

CHAPTER 6: LIMNOLOGY AND WATER QUALITY

B. STREAM WATER QUALITY – SENECA LAKE.

SUMMARY

Stream hydrology and water chemistry data are critical to understand and manage a freshwater resource like Seneca Lake because surface runoff is a major contributor of the nonpoint source pollution to the lake, and nonpoint source pollution is still a major threat to the health of a lake. Here, we report on stream discharge and the following water quality parameters: calcium (hardness), chloride, atrazine (a common herbicide), nutrients (nitrate, phosphate and silica), dissolved oxygen, turbidity, and conductivity, and suggest testable linkages between each parameter and subwatershed areas, agricultural landuse or other factors. We regret that information on additional parameters like heavy metals, polychlorinated organics and other pollutants are not available at the present time. Thus, we strongly recommend a focused effort to better understand the water quality of the streams and creeks in the watershed, and further investigate linkages between the water quality, landuse and other variables in the immediate future.

INTRODUCTION

Freshwater resources have historically played an important role in community development and economic stability. Management of these resources depends largely on identification of both the cause and effect of elements likely to reduce the water quality and economic value of that resource. Besides potential groundwater and atmospheric sources, streams and surface runoff are the major sources of pollutants and contaminants to a lake, especially from nonpoint sources. For example, runoff from agricultural areas typically increases the nutrient load to the lake and promotes the eutrophication of the water body. Here, we report on our, albeit limited, understanding of the hydrology and water quality of the streams that empty into Seneca Lake. The information is based on water quality measurements taken by Hobart and William Smith Colleges in conjunction with Seneca Lake Pure Waters Association, the watershed's local, citizen-based, watchdog group. Additional data was obtained from NYSDEC from their CSLAP monitoring program.

METHODS

The current monitoring program at Hobart and William Smith Colleges utilizes undergraduate students to collect and analyze stream hydrochemical data from selected streams. The current fieldwork routinely samples up to 6 selected streams within the watershed (Wilson, Kashong, Keuka Outlet, Plum Point, Big Stream and Reeder) and 1 stream just on the northeast corner of the watershed (Kendig). Sample sites are typically located near the terminus of each stream, where a road and pertinent landowners provide permission to access the stream (Fi. 6b-1). These 7 streams were selected to assess the impact of agricultural landuse and basin areas on the stream hydrochemistry because they provide a diverse cross-section of these parameters within the watershed. For example, landuse ranges from primarily agricultural to primarily forested land (Wilson vs. Reeder), and basin area ranges from approximately 10 to 100 square kilometers (Reeder vs. Big)

for these 7 streams. Sample dates and stream locations were a function of specific undergraduate classroom and independent study projects over the last 4 to 5 years. Thus, it was not periodic and has not always focused on these 7 streams. No special effort was made to sample major hydrologic events like heavy rainstorms or spring snowmelt as well.

At each site, stream discharge was measured by hand, and water samples were typically analyzed for dissolved oxygen, pH, chloride, alkalinity, hardness, nutrients (nitrates, phosphates, silica), total suspended solids and specific conductance (conductivity normalized to 25°C). The analytical methods follow standard limnological procedures and details are available upon request (Halfman, 1994, Wetzel and Likens, 1991). Water samples were analyzed for atrazine (a common herbicide) during 1999 as well. The atrazine analytical methods are outlined in Halfman et al. (submitted).

RESULTS

The data are summarized in Table 6b-1. Water discharge was plotted versus subwatershed area to investigate the potential relationship (Fig. 6b-2). For each chemical species, the mean concentration was plotted against agricultural landuse to investigate this potential nonpoint source (Figs. 6b-3 through 6b-5). However, please be cautioned that basin area and agricultural landuse are not an exhaustive list of sources. When known, other factors that control the concentration of a given chemical species are discussed but this list is not exhaustive. Additional caution is required when interpreting these plots because mean values remove the natural variability in the data.

Table 6B-1. Mean, maximum and minimum water quality values for selected parameters collected by Hobart and William Smith Colleges over the past 5 years from selected streams within or near the Seneca Lake Watershed.

