New York State
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Water

Streams Tributary to Onondaga Lake

Biological Assessment

2008 Survey

New York State
Department of Environmental Conservation

BIOLOGICAL STREAM ASSESSMENT

Streams Tributary to Onondaga Lake
Onondaga County, New York
Seneca-Oneida-Oswego River Basin

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Streams: Onondaga Creek, Sawmill Creek, Ninemile Creek, Ley Creek, Harbor Brook, Geddes Brook, and Bloody Brook

River Basin: Seneca-Oneida-Oswego

Reach: Multiple, in the vicinity of Syracuse, NY

Background

The Stream Biomonitoring Unit (SBU) sampled seven streams tributary to Onondaga Lake, Onondaga County, New York, on June 24 - 26, 2008. Sampling was conducted to assess current water quality conditions and compare findings to historical surveys, documenting changes in water quality.

To characterize water quality based on benthic macroinvertebrate communities, either a traveling-kick or net-jab sample was collected, depending on habitat, at each of fourteen sites on seven streams (Onondaga Creek, Sawmill Creek, Ninemile Creek, Ley Creek, Harbor Brook, Geddes Brook, and Bloody Brook). Methods used are described in the Quality Assurance Work Plan for Biological Stream Monitoring in New York State (Bode et al. 2002) and summarized in Appendix I. Each sample was field-inspected to determine major groups of organisms present, and then preserved in alcohol for laboratory inspection of 100-specimen subsamples from each site.

Macroinvertebrate community parameters used to determine water quality included: species richness, biotic index, EPT richness, and, for traveling-kick samples, percent model affinity. The parameter non-Chironomidae/Oligochaete richness replaced percent model affinity for net-jab samples (see Appendices II and III). The expected variability of results is stated in Smith and Bode 2004. Table 1 provides a listing of sampling sites, and Tables 4a - 4n provide a listing of all species collected at each sampling location in the present survey. This is followed by field and laboratory data summaries, including raw data from each site.

Results and Conclusions

1. Water quality in streams tributary to Onondaga Lake ranged from slightly impacted to moderately impacted; historical sources of pollution still affect the biological community.

2. In Onondaga Creek, water quality is affected by nutrients, siltation from the Tully Valley Mud Boils, and urban runoff, including sewage.

3. Water quality in the remaining tributaries reflects the urban nature of the drainages. Sources of impact are likely a complex mixture of urban runoff, including municipal and industrial sources. Some improvements in water quality were noted compared to historical surveys.

Discussion

Pollution in streams tributary to Onondaga Lake, Syracuse, NY, and its effects on lake water quality, have long been of concern to the New York State Department of Environmental Conservation (NYSDEC) Division of Water (Cooper et al. 1974, Simpson 1981, Bode et al. 1989, Bode et al. 2004, Mueller and Estabrooks 2006). Currently, several portions of Onondaga Lake tributaries–Ley Creek, Geddes Brook, Ninemile Creek, and Harbor Brook–are listed as Superfund sites in a 2005 Record of Decision (ROD) published by NYSDEC and the United States Environmental Protection Agency (USEPA). The ROD outlines specific plans for cleanup of Superfund sites in and around the lake (NYSDEC 2005a; NYSDEC 2005b). These plans are designed to reduce or eliminate exposure to chemicals in the lake, such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and mercury, many of which originate in its tributaries (NYSDEC 2005b). In addition to NYSDEC and USEPA, many other organizations are working to improve water-quality conditions throughout the Onondaga Lake watershed, and cleanup efforts continue to be highly visible.

This biological survey was conducted to assess current water-quality conditions and compare them to historical NYSDEC surveys (Cooper et al. 1974, Simpson 1981, Bode et al. 1989, Bode et al. 2004), documenting any changes in water quality. In addition, the data collected will provide a baseline of comparison to conditions that exist after remedial actions are carried out by NYSDEC and its partners.

Unlike historical surveys, this survey collected net-jab samples at stream locations with habitat that was unsuitable for collecting kick samples. In order to properly analyze benthic macroinvertebrate communities, the sample collection method, water-quality metrics and water-quality scales used in sample analysis should be specific to the dominant stream habitat. Kick samples should only be collected from riffle habitats. In slow sandy streams, where riffle habitats do not exist, invertebrate fauna are different from those in riffles. As a result, using measures applicable to riffles will often reduce the accuracy of a water-quality analysis on a sample from a slow sandy stream.

Therefore, at streams where current was slow and substrates were primarily sand, silt and clay, a net jab was used for the collection of invertebrates, and "sandy streams" water-quality criteria were applied (Appendix XIII). Community metrics and water-quality scales applied differ from those used to analyze riffle habitats, resulting in more appropriate and realistic community and water-quality assessment information.

This change in sampling and assessment methods was applied to samples collected at Ninemile Creek Station 02, Geddes Brook Station 01, Ley Creek Station 02, Harbor Brook Station 02, and Bloody Brook Station 06.

Onondaga Creek

Onondaga Creek is one of the largest tributaries to Onondaga Lake. At approximately 285 km^2 in drainage area, it flows 48 km northwest from the Tully Valley until it reaches Onondaga Lake in the City of Syracuse. It enters Onondaga Lake at the southeastern end via a channelized canal. Although Onondaga Creek flows directly through Syracuse 54% of its watershed area is forested. Water quality in the lower and middle reaches, including minor tributaries of the stream (mouth to Nedrow, NY) are impaired by combined sewer overflows (CSOs), urban runoff, and past industrial operations (NYSDEC 2008). Upstream of Nedrow, water quality in Onondaga Creek and its tributaries are only slightly impacted. In this reach, silt/sediment loads and high specific conductance from mud boils and historical salt-brine mining operations contribute to water-quality impacts (NYSDEC 2008).

Remediation plans for impaired segments of Onondaga Creek are being implemented or are currently in development. NYSDEC has issued consent orders with Onondaga County and other municipalities to address the impact of CSOs and to clean up hazardous waste sites, among other restoration projects. Impacts from mud boils and salt mining are being addressed by the NYS Attorney General, as well as actions taken by the United States Geological Survey (USGS) and the Onondaga Lake Partnership (OLP) (NYSDEC 2008).

The SBU first surveyed the stream at four sites in 1981 to investigate turbidity problems in its upper reaches near Tully, NY. The source of the turbidity was known to be a "mud vent," currently known as the Tully Mud Boils, which release highly turbid groundwater into the stream. The Tully Mud Boils were first observed during the late 1890s, the result of artesian pressure moving water and sediment to the surface from below ground aquifers laden with silt and clay (USGS 1998).

Some have speculated that solution mining for salt in the area has exacerbated the activity of the mud boils (OLP 2010). Although the mud boils are a significant source of suspended sediment to Onondaga Creek, invertebrate fauna downstream from them was not severely altered (Simpson 1981). Three of the sites sampled in 1981 were repeated in 2008; stations 01 (Tully Farms), 02 (Tully Valley), and 03 (Cardiff) (Figures 1a, 1b, and 1d).

Two of the sites sampled in 1989 were repeated in 2008; stations 02B (Cardiff) and 05 (Syracuse) (Figures 1c and 1f). Water quality was assessed as slightly impacted at Station 02B and severely impacted at Station 05 in 1989 (Bode et al. 1989). During the 1989 survey, impacts were attributed to sedimentation from the mud boils at Station 02B and sewage effluent at Station 05.

Sampling was also conducted at stations 02B and 05 in 1990, 1995 and 2001 as part of the NYSDEC Rotating Integrated Basin Studies program (RIBS) (Bode et al. 2004). Results indicated a decline in 2001 at Station 02B (moderately impacted) compared to 1990 and 1995 (slightly impacted). Water quality continued to be assessed as severely impacted (1990, 1995, and 2001) at Station 05. Based on historical descriptions, present day sources of impact appear consistent with the 1989 survey.

At the six stations surveyed in 2008 (Table 1, Figures 1 and 1a-f), water quality ranged from slightly impacted to moderately impacted (Figure 3). Upstream of the mud boils at stations 01 and 02 water quality was assessed as slightly impacted. Both samples were dominated by facultative taxa indicative of nutrient enrichment such as the riffle beetle, *Optioservus fastiditus* (Tables 4a and 4b).

Water quality at Station 02B downstream of the mud boils was assessed as moderately impacted. This is consistent with the last 2001 RIBS survey (Figure 3). Sedimentation and high specific conductance as a result of the turbid groundwater discharges remain the source of impact as indicated by an impact source determination (ISD) analysis (Table 3).

Substrate characterization conducted on the day of the survey showed an increase from upstream sites in the percentage of silt at Station 02B (Figure 4), as well as in substrate embeddedness (Table 2). The embeddedness results indicate a loss of important habitat for colonization of the invertebrate community at this site. Increased sedimentation embeds and covers coarse substrates essential to the survival and reproduction of many aquatic organisms (Berkman and Rabeni 1987, Vondracek et al. 2005, Asmus et al. 2009) and can decrease macroinvertebrate density (Lenat et al. 1981, Asmus et al. 2009).

In addition to increased sediment, specific conductance shows a dramatic increase from 492 μmhos/cm at Station 01 to 1,619 μmhos/cm at Station 02B (Table 2). Data from throughout New York State suggests biological communities begin to show detrimental impacts when specific conductance exceeds 800 μmhos/cm (Appendix XII). Specific conductance at every site below the mud boils was twice this amount, some of which may be related to the natural composition of upwelling groundwater (Table 2).

Water-quality conditions at Cardiff (Station 03) improved to slightly impacted, which was likely the result of several factors. Substrate composition continued to show signs of siltation but larger rock material was also present. Embeddedness decreased, meaning some habitat was regained. In addition, field notes suggest improved water clarity as several tributaries combine with the creek between stations 02B and 03. The added volume of water from the tributaries combined with the larger substrate material may reduce the overall effect of sedimentation.

Downstream of Cardiff, Onondaga Creek enters the City of Syracuse where it is heavily channelized and receives input from CSOs and other discharges. Water quality in Syracuse (stations 04 and 05) was assessed as moderately impacted (Figure 3). ISD continues to suggest siltation as a source of impairment at Station 04 and identifies complex, municipal/industrial wastes as the source of impairment at Station 05 (Table 3).

Although both sites were assessed as moderately impacted, there is a dramatic difference in the composition of their invertebrate communities (Tables 4e and 4f). Station 04 is dominated by the facultative riffle beetle *Stenelmis crenata*, filter feeding caddisflies (Hydropsychidae), and the midge *Polypedilum flavum*. Riffle beetles and caddisflies are absent from Station 05, and the community is made up of highly tolerant oligochaetes (*Nais communis*, Enchytraeidae, and *Limnodrilus hoffmeisteri*), and a midge (*Cricotopus bicinctus*) indicative of toxic effluents contamination.

The dominance of the oligochaete taxa indicates the presence of organic wastes in the stream (Simpson 1981) and is consistent with 1989, 1990, 1995 and 2001 results (Bode et al. 1989, Bode et al. 2004). The source of organic wastes is likely the combined presence of a heavily urbanized area and the multiple combined sewer basins that discharge to the stream. Containment of these CSOs is underway to reduce their influence on the lower reaches of Onondaga Creek and Onondaga Lake.

Sawmill Creek

Sawmill Creek is a small tributary to Onondaga Lake with a drainage area of 6.9 km^2. It enters the lake at the northern end near the western edge of Liverpool, NY and just east of the Seneca River (Figure 2). Approximately 45 percent of the Sawmill Creek drainage is classified as developed. The sampling location in Liverpool (Station 01), has remained the same since the 1980s (Table 1, Figures 2 and 2a). This site was assessed as moderately impacted in 1989, 1995 and 2001 (Bode et al. 1989, Bode et al. 2004). Suspected sources of impairment are CSO and other sewer discharges, industrial activities and urban runoff. Various remediation activities to address these discharges are underway (NYSDEC 2008).

During the current survey, the biological community was again assessed as moderately impacted (Figure 3). Although some improvements were noted in several of the individual community metric scores and the overall water-quality score (Figure 3), the taxa dominating the sample showed little difference from1989. The community still contained high numbers of pollution tolerant sow bugs (*Caecidotea racovitzai*) and scuds (*Gammarus sp.*), and was dominated by the riffle beetle *Stenelmis crenata*. ISD again pointed to toxic and industrial wastes, along with sewage as the sources of impact (Table 3).

Ninemile Creek

Ninemile Creek is the largest tributary to Onondaga Lake with an approximate drainage area of 503 km^2. It enters the lake from the west after it is joined by Geddes Brook, and flows past the New York State Fairgrounds near Lakeland/Solvay, NY (Figure 2). Although it is close to Syracuse, a considerable amount (45 percent) of the land area within the Ninemile Creek watershed is forested. The stream is the outlet of Otisco Lake, which has only minor impacts due to increased nutrients (NYSDEC 2008).

A biological assessment of Ninemile Creek from Otisco Lake to Onondaga Lake was conducted by the NYSDEC Avon Pollution Investigation Unit in July, 1974 (Cooper et al. 1974). In this study, water quality was determined to range from “good” to “moderately” impacted, equivalent to what the SBU now refers to as slightly too severely impacted. Two stations were in the same approximate locations as the sites sampled in 2008, Station 01 (Cooper et al. 1974, Station 07) and Station 02 (Cooper et al. 1974, Station 09). Water quality in 1974 at these two sites was slightly impacted (Station 01) and severely impacted (Station 02). At Station 02, there was only one organism observed in the sample due to pollution from the Solvay Plant of Allied Chemical Co. (Cooper et al. 1974).

Two sites on Ninemile Creek were sampled during the 2008 survey, one upstream in the Town of Amboy (Station 01), and one downstream near Lakeland/Solvay (Station 02) (Table 1) (Figures 2 and 2b). Both sites are located in the lower reach of Ninemile Creek listed as an impaired segment by NYSDEC due to CSOs, urban runoff, and industrial activities (NYSDEC 2008).

Water quality was assessed as slightly impacted at Station 01 and moderately impacted at Station 02. Current assessments suggest considerable improvement in water quality conditions at Station 01 compared to sampling conducted in 1989 when the site was assessed as severely impacted (Bode et al. 1989, Bode et al. 2004). The invertebrate community at this site was diverse with 28 different taxa present, although most were facultative. *Gammarus* sp. was present in high numbers, suggesting a stressed community with high specific conductance. However, several species of mayfly were present, along with various net-spinning caddisfly taxa (Table 4h).

Results at Station 02 suggest moderate water-quality impact. Previously, this site was assessed as severely impacted in 1989, 1990, 1995 and 2001 (Bode et al. 1989, Bode et al. 2004) (Figure 3). Some of the improvement over previous years may be attributable to the difference in sampling methods and the application of sandy streams assessment criteria as discussed earlier (Appendix XIII). Using the ISD method, complex municipal/industrial wastes were identified as the likely source of contaminants (Table 3). The invertebrate community was limited and dominated by tolerant organisms such as oligochaetes in the family Tubificidae, *C. racovitzai* and the *Gammarus* sp., all of which indicate the presence of polluted runoff and organic wastes.

Geddes Brook

Geddes Brook is a small tributary (27.9 km^2) to Ninemile Creek that originates in the area of Fairmount, NY, joining Ninemile Creek just west of the NYS Fairgrounds. Thirty-four percent of the watershed area is considered urban. Historical surveys of this site indicated moderately (1989) and slightly (2001 and 2006) impacted water quality (Bode et al. 1989, Bode et al. 2004). Using sandy streams assessment criteria during the present survey, instead of riffle streams assessment criteria as in previous surveys, slightly impacted water quality was found.

Species data shows that a shift in the dominant macroinvertebrate taxa within the community has occurred since 1989, suggesting improvements to water quality. In 1989, the macroinvertebrate community was dominated by pollution-tolerant oligochaetes *Nais elinguis* and undetermined enchytraeids, along with the sowbug *Caecidotea. racovitzai* (Bode et al. 1989). Current data suggests the community is now dominated by various species of Chironomidae, freshwater scuds, mayflies and caddisflies. Similar communities were noted in

2001 and 2006. Even though water quality at this site has improved since 1989, problems still exist.

Ley Creek

Ley Creek is a large tributary to Onondaga Lake draining about 79 km^2 of land in northern Syracuse. It enters Onondaga Lake at the south end just north of Onondaga Creek (Figure 2). More than half (57%) of its drainage area is classified as developed. The two sites that were sampled (stations 01 and 02) in 2008 corresponded with historical sampling locations (Figure 2c).

The upstream site, Station 01 in Mattydale, was surveyed in 1989 (Bode et al. 1989), 1990, 1995, 2001, (Bode et al. 2004) 2006 and 2007. Water-quality assessments from these surveys ranged from severely impacted in 1989 and 1990 to moderately impacted in 1995, 2001, 2006 and 2007.

Surveys at the downstream site, Station 02 in Syracuse, were conducted in 1989 (Bode et al. 1989), 1990, 2001 (Bode et al. 2004), and 2007. Water quality has consistently been assessed as severely impacted at Station 02 (Figure 3).

