 Annual Report. ***(Assessment Measure).***

AMP PROGRAM OBJECTIVE

The macroinvertebrate community is designated by NYSDEC Macroinvertebrate Biological Assessment Profile as slightly impacted or better at all sites.

Current Conditions	
NYSDEC Biological Assessment Profile	Based on 2000 survey: • One site slightly impacted • Three sites moderately impacted • One site severely impacted
Community Composition	Baseline conditions: more than 70 taxa in the lake's littoral zone. Communities dominated by oligochaetes and chironomids.
Forcing Functions	• Sediment texture • Sediment contamination • Eutrophication • Ammonia
Monitoring and Assessment Program	
Hypothesis to be tested *Note: effects may vary by strata, with southern strata (2, 3, and 4) most likely to show improvement*	• Implementation of load reductions at Metro and CSO remediation will increase species richness of littoral benthic macroinvertebrates • Implementation of load reductions at Metro and CSO remediation will increase the relative abundance of benthic macroinvertebrates that are not chironomids or oligochaetes • Implementation of load reductions at Metro and CSO remediation will improve the NYSDEC Biological Assessment Profile as compared to baseline conditions. • Implementation of load reductions at Metro and CSO remediation will improve the littoral macroinvertebrate HBI as compared to baseline conditions (indicating increased importance of pollution sensitive organisms in the community)
Lake Monitoring	A total of 180 littoral samples to be collected once every five years, beginning in 2000 (baseline monitoring was completed in 1999 to finalize program design). Sampling includes 36 replicates from water depths 1.0 – 1.5 m in each of 5 strata (defined based on substrate composition and wind energy).
Tools for Decision Making	
Metrics	• NYSDEC macroinvertebrate indices based on species diversity and presence/absence of pollution tolerant species. • Hilsenhoff Biotic Index • Percent oligochaetes

Table 3-19. Progress towards water quality improvement: Fish Community. AMP 2004 Annual Report. ***(Assessment Measure).***

AMP PROGRAM OBJECTIVE

Expand habitat for fish community and promote water quality conditions that support diverse warmwater fish community. Self-sustaining sport fishery.

Current Conditions	
Current Conditions	Community composed of pollution tolerant, warmwater species with a high proportion of planktivores. Many adult species show some evidence of reproduction in lake. Nesting mostly limited to north basin. Low incidence of deformities, erosions, lesions, tumors, and fungal infections.
Community Composition	Warmwater fish community dominated by alewives. Insectivorous sunfishes in littoral zone. Sport fish present (channel catfish, smallmouth bass, largemouth bass, walleye). Open connection with Seneca River important to community structure. As of 2004, 38 species captured during AMP efforts.
Forcing Functions	• Ammonia toxicity • Extent of aerobic habitat • Abundance of preferred food sources • Habitat for spawning and juveniles
Monitoring and Assessment Program	
Hypothesis to be tested	• Implementation of load reductions at Metro and CSO remediation will increase the number of fish species present in Onondaga Lake • Implementation of load reductions at Metro and CSO remediation will increase the number of fish species that are sensitive to pollution present in Onondaga Lake • Implementation of load reductions at Metro and CSO remediation will increase the number of fish species reproducing in Onondaga Lake • Implementation of load reductions at Metro and CSO remediation will improve the lake's IBI . • Effects may be seen in strata 2,3, and 4 • Implementation of load reductions at Metro and CSO remediation will increase the habitat available for the coolwater fish community
Lake Monitoring	Annual monitoring, beginning in 2000 to assess reproductive success and community structure • Number and distribution of littoral nests • ID and enumerate larval fishes • ID and enumerate juvenile and YOY stages • ID and estimate (CPUE) of adult community using gillnets, electrofishing, and angler diaries • Assess and record DELT-FM anomalies • Calculate IBI by strata (adult electrofishing data)
Tools for Decision Making	
Quantitative and Qualitative Analysis	Data collection techniques and data analysis comparable to standard procedures used throughout New York.

Table 3-20. List of Onondaga Lake remedial projects currently underway[1].

Project Category	Project Title	Project Description
ACJ Combined Sewer Overflow	Construct Sewer Separation	Thirteen combined sewer basins along Onondaga Creek are scheduled to be separated into independent stormwater and sanitary conveyance systems as part of the CSO Abatement Program. The U.S. Army Corps of Engineers is supervising the design of most of these sewer separation projects. Construction will proceed over the period of the Court Order based on coordination with the County and the City of Syracuse. An exact schedule for this program detailing which areas would be separated first has yet to be determined. The projects will most probably involve the construction of new sanitary sewers and the relining of existing combined sewers to convey stormwater only.
ACJ METRO	Combined Ammonia/Phosphorus Removal & UV Disinfection Project	This project is a combined project to upgrade and modify the existing Metro plant to meet full-scale ammonia removal and Stage II phosphorus effluent concentrations and to improve disinfection of Metro effluent.
	Ambient Monitoring Program	Project provides on-going ambient water quality and ecological monitoring of Onondaga Lake, its tributaries, and the Seneca River. The monitoring program will continue throughout the completion of Amended Consent Judgment projects.
	Lake Oxygenation Demonstration Project	The intent of this project is to prepare a Preliminary Experimental Design Plan Report for an in-lake air/oxygenation delivery system. The scope of this project is to determine the feasibility and viability of in-lake oxygenation, and if feasible, recommend an appropriate design plan(s) and set forth a monitoring plan based upon specified parameters. The Preliminary Experimental Design Plan Report shall include sufficient detailed information for scientific, engineering, and cost factors necessary for preparation and development of appropriate work plans and specifications by others. Onondaga County has issued a request for Proposals for Implementation of a pilot testing program in 2006 – 2009
Industrial Pollutants (Non-NPL)	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 104(e) Investigations	This project involves NYSDEC investigations of suspected contaminated sites to determine whether the CERCLA process should be initiated.
	Allied Wastebeds 1-8 CERCLA Remediation	Investigation of the former Allied wastebeds 1-8 by NYSDEC. The objective is to gather information needed to make a site status determination of whether the site should be classified as an inactive hazardous waste site and/or whether the site should be evaluated further under the Onondaga Lake National Priority List (NPL) Site Program.

[1] *Information in this table was obtained from http://www.onlakepartners.org/olclean/now/actproj/index.cfm.*

Table 3-20. List of Onondaga Lake remedial projects currently underway (continued).

