Chapter 6. Watershed and Subwatershed Technical Findings

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6.1 Overview:

Cayuga Lake's water quality is generally very good. The lake supports its designated best use as a public drinking water supply and recreational resource; the fish community is diverse and productive. Overall, the tributary streams exhibit moderate to high water quality and habitat conditions that support a balanced biological community.

Cayuga Lake has been well characterized and is the focus of several significant long-term monitoring initiatives. There is much less information available to characterize the tributaries. A few long-term tributary monitoring programs are in place; most are directed at the southern tributaries.

Despite the conclusion that water quality is high, a number of specific areas of concern are evident:

- ***Agricultural chemicals*** such as nitrate-nitrogen and pesticides and metabolites are detected in both tributary streams and the lake. While there are no exceedances of ambient water quality standards associated with human health or ecosystem protection, these data provide direct evidence of losses from agricultural lands and transport to the lake.

- ***Sediment*** is a significant water quality, habitat, and use impairment issue, particularly in the southern tributaries and southern Cayuga Lake. Destruction and fill of the extensive wetland areas in southern Cayuga Lake in the early 1900s has exacerbated this problem by removing a natural filtration process that captured sediment before it flowed into the lake. In the southern tributaries, the primary source of sediment appears to be streambank erosion, not runoff from construction sites or cultivated fields. The primary sources of sediment in other tributaries are not known and may differ based on land use and geology.

- ***Heavy metals*** are present in sediments of Fall Creek at concentrations exceeding the NYSDEC assessment criteria, which represent the upper limit of background levels. Seven heavy metals (chromium, copper, iron, lead, manganese, nickel and zinc) were detected during 1995 – 1996 monitoring. Nearshore sediments of Cayuga Lake also exhibit elevated concentrations of some heavy metals. These data suggest the need for improved stormwater management.

- ***Phosphorus*** is the limiting nutrient for algal growth in Cayuga Lake as it is for most inland lakes in the Northeast. Ambient concentrations measured in the deep portion of the lake confirm that Cayuga Lake is mesotrophic, with moderate levels of primary productivity. A phosphorus guidance value for lakes has been adopted by NYSDEC to protect recreational uses. Cayuga Lake meets the NYSDEC total phosphorus guidance value of 20 μg/l, summer average upper waters, measured at a mid-lake station. However, phosphorus concentrations in the southern, Class A segment of Cayuga Lake occasionally exceed the 20 μg/l guidance value. There is strong evidence that these elevated concentrations reflect sediment-borne phosphorus as well as phosphorus in the discharges of the two wastewater treatment plants.

- ***Urban runoff.*** Stormwater runoff from developed areas carries sediment and contaminants including salts to the streams ultimately to Cayuga Lake.

- ***Pathogens and indicators.*** The presence of pathogenic microorganisms in the lake and its tributary streams is a potential area of concern. Pathogens originate from untreated or inadequately treated human sewage and wild and domestic animal waste. Human exposure to pathogens can occur from direct contact with or ingestion of contaminated waters. The potential presence and abundance of pathogenic microorganisms is assayed using indicator organisms such as coliform bacteria.

- ***Exotic species***. Because of its connections to the Great Lakes through the Seneca River, Cayuga Lake is vulnerable to invasion by nonindigenous species of plants and animals. There have been a number of exotic species invading Cayuga Lake over the years. Three recent invaders are a focus of special concern due to their potential to alter the food web. These organisms are the zebra and quagga mussel (*Dreissena polymorpha* and *Dreissena bugensis*) and a predatory cladoceran zooplankton (*Cercopagis pengoi).* The macrophyte eurasian

water milfoil (*Myriophyllum spicatum*) is another introduced species that has, until recently, been a nuisance in Cayuga Lake.

- Impacts of Cornell ***Lake Source Cooling***

- ***Native American territory*** disputes

Specific areas of concern for the tributary watersheds are summarized in Table 6.1. A similar table for the lake is presented as Table 6.2.