Results from the 2008 sampling of Station 01 in Mattydale suggest that moderately impacted conditions persist (Figure 3). An ISD analysis identified siltation as the major source of impact to this site. A mixture of urban pollutant sources including municipal/industrial wastes, toxics and sewage, are the underlying problems (Table 3). The entire stream and its tributaries are currently listed as impaired due to CSOs, urban runoff, industrial activities, and runoff from the Syracuse International Airport and a municipal landfill (NYSDEC 2008). These sources of pollutants are reflected in the condition of the aquatic community.

In 1989, the macroinvertebrate community at Station 01 was limited and dominated by the sowbug *Caecidotea racovitzai* (84%). Mayflies, stoneflies, and caddisflies were absent. By 2008 the community had dramatically shifted to one dominated by various species of Chironomidae and several species of caddisflies (Table 4j). The presence of caddisflies signifies major improvement, but water quality is still substantially altered from its natural condition.

Sampling at Station 02 in 2008 was conducted using sandy streams criteria and suggests moderately impacted water quality as well. The invertebrate community in 1989 was dominated by *L. hoffmeisteri* (67%). This species still dominates the community today, although in less abundance (Table 4k).

Due to the lack of any major shift in the invertebrate community in the current survey compared to historical data, the apparent improvement in the assessment at this site is likely due to the use of sandy streams instead of riffle streams criteria in the assessment methods. An ISD analysis indicates impoundment effects influencing the invertebrate community (Table 3). This is likely the result of the slow moving, pooling characteristics of this reach of the stream.

Harbor Brook

Harbor Brook enters Onondaga Lake at its southern end, just south of Onondaga Creek in the area of Solvay, NY (Figure 2). Harbor Brook is the fourth largest tributary to Onondaga Lake (35 km^2). The section of stream surveyed is currently listed as impaired due to CSOs, urban runoff, and industrial activities (NYSDEC 2008). Remediation activities are underway to alleviate many of the sources of impact, including work on CSOs and cleanup of contaminated waste sites (NYSDEC 2008).

One site in Syracuse (Station 02) was sampled during this survey (Figure 2d). This location was also sampled in 1989 (Bode et al. 1989), 1995 and 2001 (Bode et al. 2004). Water quality has been assessed either as severely or moderately impacted in the past, although the change in invertebrate community structure was small. Results from the 2008 sampling using sandy streams criteria indicate moderately impacted conditions (Figure 3). An ISD analysis indicated sewage as the source of impact to the biological community (Table 3). The invertebrate community was dominated by the worm, *Limnodrilus hoffmeisteri* and appeared similar to the community present in 1989 (Table 4l).

Bloody Brook

Bloody Brook is one of the smallest tributaries to Onondaga Lake with a drainage area of about 9 km^2. It enters Onondaga Lake from the east, near Liverpool, NY (Figure 2). Its watershed is approximately 70% urban. The entire stream and its tributaries are impaired due to pathogens and other pollutants from urban runoff and historical industrial uses (NYSDEC 2008).

Historical surveys at this site in 1989 (Bode et al. 1989), 1994, 1995, 2001(Bode et al. 2004), and 2006 indicated moderately impacted water quality. Municipal/industrial and urban runoff were consistently identified as the sources of impact in these surveys.

Results of the current water-quality assessment using sandy streams criteria indicate moderately impacted conditions (Figure 3). An ISD analysis was inconclusive, but suggests sewage and municipal/industrial pollutants as the sources of impact (Table 3). The invertebrate community was similar to previous years, dominated by facultative to tolerant Chironomidae and freshwater scuds. Poor riffle habitat, channelization and general physical stream-habitat alteration are a concern on this stream and likely negatively affect the invertebrate community.

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Table 1. Station Locations, streams tributary to Onondaga Lake, Onondaga County, NY, 2008. Site photographs, if available, follow each description.

Station	Location
ONON-01	Tully Farms
Onondaga Creek	Tully Farms Road crossing
	Latitude: 42.82478
	Longitude: -76.14327

ONON-02	Tully Valley
Onondaga Creek	Immediately upstream of mud boils at Otisco Road
	Latitude: 42.85563
	Longitude: -76.13839

ONON-02B	Cardiff
Onondaga Creek	Downstream of Webster Road crossing
	Latitude: 42.88303
	Longitude: -76.15375

ONON-03	Cardiff
Onondaga Creek	Indian Road bridge
	Latitude: 42.91379
	Longitude: -76.16967

ONON-04	Syracuse
Onondaga Creek	Downstream of Route 173 bridge
	Latitude: 43.00188
	Longitude: -76.14876

ONON-05	Syracuse
Onondaga Creek	Kirkpatrick Street bridge
	Latitude: 43.05930
	Longitude: -76.16376

Table 1 cont'd. Station Locations, streams tributary to Onondaga Lake, Onondaga County, NY, 2008. Site photographs, if available, follow each description.

Station	Location	
SAWM-01 Sawmill Creek	Liverpool Upstream of Route 370 bridge Latitude: 43.11844 Longitude: -76.22634	SAWM-01 No Site Photo
NINE-01 Ninemile Creek	Amboy Downstream of Warners Road bridge Latitude: 43.06993 Longitude: -76.27341	
NINE-02 Ninemile Creek	Lakeland off State Fair Boulevard Latitude: 43.08063 Longitude: -76.22647	
LEY-01 Ley Creek	Mattydale Upstream of Lemoyne Avenue bridge Latitude: 43.09008 Longitude: -76.14487	
LEY-02 Ley Creek	Syracuse Park Street bridge Latitude: 43.0763 Longitude: -76.1715	

Table 1 cont'd. Station Locations, streams tributary to Onondaga Lake, Onondaga County, NY, 2008. Site photographs, if available, follow each description.

Station	Location	
HARB-02 Harbor Brook	Syracuse Downstream of Hiawatha Boulevard bridge Latitude: 43.0561 Longitude: -76.1853	HARB-02 No Site Photo
GEDD-01 Geddes Brook	Camillus Downstream of Horan Road bridge Latitude: 43.05761 Longitude: -76.23376	
BLDY-06 Bloody Brook	Liverpool Downstream of Onondaga Lake Parkway bridge Latitude: 43.09730 Longitude: -76.20161	

Figure 1. Overview Map, sampling locations on Onondaga Creek, Onondaga County.

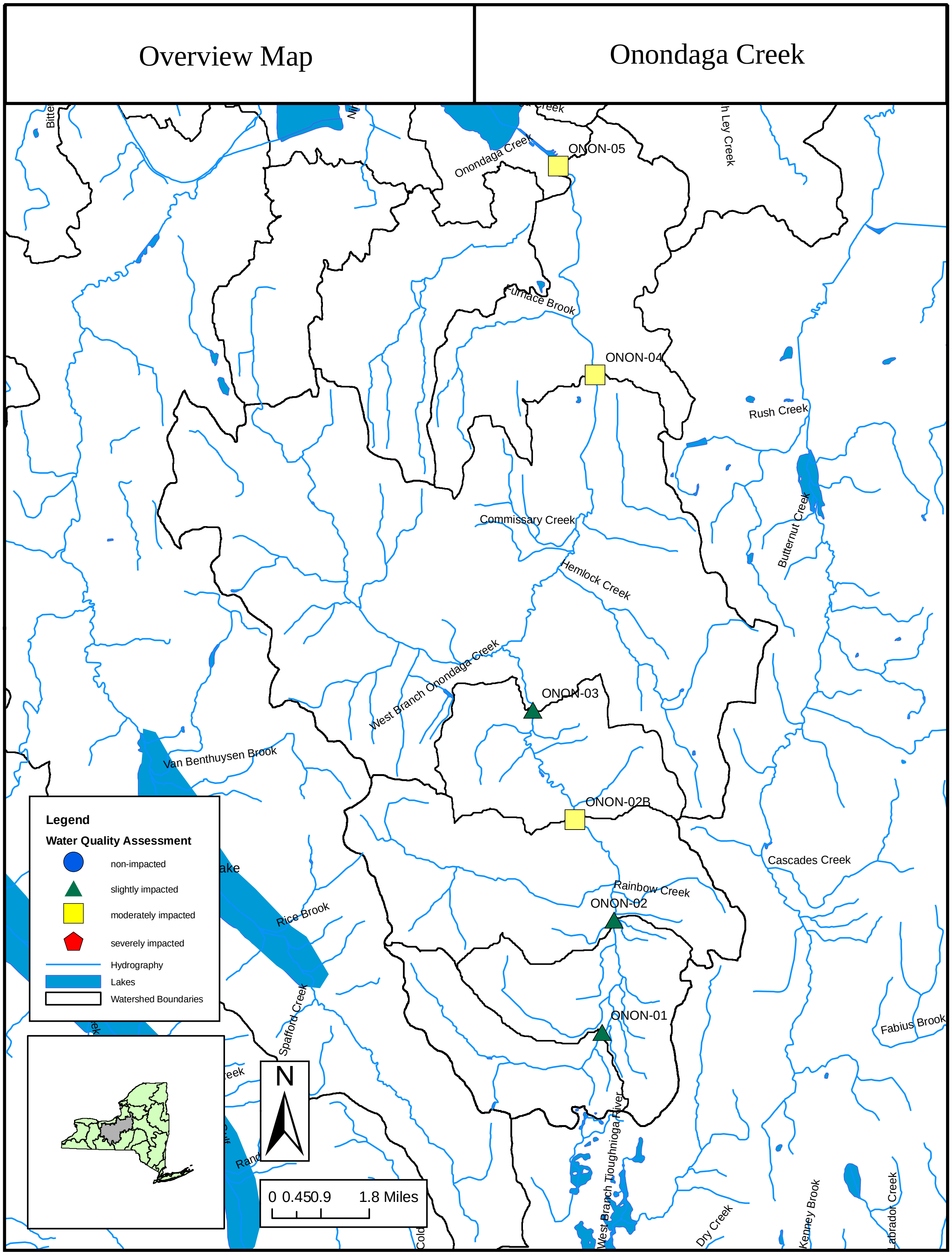

Figure 1a. Station Map, Onondaga Creek, Station 01, Onondaga County.

Site Location Map	Onondaga Creek

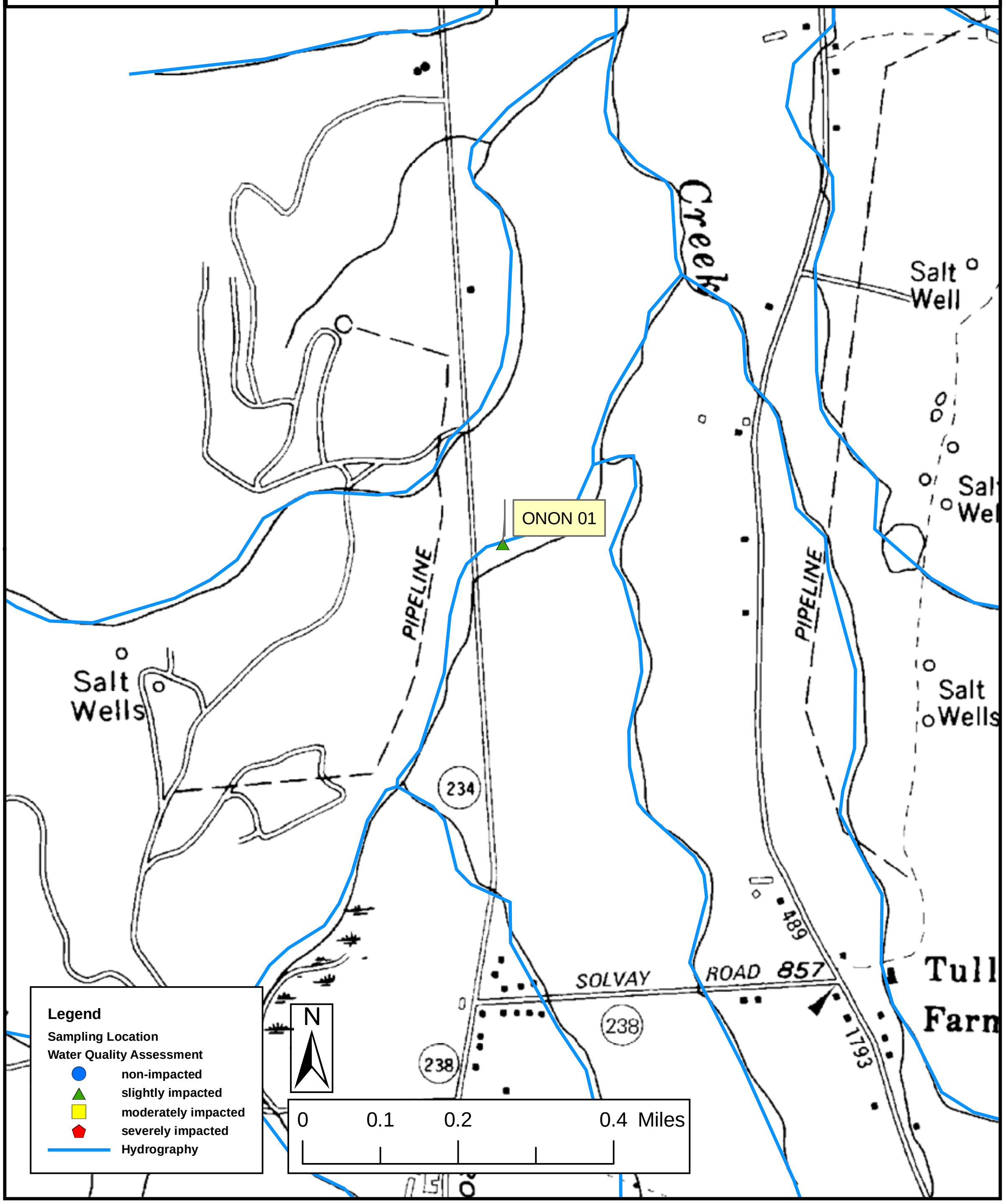

Figure 1b. Station Map, Onondaga Creek, Station 02, Onondaga County.

Site Location Map	Onondaga Creek

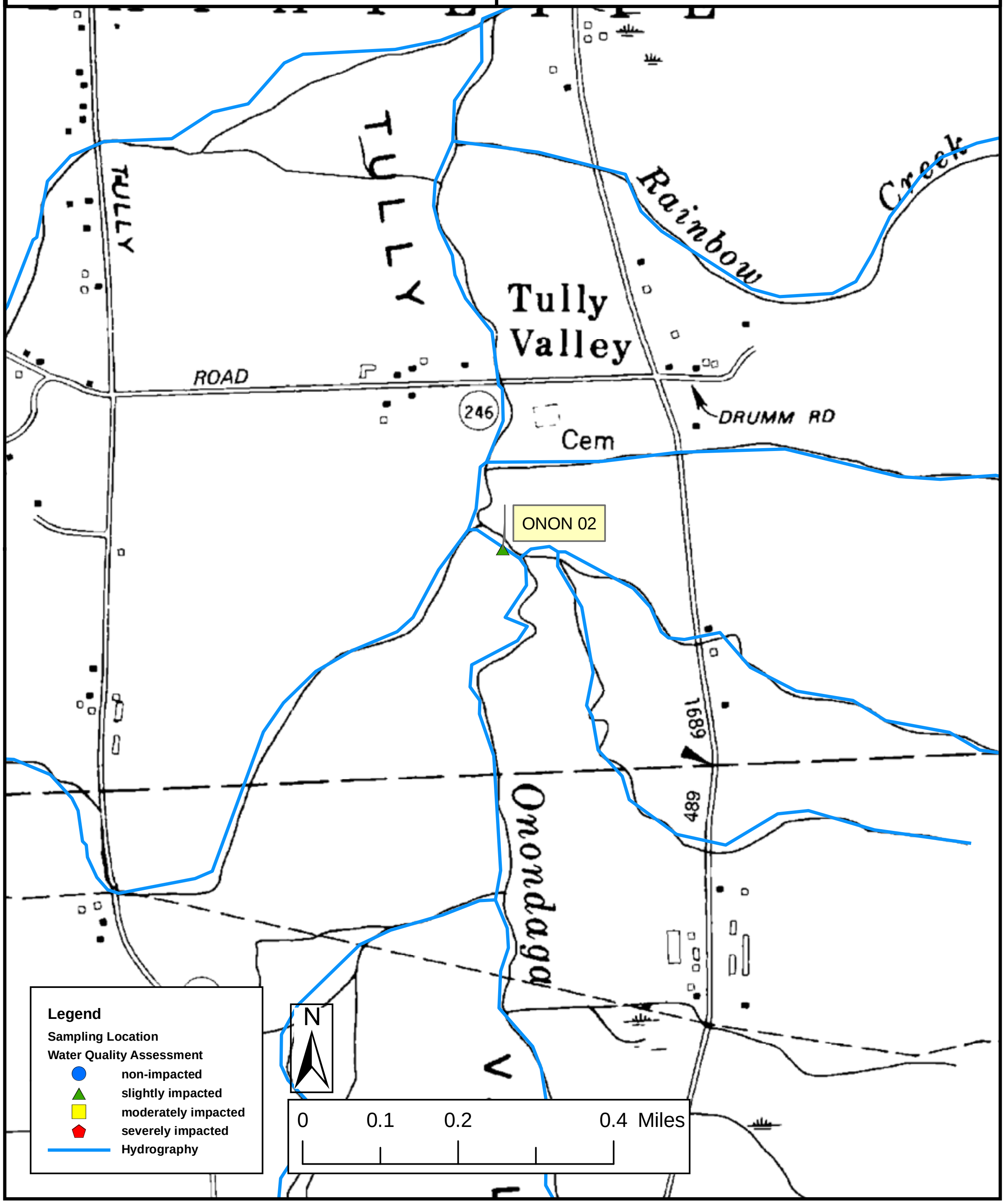

Figure 1c. Station Map, Onondaga Creek, Station 02B, Onondaga County.