Project Category	Project Title	Project Description
Industrial Pollutants (Non-NPL) continued	American Bag & Metal - CERCLA Remediation	This project involves S&W Redevelopment's investigation and potential remediation of suspected contamination at this site. NYSDEC is monitoring the project, which is currently in the Remedial Investigation/Feasibility Study (RI/FS) phase under NYS voluntary cleanup program.
	Bloody Brook - CERCLA Remediation	This project involves Lockheed Martin's CERCLA investigation of the Bloody Brook site. NYSDEC is monitoring the project and evaluating the investigative documents. The project is currently in the Remedial Investigation/Feasibility Study (RI/FS) phase.
	Roth Steel - CERCLA Remediation	This project involves Roth Steel's CERCLA investigation of their Hiawatha Boulevard site. NYSDEC is in the process of negotiating a consent order with Roth Steel and are monitoring the project.
	Niagara Mohawk Erie Blvd - CERCLA Remediation	This project involves Niagara Mohawk's CERCLA investigation into this former coal gasification facility on the NIMO headquarters property on Erie Boulevard. NYSDEC is monitoring progress on the project, which is in the Remedial Investigation/Feasibility Study (RI/FS) phase.
	Niagara Mohawk Hiawatha Blvd Site - CERCLA Remediation	This project involves Niagara Mohawk's CERCLA investigation into this former coal gasification facility on Hiawatha Boulevard. NYSDEC is monitoring progress on the project, which is in the Remedial Investigation/Feasibility Study (RI/FS) phase.
	Solvents & Petroleum Services - RCRA Remediation	This project involves Solvent & Petroleum Services' investigation of possible site contamination under the NYS Resource Conservation and Recovery Act (RCRA) program. NYSDEC is monitoring progress of the project.
	Allied Wastebeds 9-15 - CERCLA Remediation	This project involves Honeywell's investigation and remediation of contaminated property (Allied Wastebeds 9-15). NYSDEC Division of Solid and Hazardous Materials is monitoring project progress. The project is in the conceptual development phase.
	Willis Avenue Ballfield Site - CERCLA Remediation	This project involves Honeywell's CERCLA investigation into a suspected contaminated waste disposal area. NYSDEC is monitoring progress of the project. The project is currently in the Preliminary Site Assessment phase.
	Harbor Brook/Wastebed B - CERCLA Remediation	This project involves Honeywell's CERCLA investigation into suspected contamination at the former Solvay Process Company Wastebed-B and adjacent areas. NYSDEC is monitoring this project, which is in the Preliminary Site Assessment phase.

Table 3-20. List of Onondaga Lake remedial projects currently underway (continued).

Project Category	Project Title	Project Description
Industrial Pollutants (Non-NPL) *continued*	Crucible Doring Property - CERCLA Remediation	This project involves Crucible Steel's investigation into potential contamination at the property. A preliminary site assessment is proposed and being coordinated with the NYSDEC.
	Crucible Lake Pump Station	This project involves Crucible Steel's investigation into potential contamination at the property. A preliminary site assessment is proposed and being coordinated with the NYSDEC.
Management and Coordination	Develop OLP Website Content - FY01	The intent of this project is to develop the initial content for the Onondaga Lake Partnership website to aid in achieving the goals specified in the Onondaga Lake Partnership Charter. The U.S. Army Corps of Engineers has funded the creation of an OLP website. The website will be created by a contractor selected by a competitive RFP process. Further development of the website will involve providing the necessary hardware and software and technical services to create and maintain the basic website for the OLP. Project MCP-020 involves gathering, consolidating, organizing, and publishing on this website, additional content and website functions related to lake cleanup. The content is expected to include scientific, engineering, regulatory, educational, and items of public interest as determined by the OLP.
	Develop Onondaga Lake Watershed Database/GIS - FY01	The intent of this project is to develop a comprehensive GIS to aid the OLP in achieving the goals specified in the Onondaga Lake Partnership Charter. The project involves determining the data needs of the OLP, identifying and researching existing sources of data and systems, and designing and fielding a GIS package meeting the project intent. Given the complexity of the watershed, the scope of this project will be restricted to a limited set of data priorities to be determined by the OLP. The GIS will be designed in a modular fashion to allow expansion of data and capabilities. It is envisioned the GIS product would be delivered as a stand-alone software package which could be distributed to OLP members for their use. If adequate project funding exists, an internet-based GIS may be possible.

Table 3-20. List of Onondaga Lake remedial projects currently underway (continued).

Project Category	Project Title	Project Description
Management and Coordination *(continued)*	OLP Project Development FY01	The intent of this project is to establish an accurate and thorough comprehensive project database to aid the OLP in achieving the goals specified in the Onondaga Lake Partnership Charter. Establishing a baseline project program which identifies current and future project needs and resources is critical to OLP activities. The project involves researching the existing project data, identifying OLP data needs, and developing standardized project definition packages for existing and future projects. The data package for each project will at a minimum include statements of work, detailed cost estimates, and project schedules. The envisioned product will be a comprehensive project database to serve as the repository for lake improvement project data. This database will be capable of producing reports related to project requirements, resources, scheduling, and technical data.
Non-Point Source Pollution	Develop & Implement Urban Best Management Practices (BMPs) - FY01	The intent of this project is to mitigate urban non-point source pollution (runoff) to tributaries of Onondaga Lake through the development of best management practices within the city of Syracuse and Onondaga County. The project involves identifying sources of urban non-point source pollution and developing and implementing best management practices to minimize the volume of runoff or concentrations of contaminants in runoff to tributaries of Onondaga Lake.
	Develop & Implement Rural Best Management Practices (BMPs) - FY01	Develop and implement rural best management practices (BMPs) at farms throughout the Onondaga Lake Watershed. Implementation of these BMPs will reduce contaminant and pathogen loading to the tributaries feeding Onondaga Lake. This project will implement BMPs at several roadbanks and streambanks within the Onondaga Creek Watershed.

Source: Onondaga Lake partnership web site
www.onlakepartnters.org/olp/indix.cfm

3.5 Data Integration

3.5.1 Changes in the lake phytoplankton and zooplankton communities

The relative importance of cyanobacteria (blue-green algae) is of concern to lake managers because these organisms can proliferate and become nuisance algae, degrading water quality and the aesthetic environment. As displayed in Figure 2-29 (in Chapter 2 of this report), the percent contribution of cyanobacteria to the total phytoplankton community has been greatly reduced since the mid and late 1990s. A further analysis of cyanobacteria biomass since 1998 shows that although the duration of cyanobacteria presence in the lake remains largely unchanged, the intensity of the blooms has been greatly reduced in the lake since 2000 (Figure 3-3).