Table 6.1. Summary of Areas of Concern, Tributary Subwatersheds

Parameter	Location	Use Affected	Primary Cause	Potential for Improvement
Sediment	Fall Creek, Cayuga Inlet, Sixmile Creek, Yawger Creek, Cascadilla Creek	Fishing, fish propagation, water supply	Streambank erosion, agriculture, urban runoff	Moderate. Requires field investigations to identify causes and contributing factors. In some areas only viable solution may be riparian greenbelt to allow natural meanders. Requires watershed –wide commitment to land use and riparian zone management
Phosphorus	Salmon Creek	Water clarity, aesthetics	Agriculture	Moderate
Nitrate	Great Gully Paines Brook Salmon Creek Mack Br Williams Cr Indian Creek	Potential water supply	Agriculture	Unknown. Highly dependent on mix of agriculture and practices in watershed.
Petroleum products	Trumansburg Ck Cayuga Inlet	Benthos Fish propagation Fish tainting	Spills	Moderate – high (natural flushing and breakdown_
Pesticides	Salmon Creek, Paine Brook, Yawger Creek (other locations not surveyed)	Presently, none detected over limits of concern. Could affect drinking water use.	Agriculture	Highly dependent on mix of agriculture and practices in watershed.
Heavy metals in sediment	Fall Creek (confirmed) Cayuga Inlet (likely based on land use)	Chronic toxicity to vulnerable biota Bioaccumulation	Urban runoff	High. Controls on point sources (including air emissions) more stringent. Sedimentation buries more contaminated sediments
Pathogens and Indicators	Unknown	Water consumption, contact recreation	Stormwater, on-site systems	Unknown, likely moderate

Table 6.2 Summary of Areas of Concern, Lake				
Parameter	Location	Use Affected	Primary Cause	Potential for Improvement
Sediment	Mouths of tributaries, particularly southern lake	Aesthetics (water clarity and enhanced habitat for macrophytes) Drinking water	Streambank erosion, agriculture, urban runoff	Difficult. Requires watershed –wide commitment to land use and riparian zone management
Exotic species	Lakewide	Ecological integrity, fishing, swimming, aesthetics	Entrance through Seneca River	Difficult to control. Requires technical and regulatory controls throughout Great Lakes, public education
Phosphorus	Lakewide, particularly in southern and northern basins	Water clarity, aesthetics	Southern: treated wastewater Northern: on-site systems	Reductions in municipal point source loading are planned. Controls on nonpoint sources are more difficult
Pesticides and metabolites	Lakewide	Presently, none detected over limits of concern. Could affect drinking water use and fish bioaccumulation.	Agriculture	Highly dependent on mix of agriculture and practices in watershed.
Metals in sediment	Spatial extent of problem is unknown. Nearshore southern lake data show exceedances of some criteria.	Biological availability of metals appears to be low based on AVS. Minimal potential for release into water column, based on water chemistry and equilibrium partitioning models.	Historical industrial use, atmospheric deposition	High. Controls on point sources (including air emissions) more stringent. Sedimentation buries more contaminated sediments
Pathogens and indicators	Existence or spatial extent of problem is unknown.	Ingestion, primary water contact recreation	Unknown relative contribution of urban stormwater, waterfowl.	Depends on sources

6.2 Data Needs

There are data gaps that limit our ability to draw conclusions regarding the status of the lake and its watershed. These data gaps exist for both the lake and the tributary watersheds. The listing does not reflect an assessment of priorities.

6.2.1 Data Needs: Subwatersheds

- Baseline characterization of water quality and loading

  Likens' 1970 – 1971 work represents the only synoptic survey of baseline water quality of all tributaries to Cayuga Lake. These chemical profiles provide important insights regarding quality of waters draining individual subwatersheds and total external loading to the Lake. There have been significant changes to loads of several subwatersheds over the last three decades; for example, salt loading to Gulf Creek has been greatly reduced, and the outfall of the Ithaca Area Wastewater Treatment Plant has been relocated from Cayuga Inlet. It is therefore recommended that a synoptic survey be conducted over at least one full year.