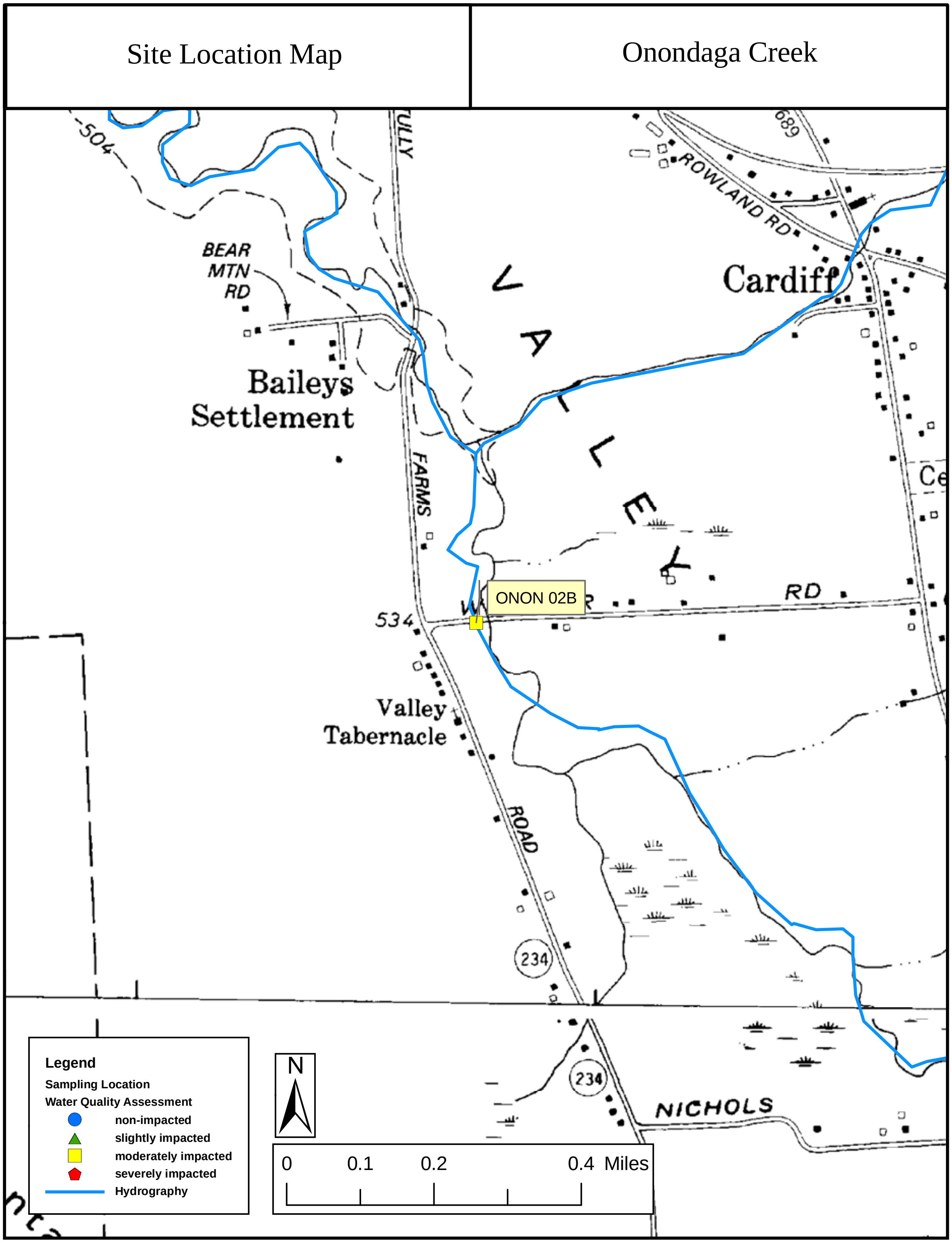

Figure 1d. Station Map, Onondaga Creek, Station 03, Onondaga County.

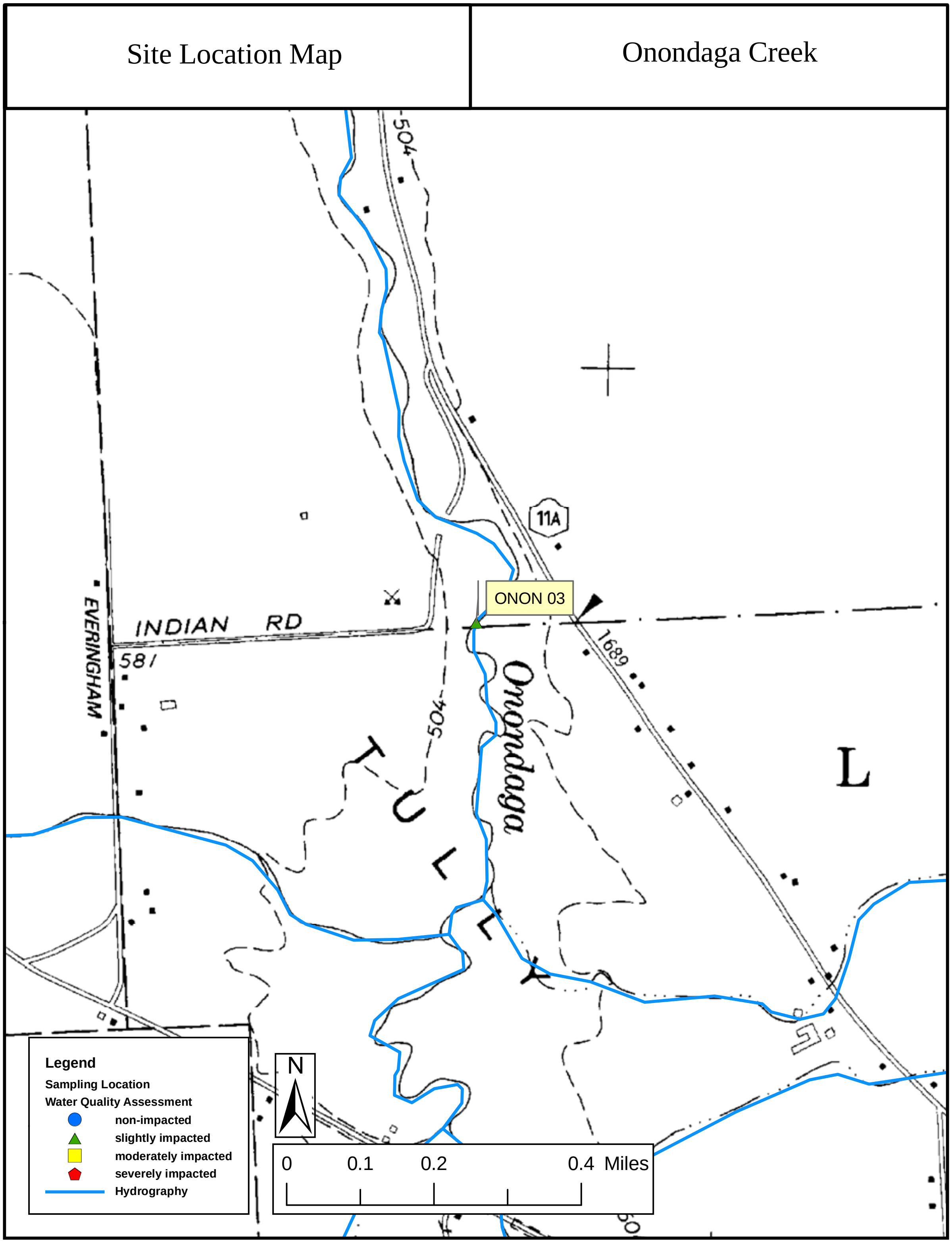

Figure 1e. Station Map, Onondaga Creek, Station 04, Onondaga County.

Site Location Map	Onondaga Creek

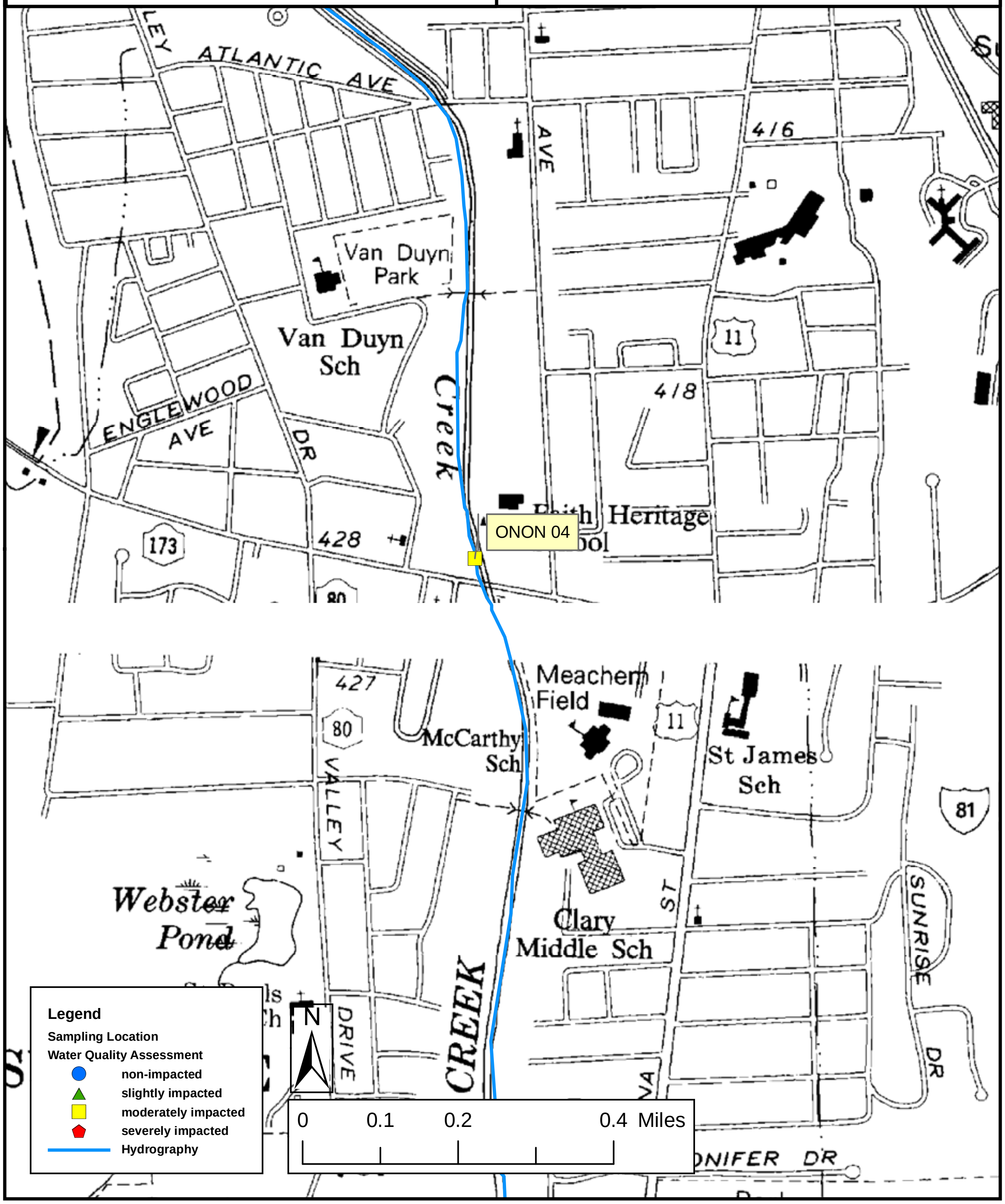

Figure 1f. Station Map, Onondaga Creek, Station 05, Onondaga County.

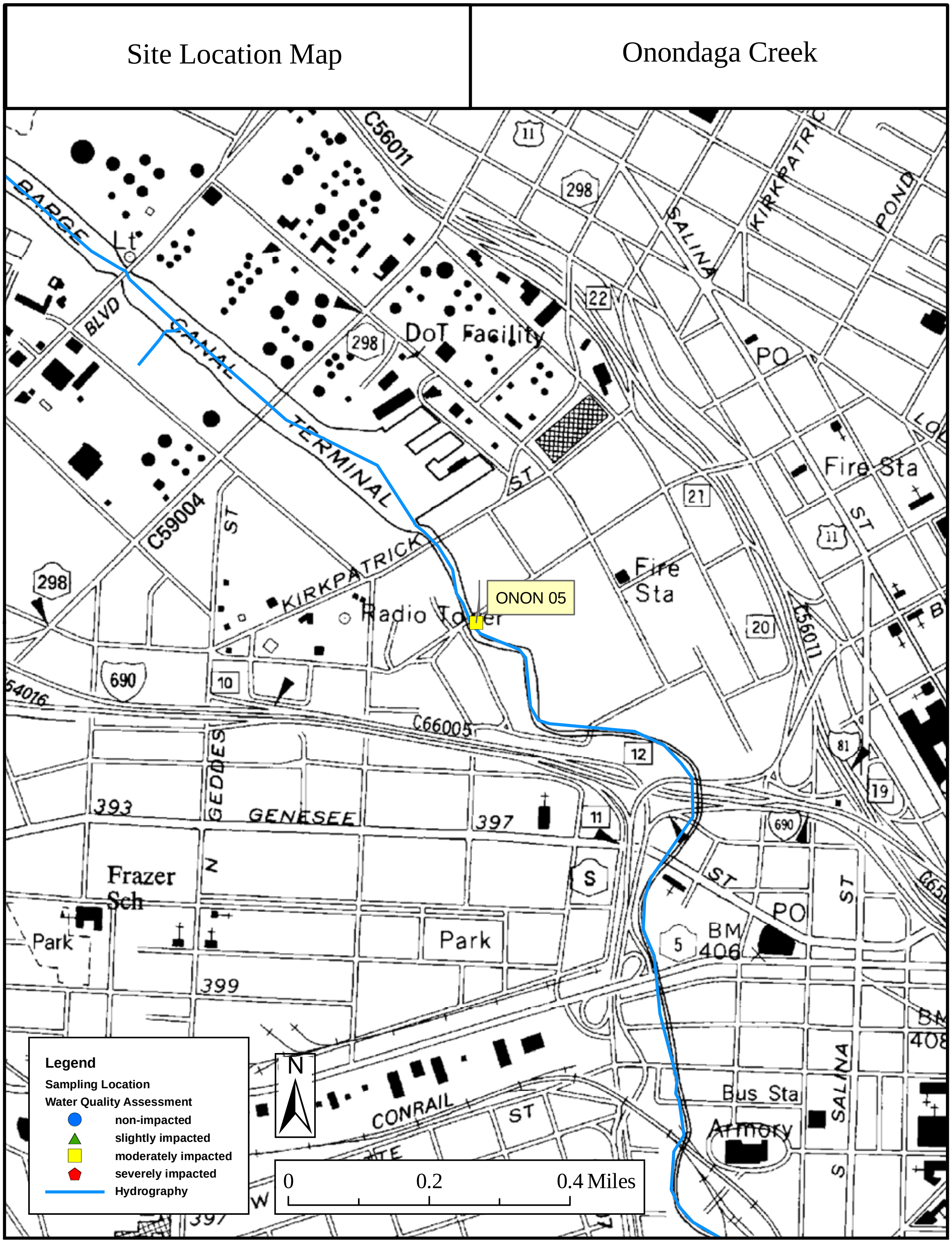

Figure 2. Overview Map, sampling locations on streams tributary to Onondaga Lake, Onondaga County.