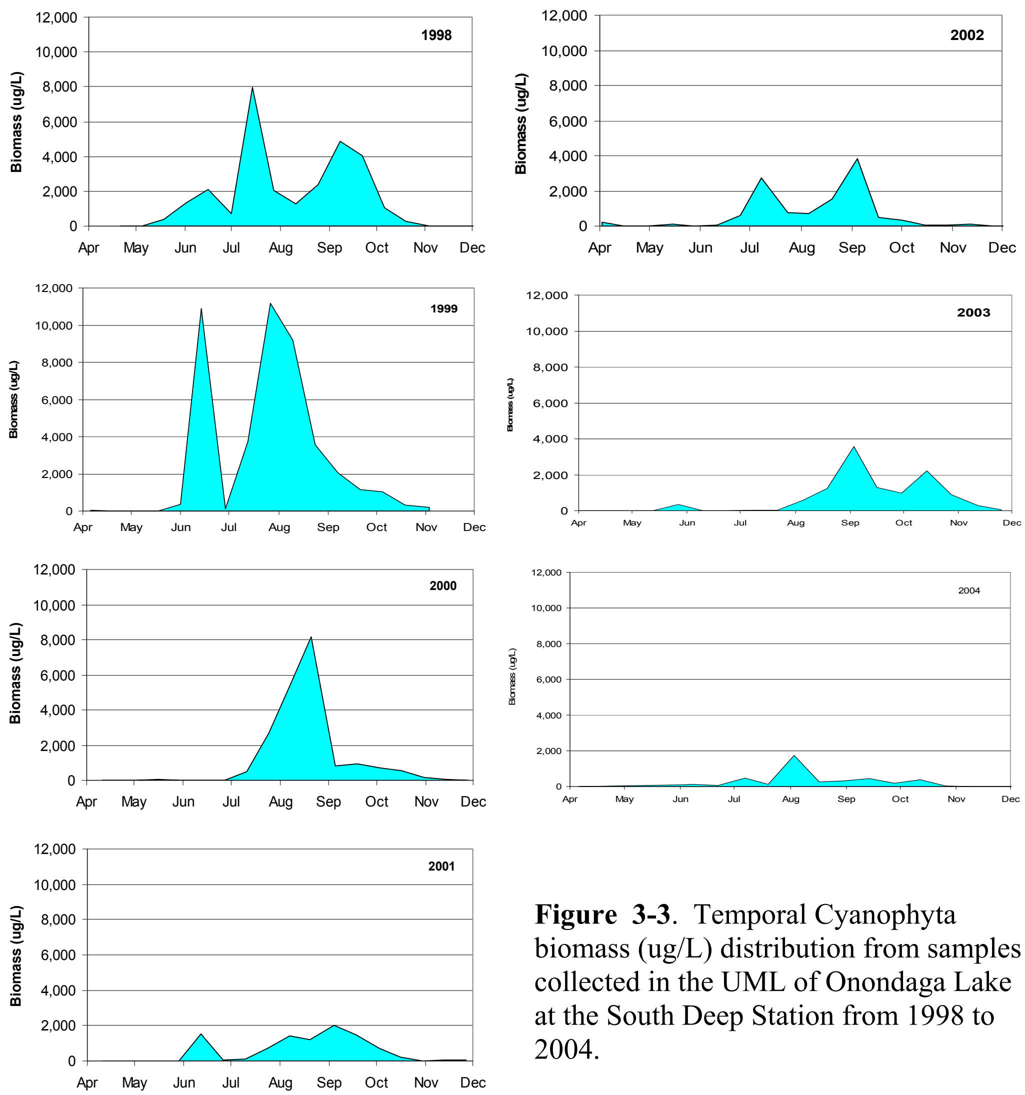


Figure 3-3. Temporal Cyanophyta biomass (ug/L) distribution from samples collected in the UML of Onondaga Lake at the South Deep Station from 1998 to 2004.

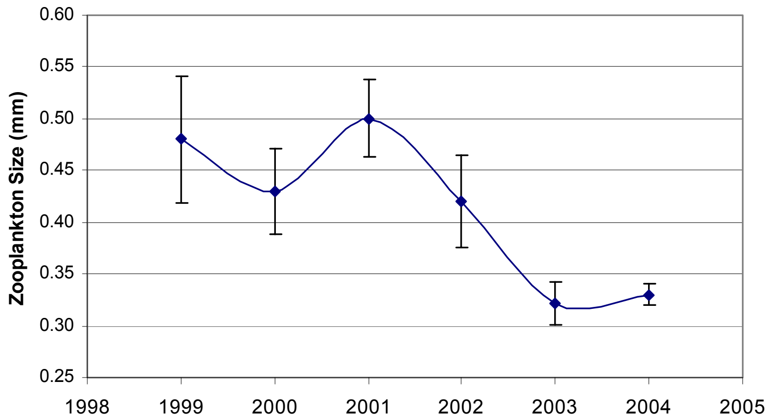


Figure 3-4. Average size of zooplankton (all taxa combined) in Onondaga Lake from April until October in 1999 to 2004. *Note:* error bars are standard error.

Size structure of zooplankton communities may be influenced by the relative degree of planktivory, which can cause a distinct shift favoring survival of smaller species as planktivorous fish prefer to graze on the larger organisms (Wetzel 1983). Mean zooplankton size in Onondaga Lake exhibited a substantial decline in 2003 and 2004 (Figure 3-4). The decrease evident in 2003 and 2004 was due to the loss of the larger zooplankton, notably *Daphnia galeata* and diaptomids, from the community. The loss of the larger plankton is attributed to the dramatic increase in the planktivorous alewife in these same years (see Section 2.5 of this report). The reduction in population of these larger zooplankton taxa was evident in late summer 2002 when young-of-the-year alewives first became abundant. The extirpation of larger zooplankton by alewives caused a decline in total zooplankton biomass in 2003 and 2004 (Figure 3-5A). Other taxa once prevalent in Onondaga Lake have also become scarce since the influx of alewives. These groups include Nauplii and copepodites, and *Diacyclops thomasi*; the biomass of *Bosmina longirostris* has greatly increased over this time period, probably in response to decreased completion with other once prevalent species (Figure 3-5B). The decline of larger zooplankton in Onondaga Lake has considerable implications for the future of the phytoplankton community and water clarity in the lake. Phytoplankton will grow as long as environmental conditions such as temperature and light are favorable, and nutrients are available. In a balanced food web, maximum possible growth is controlled, to a certain extent, by predation. In the aquatic environment, larger zooplankton are the most effective grazers of phytoplankton and exert a major control on the standing crop (Mills et al. 1987). Consequently, their disappearance from the lake will affect phytoplankton standing crop and water clarity. For example, there is a correlation between mean zooplankton size and water clarity in Onondaga Lake from 1999-2004, indicating that zooplankton size is related to water clarity (Figure 3-6).

However, the interactions between trophic levels are complex; note that a plot of average annual biomass for phytoplankton and zooplankton from 1999-2004 indicates that this relationship is weak (Figure 3-7). It appears that the biomass of the zooplankton community is less important than the size of the individuals composing the community. Other interactions among the various trophic levels, including other grazing organisms such as zebra mussels and higher level interactions of the fish community may be affecting phytoplankton in addition to the effects of nutrients, lights, and temperature.