	Big Stream	Kashong Creek	Keuka Outlet	Plum Pt. Creek	Wilson Creek	Re
Subwatershed Area (km²)	96	81	80	15	47	
Agricultural Landuse (%)	53	83	41	53	79	
Calcium (ppm, Ca)						
Average All Data	67	Count All Data	101			
Mean	43	81	43	54	94	
Max	97	120	70	96	120	
Min	21	58	29	37	58	
count	19	22	19	11	18	
Nitrate (ppm, N)						
Average All Data	0.38	Count All Data	119			
Mean	0.11	0.63	0.37	0.32	0.33	
Max	0.29	4.18	1.47	1.06	0.90	
Min	0.03	0.06	0.03	0.06	0.07	
count	18	34	24	13	18	
Phosphate (ppb, P)						
Average All Data	21.1	Count All Data	90			
Mean	6.3	27.2	34.5	11.5	20.7	
Max	37.0	252.2	262.5	23.7	107.7	
Min	0.3	0.0	0.0	5.4	1.2	
count	13	25	18	6	16	
Silica (ppb, Si)						
Average All Data	1284	Count All Data	72			
Mean	50	1835	853	1722	1347	
Max	100	2889	2809	2477	3198	
Min	15	576	119	666	586	
count	8	16	12	8	16	
Atrazine (ppb)						
Average All Data	0.17	Count All Data	52			
Mean	0.06	0.11	0.13	-	0.25	
Max	0.08	0.18	0.42	-	0.44	
Min	0.05	0.05	0.05	-	0.09	
count	6	7	7		10	
Dissolved Oxygen (ppm)						
Average All Data	11.4	Count All	113			
Mean	11.7	11.9	11.3	10.2	11.5	
Max	15.0	15.0	15.8	12.2	21.7	
Min	6.2	7.4	5.7	8.5	6.1	
count	15	28	26	8	12	
Chloride (ppm)						
Average All Data	53	Count All	150			
Mean	59	54	42	63	60	