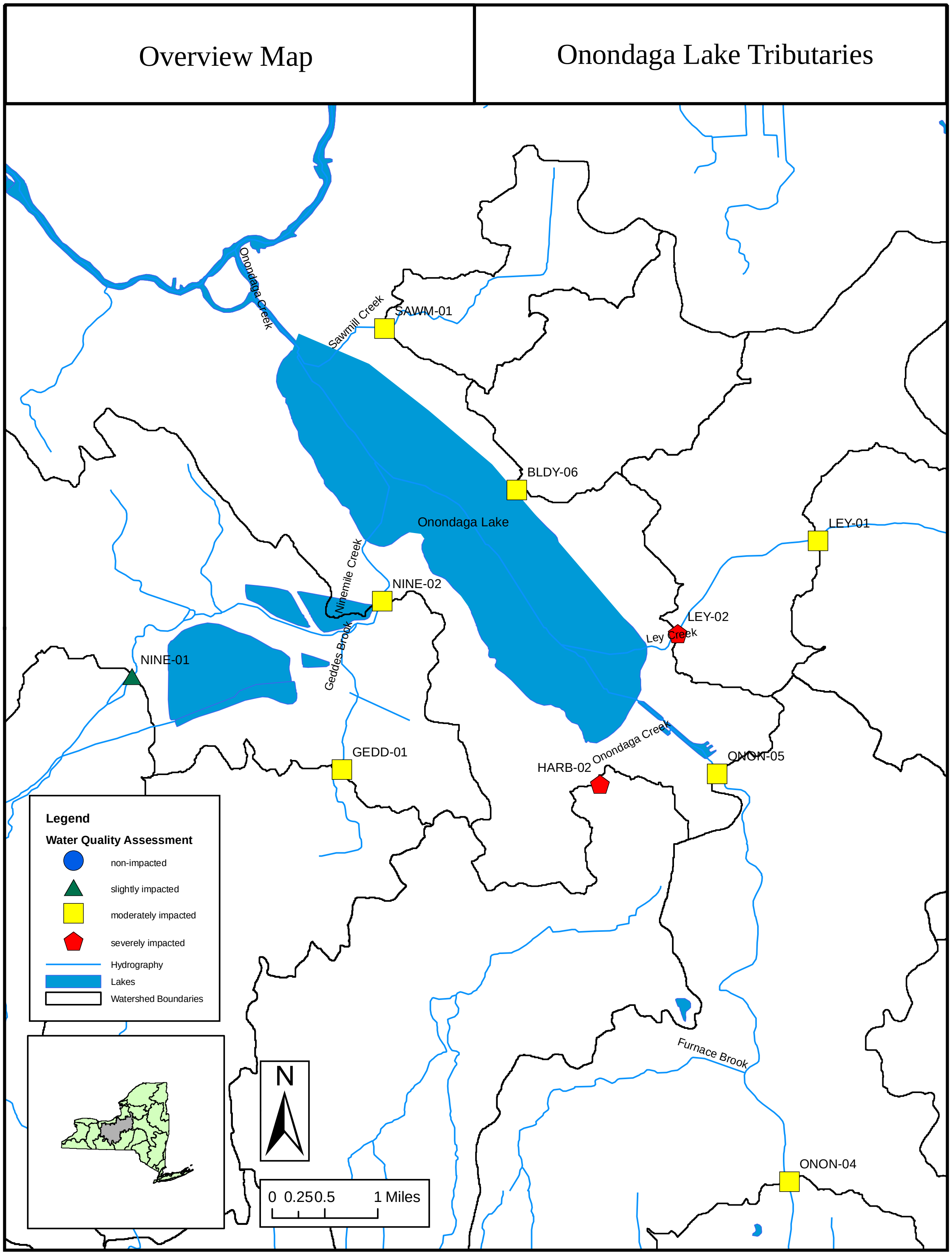

Figure 2a. Station Map, Sawmill Creek Station 01, Onondaga County.

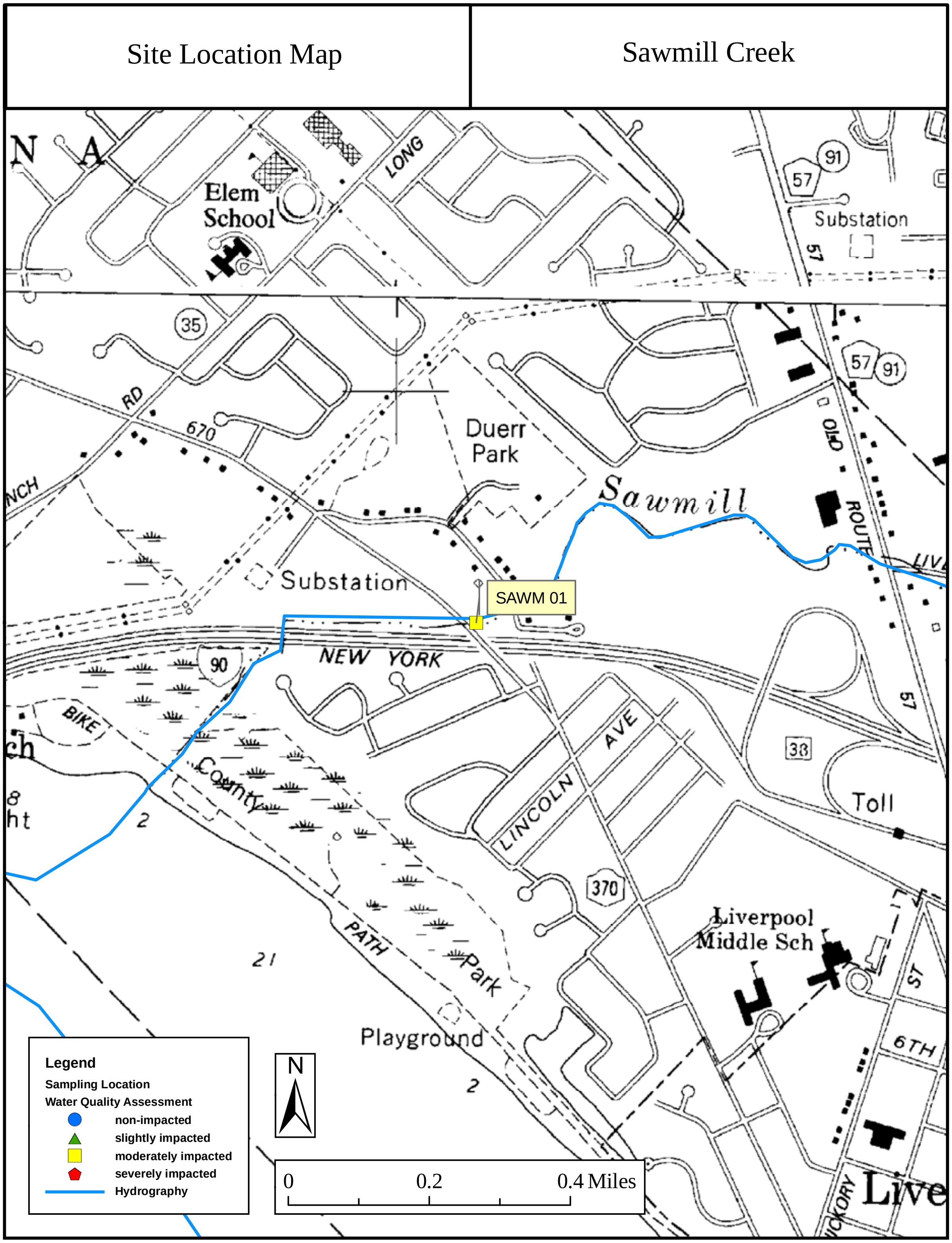

Figure 2b. Station Map, Ninemile Creek stations 01 and 02, Geddes Brook Station 01, Onondaga County.

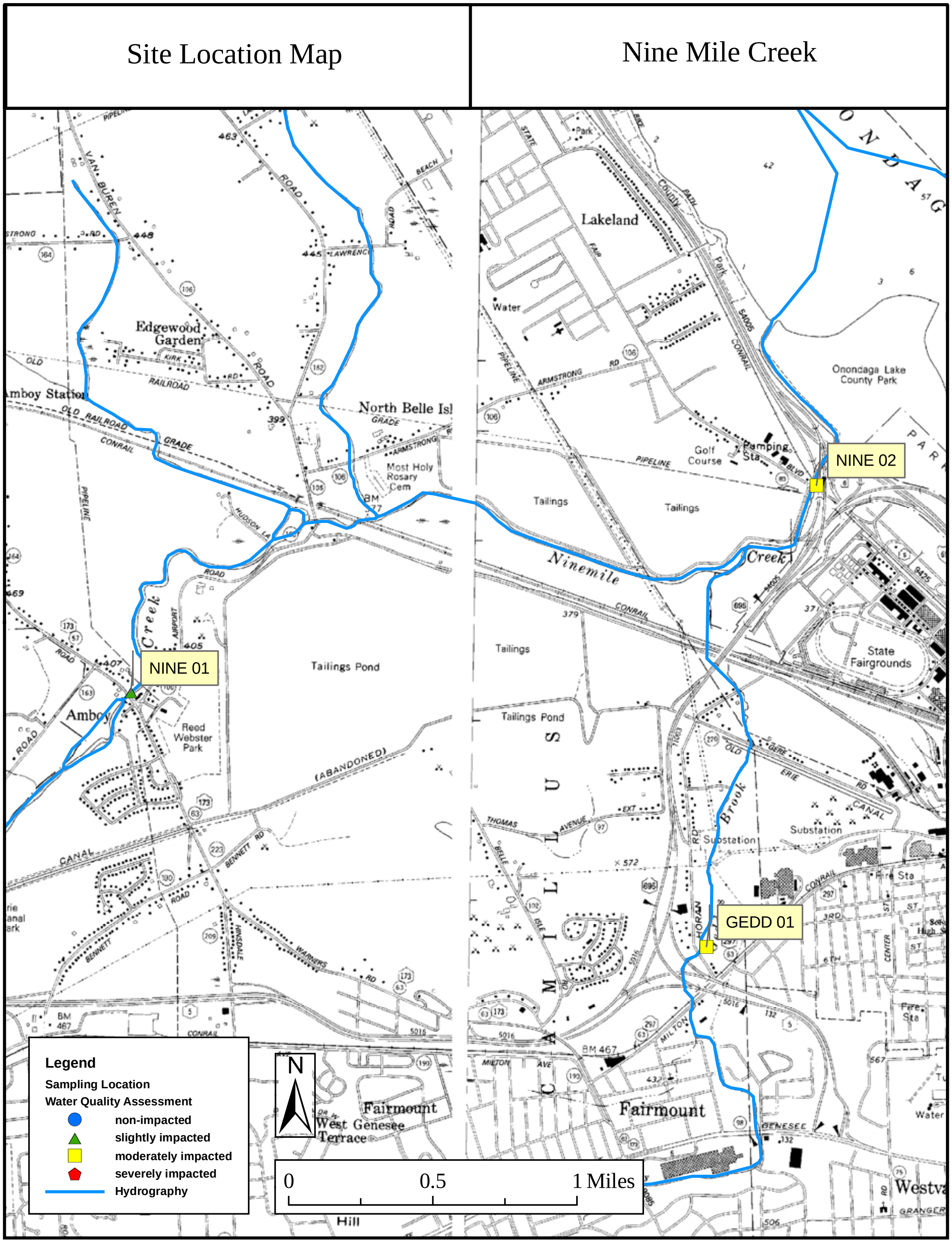

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Figure 2c. Station Map, Ley Creek stations 01 and 02, Onondaga County.

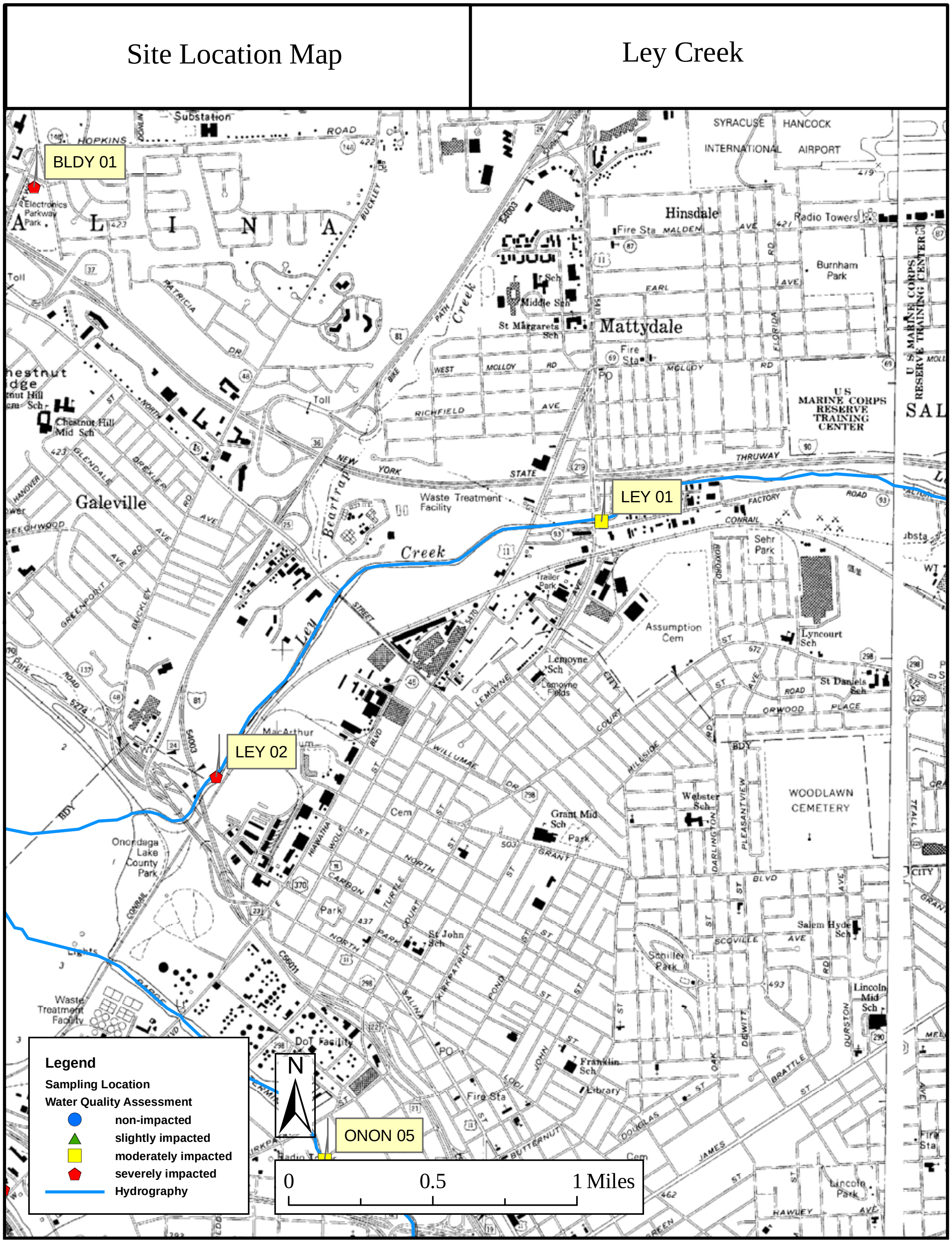


Figure 2d. Station Map, Harbor Brook Station 02, Onondaga County.

Site Location Map	Harbor Brook

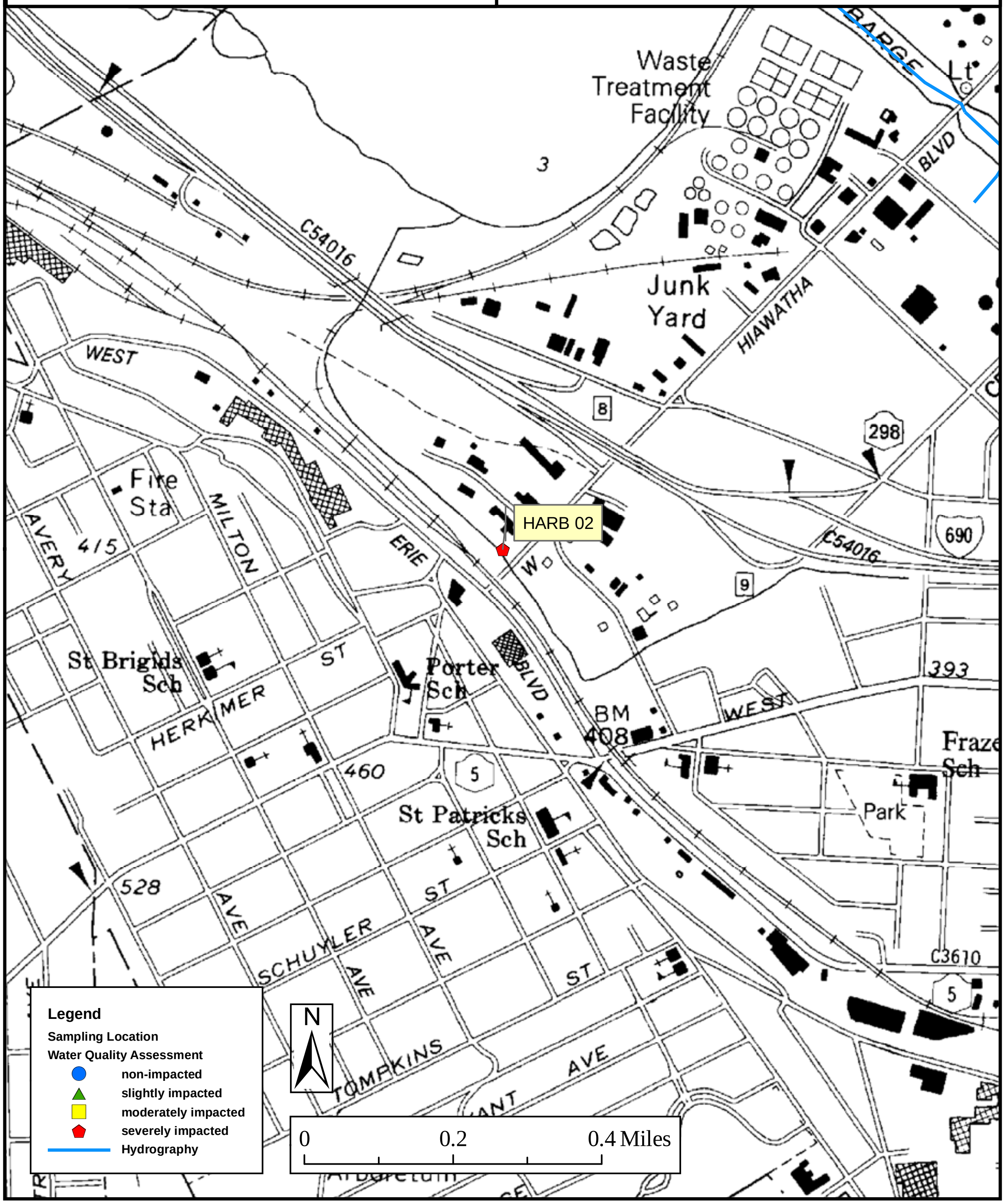


Figure 2e. Station Map, Bloody Brook Station 06, Onondaga County.