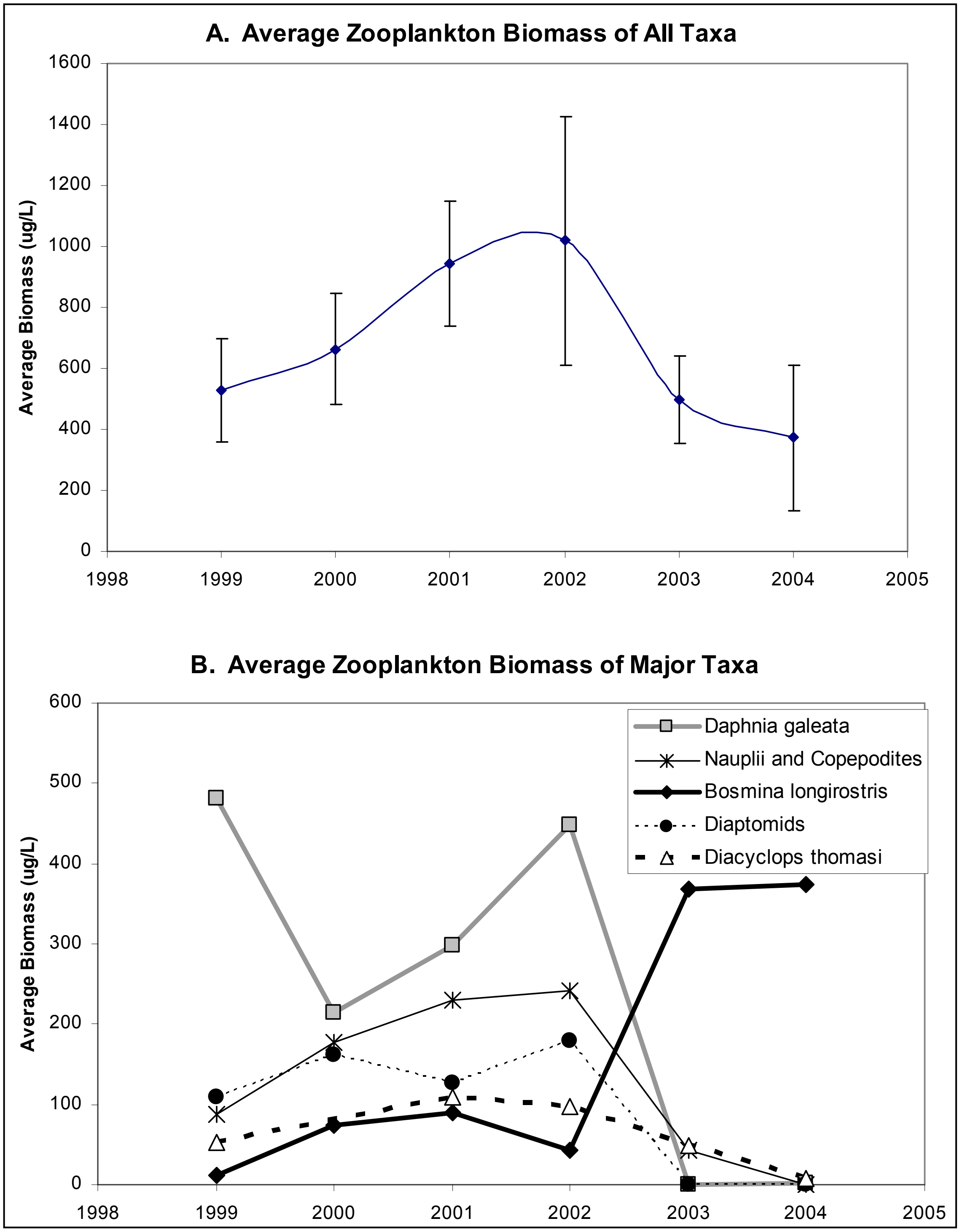


Figure 3-5. Average biomass of zooplankton (all taxa combined) and major taxa in Onondaga Lake from April through October in 1999-2004. Note: error bars in figure A are standard error.

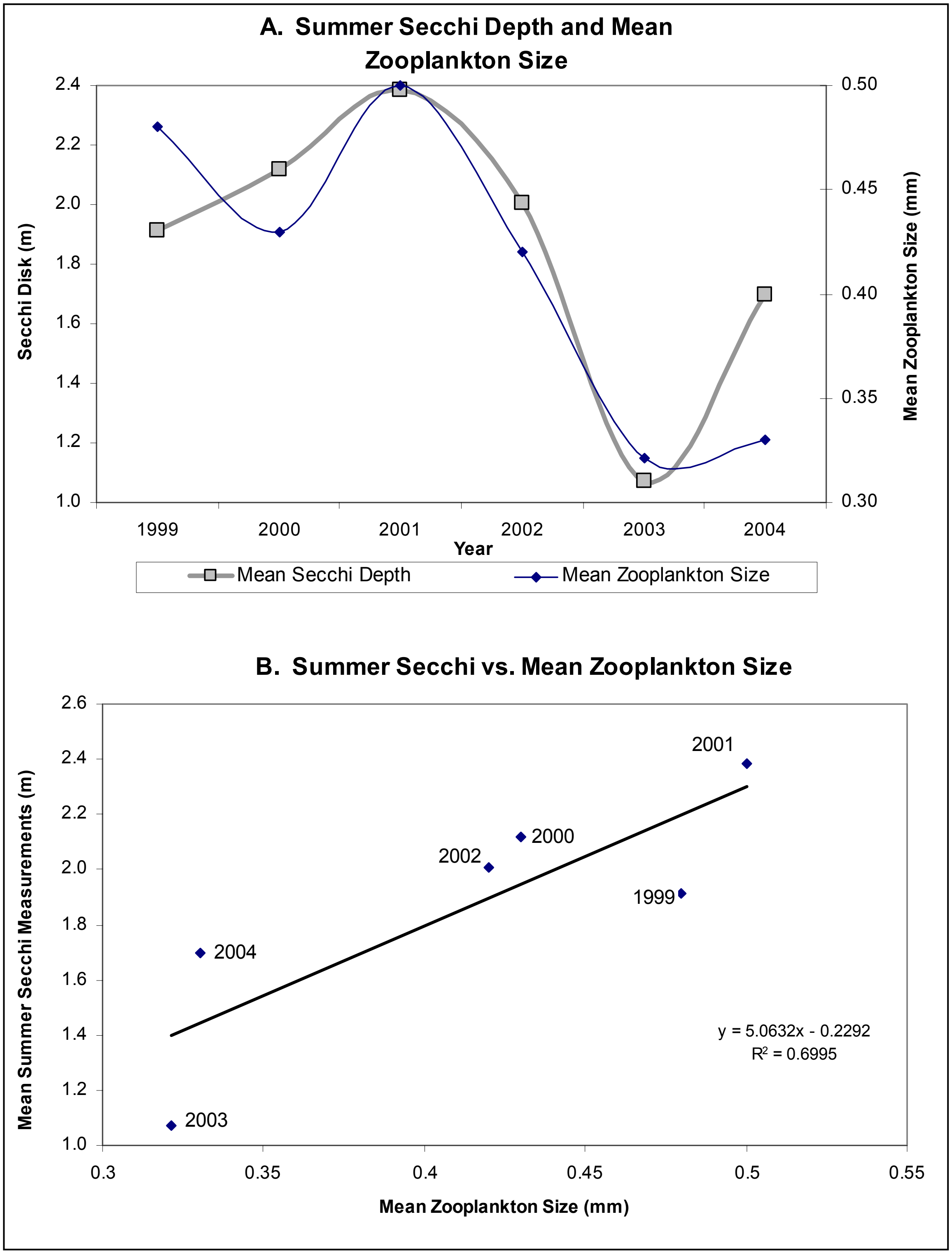


Figure 3-6. A) Mean summer Secchi disk measurements and mean zooplankton size from Onondaga Lake, 1999 to 2004. Error bars are standard error. B) Regression of mean summer Secchi disk measurements and mean zooplankton size in Onondaga Lake 1999 to 2004, labels are the year.