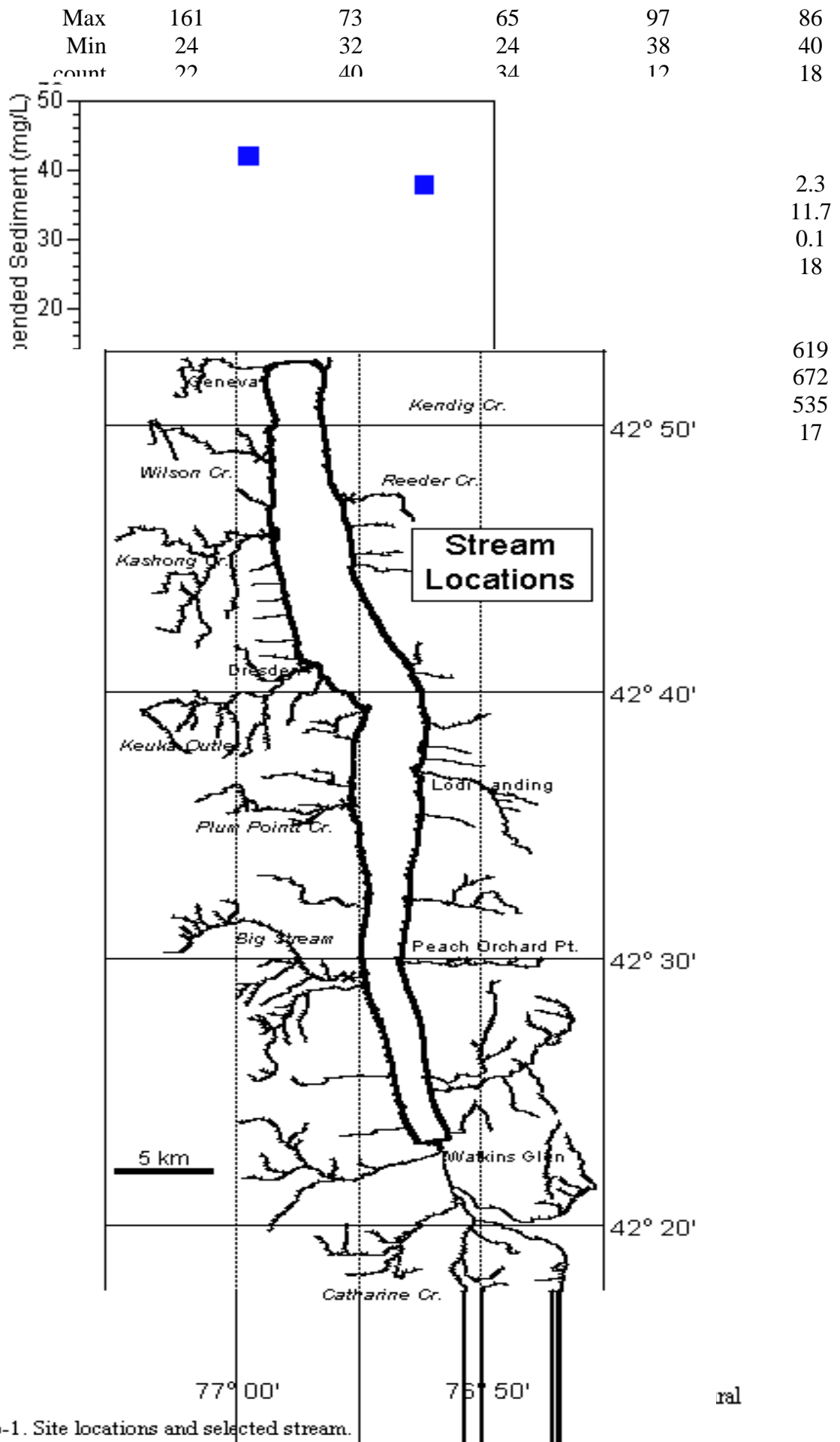


Figure 6b-1. Site locations and selected stream.

Water Discharge

Mean discharge for the 7 selected streams range from a low of 0.1 to a high of 3.2 m³/s. The 3.2 value is significantly higher than the other creeks sampled (Fig. 6b-2). The next highest mean discharge is 0.9 m³/s. If the 3.2 value is excluded, then mean discharge is roughly proportional to basin area, as expected. The trend is similar to the linear relationship between mean daily discharge and basin area for the USGS gauged stream data from central New York State. The 3.2 value is from the Keuka Outlet. If its subwatershed area includes the Keuka Lake Watershed as well as the “traditional” portion of the subwatershed from the Keuka Lake Outlet to Seneca Lake (as indicated in an earlier chapter of this report), then its discharge is more consistent with the proportional trend.

Spring snowmelt, major precipitation events, and longer-term climatic cycles clearly influence the discharge. The streams in this watershed are typically flashy, and most streams are high during snowmelt and progressively lower to dry or ephemeral conditions by the middle or end of summer. In 1999, low flow or ephemeral conditions were intensified by the late spring / early summer drought. Discharge in the Keuka Outlet is significantly influenced by the dam at the Keuka Lake Outlet in Penn Yan.

Discharge is essential to calculate the load (quantity per unit time) of any chemical parameter to the lake because the load is proportional to both stream discharge and its concentration. However, only concentration data are provided below. This caution is mentioned because a large concentration may not provide a large load to the lake, if the stream discharge is correspondingly small. Chemical loads were not calculated here because not enough data are available from major hydrologic events like the spring snowmelt and heavy rainstorms, presumably when the majority of the chemical is flushed into the lake. Both discharge and concentration typically increase during these events. However, basin average stream concentrations are useful to compare to lake concentrations because both values should be similar in this watershed at equilibrium conditions. Dissimilar concentrations indicate additional sources or sinks for the system. For example, smaller stream than lake concentrations indicates another source for the substance to the lake. For example, chloride enters the lake from stream and groundwater sources (Chapter 6a). Other potential sources include the atmosphere, biogeochemical processes and anthropogenic modifications. Larger stream than lake concentrations flags an important removal process from the water column. For example, algal remove nutrients from the water column of the lake. Alternatively, equilibrium conditions may not yet be established for this substance in the lake as well.