Site Location Map	Bloody Brook

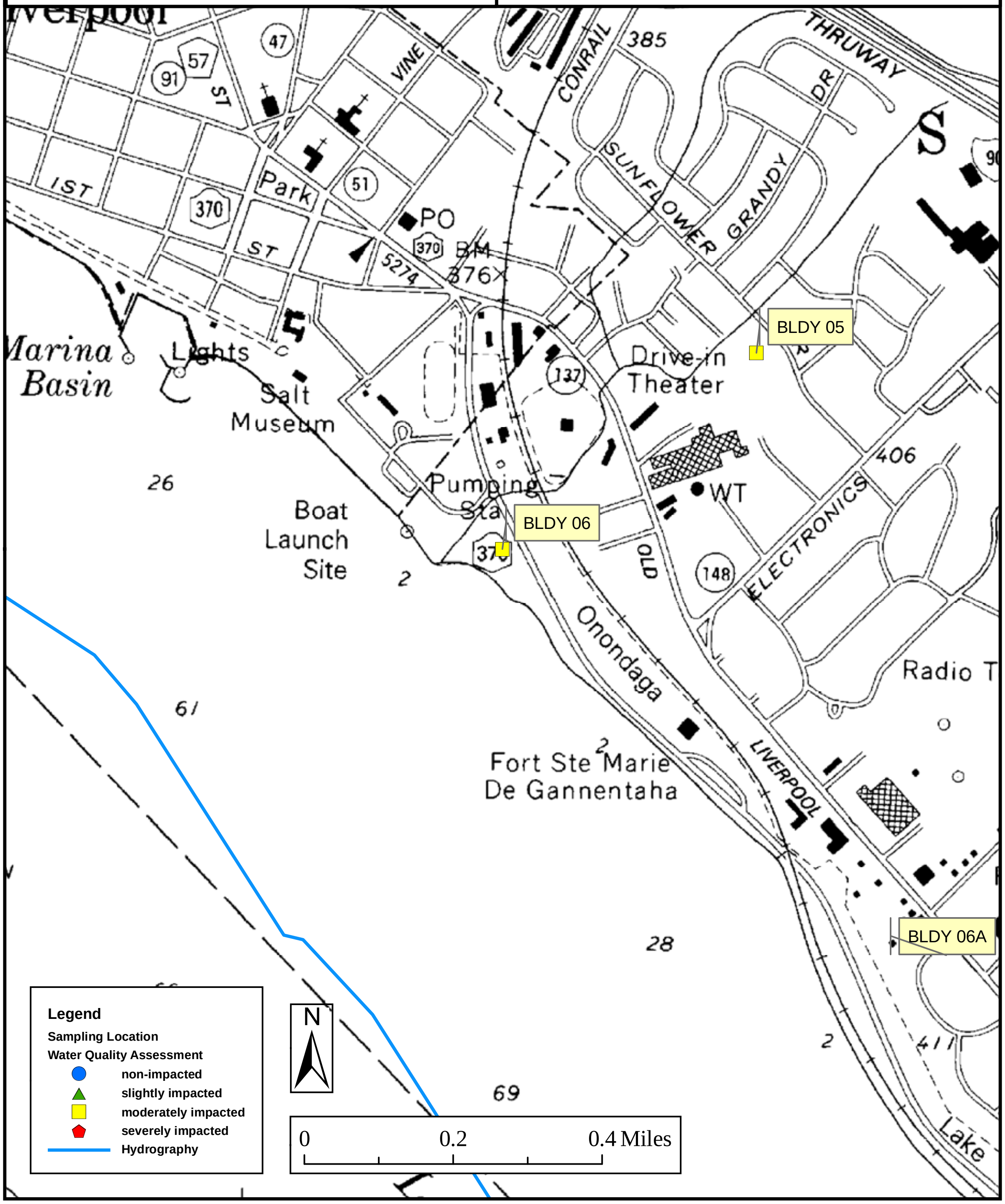


Figure 3. Biological Assessment Profile (BAP) of Index Values, Onondaga Creek (A) and tributaries to Onondaga Lake (B), 2008 and select historical data. Values are plotted on a normalized scale of water quality. Water quality scores represent the mean of four values for each site: species richness, EPT richness, Hilsenhoff's Biotic Index and Percent Model Affinity or Non-Chironomid/Oligochaete richness. See Appendix IV for a more complete explanation.

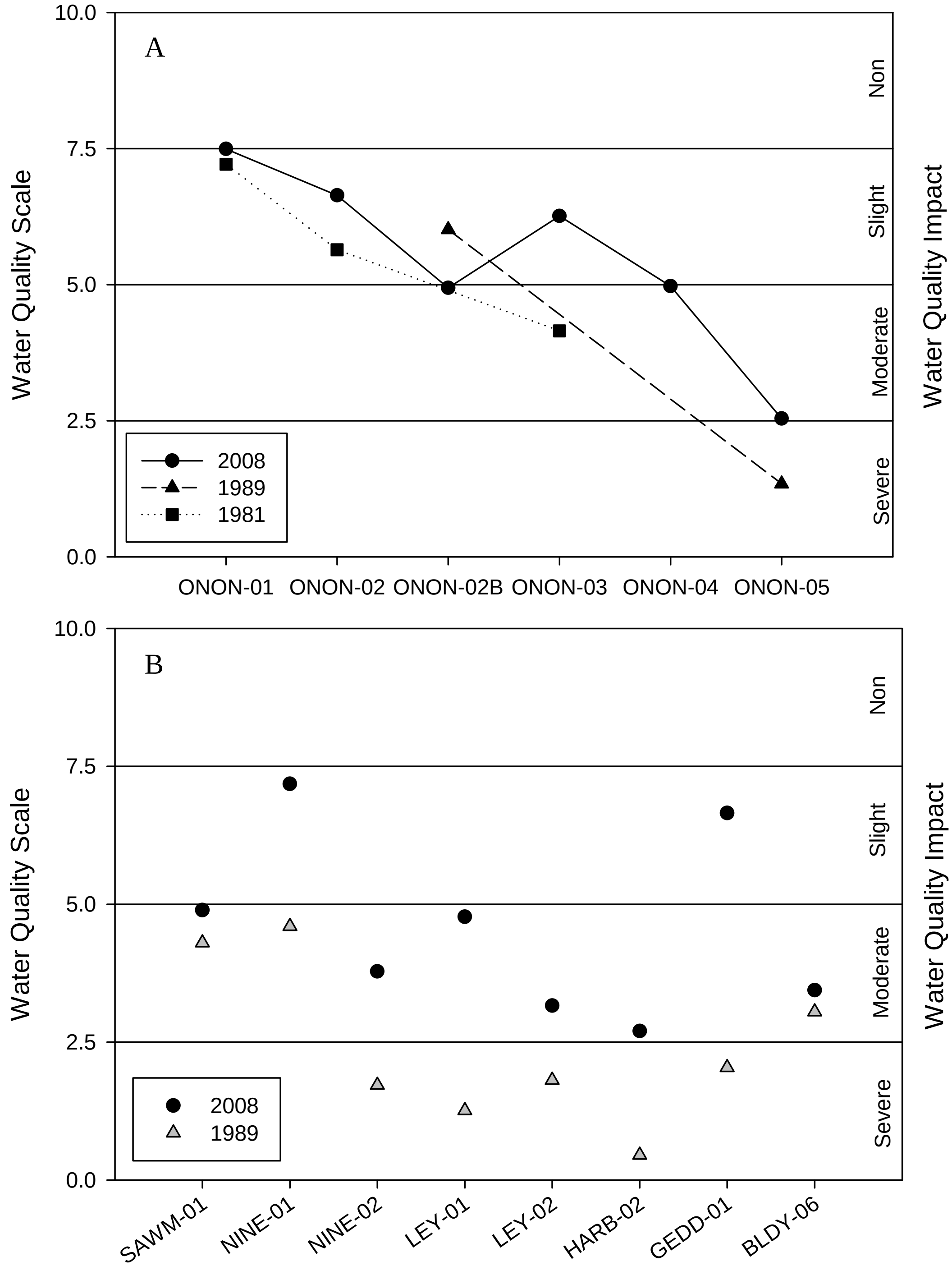


Table 2. Overview of Field Data. Cells marked with a dash (-) signify that the parameter was not recorded in the field.

Location	Station	Depth (meters)	Width (meters)	Current (cm/sec)	Canopy (%)	Embedd (%)	Temp (˚C)	Cond. (μmhos /cm)	pH (units)	DO (mg/l)
ONON	01	0.1	4	83	50	15	14.3	321	8.3	10.4
ONON	02	0.1	4	100	25	25	16.8	492	8.35	8.2
ONON	02B	0.2	5	77	25	60	18	1619	8.2	7.6
ONON	03	0.2	6	100	75	50	19	1743	8.2	9.1
ONON	04	0.1	10	83	10	40	22.5	1222	8.4	11.2
ONON	05	0.3	15	-	25	75	19.6	3327	8.0	9.1
SAWM	01	0.1	1.5	40	75	50	19.3	1545	8.0	9.2
NINE	01	0.5	15	143	50	50	17.9	1063	8.0	9.4
NINE	02	0.2	20	43	25	50	20.1	2518	7.9	10.7
LEY	01	0.2	10	77	50	40	18.6	1413	7.6	5.8
LEY	02	1.5	20	-	10	-	19.4	1375	7.5	5.9
HARB	02	0.5	5	14	50	-	17.9	2013	7.9	8.3
GEDD	01	0.1	3	67	25	25	16.4	1781	7.6	7.8
BLDY	06	0.3	4	-	0	-	17.2	1758	8.0	9.7

Table 3. Impact Source Determination (ISD), streams tributary to Onondaga Lake, 2008. Numbers represent percent similarity to community type models for each impact category. Highest similarities at each station are shaded. Similarities less than 50% are inconclusive. Highest numbers represent probable stressor(s) to the community. See Appendix XI for further explanation.

Station		*Community Type*						
		Natural	Nutrients	Toxic	Organic	Complex	Siltation	Impoundment
ONON	01	67	47	29	36	30	39	33
	02	66	62	43	36	44	44	39
	02B	45	40	40	39	40	56	47
	03	48	48	46	52	43	61	50
	04	38	50	61	59	57	66	54
	05	15	15	45	57	58	30	53
SAWM	01	32	45	54	35	46	34	41
NINE	01	45	38	45	40	45	36	45
	02	13	21	40	53	75	27	52
LEY	01	26	44	49	46	41	52	44
	02	9	24	36	53	50	31	64
HARB	02	19	25	44	72	56	44	49
GEDD	01	33	25	35	34	38	33	35
BLDY	06	44	10	21	46	39	25	34

Note: ISDs are intended to supplement macroinvertebrate community assessments.

Figure 4. Results of substrate pebble counts for Onondaga Creek sampling locations. Each particle size is given as a percent out of 100 counted “pebbles” from each site, recorded in the field.

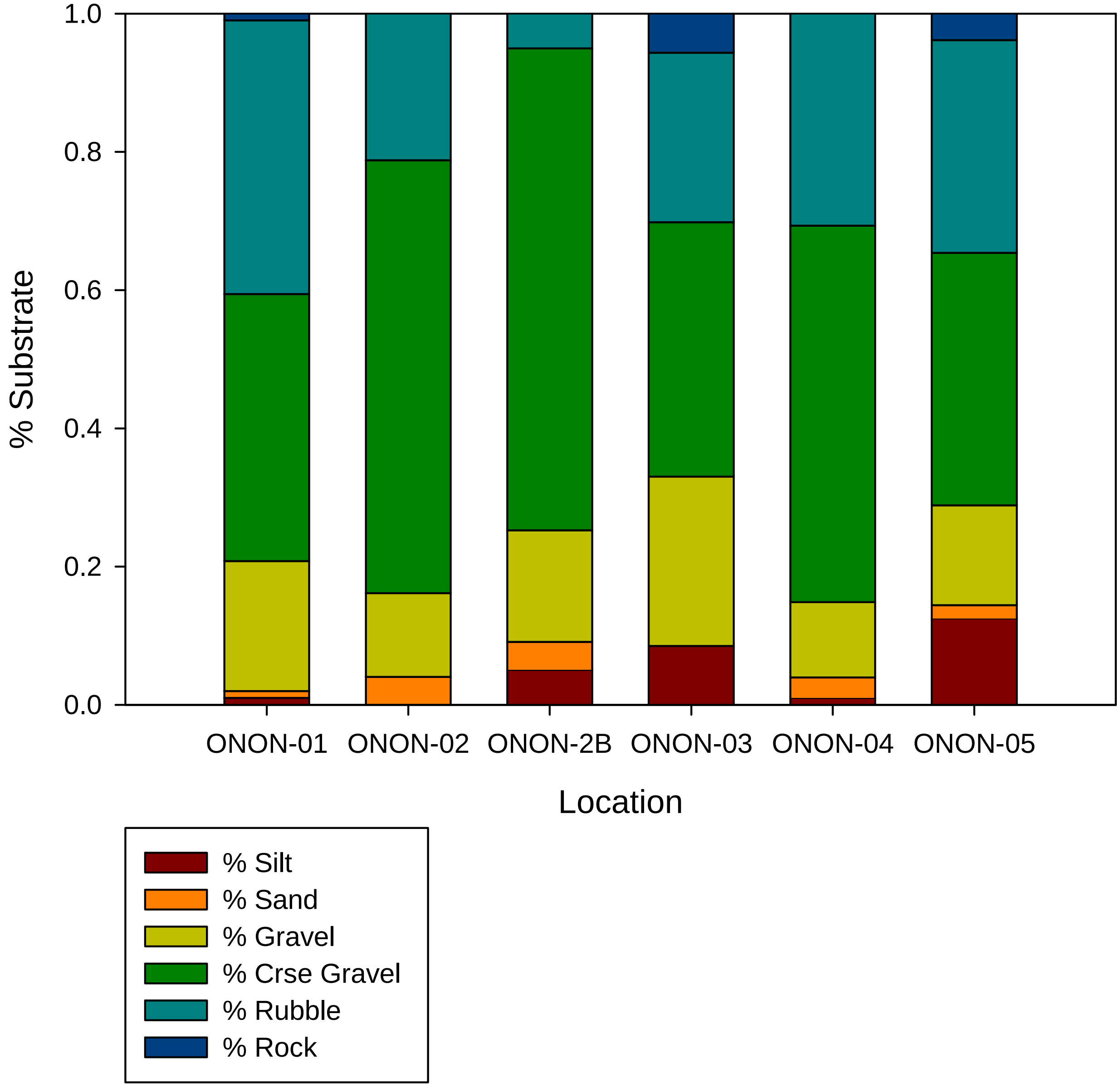


Table 4a. Macroinvertebrate Data Report (MDR), Onondaga Creek Station 01

STREAM SITE: Onondaga Creek, Station 01
LOCATION: Tully Farms Road crossing, Tully Farms, NY
DATE: 6/24/2008
SAMPLE TYPE: Kick
SUBSAMPLE: 100 organisms

MOLLUSCA			
GASTROPODA			
BASOMMATOPHORA			
	Lymnaeidae	Undetermined Lymnaeidae	1
ARTHROPODA			
CRUSTACEA			
DECAPODA	Cambaridae	Undetermined Cambaridae	1
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis tricaudatus*	5
		Undetermined Baetidae	3
	Ephemerellidae	*Dannella* sp.	1
		Serratella deficiens	5
PLECOPTERA	Capniidae	Undetermined Capniidae	1
	Perlidae	*Agnetina capitata*	1
	Perlodidae	*Isoperla* sp.	1
COLEOPTERA	Elmidae	*Optioservus fastiditus*	17
		Stenelmis crenata	2
TRICHOPTERA	Philopotamidae	*Dolophilodes* sp.	11
	Hydropsychidae	*Hydropsyche slossonae*	7
		Hydropsyche sparna	1
DIPTERA	Tipulidae	*Hexatoma* sp.	9
		Tipula sp.	1
	Simuliidae	*Simulium tuberosum*	1
	Empididae	*Hemerodromia* sp.	1
	Chironomidae	*Orthocladius* sp.	1
		Tvetenia bavarica gr.	1
		Tvetenia vitracies	6
		Polypedilum aviceps	12
		Micropsectra sp.	8
		Rheotanytarsus sp.	3
		SPECIES RICHNESS:	24
		BIOTIC INDEX:	3.87
		EPT RICHNESS:	10
		MODEL AFFINITY:	67
		ASSESSMENT:	Slight

Description:
This was the most upstream station sampled on Onondaga Creek during this survey. The sample was collected from a riffle with fast current speed and a substrate dominated by gravel. The invertebrate community was diverse with many sensitive taxa present, including several different mayfly, stonefly and caddisfly taxa. The sample was field assessed as very good, however laboratory analysis resulted in slightly impacted water quality.