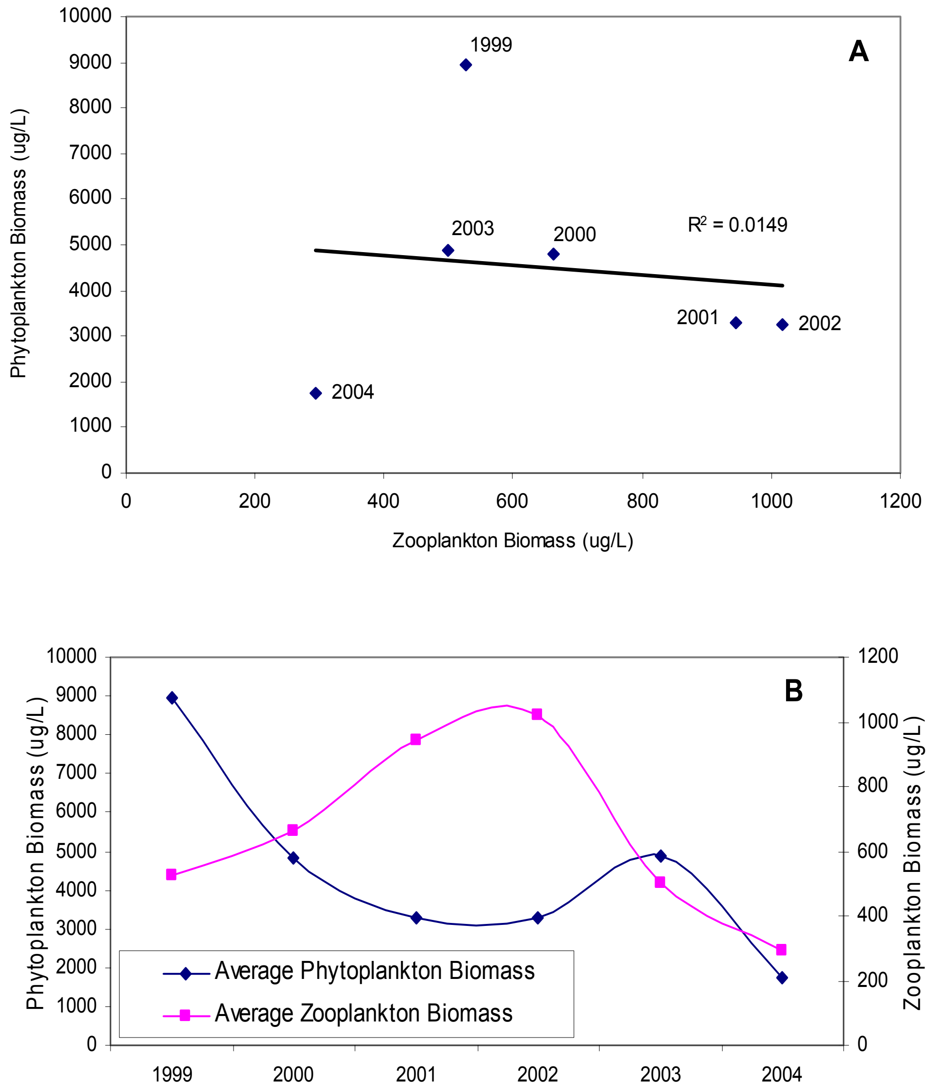


Figure 3-7. Phytoplankton biomass vs. zooplankton biomass (A) and plotted by year (B). Onondaga Lake, South Deep Station, 1999-2004.

3.5.2 Fish Habitat

Habitat plays an important role in structuring the Onondaga Lake biological community. Under current summer conditions, the lake provides habitat for a warmwater fish community. There is no stratum of the lake water column that provides both suitable temperature and adequate dissolved oxygen for coldwater fishes such as salmonids.

3.5.2.1 Historical fish community

Historically, it appears that both resident and migratory populations of coldwater fish were present in Onondaga Lake. There are reliable reports of Atlantic salmon entering the Oswego River system in June and making their way to Onondaga Lake via the Oswego and Seneca Rivers (Ringler et al. 1996). By 1815, a dam along the Seneca River at Baldwinsville appears to have negatively affected the salmon run above Onondaga Lake (Clinton 1849). However, it is known that salmon were abundant in the Seneca River downstream of the dam, and present in Onondaga Lake as late as the 1870s (Fox 1930). Although the Baldwinsville dam would not have had a direct impact on the salmon fishery in Onondaga Lake, subsequent dams built at Fulton, Minetto, and Oswego would have almost certainly have prevented salmon from reaching the lake.

The best historical information regarding a resident population of a coldwater fish describes the abundance and sudden loss of the Onondaga Lake whitefish (*Coregonus* sp.). A commercial fishery existed for the whitefish until the mid 1890s (Tango and Ringler 1996). The whitefish fishery in Onondaga Lake collapsed suddenly, dropping from 9090 kg in 1894 to 455 kg in 1895 (Tango and Ringler 1996). The whitefish were apparently extirpated from the lake by 1897 (Tango and Ringler 1996). The collapse of the fishery occurred over a period when Allied Signal began to discharge large quantities of ionic waste, and increasing amounts of barely-treated sewage entered the lake (Nemerow 1964). Also during this period, New York State granted a one-year unconditional license to anyone who wished to net for whitefish in Onondaga Lake, as they could not be caught by hook and line. The increased fishing pressure was thought, by many at the time, to have severely impacted the whitefish population. The relative contribution of habitat loss, water quality degradation, and over fishing to the extirpation of the Onondaga Lake whitefish has not been determined.

The existence of a population of coregonids in Onondaga Lake during the 1800s provides presumptive evidence that adequate dissolved oxygen levels were present in at least a portion of the lake's cooler waters during the summer (Ringler et al. 1996). A newspaper article from 1894 indicated that the Onondaga Lake whitefish "must have cool water or they will perish", and that they were found "in the very deep water". Interestingly, the article indicates that dead whitefish were often observed after heavy winds, a possible indication of seiche-induced mortality.

In the early 20th century it was thought that the Onondaga Lake whitefish was a unique species not found in other regional lakes. The January 24, 1940 edition of the Syracuse Post Standard stated that "the Onondaga Lake whitefish was an entirely separate species from the Great Lakes and Adirondack whitefish", the article continues with the information that the whitefish was also known as the "tullibee," and was found only in Onondaga and in several lakes in Manitoba, Canada. The Onondaga Lake whitefish was reported to reach five pounds as an adult. A description of a commercial catch in 1894 indicated that the average size was from two to three and a half pounds.