Chloride, Hardness, and Atrazine Concentrations

Mean chloride concentrations for the 7 selected streams average 53 ppm and range from a low 42 to a high of 63 ppm (Fig. 6b-3) and are very similar to the chloride data presented by Wing et al (1995). No relationship is observed between chloride concentrations and subwatershed or agricultural landuse area. Not enough data are available to suggest more chloride enters the lake by runoff from road salt application, except that Wing noted higher chloride concentrations during the winter in Wilson Creek. Chloride

concentrations in the streams are much lower than the lake concentrations. The difference supports Wing's conclusion that chloride also enters the lake from the lake floor (see discussion in Chapter 6a).

Mean calcium concentrations (hardness) for the 7 selected streams average 67 ppm and range from a low of 44 to a high of 94 ppm. The concentrations are higher during the spring snowmelt and precipitation events (Fig. 6b-3). No relationship is observed between hardness and subwatershed size but a positive relationship is observed between hardness and agricultural landuse in the subwatershed, except for Reeder Creek. However, inspection of the stream locations suggests that the higher hardness values are detected in streams underlain by calcium rich soils, glacial tills and limestone bedrock which are more prevalent in the northern part of the Seneca Lake Watershed. Halfman et al (submitted) suggested the latter scenario is the underlying factor that controls the concentration of calcium in streams and perhaps the limey soils control the location of better farmland but clearly more work is required to resolve this source issue.

Calcium stream concentration are larger than the average lake concentration (40 ppm). The difference probably reflects the amount of calcium removed from the water column by the authigenic precipitation of a fine-grained calcite and the incorporation of calcium into the shells of zebra mussels. Halfman et al. (submitted) estimated that over 4,000 metric tonnes of calcium are deposited on the lake floor each year by these two processes.

Mean atrazine concentrations for the 7 selected streams average 0.17 ppb and range from a low of 0.06 to a high of 0.29 ppb (Fig. 6b-4). Atrazine is a common herbicide used to control broad leaf weeds in corn and other common crops. These concentrations are significantly below the maximum contaminant levels (MCLs) of 3.0 ppb established by the EPA. Agricultural landuse is proportional to atrazine concentrations in this watershed (except for Kashong Creek and Big Stream), and atrazine concentrations increase significantly during the mid-summer months within the agricultural streams after the application of the herbicide (Phillips et al., 1998, Halfman et al., submitted). The landuse connection and temporal correlation indicates a clear link between the runoff from agricultural areas and the delivery of atrazine to the lake. The notable exception is Kashong Creek, where the atrazine concentration is below the proportional trend. However, Kashong Creek was dry before the application of the herbicide thus landuse activities did not impact this creek. The atrazine concentrations in the lake are similar to or slightly smaller than the stream concentrations. It suggests that the larger mid-summer concentrations were balanced by smaller mid-summer stream discharges to provide a constant input of atrazine to the lake throughout the year.

Nutrient Concentrations

Mean nitrate, soluble reactive phosphate and soluble reactive silica concentrations from the 7 selected streams average 380, 21, 1284 ppb, and range from a low of 110, 6.3 and 50 ppb to a high of 630, 20.7, and 1835 ppb, respectively (Fig. 6b-4). The values are larger during extreme hydrologic events, especially snowmelt, and after the application of fertilizer on agricultural areas. For example, the few phosphate concentrations that exceeded 100 ppb occurred during major snowmelt events. No relationship is observed

between the nutrient concentrations and subwatershed area. Surprisingly minimal relationships are observed between agricultural landuse and nutrient concentrations. This minimal correlation is not consistent with that used by the landuse modeling in another chapter of this report. Perhaps a more consistent landuse linkage will be observed when detailed hydrologic event sampling is incorporated in this analysis because major hydrologic events contribute the largest loads of many chemical parameters, like nutrients. This event / loading relationship was observed earlier this decade in Kendig Creek (Makarewicz et al., 1996). Other factors may control the concentration of nutrients in streams and include, for example, the quantity and quality of wastewater treatment facilities and septic systems or wetlands in the subwatershed.

Nutrient concentrations in the streams are larger than the lake concentrations. It reflects the biological uptake of the nutrients delivered to the lake. It also reflects the importance of managing nutrient loads to the lake, because increased nutrient loads results in increased biological growth and eutrophication of the lake. Makarewicz et al. (1996) indicate that the nutrient loading by Kendig Creek is similar in magnitude to nutrient loading in severely impacted streams near Rochester, New York (Irondequoit Creek at Browncroft Blvd.). Nutrient loads (concentration times discharge) are similar in magnitude in the other sampled creeks. It suggests that nutrient runoff significantly impacts the water quality of the streams in the Seneca Lake Watershed.