Table 4b. Macroinvertebrate Data Report (MDR), Onondaga Creek Station 02

STREAM SITE:	Onondaga Creek, Station 02
LOCATION:	Immediately upstream of mud boils at Otisco Road, Tully Valley, NY
DATE:	6/24/2008
SAMPLE TYPE:	Kick
SUBSAMPLE:	100 organisms

ARTHROPODA			
INSECTA			
EPHEMEROPTERA			
	Baetidae	*Baetis tricaudatus*	13
	Heptageniidae	*Heptagenia* sp.	2
	Ephemerellidae	*Dannella* sp.	1
COLEOPTERA	Elmidae	*Optioservus fastiditus*	23
		Stenelmis sp.	9
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche* sp.	3
		Hydropsyche bronta	5
		Hydropsyche slossonae	1
		Hydropsyche sparna	11
	Rhyacophilidae	*Rhyacophila fuscula*	2
DIPTERA	Tipulidae	*Dicranota* sp.	1
	Simuliidae	*Simulium tuberosum*	1
		Simulium vittatum	7
	Empididae	*Hemerodromia* sp.	1
	Chironomidae	*Pagastia orthogonia*	1
		Tvetenia vitracies	3
		Polypedilum aviceps	13
		Polypedilum flavum	1
		Tanytarsus sp.	1
	Chrionomidae	Undetermined Chironominae	1
		SPECIES RICHNESS:	20
		BIOTIC INDEX:	4.88
		EPT RICHNESS:	8
		MODEL AFFINITY:	65
		ASSESSMENT:	Slight

Description:
Station 02 was the last sampling location upstream of the Tully Mud Boils on Onondaga Creek. The sample was collected from a riffle dominated by rubble and gravel with fast current speed. Embeddedness was higher here compared to upstream. The invertebrate community was dominated by riffle beetles and was less diverse compared to upstream, yet was still assessed as slightly impacted.

Table 4c. Macroinvertebrate Data Report (MDR), Onondaga Creek Station 02B

STREAM SITE:	Onondaga Creek, Station 02B
LOCATION:	Downstream of Webster Road crossing, Cardiff, NY
DATE:	6/24/2008
SAMPLE TYPE:	Kick
SUBSAMPLE:	100 organisms

ARTHROPODA			
CRUSTACEA			
AMPHIPODA			
	Gammaridae	*Gammarus* sp.	1
INSECTA			
COLEOPTERA	Elmidae	*Optioservus fastiditus*	16
		Stenelmis sp.	4
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche* sp.	6
		Hydropsyche betteni	2
		Hydropsyche bronta	16
		Hydropsyche slossonae	2
DIPTERA	Empididae	*Hemerodromia* sp.	2
	Chironomidae	*Diamesa* sp.	1
		Pagastia orthogonia	1
		Cricotopus bicinctus	5
		Cricotopus trifascia gr.	6
		Eukiefferiella devonica gr.	5
		Orthocladius sp.	7
		Rheocricotopus robacki	1
		Tvetenia vitracies	1
		Microtendipes pedellus gr.	20
		Rheotanytarsus sp.	2
		Tanytarsus sp.	2
		SPECIES RICHNESS:	19
		BIOTIC INDEX:	5.43
		EPT RICHNESS:	4
		MODEL AFFINITY:	43
		ASSESSMENT:	Moderate

Description:
Station 02B was the first sampling location downstream of the Tully Mud Boils on Onondaga Creek. The sample was collected downstream of Webster Road. The substrate continued to be dominated by gravel and rubble with fast current speed. Embeddedness was higher here compared to upstream. Specific conductance was 1,619 μmol/cm, an increase from the upstream measurement of 492 μmol/cm. The invertebrate community lacked many of the sensitive clean water taxa present at upstream stations. Here the sample was dominated by caddisflies, riffle beetles and facultative midge larvae. The site was assessed as moderately impacted.

Table 4d. Macroinvertebrate Data Report (MDR), Onondaga Creek Station 03

STREAM SITE:	Onondaga Creek, Station 03
LOCATION:	Indian Road bridge, Cardiff, NY
DATE:	6/24/2008
SAMPLE TYPE:	Kick
SUBSAMPLE:	100 organisms

ANNELIDA			
OLIGOCHAETA			
TUBIFICIDA			
	Tubificidae	Undet. Tubificidae w/ cap. setae	3
		Undet. Tubificidae w/o cap. setae	1
ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Caenidae	*Caenis* sp.	1
COLEOPTERA	Elmidae	*Optioservus fastiditus*	6
		Promoresia elegans	1
		Stenelmis crenata	12
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche* sp.	3
		Hydropsyche betteni	3
		Hydropsyche bronta	12
		Hydropsyche slossonae	1
		Hydropsyche sparna	4
DIPTERA	Simuliidae	*Simulium* sp.	1
	Athericidae	*Atherix* sp.	2
	Empididae	*Hemerodromia* sp.	4
	Chironomidae	*Thienemannimyia* gr. spp.	1
		Pagastia orthogonia	1
		Cricotopus bicinctus	10
		Cricotopus trifascia gr.	4
		Eukiefferiella devonica gr.	7
		Orthocladius sp.	2
		Parametriocnemus sp.	1
		Rheocricotopus robacki	9
		Thienemanniella sp.	1
		Cryptochironomus sp.	1
		Microtendipes pedellus gr.	3
		Micropsectra sp.	1
		Rheotanytarsus sp.	4
		Tanytarsus sp.	1
		SPECIES RICHNESS:	28
		BIOTIC INDEX:	5.65
		EPT RICHNESS:	6
		MODEL AFFINITY:	52
		ASSESSMENT:	Slight

Description:
The sample at Station 03 was collected downstream of the bridge on Indian Road. The substrate continued to be dominated by gravel and rubble with fast current speed. Embeddedness was higher here compared to most upstream sites. Although species richness was greater here compared to Station 02B, the invertebrate community still lacked many of the sensitive clean water taxa present at upstream stations 01 and 02,particularly, stoneflies and many mayfly taxa were absent here. Water quality at this site was assessed as slightly impacted.

Table 4e. Macroinvertebrate Data Report (MDR), Onondaga Creek Station 04

STREAM SITE:	Onondaga Creek, Station 04
LOCATION:	Downstream of Route 173 bridge, Syracuse, NY
DATE:	6/24/2008
SAMPLE TYPE:	Kick
SUBSAMPLE:	100 organisms

MOLLUSCA			
GASTROPODA			
BASOMMATOPHORA			
	Physidae	*Physella* sp.	1
ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Gammaridae	*Gammarus* sp.	3
INSECTA			
COLEOPTERA	Elmidae	*Optioservus* sp.	2
		Promoresia elegans	1
		Stenelmis crenata	20
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche* sp.	15
		Hydropsyche betteni	6
		Hydropsyche bronta	10
		Hydropsyche sparna	2
DIPTERA	Chironomidae	*Thienemannimyia* gr. spp.	3
		Pagastia orthogonia	1
		Cricotopus trifascia gr.	5
		Eukiefferiella brehmi gr.	1
		Eukiefferiella devonica gr.	1
		Orthocladius sp.	5
		Tvetenia bavarica gr.	1
		Tvetenia vitracies	10
		Polypedilum flavum	12
		Tanytarsus sp.	1
		SPECIES RICHNESS:	19
		BIOTIC INDEX:	5.44
		EPT RICHNESS:	4
		MODEL AFFINITY:	44
		ASSESSMENT:	Moderate

Description:
At Station 04, the stream was heavily channelized with limited canopy cover. Onondaga Creek, at this point, becomes a much more urbanized stream. Trash was abundant along stream banks. The substrate was still dominated by gravel and rubble and current speed remained fast. Mayflies and stoneflies were absent from the sample and riffle beetles, net-spinning caddisflies, and facultative midge larvae dominated. Water quality at this site declined and was assessed as moderately impacted.

Table 4f. Macroinvertebrate Data Report (MDR), Onondaga Creek Station 05

STREAM SITE:	Onondaga Creek, Station 05
LOCATION:	Kirkpatrick Street bridge, Syracuse, NY
DATE:	6/24/2008
SAMPLE TYPE:	Kick
SUBSAMPLE:	100 organisms

PLATYHELMINTHES			
TURBELLARIA			
TRICLADIDA			
		Undetermined Turbellaria	4
ANNELIDA			
OLIGOCHAETA			
LUMBRICULIDA	Lumbriculidae	Undetermined Lumbriculidae	3
TUBIFICIDA	Enchytraeidae	Undetermined Enchytraeidae	8
	Tubificidae	*Limnodrilus hoffmeisteri*	4
		Undet. Tubificidae w/ cap. setae	4
	Naididae	*Nais communis*	14
MOLLUSCA			
GASTROPODA			
BASOMMATOPHORA	Physidae	*Physella* sp.	1
ARTHROPODA			
CRUSTACEA			
ISOPODA	Asellidae	*Caecidotea racovitzai*	5
AMPHIPODA	Gammaridae	*Gammarus* sp.	9
INSECTA			
DIPTERA	Chironomidae	*Cricotopus bicinctus*	35
		Cricotopus trifascia gr.	2
		Cricotopus sp.	1
		Chironomus sp.	5
		Stictochironomus sp.	2
		Tribelos/Endochironomus/Phaenopsectra Complex	3
		SPECIES RICHNESS:	15
		BIOTIC INDEX:	7.69
		EPT RICHNESS:	0
		MODEL AFFINITY:	35
		ASSESSMENT:	Moderate

Description:
Station 05 is in Syracuse and reflects the water quality expected of a heavily urbanized stream. Assessed as moderately impacted, the invertebrate community at this site suggests some of the worst conditions of all Onondaga Creek stations surveyed. Tolerant worms, crustaceans and midge larvae dominated the sample. Specific conductance was highest of all the sites in the survey (3,327µmol/cm). Heavy siltation was evident, but overall, substrate was similar to upstream locations, dominated by gravel and rubble. Significant areas of trash were observed along the stream bank and incorporated into the stream substrate.

Table 4g. Macroinvertebrate Data Report (MDR), Sawmill Creek Station 01

STREAM SITE:	Sawmill Creek, Station 01
LOCATION:	Upstream of Route 370 bridge, Liverpool, NY
DATE:	6/25/2008
SAMPLE TYPE:	Kick
SUBSAMPLE:	97 organisms

PLATYHELMINTHES			
TURBELLARIA			
TRICLADIDA			
		Undetermined Turbellaria	12
ARTHROPODA			
CRUSTACEA			
ISOPODA	Asellidae	*Caecidotea racovitzai*	8
AMPHIPODA	Gammaridae	*Gammarus* sp.	8
INSECTA			
COLEOPTERA	Psephenidae	*Ectopria nervosa*	1
	Elmidae	*Stenelmis crenata*	17
TRICHOPTERA	Philopotamidae	*Chimarra aterrima*?	16
	Hydropsychidae	*Cheumatopsyche* sp.	9
		Hydropsyche betteni	2
DIPTERA	Tipulidae	*Tipula* sp.	1
	Simuliidae	*Simulium vittatum*	3
	Chironomidae	*Thienemannimyia* gr. spp.	4
		Diamesa sp.	1
		Cricotopus bicinctus	1
		Orthocladius sp.	1
		Parametriocnemus sp.	9
		Polypedilum flavum	3
		Polypedilum laetum	1

SPECIES RICHNESS:	17
BIOTIC INDEX:	5.52
EPT RICHNESS:	3
MODEL AFFINITY:	50
ASSESSMENT:	Moderate

Description:
Station 01 on Sawmill Creek was sampled upstream of the Route 370 bridge. Water quality was field assessed as poor, but later assessed as moderately impacted based on laboratory analysis. Although canopy cover was extensive (75%) and the substrate favorable for invertebrate colonization (mix of rock, rubble and gravel) the stream is small (1.5 m wide) and current speed was slow (40 cm/sec). Specific conductance was high for this small tributary (1,545μmol/cm). The invertebrate community at this site was not diverse and included tolerant organisms such as the sowbug (Caecidotea racovitzai), scuds (Gammarus sp.), and flat worms (Undetermined Turbellaria).

Table 4h. Macroinvertebrate Data Report (MDR), Ninemile Creek Station 01

STREAM SITE:	Ninemile Creek, Station 01		
LOCATION:	Warners Road bridge, Amboy, NY		
DATE:	6/25/2008		
SAMPLE TYPE:	Kick		
SUBSAMPLE:	100 organisms		
MOLLUSCA			
PELECYPODA			
VENEROIDEA			
	Sphaeriidae	*Pisidium* sp.	1
ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Gammaridae	*Gammarus* sp.	22
DECAPODA	Cambaridae	Undetermined Cambaridae	1
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis flavistriga*	1
		Baetis tricaudatus	7
	Ephemerellidae	*Ephemerella invaria*	1
COLEOPTERA	Elmidae	*Optioservus* sp.	3
		Promoresia elegans	1
		Promoresia tardella	3
		Stenelmis sp.	3
MEGALOPTERA	Corydalidae	*Nigronia serricornis*	1
TRICHOPTERA	Philopotamidae	Undetermined Philopotamidae	4
	Hydropsychidae	*Cheumatopsyche* sp.	2
		Hydropsyche betteni	2
		Hydropsyche slossonae	4
		Hydropsyche sparna	3
	Rhyacophilidae	*Rhyacophila fuscula*	1
	Hydroptilidae	*Hydroptila* sp.	5
DIPTERA	Simuliidae	*Simulium vittatum*	3
	Chironomidae	*Thienemannimyia* gr. spp.	2
		Pagastia orthogonia	1
		Cricotopus trifascia gr.	7
		Eukiefferiella claripennis gr.	1
		Eukiefferiella devonica gr.	17
		Orthocladius sp.	1
		Microtendipes pedellus gr.	1
		Polypedilum aviceps	1
		Micropsectra sp.	1
		SPECIES RICHNESS:	28
		BIOTIC INDEX:	5.09
		EPT RICHNESS:	10
		MODEL AFFINITY:	59
		ASSESSMENT:	Slight

Description:
Station 01 on Ninemile Creek was sampled downstream of Warners Road bridge. This station was the most upstream of two sites sampled on Ninemile Creek. Water quality was field assessed as good and was later assessed as slightly impacted after laboratory analysis. The invertebrate community was diverse. Stoneflies were noted in the field although not captured in the subsampling.

Table 4i. Macroinvertebrate Data Report (MDR), Ninemile Creek Station 02

STREAM SITE:	Ninemile Creek, Station 02
LOCATION:	Off State Fair Boulevard, Lakeland, NY
DATE:	6/25/2008
SAMPLE TYPE:	Net Jab
SUBSAMPLE:	100 organisms

ANNELIDA			
OLIGOCHAETA			
TUBIFICIDA			
	Tubificidae	Undet. Tubificidae w/ cap. setae	2
		Undet. Tubificidae w/o cap. setae	23
MOLLUSCA			
GASTROPODA			
BASOMMATOPHORA	Physidae	*Physella* sp.	2
ARTHROPODA			
CRUSTACEA			
ISOPODA	Asellidae	*Caecidotea racovitzai*	15
AMPHIPODA	Gammaridae	*Gammarus* sp.	38
INSECTA			
COLEOPTERA	Elmidae	*Promoresia* sp.	1
		Stenelmis crenata	2
DIPTERA	Simuliidae	*Simulium vittatum*	3
	Empididae	*Hemerodromia* sp.	1
	Chironomidae	*Thienemannimyia* gr. spp.	3
		Prodiamesa olivacea	1
		Cricotopus bicinctus	1
		Cricotopus sylvestris gr.	1
		Orthocladius sp.	3
		Microtendipes pedellus gr.	3
		Polypedilum aviceps	1
		SPECIES RICHNESS:	16
		BIOTIC INDEX:	7.33
		EPT RICHNESS:	0
		MODEL AFFINITY:	31
		ASSESSMENT:	Moderate

Description:
Water quality was assessed as moderately impacted. The sample was collected off State Fair Boulevard at a point where the stream becomes slow and flat. There were no riffles at this site and the sample was collected from a muck/silt substrate using a net jab. Habitat constraints on the invertebrate community contributed to the assessment of moderately impacted water quality at this site.