The Onondaga Lake whitefish was distinguished from other coregonids at the time not only by its large size, but also by the deep green stripe on the dorsal fin, the square perch-like mouth, small stomach and strong cucumber odor of the flesh (Syracuse Sunday Herald Jan. 6, 1901). It is now thought that the Onondaga Lake whitefish was a Great Lakes cisco (*Coregonus artedii*), a once-common species with a high degree of morphological variability (Clady 1966). This species is present in Oneida Lake, although it is not common. The Great Lakes cisco is the most tolerant of the coregonids to warm water temperatures. Lake Mendota in Madison, Wisconsin supports a cisco population; this lake is subject to annual hypolimnetic anoxia. Summer dieoffs of cisco in Lake Mendota have occurred during warm years (Rudstam et al. 1993).

3.5.2.2 Using AMP Data to Track Habitat Conditions

As described in Section 3.4, there are numerous projects underway to improve water quality and habitat conditions throughout the watershed. The AMP data provide a basis for measuring changes in water quality conditions that may affect fish habitat. To this end, recent temperature and DO data have been used in combination to define in-lake fish habitat conditions.

Two metrics have been developed to aid in quantifying the extent to which DO and temperature conditions would support coldwater and coolwater fish populations. Warmwater fish were excluded from this analysis since the amount of suitable habitat for those species is almost exclusively controlled by the warmth of the summer and not by in-lake processes. The criteria used to track the metrics can be modified by the user within the DVT to reflect potential management scenarios and requirements of different fish species.

The DVT fish space tool is useful for monitoring changes in available habitat in the lake and for helping to determine if water quality is suitable for sustaining defined fish populations. It will not, however, determine if defined fish populations are sustainable as the ability to have a sustainable population relies on variables in addition to temperature and DO, such as forage base and reproductive habitat.

Both metrics will calculate habitat in three ways, and display the available habitat graphically. The first calculation is the percent of total available habitat. The percent of total available habitat is based on the total number of volume days (one volume day equals one lake volume for one day) over the designated time period. Both the coldwater and coolwater metrics use a 185 day time frame from May 15 to November 15 of each year. There are a total of 185 possible volume days of habitat available (the entire volume of the lake for all 185 days). The coldwater metric uses this value as the total and calculates the percent of this total that was evident in a given year. Depth strata of the lake with DO and/or temperature out of range has its volume day subtracted from the total number of volume days possible (185). For example; if half the lake was within the criteria range for all 185 days there would be 92.5 volume days of habitat. The calculation would then report a result of 50% of the total potential habitat.

The percent of total available habitat is calculated in a slightly different way for the coolwater fish habitat metric. The total number of possible volume-days is not 185 like the coldwater metric, but varies annually depending on how many volume days the temperature is within the criteria range. Only areas of the lake where DO infringes upon this preferred temperature zone are used in the calculation. The metric is calculated in this way because the lake's hypolimnion, even with adequate DO, would be too cold for the coolwater species.

As an example of the coolwater habitat calculation, assume that the temperature of half the lake's volume (i.e. surface to a depth of 8 m) was suitable for the coolwater species over the entire period from May 15 to November 15. The metric calculates 92.5 volume-days of possible habitat. If 10% of this potential habitat had DO concentrations below the acceptable range, the calculation would return a value of 90% of total potential habitat.

The second and third calculations are similar: the total number of days where criteria are met in at least one vertical meter of the lake, and the maximum number of consecutive days where criteria are met within one vertical meter of the lake. These metrics calculated the same way for both the coldwater and coolwater fish habitat. The total number of days and maximum number of consecutive days within criteria range represents whether the lake provides refuge. For example, if a one meter layer of water existed where both DO and temperature criteria were met for the entire period, both calculations would return a result of 180 days. The same would be true if the entire lake volume met criteria for the entire sample period. If, however, one day did not meet criteria anywhere in the lake, for example at day 50, but the remaining days did, the number of days where criteria are met calculation would return a result of 179 days while the maximum consecutive days calculation would return a result of 130 days.

The two default metrics that are included to illustrate the approach are:

(1) <u>Coldwater Fish Habitat Metric</u>. Default values are: temperature ≤ 22º C <u>and</u> dissolved oxygen ≥ 5 mg/L between May 15 and November 15.

These default criteria were selected to be protective of a coldwater fish community; these limits do not represent either preferred or critical conditions for all salmonids. The default values can be changed to reflect any condition a lake manager may wish, including optimal and lethal conditions. Any fish species can be selected. The temperature tolerance of brown trout (*Salmo trutta*) was used as the default for coldwater fish. Other coldwater species have similar tolerances. The default DO criteria is based upon NYSDEC minimum guidance values for trout waters (section 303.3 of NYSDEC Ambient Water Quality Standards). These values should not be interpreted as representing a water quality goal for the lake; the defaults are included as an illustration of the methodology to define habitat criteria. Brown trout are already present in the lake during parts of the year and would likely be the first coldwater species to repopulate the lake year round, if adequate temperature and DO conditions occur. For these reasons the brown trout was selected to illustrate the habitat metrics.

Brown trout have upper lethal temperature of about 26º-27ºC, with a preferred range from about 12º-19º C (Raleigh et al. 1986). The lower lethal limit of dissolved oxygen for brown trout is about 3 mg/L (Raleigh et al. 1986). Optimal dissolved oxygen concentration at temperature above 10º C is greater than 12 mg/L (Raleigh et al. 1986). Historically these temperature and DO conditions are not met in Onondaga Lake during the summer, thus limiting the potential for a resident year-round coldwater fish community. Typically, DO in the cooler lower waters falls below 5 mg/l by early June. At the same time, water temperatures are rising in the upper waters and typically exceed 22º C by early July. By mid-July there is little or no habitat available that is conducive to a productive coldwater fish community. These conditions tend to persist until about September when upper waters cool to levels that are in the upper range for coldwater species. In some years DO levels fall below 5 mg/L during fall turnover in October, further limiting available habitat throughout the water column for several days or weeks.

In 2004 the pattern observed in previous years was generally repeated, but with some important differences. The DO was less than 5 mg/l in the deeper cool waters from early-June through October, and water temperatures were above 22º C throughout much of the upper, oxygenated layer from early July through early September. The percent of available habitat and number of days within criteria were the highest since the monitoring program begun in 2000 although not considerably higher than past years (Table 3-21). The maximum number of consecutive days within the criteria range, however, was much higher than past years. A closer look at the DVT for 2004 shows a restricted area where criteria were within range present from early August through November 15 (Figure 3-8). Most importantly, this layer was sustained during periods of warm surface temperatures in August with only intermittent interruptions in July. The layer varied in vertical thickness during August from only about 1m on several occasions to a maximum of about 9m (surface to 9m depth) in late August.