Other Parameters

Mean total suspended sediment (TSS) concentrations, dissolved oxygen (DO) concentrations and specific conductance data from the 7 selected streams average 19 mg/L, 11.4 ppm and 487 mhos/cm, and range from a low of 1.4, 10.1, and 394 to a high of 42, 11.9, and 619, respectively (Fig. 6b-5). None of these parameters reveal basin area or landuse correlations. The larger TSS and conductance values occur during significant hydrologic events. The increase in TSS values is at least an order of magnitude. The dissolved oxygen values are always saturated or nearly saturated. Saturated values suggest that the Biological Oxygen Demand from bacteria and other respiratory needs is minimal in these streams and / or these streams are shallow or turbid enough to promote rapid transfer of oxygen from the atmosphere to the water.

Other Information

The Priorities Waterbodies List (PWL, 1996) indicates that segments of Catherine Creek, Upper Dam Lake, Sugar Creek, Punch Bowl Lake, Kashong Creek, Keuka Lake Outlet and Hector Falls Creek are stressed or threatened by agricultural activities, gravel removal, failing septic systems, stream bank erosion, roadbank erosion, urban runoff, landfills, onsite systems, and industrial wastes but minimal documentation exists to confirm these findings (Table 6b-2). The report states excessive nutrients and sediments restrict recreational use of the watershed in general. The primary water quality concerns in the Keuka Outlet Watershed involve the lake fishery. A health advisory for Keuka Lake recommends eating no more than one meal per month of larger lake trout (over 25 inches) due to DDT contamination. Additionally, elevated temperatures in the outlet during the summer cannot sustain lake trout populations although other trout species are

surviving in the stream. Iron, lead, mercury, pH, chloroform and total coliform were parameters of concern in the water column of Keuka Outlet but metals were not a concern in the bottom sediments and macroinvertebrate kick samples indicated only a slightly impacted community presumably from nonpoint source enrichment. Clearly, more work is required to resolve the state-of-the-streams in the Seneca Lake Watershed. Minimal information is available on heavy metal and other pollutant concentrations in the streams of this watershed.

CONCLUSIONS

Bedrock and agriculture controls the water quality of the streams within the Seneca Lake Watershed. For example, calcium and atrazine concentrations appear to reflect nonpoint sources, specifically bedrock composition and agricultural landuse practices, respectively. Other factors are probably important as well but insufficient data precludes a complete analysis. Caution is advised when analyzing this data because the data are limited, not systematically gathered and do not focus on hydrologic events like spring snowmelt and summer rainstorms that have been shown to dominate the load of various parameters to the lake. Clearly, more work is required to substantiate these claims and investigate the likelihood of additional pollutants.

Table 6B.2. The Priority Waterbodies List for Seneca Lake and its Tributaries.

Name	Resolution	Stream	Use	Severity	Documentation	Type of	Source(s) of	Segment	Description	County
	Potential	Class	Impairment(s)			Pollutant(s)	Pollutant(s)	Size		
Catharine Creek	Medium	C(TS)	Fish Propagation*	Threatened	Some	Nutrients*	On-site Systems*	6.0 miles	Pine Valley to Schuyler Co line	Chumung
			Fish Survival	Threatened	Some	Silt (Sediment)	Agriculture			
			Aesthetics	Threatened	Some	Thermal Changes	Streambank Erosion			
	Medium	C	Fish Propagation	Stressed	Poor	Silt (Sediment)*	Agriculture*	8.5 miles	Chumung County line to Lake	Schuyler
			Fish Survival	Stressed	Poor	Oxygen Demand	Streambank Erosion			
			Boating*	Stressed	Some	Pesticides	Silviculture			
						Nutrients	Roadbank Erosion			
							Land Disposal			
Kashong Creek	Medium	C<D	Fish Propagation*	Stressed	Some	Silt (Sediment)*	Agriculture*	4.5 miles	Yates County line to Seneca Lake	Ontario
			Fish Survival	Stressed	Some	Pesticides	Streambank Erosion			
						Nutrients	Roadbank Erosion			
	Medium	C>D	Fish Propagation*	Stressed	Some	Silt (Sediment)*	Agriculture*	2.0 miles	Headwaters to Ontario County line	Yates
			Fish Survival	Stressed	Some	Pesticides	Streambank Erosion			
						Nutrients	Roadbank Erosion			
Keuka Lake Outlet	Medium	C(T)	Fish Survival*	Impaired	Some	Thermal*	Hydrologic modification*	7.0 miles	From Keuka Lake to Seneca Lake	Yates
						Unknown Toxicity	Agriculture			
						Silt (Sediment)	Land Disposal			