Table 4j. Macroinvertebrate Data Report (MDR), Ley Creek Station 01

STREAM SITE: Ley Creek, Station 01
LOCATION: Upstream of Lemoyne Avenue bridge, Mattydale, NY
DATE: 6/25/2008
SAMPLE TYPE: Kick
SUBSAMPLE: 100 organisms

MOLLUSCA			
PELECYPODA			
VENEROIDEA			
	Sphaeriidae	*Sphaerium* sp.	2
ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Gammaridae	*Gammarus* sp.	8
DECAPODA	Cambaridae	Undetermined Cambaridae	1
INSECTA			
COLEOPTERA	Elmidae	*Stenelmis* sp.	8
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche* sp.	1
		Hydropsyche betteni	1
		Hydropsyche sparna	9
	Hydroptilidae	*Hydroptila* sp.	2
DIPTERA	Chironomidae	*Cricotopus bicinctus*	23
		Cricotopus trifascia gr.	4
		Cricotopus sp.	11
		Orthocladius sp.	5
		Rheocricotopus robacki	10
		Tvetenia bavarica gr.	2
		Polypedilum illinoense	4
		Polypedilum tritum	7
		Tribelos/*Endochironomus*/*Phaenopsectra* Co	1
		Tanytarsus sp.	1
		SPECIES RICHNESS:	18
		BIOTIC INDEX:	6.25
		EPT RICHNESS:	4
		MODEL AFFINITY:	48
		ASSESSMENT:	Moderate

Description:
Station 01 is the most upstream of the two sites sampled on Ley Creek. It is located in Mattydale, a suburb of Syracuse. The stream is channelized at this station and an abundance of trash was observed. The sample was dominated by non-biting midge larvae (Chironomidae) many of which were facultative or tolerant. Mayflies, and stoneflies were absent and the caddisfly community was dominated by net-spinning taxa. The station was assessed as moderately impacted.

Table 4k. Macroinvertebrate Data Report (MDR), Ley Creek Station 02

STREAM SITE:	Ley Creek, Station 02
LOCATION:	Park Street bridge, Syracuse, NY
DATE:	6/25/2008
SAMPLE TYPE:	Net Jab
SUBSAMPLE:	100 organisms

PLATYHELMINTHES			
TURBELLARIA			
TRICLADIDA			
		Undetermined Turbellaria	1
ANNELIDA			
OLIGOCHAETA			
TUBIFICIDA	Tubificidae	*Aulodrilus piqueti*	3
		Limnodrilus hoffmeisteri	38
		Undet. Tubificidae w/ cap. setae	1
	Naididae	*Dero digitata*	6
MOLLUSCA			
GASTROPODA			
BASOMMATOPHORA	Physidae	*Physella* sp.	9
MESOGASTROPODA	Hydrobiidae	Undetermined Hydrobiidae	10
PELECYPODA			
VENEROIDEA	Sphaeriidae	*Pisidium* sp.	1
ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Gammaridae	*Gammarus* sp.	13
INSECTA			
ODONATA	Coenagrionidae	*Enallagma* sp.	1
DIPTERA	Chironomidae	*Procladius* sp.	2
		Cricotopus bicinctus	1
		Cricotopus sylvestris gr.	1
		Chironomus sp.	4
		Polypedilum illinoense	7
		Micropsectra sp.	2

SPECIES RICHNESS:	16
BIOTIC INDEX:	8.56
EPT RICHNESS:	0
MODEL AFFINITY:	32
ASSESSMENT:	Severe

Description:
The sample at Ley Creek Station 02 was collected using a net jab. This station was slow and sandy compared to the upstream station. The invertebrate community consisted of many worms and was dominated by the very pollution tolerant worm Limnodrilus hoffmeisteri. Mayflies, stoneflies, and caddisflies were absent entirely from the sample. The site was assessed as severely impacted.

Table 4l. Macroinvertebrate Data Report (MDR), Harbor Brook Station 02

STREAM SITE:	Harbor Brook, Station 02
LOCATION:	Downstream of Hiawatha Boulevard, Syracuse, NY
DATE:	6/25/2008
SAMPLE TYPE:	Kick
SUBSAMPLE:	100 organisms

ANNELIDA			
OLIGOCHAETA			
LUMBRICIDA			
		Undetermined Lumbricina	1
TUBIFICIDA	Enchytraeidae	Undetermined Enchytraeidae	2
	Tubificidae	*Limnodrilus hoffmeisteri*	27
		Undet. Tubificidae w/ cap. setae	1
MOLLUSCA			
GASTROPODA			
BASOMMATOPHORA	Physidae	*Physella* sp.	3
MESOGASTROPODA	Hydrobiidae	Undetermined Hydrobiidae	2
ARTHROPODA			
CRUSTACEA			
ISOPODA	Asellidae	*Caecidotea racovitzai*	4
INSECTA			
DIPTERA	Chironomidae	*Pagastia orthogonia*	1
		Cricotopus bicinctus	18
		Cricotopus sylvestris gr.	1
		Cricotopus sp.	5
		Chironomus sp.	11
		Polypedilum illinoense	17
		Tribelos/*Endochironomus*/*Phaenopsectra* Co	3
		Micropsectra sp.	4
		SPECIES RICHNESS:	15
		BIOTIC INDEX:	8.28
		EPT RICHNESS:	0
		MODEL AFFINITY:	34
		ASSESSMENT:	Severe

Description:
The stream was channelized and narrow. The invertebrate community was similar to Ley Creek Station 02, dominated by tolerant worms and non-biting midge larvae, for example, *Limnodrilus hoffmeisteri* and *Chironomus* sp.. The site was assessed as severely impacted.

Table 4m. Macroinvertebrate Data Report (MDR), Geddes Brook Station 01

STREAM SITE:	Geddes Brook, Station 01
LOCATION:	Downstream of Horan Road bridge, Camillus, NY
DATE:	6/25/2008
SAMPLE TYPE:	Kick
SUBSAMPLE:	99 organisms

ANNELIDA			
OLIGOCHAETA			
LUMBRICIDA			
		Undetermined Lumbricina	5
TUBIFICIDA	Tubificidae	Undet. Tubificidae	1
MOLLUSCA			
PELECYPODA			
VENEROIDEA	Sphaeriidae	Undetermined Sphaeriidae	1
ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Gammaridae	*Gammarus* sp.	25
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis tricaudatus*	7
TRICHOPTERA	Philopotamidae	*Dolophilodes* sp.	1
	Hydropsychidae	*Hydropsyche betteni*	2
	Hydroptilidae	*Hydroptila* sp.	1
DIPTERA	Simuliidae	*Prosimulium* sp.	1
		Simulium sp.	1
	Muscidae	Undetermined Muscidae	1
	Chironomidae	*Thienemannimyia* gr. spp.	1
		Limnophyes sp.	3
		Tvetenia bavarica gr.	38
		Polypedilum aviceps	1
		Polypedilum tritum	2
		Micropsectra sp.	7
		SPECIES RICHNESS:	17
		BIOTIC INDEX:	5.27
		EPT RICHNESS:	4
		MODEL AFFINITY:	46
		ASSESSMENT:	Moderate

Description:
The sample was collected from an adequate riffle with a substrate consisting predominately of rock and rubble. The invertebrate community contained some mayflies and caddisflies, however the species present were facultative. Stoneflies were absent from the sample. The site was assessed as moderately impacted.

Table 4n. Macroinvertebrate Data Report (MDR), Bloody Brook Station 06

STREAM SITE:	Bloody Brook, Station 06
LOCATION:	Downstream of Onondaga Lake Parkway, Liverpool, NY
DATE:	6/25/2008
SAMPLE TYPE:	Kick
SUBSAMPLE:	100 organisms

ARTHROPODA			
CRUSTACEA			
AMPHIPODA			
	Gammaridae	*Gammarus* sp.	34
INSECTA			
DIPTERA	Chironomidae	*Thienemannimyia* gr. spp.	2
		Cricotopus bicinctus	6
		Orthocladius sp.	3
		Thienemanniella sp.	1
		Chironomus sp.	3
		Cryptochironomus sp.	1
		Dicrotendipes fumidus	4
		Dicrotendipes sp.	1
		Paratendipes sp.	2
		Tribelos/*Endochironomus*/*Phaenopsectra* Co	3
		Sublettea coffmani	38
		Tanytarsus sp.	1
		SPECIES RICHNESS:	14
		BIOTIC INDEX:	5.64
		EPT RICHNESS:	0
		MODEL AFFINITY:	30
		ASSESSMENT:	Moderate

Description:
The sample was collected from an area where the substrate was predominately sand and the current was slow. The stream was channelized with stonewalls. The invertebrate community was limited and consisted mostly of facultative or tolerant non-biting midge larvae (Chironomidae). The site was assessed as moderately impacted.

Table 5. Laboratory Data Summary, streams tributary to Onondaga Lake, Onondaga County, NY, 2008.

STATION	*ONON-01*	*ONON-02*	*ONON-02B*	*ONON-03*	*ONON-04*	*ONON-05*
Date	6/24/2008	6/24/2008	6/24/2008	6/24/2008	6/24/2008	6/24/2008
Five Most Dominant Species and Percent Contribution to the Sample	Optioservus fastiditus (17%)	Optioservus fastiditus (23%)	Microtendipes pedellus gr. (20%)	Hydropsyche bronta (12%)	Stenelmis Crenata (20%)	Cricotopus bicinctus (35%)
	Polypedilum aviceps (12%)	Baetis tricaudatus (13%)	Hydropsyche bronta (16%)	Stenelmis crenata (12%)	Cheumatopsyche sp. (15%)	Nais communis (14%)
	Dolophilodes sp. (11%)	Polypedilum aviceps (13%)	Optioservus fastiditus (16%)	Cricotopus bicinctus (10%)	Polypedilum flavum (12%)	Gammarus sp. (9%)
	Hexatoma sp. (9%)	Hydropsyche sparna (11%)	Orthocladius sp. (7%)	Rheocricotopus Robacki (9%)	Hydropsyche bronta (10%)	Undetermined Enchytraeidae (8%)
	Micropsectra sp. (8%)	Stenelmis sp. (9%)	Cheumatopsy che sp. (6%)	Eukiefferiella devonica gr. (7%)	Tvetenia vitracies (10%)	Chironomus sp. (5%)
Percent Contribution of Major Taxonomic Groups						
Chironomidae	31	19	51	46	40	48
Trichoptera	19	22	26	23	33	0
Ephemeroptera	14	16	0	1	0	0
Plecoptera	3	0	0	0	0	0
Coleoptera	19	32	20	19	23	0
Oligochaeta	0	0	0	4	0	33
Mollusca	1	0	0	0	1	1
Crustacea	1	0	1	0	3	14
Other Insects	12	11	2	7	0	0
Other Inverts.	0	0	0	0	0	1
Water Quality Assessment Metric Scores						
Species Richness	24	20	19	28	19	15
Biotic Index	3.87	4.88	5.43	5.65	5.44	7.69
EPT Richness	10	8	4	6	4	0
Percent Model Affinity	67	65	43	52	44	35
Biological Assessment Profile Score	7.49	6.64	4.94	6.26	4.97	2.54
Overall Assessment	Slightly impacted	Slightly impacted	Moderately impacted	Slightly impacted	Moderately impacted	Moderately impacted

Table 5 cont'd. Laboratory Data Summary, streams tributary to Onondaga Lake, Onondaga County, NY, 2008.

STATION	*NINE-01*	*NINE-02*	*LEY-01*	*LEY-02*
Date	6/25/2008	6/25/2008	6/25/2008	6/25/2008
Five Most Dominant Species and Percent Contribution to the Sample	Gammarus sp. (22%)	Gammarus sp. (38%)	Cricotopus bicinctus (23%)	Limnodrilus hoffmeisteri (38%)
	Eukiefferiella devonica gr. (17%)	Undet. Tubificidae w/o cap. setae (23%)	Cricotopus sp. (11%)	Gammarus sp. (13%)
	Baetis tricaudatus (7%)	Caecidotea racovitzai (15%)	Rheocricotopus robacki (10%)	Undetermined Hydrobiidae (10%)
	Cricotopus trifascia gr. (7%)	Simulium vittatum (3%)	Hydropsyche sparna (9%)	Physella sp. (9%)
	Hydroptila sp. (5%)	Thienemannimyia gr. spp. (3%)	Stenelmis sp. (8%)	Polypedilum illinoense (7%)
Percent Contribution of Major Taxonomic Groups				
Chironomidae	32	13	68	17
Trichoptera	21	0	13	0
Ephemeroptera	9	0	0	0
Plecoptera	0	0	0	0
Coleoptera	10	3	8	0
Oligochaeta	0	25	0	48
Mollusca	1	2	2	20
Crustacea	23	53	9	13
Other Insects	4	4	0	1
Other Inverts.	0	0	0	1
Water Quality Assessment Metric Scores				
Species Richness	28	16	18	16
Biotic Index	5.09	7.33	6.25	8.56
EPT Richness	10	0	4	0
Percent Model Affinity	59	31	48	32
Biological Assessment Profile Score	7.18	2.53	4.77	2.18
Overall Assessment	Slightly impacted	Moderately impacted	Moderately impacted	Severely impacted

Table 5 cont'd. Laboratory Data Summary, streams tributary to Onondaga Lake, Onondaga County, NY, 2008.

STATION	*HARB-02*	*GEDD-01*	*BLDY-06*	*SAWM-01*
Date	6/25/2008	6/25/2008	6/25/2008	6/25/2008
Five Most Dominant Species and Percent Contribution to the Sample	Limnodrilus hoffmeisteri (27%)	Tvetenia bavarica gr. (38%)	Sublettea coffmani (38%)	Stenelmis crenata (17%)
	Cricotopus bicinctus (18%)	Gammarus sp. (25%)	Gammarus sp. (34%)	Chimarra aterrima? (16%)
	Polypedilum illinoense (17%)	Baetis tricaudatus (7%)	Cricotopus bicinctus (6%)	Undetermined Turbellaria (12%)
	Chironomus sp. (11%)	Micropsectra sp. (7%)	Dicrotendipes fumidus (4%)	Cheumatopsyche sp. (9%)
	Cricotopus sp. (5%)	Undetermined Lumbricina (5%)	Tribelos/Endochironomus /Phaenopsectra Co (3%)	Parametriocnemus sp. (9%)
Percent Contribution of Major Taxonomic Groups				
Chironomidae	60	52	66	20
Trichoptera	0	4	0	27
Ephemeroptera	0	7	0	0
Plecoptera	0	0	0	0
Coleoptera	0	0	0	18
Oligochaeta	31	6	0	0
Mollusca	5	1	0	0
Crustacea	4	25	34	16
Other Insects	0	4	0	4
Other Inverts.	0	0	0	1
Water Quality Assessment Metric Scores				
Species Richness	15	17	14	17
Biotic Index	8.28	5.27	5.64	5.52
EPT Richness	0	4	0	3
Percent Model Affinity	34	46	30	50
Biological Assessment Profile Score	2.29	4.92	2.87	4.89
Overall Assessment	Severely impacted	Moderately impacted	Moderately impacted	Moderately impacted

Table 6. Field Data Summary, streams tributary to Onondaga Lake, Onondaga County, NY, 2008.

Station	*ONON-01*	*ONON-02*	*ONON-02B*	*ONON-03*	*ONON-04*	*ONON-05*
Arrival Time	11:00	12:53	2:00	3:04	4:35	6:00
Physical Characteristics						
Depth (meters)	0.1	0.1	0.2	0.2	0.1	0.3
Width (meters)	4	4	5	6	10	15
Current Speed (cm/sec)	83	100	77	100	83	
Canopy (%)	50	25	25	75	10	25
Embeddedness (%)	15	25	60	50	40	75
Substrate (%)						
Rock (>25.4 cm, or bedrock)	5	5	3	10	5	5
Rubble (6.35 - 25.4 cm)	25	40	27	30	35	25
Gravel (0.2 - 6.35 cm)	63	45	60	40	55	40
Sand (0.06 - 2.0 mm)	5	5	5	10	5	10
Silt (0.004 - 0.06 mm)	2	5	5	10		20
Chemical Measurements						
Temperature (o^{C})	14.3	16.84	18	19.01	22.47	19.56
Specific Conductance (µmhos)	321	492	1619	1743	1222	3327
Dissolved Oxygen (mg/l)	10.4	8.2	7.58	9.08	11.23	9.07
DO - Saturation (%)	102	84.5	80.6	98.5	130.2	99
pH (units)	8.13	8.35	8.19	8.19	8.35	8.04
Biological Attributes						
Aquatic vegetation						
Algae - suspended						
Algae - filamentous	X		X	X		X
Algae - diatoms	X		X			
Macrophytes	X		X			
Occurrence of Macroinvertebrates						
Ephemeroptera	X		X		X	
Plecoptera	X	X	X	X		
Trichoptera	X	X	X	X	X	
Coleoptera		X				
Megaloptera						
Odonata						
Chironomidae	X	X	X	X	X	X
Simuliidae		X				
Decapoda	X		X	X	X	
Gammaridae						X
Mollusca					X	
Oligochaeta						X
Others	X	X				X
Faunal Condition (field)	Very Good	Good	Good	Poor	Poor	Very Poor

Table 6 cont'd. Field Data Summary, streams tributary to Onondaga Lake, Onondaga County, NY, 2008.