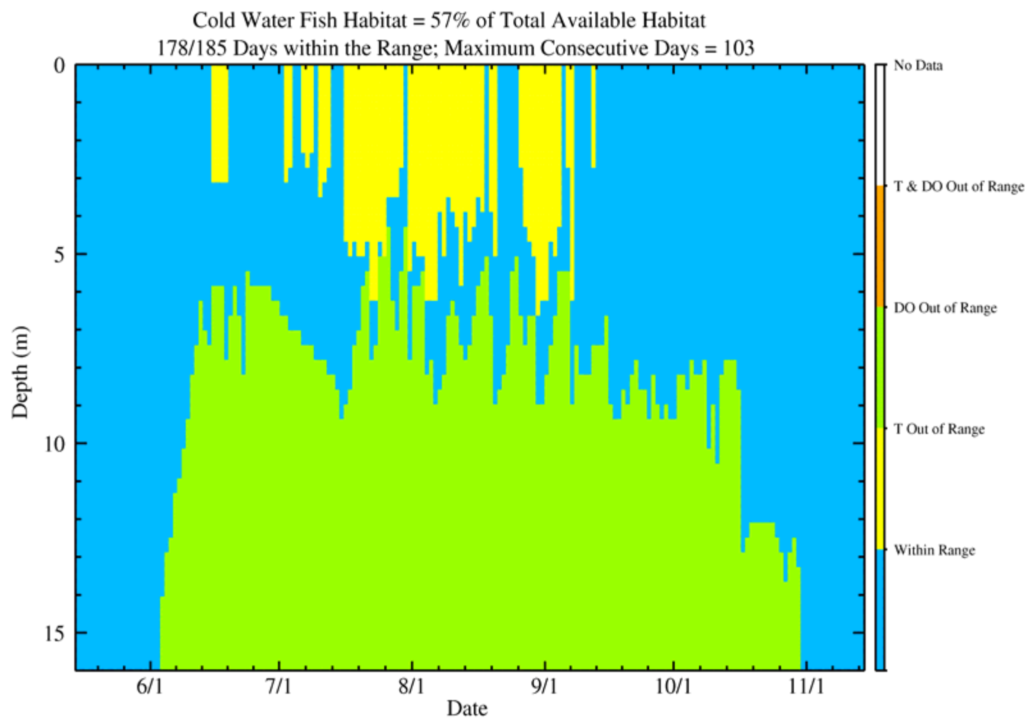
This metric indicates that there are likely suitable habitat conditions for coldwater fishes in Onondaga Lake in early spring and after fall turnover in most years; this has been verified by catches of brown and rainbow trout in Onondaga Lake in the spring and fall since the early 1990s (Gandino 1996, Tango and Ringler 1996, EcoLogic 2003). In some years there may also be small areas of refuge for some coldwater fish that could allow for limited year round residency of these species in the lake. However, this has yet to be verified by inlake catches of coldwater species in summer.

Table 3-21. Habitat availability for coldwater fishes in Onondaga Lake from 2000 to 2004 based on default DVT criteria.

Year	Coldwater Habitat		
	% Available Habitat[1]	Total # Days In Range[2] (max 185 days)	# Consecutive Days In Range[2] (max 185 days)
2000	55	167	79
2001	54	164	78
2002	46	134	60
2003	50	121	49
2004	57	178	103

1 Assumes entire volume of the lake from May 15 to November 15 is available.

2 Number of days where temperature and DO are within range in at least a one meter vertical section of the lake.



Fish Habitat in Onondaga Lake in 2004

Note: Water temperature < 22 deg.C and dissolved oxygen > 5 mg/L between May 15 and November 15.

Figure 3-8. Graphical depiction of the extent of habitat for coldwater fish in Onondaga Lake in 2004 based on default DVT criteria.

(2) Coolwater Fish Habitat Metric. Default values are: temperature between 18º - 25º C and dissolved oxygen $\geq$ 6 mg/L between May 15 and November 15.

This metric depicts preferred water quality conditions for coolwater fish. The temperature range was derived from the preferred range for walleye (Chu et al. 2004, McMahon et al 1984). The minimum DO level is based on NYSDEC guidance values for non-trout waters. Other values may be entered by the user in the DVT to depict selected criteria (e.g., lethal conditions and preferred ranges for other species.)

Typically, preferred coolwater fish habitat in Onondaga Lake during summer extends from the upper boundary of the LWL to several meters below the surface (Figures 3-9). Water temperatures within the LWL are colder than preferred and surface temperatures are typically warmer. In some years, hypoxia extends upward through the water column and may reach strata with temperatures in the preferred range for coolwater species. As a result, fish are restricted to a narrow stratum of suitable habitat from about three to five meters below the water surface. Alternatively, coolwater fish may be forced into the littoral zone to find adequate DO, but also find temperatures above their preferred range.

The percent of total available habitat for coolwater fish has remained high since the AMP fish monitoring began in 2000 varying from 84% to 95% (Table 3-22). The percent of total available habitat for coolwater species in a given year appears to be mostly controlled by UML water temperature and to a lesser extent the intrusions of low DO water into the UML from the LWL. Warmer years support less coolwater habitat and cooler years support more.

In 2004, water temperatures remained sufficiently cool throughout the UML to provide substantial coolwater habitat throughout the summer (Figure 3-9). This occurred despite the periodic incursions of lower DO water to mid-water depths.

Table 3-22. Habitat availability for coolwater fishes in Onondaga Lake from 2000 to 2004 based on default DVT criteria.

	Coolwater Habitat		
Year	% Available Habitat[3]	Total # Days In Range[2] (max 185 days)	# Consecutive Days In Range[2] (max 185 days)
2000	91	114	109
2001	95	115	113
2002	87	122	122
2003	84	110	110
2004	95	132	121