Seneca Lake/Tribs	Medium	A	Water Supply*	Stressed	Some	Salts*	Industrial*		Tribs flowing into Seneca Lake	Ontario
			Fish Propagation	Threatened	Poor	Silt (Sediment)	On-Site Systems			
						Oxygen Demand	Other (Natural Salt Deposits)			
						Nutrients	Agriculture			
						Pathogens	Roadbank Erosion			
						Pesticides	Urban Runoff			
Seneca Lake	Medium	A	Water Supply*	Threatened	Poor	Salts*	Industrial*	7136.0 acres	Entire Lake within County	Schuyler
			Fish Propagation	Threatened	Poor	Silt (Sediment)	Silviculture			
						Pesticides	Roadbank Erosion			
						Oxygen Demand	Other (Natural Salt Deposits)			
						Nutrients	Contaminated Sediment			
						Pathogens	De-icing Agents			
							Agriculture			
							Streambank Erosion			
	Medium	A	Water Supply*	Stressed	Some	Salts*	Industrial*	23819.0 acres	Entire Lake within County	Seneca
			Fish Propagation	Threatened	Poor	Silt (Sediment)	Land Disposal			
			Aesthetics	Stressed	Some	Pesticides	Other (Natural Salt Deposits)			
						Pathogens	Contaminated Sediment			
						Nutrients	On-Site Systems			
							Agriculture			
							Roadbank Erosion			
	Medium	A	Water Supply*	Stressed	Some	Salts*	Industrial*	12193.0 acres	West side of lake within Yates County	Yates

			Fish Propagation	Threatened	Poor	Nutrients	Roadbank Erosion			
						Pesticides	Other (Natural Salt Deposits)			
						Silt (Sediment)	Contaminated Sediment			
						Priority Organics	Agriculture			
Hector Falls Creek	Medium	C(T)	Fish Propagation*	Stressed	Poor	Unknown Toxicity*	Land Disposal*	2.0 miles	Segment approximately 2 miles upstream of County Route 4 & Route 79	Schuyler
			Fish Survival	Stressed	Poor	Nutrients	Agriculture			
			Aesthetics	Stressed	Poor	Silt (Sediment)				
Punch Bowl Lake	Medium	B	Bathing*	Stressed	Some	Silt (Sediment)*	Streambank Erosion*	13.0 acres	Entire Lake	Schuyler
			Fish Survival	Stressed	Some	Nutrients	Agriculture			
			Aesthetics	Stressed	Some	Oxygen Demand				
			Boating	Stressed	Some					
Upper Dam Lake	Medium	B	Bathing*	Stressed	Some	Silt (Sediment)*	Streambank Erosion*	2.0 acres	Entire Lake	Schuyler
			Fish Survival	Stressed	Some	Nutrients	Agriculture			
			Aesthetics	Stressed	Some	Oxygen Demand				
			Boating	Stressed	Some					
Whites Hollow Lake	Medium	B	Bathing*	Stressed	Some	Silt (Sediment)*	Streambank Erosion*	13.0 acres	Entire Lake	Schuyler
			Fish Survival	Stressed	Some	Nutrients	Agriculture			
			Aesthetics	Stressed	Some	Oxygen Demand				
			Boating	Stressed	Some					
*Primary Use Impairment/Pollutant/Source										
Source: Adapted from The 1996 Priority Waterbodies List for the Oswego-Seneca-Oneida River Basin, NYSDEC, September 1996										