  Monitored parameters should include: calcium, sodium, chloride, magnesium, potassium, sulfate and total alkalinity, total suspended solids, total P, total soluble P, soluble reactive P, pesticides and metabolites, and nitrate N. The sampling program should be conducted for at least one full year, with concentrated sampling during high flow events. Based on existing data, seasonal, event-driven, and land use activities in the subwatersheds all affect external loading.

  Need for seasonal sampling

  Many of the monitored parameters exhibit strong seasonal concentrations that reflect biogeochemical processes, human activities on the landscape, and the hydrologic cycle.

  Need for event sampling

  Based on the Fall Creek data set, most of the annual loading of sediment and phosphorus to Cayuga Lake occurs during high flow events. Sampling during high flows will greatly reduce the standard error of estimates of annual loading.

  Need for sampling to be linked to agricultural activities in the subwatersheds

  The July 1998 low level pesticide sampling of Yawger Creek, Salmon Creek and Paine Brook conducted by Dave Eckhardt and colleagues of USGS illustrates the need to consider major land use activities in the watershed in designing a monitoring program.

  Need for additional flow monitoring

  Load estimates require accurate gauging in the watershed. Several gauging stations have been installed throughout the watershed and operated for various periods to meet specific program objectives. Only Cayuga Inlet, Fall Creek, and Sixmile Creek are currently gauged for flow. These stations monitor flow from approximately 204 square miles of the 785 square mile direct drainage. Reactivating the gauge at Salmon Creek would monitor an additional 81.7 square miles.

  Need for monitoring in various geological and land use settings

  The Cayuga Lake watershed has diverse geological and land use settings, and the results from one area may not be transferable to regions with different geology soils and land use.

  Need for subwatershed modeling

  An assessment of which tributaries contribute disproportionate loads of sediment, phosphorus, nitrate, and pesticides to Cayuga Lake would help identify priority areas for remediation. Data are not yet sufficient to define these resource-based priorities for Cayuga Lake.

- Atmospheric deposition

  There are no recent data characterizing chemical quality of precipitation (wetfall and dry fall) in the basin. This is important for load calculations as well as for general surveillance of acid precipitation.

- Septic system performance

  Based on generalized geology and soils maps, there are large areas of the watershed with severe constraints to on-site wastewater disposal systems (septic systems). There has been no watershed-wide effort to characterize

the performance of these individual systems and how leachate from septic systems contributes to nitrate, phosphorus, and pathogen levels. The experience of Cayuga County, which has a comprehensive inspection program, could serve as a guide.

- Macroinvertebrate screening of tributaries

  Species composition and abundance of the macroinvertebrate community can be used to indicate water quality conditions and assess site-specific impacts of point and nonpoint discharges. Sampling tributaries in various geologic and land use settings can identify areas where the biological community is stressed.

- Effectiveness of mitigating measures (Best Management Practices) in reducing export of sediment and nutrients from subwatersheds

  Before and after monitoring is lacking on tributaries where remedial measures such as streambank stabilization or stormwater controls has been implemented. Monitoring should occur over a range of hydrologic conditions, particularly high flow events.

- Riparian zones and wetlands

  There is a need to identify wetlands and riparian areas that are most critical for protecting water quality and floodplains.

- Ecological and human health effects of trace concentrations of agricultural herbicides and other pesticides

  Herbicides used in cultivation of corn have been detected at low concentrations in monitored tributaries and in the lake. Concentrations are at least one order of magnitude below the most stringent water quality criteria or standard. Additional assessment of human health and ecological impacts of these trace concentrations of chemicals is needed. The potential for agricultural chemicals to be adsorbed to sediment particles and transported to the lake has not been fully assessed. Limited testing of lake sediments has not detected agricultural residues. However, testing has not been conducted in depositional areas of streams draining agricultural watersheds, nor in the lake at the mouths of tributaries.