1 Assumes entire volume of the lake from May 15 to November 15 is available.

2 Number of days where temperature and DO are within range in at least a one meter vertical section of the lake.

3 Assumes only areas of the lake within temperature criteria are available.

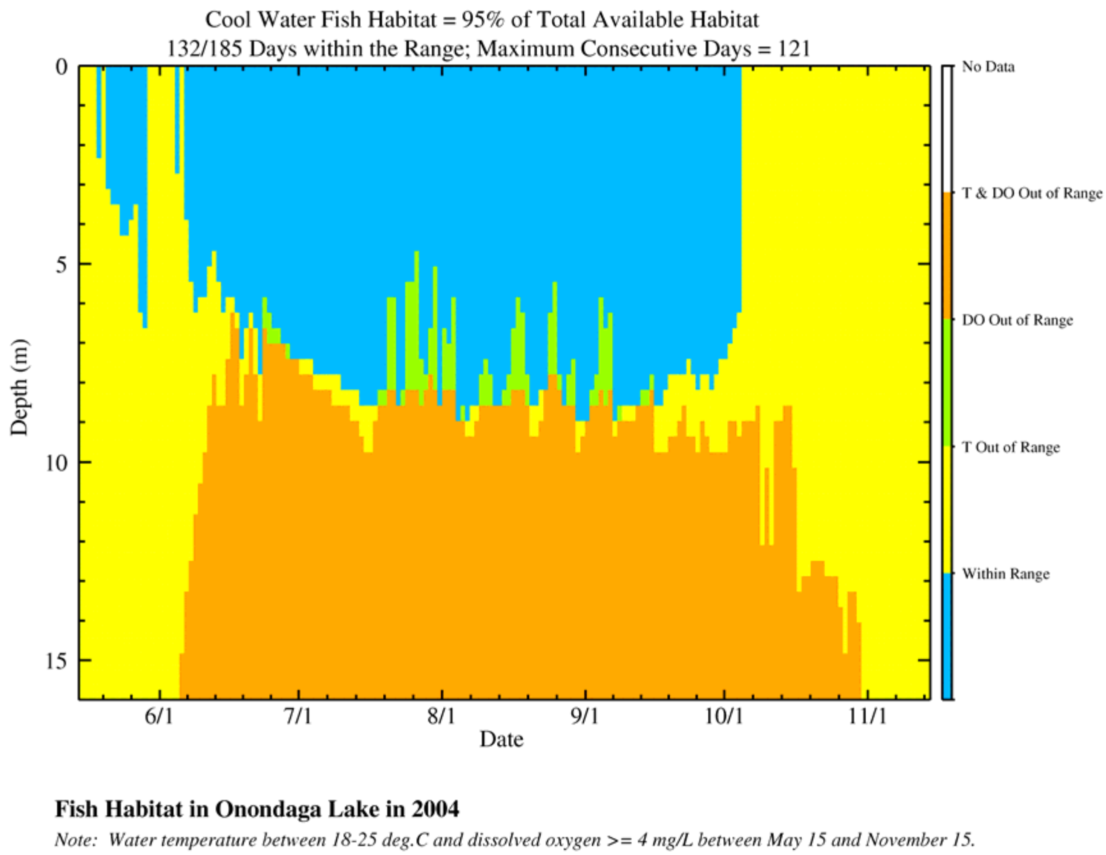


Figure 3-9. Graphical depiction of the extent of habitat for coolwater fish in Onondaga Lake in 2004 based on default DVT criteria.

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CHAPTER 4

RECOMMENDATIONS

The following eight recommendations reflect the findings of the 2004 AMP.

1. It is recommended that Onondaga County continue to disseminate the findings of the AMP to the scientific community, water resources managers, OLP stakeholders, and the interested public.

The success of the wastewater treatment plant improvements and progress towards recovery of Onondaga Lake are issues of great interest to many, including state and local officials and the community at large. Four points support this recommendation:

- The AMP is designed and implemented with a commitment to high technical standards and an open process.
- Carefully designed methodologies, QA/QC protocols, and inter-laboratory comparisons have focused on maintaining the highest standards in laboratory data.
- The County uses technical experts to review program design, provide guidance on data analysis and interpretation, and comment on technical reports.
- There is a parallel commitment to community outreach through the Onondaga County website, fact sheets, brochures, and user-friendly versions of the annual report.
- OCDWEP maintains a web site to communicate the results of the AMP to the public. The web site is: http://www.lake.onondaga.ny.us/ol33.htm.

2. It is recommended that the database be modified to enhance integration of the phytoplankton and zooplankton data with the water quality data.

OLTAC member Dr. William W. Walker Jr. has developed a custom database for managing the extensive AMP water quality data set. The water quality database makes data analysis and reporting much easier and consequently facilitates efforts to turn data into information. Th phytoplankton and zooplankton data are archived in separate excel workbooks. Linking these files into the water quality database will make it easier to integrate the lower trophic level data.

3. It is recommended that OCDWEP continue to integrate AMP findings with OLP projects and issues.

There are a number of significant initiatives underway in the Onondaga Lake watershed in addition to the AMP; many are funded and coordinated through the Onondaga Lake Partnership. Continued communications at the technical and policy levels will enhance the collective efforts to improve water quality and habitat conditions**.**

4. **The Biological Working Group should evaluate the effectiveness of various means to estimate the abundance, biomass, size, and age structure of the alewife population in Onondaga Lake.**

   Analysis of biological data collected between 2002 and 2004 has resulted in a recommendation to continue to explore the impacts of the alewife on the lake's zooplankton community.

5. **It is recommended that Onondaga County implement a cooperative program with Cornell University (or another suitable institution) to explore the rich phytoplankton data set with the ultimate goal of contributing to the scientific literature on environmental factors affecting structure and function of the lake's phytoplankton and zooplankton communities.**

   Onondaga County has compiled highly detailed data describing the lake's phytoplankton community. There is a tremendous potential value for further exploration of the data, particularly from the perspective of functional groups as described by plankton ecologist Colin S. Reynolds of the Centre for Ecology and Hydrology, Algal Modeling Unit, Ferry House, Ambleside LA22 0LP, Cumbria, England.

6. **It is recommended that OCDWEP continue to manage development of the lake model in an open and collaborative manner so that this tool is accepted by stakeholders and meets the needs of lake managers.**

   The AMP is designed to provide data and information regarding existing conditions in the lake and watershed. In order to make informed decisions regarding the need for additional controls on point and nonpoint sources of pollution, a predictive model is needed. QEA LLC, selected to develop the lake water quality model, began work on the model in 2005. The model will support:

   a) Quantitative projections of the impacts of future reductions in Metro and nonpoint phosphorus and nitrogen loads on lake water quality.
   b) Projections of the impacts of Metro diversion on the lake.
   c) Evaluation of the impact of Metro diversion on the river.
   d) Projections of the impacts of best management practices and land use changes in the watershed (linked with quantitative estimates of watershed nutrient loadings generated by the USGS watershed model).

   The modeling effort includes a peer review at each phase. So that stakeholders and lake managers find this tool useful, it is recommended that OCDWEP continue to manage development of the lake model in an open and collaborative manner.

7. **The Biological Working Group recommended at their March 2005 meeting that OCDWEP support a focused effort to explore the potential utility of several fisheries management models for application to the Onondaga Lake dataset.**

   The AMP includes an extensive program of fisheries investigations. There are relatively simple fisheries management models that can be used to explore the potential consequences of management actions such as changes in fishing pressure. OLTAC members Dr. Ed Mills and Dr. Lars Rudstam of the Cornell Biological Field Station will guide this exploratory effort as part of the 2006 program.

8. **It is recommended that Onondaga County establish data-sharing protocols with NYSDEC and others, particularly Honeywell International, to compile data on the contaminant burden in fish and report on progress towards use attainment.**

   The ACJ directs Onondaga County to track data reported by other agencies regarding the contaminant burden in fish. Since other stakeholders are actively collecting these data in and around Onondaga Lake, cooperation and data-sharing with these entities would enhance county efforts to meet the requirements of the ACJ.

9. **It is recommended that Onondaga County DWEP continue its internal training and auditing procedures.**

   The ACJ directs Onondaga County to dedicate the staffing and resources needed to ensure that the AMP collects defensible data that can be used to support sound management decisions. The internal programs to train staff and audit the AMP field and laboratory components have been of great value and should continue.

10. **It is recommended that Onondaga County continue to update the Data Analysis and Interpretation Plan (Appendix 9) and the Statistical Framework in the future.**

    These documents will continue to evolve as data are turned into information. They provide a basis for Onondaga County and the other technical stakeholders to review the design and findings of the AMP to ensure that the AMP data will support management decisions.