- Watershed sources of heavy metals detected in Fall Creek sediments

  The 1995 –1 996 RIBS sampling program conducted by NYSDEC detected seven heavy metals above the assessment criteria, defined as the upper range of background levels but below thresholds that might cause adverse impacts. Nearshore sediments in southern Cayuga Lake also contained levels of some heavy metals above thresholds of ecological concern. Based on land use patterns and data from other areas, urban stormwater is the likely source of these heavy metals in Fall Creek. Additional sampling of tributary sediment in subwatersheds and stream reaches with different mixes of land use might help identify factors contributing to the presence and concentration of heavy metals.

- Urban stormwater monitoring

  The quality of urban stormwater has not been assessed in the Cayuga Lake watershed. The concentration of metals, phosphorus, sediment, petroleum compounds, and pathogens in stormwater is not characterized; moreover, the importance of this source in relation to other sources is not known.

- Floodplain delineation, management and mitigation

  Water level management and flooding are important issues. The loss of wetlands and increase in impervious areas have altered the natural hydrology.

- Underground storage tanks

Underground storage tank permit data is provided in Chapter 3. However, additional field work could provide useful information on pre-permit and unpermitted storage sites.

- Junk yards and dumps

  Data is provided in Chapter 3 for known inactive hazardous waste sites and permitted waste sites. However, additional field work would provide useful information on unpermitted waste sites, junk yards and dumps.

- Mines and wells

  Data is provided in Chapter 3 for permitted mines and wells. However, additional field work would provide useful information on unpermitted mines and wells and the status of permitted mines and wells.

- Recreation

  There is a need for better and more accurate recreational data including the impact of boating and fishing on water quality. This could be provided through a recreation inventory.

- Land use

  Development of a high resolution digital land use coverage would lead to a better understanding of the role of nonpoint sources and the impact of land use on the quality of water in the lake and its tributaries.

- Soils

  Development of a high resolution digital soils coverage would lead to a better understanding of the physical nature of the watershed along with the role of nonpoint sources and the impact of land use on the quality of water in the lake and its tributaries.

- The role and status of the quality of groundwater in the watershed.

- Groundwater by usage - number of individuals on private wells, number of individuals using groundwater (and surface water) for irrigation.

- The impact of water quality on economic indicators such as tourism and property tax.

- Source of nonpoint source pollutants

- Seneca-Cayuga Canal

6.2.2 Data Needs: Lake

There are specific areas of research and monitoring where additional information would further characterize the lake's water quality and ecological status. These are noted below.

- Trophic status indicators

  Annual monitoring of a limited suite of limnological parameters will provide a basis for long-term trend analysis. These parameters include total phosphorus, soluble reactive phosphorus, total soluble phosphorus, dissolved oxygen profiles, chlorophyll *a*, Secchi disk transparency, and turbidity. Biological parameters can provide information regarding trends as well.

- Ecological effects of sedimentation

Visual evidence and limited sampling confirm the periodic sediment plumes in southern Cayuga Lake following storms. The ecological effects of high suspended solids carry contaminants and nutrients to the lake. Physical burial of plant and animal habitat is likely. Finally, the importance of sediment-borne phosphorus to Cayuga Lake's trophic status is not well understood. This issue has implications for the relative value of investment in point and nonpoint source reduction.

- Significance of low-level pesticides to human health and lake ecology

  Using analytical methods with low detection limits, investigators from USGS and NYSDEC have documented trace concentrations of pesticides in Cayuga Lake and its tributary streams. The chemicals are present at levels far below ambient water quality standards or guidelines based on toxicology and risk assessment. It is important to continue to track these chemicals in all components of the ecosystem: water column, sediments, and throughout the food web.

- Pathogens and indicator organisms

  Measurements of pathogens and indicator organisms in Cayuga Lake are very limited. Storm event monitoring in the lake and streams could help define the importance of urban runoff as a source of pathogens. The importance of waterfowl as a source of microorganisms is not known.

- The significance of exotic species

  Because of its connections to the Great Lakes through the Seneca River, Cayuga Lake is vulnerable to invasion by nonindigenous species of plants and animals. The impacts on the food web and ecology of the Lake will be an important area of research.

- Water quality modeling

  A mechanistic mathematical model of Cayuga Lake would provide a tool for linking the inputs from the tributaries to the lake's water quality response.

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