Station	*NINE-01*	*NINE-02*	*LEY-01*	*LEY-02*
Arrival Time		3:13	8:15	9:30
Physical Characteristics				
Depth (meters)	0.5	0.2	0.2	1
Width (meters)	15	20	10	20
Current Speed (cm/sec)	143	43	77	
Canopy (%)	50	25	50	10
Embeddedness (%)	50	50	40	
Substrate (%)				
Rock (>25.4 cm, or bedrock)		10	10	10
Rubble (6.35 - 25.4 cm)		20	30	
Gravel (0.2 - 6.35 cm)		40	40	20
Sand (0.06 - 2.0 mm)		10	10	10
Silt (0.004 - 0.06 mm)		20	10	60
Chemical Measurements				
Temperature (o^C)	17.87	20.14	18.6	19.4
Specific Conductance (µmhos)	1063	25.18	1413	1375
Dissolved Oxygen (mg/l)	9.44	10.73	5.8	5.85
DO - Saturation (%)	99.7	119.5	62	63.7
pH (units)	8.02	7.96	7.6	7.52
Biological Attributes				
Aquatic vegetation				
Algae - suspended	X			
Algae - filamentous	X	X	X	X
Algae - diatoms	X	X	X	X
Macrophytes		X	X	X
Occurrence of Macroinvertebrates				
Ephemeroptera	X			
Plecoptera				
Trichoptera	X		X	
Coleoptera		X		
Megaloptera				
Odonata				X
Chironomidae	X	X	X	X
Simuliidae				
Decapoda	X	X	X	X
Gammaridae		X	X	X
Mollusca			X	X
Oligochaeta		X	X	
Others		X	X	
Faunal Condition (field)	Good	Very Poor	Very Poor	Very Poor

Table 6 cont'd. Field Data Summary, streams tributary to Onondaga Lake, Onondaga County, NY, 2008.

Station	*HARB-02*	*GEDD-01*	*BLDY-06*	*SAWM-01*
Arrival Time	5:50	4:50	10:12	12:20
Physical Characteristics				
Depth (meters)	0.5	0.1	0.3	0.1
Width (meters)	5	3	4.5	1.5
Current Speed (cm/sec)	14	67		40
Canopy (%)	50	25	0	75
Embeddedness (%)		25		50
Substrate (%)				
Rock (>25.4 cm, or bedrock)	10	50	10	30
Rubble (6.35 - 25.4 cm)		50	20	30
Gravel (0.2 - 6.35 cm)			20	20
Sand (0.06 - 2.0 mm)			30	10
Silt (0.004 - 0.06 mm)	90		20	10
Chemical Measurements				
Temperature (o^C)	17.87	16.42	17.22	19.29
Specific Conductance (µmhos)	2013	1781	1758	1545
Dissolved Oxygen (mg/l)	8.33	7.82	9.67	9.17
DO - Saturation (%)	88	84	101	99.6
pH (units)	7.95	7.58	8.04	8.04
Biological Attributes				
Aquatic vegetation				
Algae - suspended				
Algae - filamentous	X	X	X	X
Algae - diatoms		X	X	X
Macrophytes	X		X	
Occurrence of Macroinvertebrates				
Ephemeroptera				
Plecoptera				
Trichoptera		X		X
Coleoptera			X	
Megaloptera				
Odonata	X			X
Chironomidae	X	X	X	X
Simuliidae		X		X
Decapoda			X	X
Gammaridae	X	X	X	X
Mollusca				
Oligochaeta	X	X		
Others	X			X
Faunal Condition (field)	Very Poor	Very Poor	Very Poor	Poor

Appendix I. Biological Methods for Kick Sampling

A. Rationale: The use of the standardized kick sampling method provides a biological assessment technique that lends itself to rapid assessments of stream water quality.

B. Site Selection: Sampling sites are selected based on these criteria: (1) The sampling location should be a riffle with a substrate of rubble, gravel and sand; depth should be one meter or less, and current speed should be at least 0.4 meter per second. (2) The site should have comparable current speed, substrate type, embeddedness, and canopy cover to both upstream and downstream sites to the degree possible. (3) Sites are chosen to have a safe and convenient access.

C. Sampling: Macroinvertebrates are sampled using the standardized traveling kick method. An aquatic net is positioned in the water at arms' length downstream and the stream bottom is disturbed by foot, so that organisms are dislodged and carried into the net. Sampling is continued for a specified time and distance in the stream. Rapid assessment sampling specifies sampling for five minutes over a distance of five meters. The contents of the net are emptied into a pan of stream water. The contents are then examined, and the major groups of organisms are recorded, usually on the ordinal level (e.g., stoneflies, mayflies, caddisflies). Larger rocks, sticks, and plants may be removed from the sample if organisms are first removed from them. The contents of the pan are poured into a U.S. No. 30 sieve and transferred to a quart jar. The sample is then preserved by adding 95% ethyl alcohol.

D. Sample Sorting and Subsampling: In the laboratory, the sample is rinsed with tap water in a U.S. No. 40 standard sieve to remove any fine particles left in the residues from field sieving. The sample is transferred to an enamel pan and distributed homogeneously over the bottom of the pan. A small amount of the sample is randomly removed with a spatula, rinsed with water, and placed in a petri dish. This portion is examined under a dissecting stereomicroscope and 100 organisms are randomly removed from the debris. As they are removed, they are sorted into major groups, placed in vials containing 70 percent alcohol, and counted. The total number of organisms in the sample is estimated by weighing the residue from the picked subsample and determining its proportion of the total sample weight.

E. Organism Identification: All organisms are identified to the species level whenever possible. Chironomids and oligochaetes are slide-mounted and viewed through a compound microscope; most other organisms are identified as whole specimens using a dissecting stereomicroscope. The number of individuals in each species and the total number of individuals in the subsample are recorded on a data sheet. All organisms from the subsample are archived (either slide-mounted or preserved in alcohol). If the results of the identification process are ambiguous, suspected of being spurious, or do not yield a clear water quality assessment, additional subsampling may be required.

Appendix II. Macroinvertebrate Community Parameters

1. Species Richness: the total number of species or taxa found in a sample. For subsamples of 100-organisms each that are taken from kick samples, expected ranges in most New York State streams are: greater than 26, non-impacted; 19-26, slightly impacted; 11-18, moderately impacted, and less than 11, severely impacted.

2. EPT Richness: the total number of species of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) found in an average 100-organisms subsample. These are considered to be clean-water organisms, and their presence is generally correlated with good water quality (Lenat, 1987). Expected assessment ranges from most New York State streams are: greater than 10, non-impacted; 6-10, slightly impacted; 2-5, moderately impacted, and 0-1, severely impacted.

3. Hilsenhoff Biotic Index: a measure of the tolerance of organisms in a sample to organic pollution (sewage effluent, animal wastes) and low dissolved oxygen levels. It is calculated by multiplying the number of individuals of each species by its assigned tolerance value, summing these products, and dividing by the total number of individuals. On a 0-10 scale, tolerance values range from intolerant (0) to tolerant (10). For the purpose of characterizing species' tolerance, intolerant = 0-4, facultative = 5-7, and tolerant = 8-10. Tolerance values are listed in Hilsenhoff (1987). Additional values are assigned by the NYS Stream Biomonitoring Unit. The most recent values for each species are listed in Quality Assurance document, Bode et al. (2002). Impact ranges are: 0-4.50, non-impacted; 4.51-6.50, slightly impacted; 6.51-8.50, moderately impacted, and 8.51-10.00, severely impacted.

4. Percent Model Affinity: a measure of similarity to a model, non-impacted community based on percent abundance in seven major macroinvertebrate groups (Novak and Bode, 1992). Percentage abundances in the model community are: 40% Ephemeroptera; 5% Plecoptera; 10% Trichoptera; 10% Coleoptera; 20% Chironomidae; 5% Oligochaeta; and 10% Other. Impact ranges are: greater than 64, non-impacted; 50-64, slightly impacted; 35-49, moderately impacted, and less than 35, severely impacted.

5. Non-Chironomidae and Oligochaeta (NCO) Richness: NCO denotes the total number of species of organisms other than those in the groups Chironomidae and Oligochaeta. Since Chironomidae and Oligochaeta are generally the most abundant groups in impacted communities, NCO taxa are considered to be less pollution tolerant, and their presence would be expected to be more indicative of good water quality. This measure is the Sandy Stream counterpart of EPT richness.

Appendix III. Levels of Water Quality Impact in Streams

The description of overall stream water quality based on biological parameters uses a four-tiered system of classification. Level of impact is assessed for each individual parameter and then combined for all parameters to form a consensus determination. Four parameters are used: species richness, EPT richness, biotic index, and percent model affinity (see Appendix II). The consensus is based on the determination of the majority of the parameters. Since parameters measure different aspects of the macroinvertebrate community, they cannot be expected to always form unanimous assessments. The assessment ranges given for each parameter are based on subsamples of 100-organisms each that are taken from macroinvertebrate riffle kick samples. These assessments also apply to most multiplate samples, with the exception of percent model affinity.

1. *Non-impacted*: Indices reflect very good water quality. The macroinvertebrate community is diverse, usually with at least 27 species in riffle habitats. Mayflies, stoneflies, and caddisflies are well represented; EPT richness is greater than 10. The biotic index value is 4.50 or less. Percent model affinity is greater than 64. Nutrient Biotic Index is 5.00 or less. Water quality should not be limiting to fish survival or propagation. This level of water quality includes both pristine habitats and those receiving discharges which minimally alter the biota.

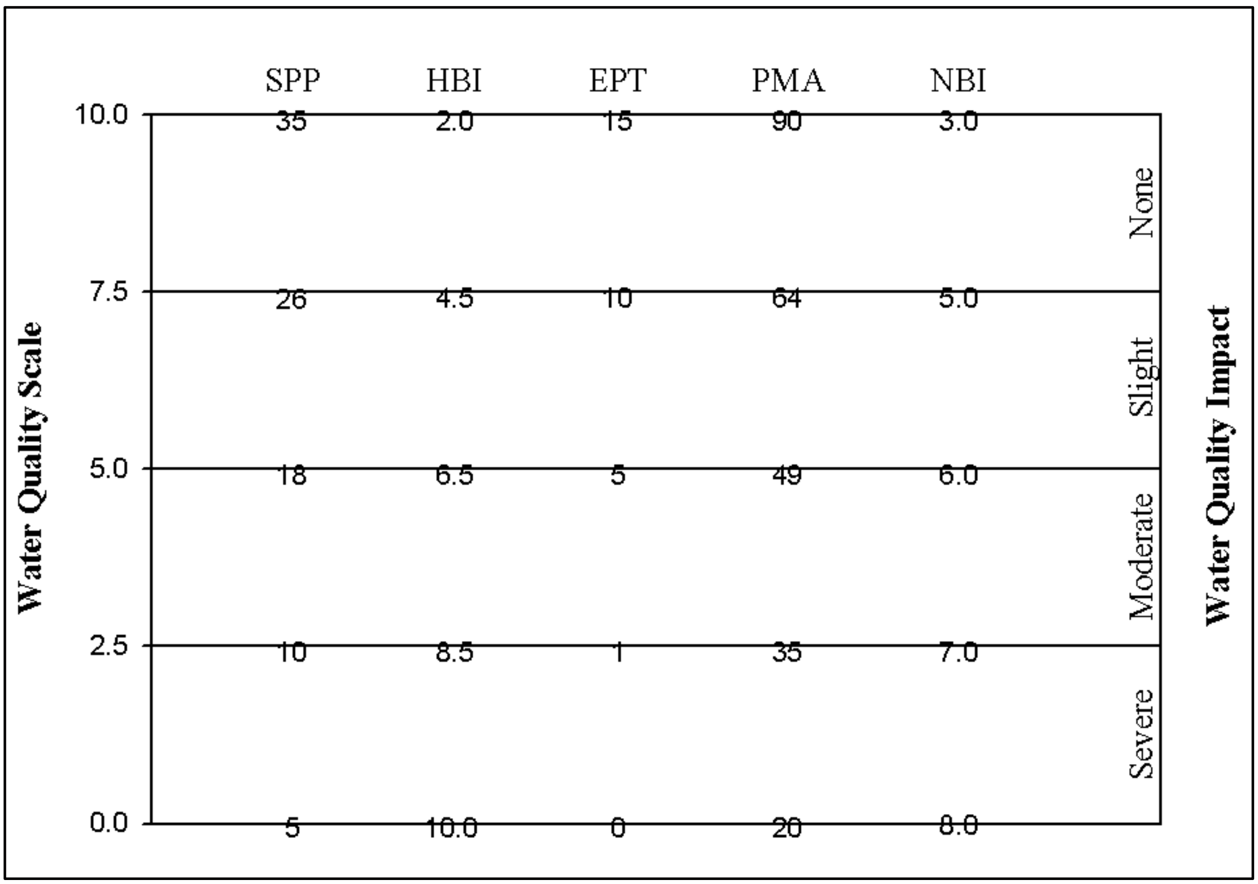
2. *Slightly impacted*: Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Species richness is usually 19-26. Mayflies and stoneflies may be restricted, with EPT richness values of 6-10. The biotic index value is 4.51-6.50. Percent model affinity is 50-64. Nutrient Biotic Index is 5.01-6.00. Water quality is usually not limiting to fish survival, but may be limiting to fish propagation.

3. *Moderately impacted*: Indices reflect poor water quality. The macroinvertebrate community is altered to a large degree from the pristine state. Species richness is usually 11-18 species. Mayflies and stoneflies are rare or absent, and caddisflies are often restricted; the EPT richness is 2-5. The biotic index value is 6.51-8.50. Percent model affinity is 35-49. Nutrient Biotic Index is 6.01-7.00. Water quality often is limiting to fish propagation, but usually not to fish survival.

4. *Severely impacted*: Indices reflect very poor water quality. The macroinvertebrate community is limited to a few tolerant species. Species richness is 10 or fewer. Mayflies, stoneflies and caddisflies are rare or absent; EPT richness is 0-1. The biotic index value is greater than 8.50. Percent model affinity is less than 35. Nutrient Biotic Index is greater than 7.00. The dominant species are almost all tolerant, and are usually midges and worms. Often, 1-2 species are very abundant. Water quality is often limiting to both fish propagation and fish survival.

Appendix IV-A. Biological Assessment Profile: Conversion of Index Values to a 0-10 Scale

The Biological Assessment Profile (BAP) of index values, developed by Phil O'Brien, Division of Water, NYSDEC, is a method of plotting biological index values on a common scale of water quality impact. Values from the five indices -- species richness (SPP), EPT richness (EPT), Hilsenhoff Biotic Index (HBI), Percent Model Affinity (PMA), and Nutrient Biotic Index (NBI)-- defined in Appendix II are converted to a common 0-10 scale using the formulae in the Quality Assurance document (Bode, et al., 2002), and as shown in the figure below.



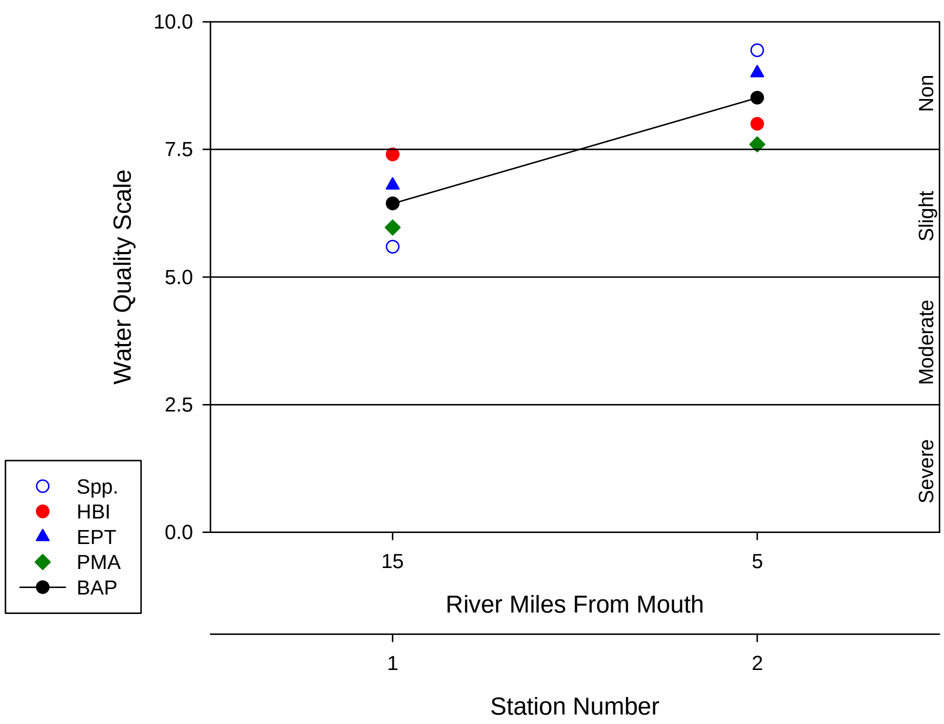
Appendix IV-B. Biological Assessment Profile: Plotting Values

To plot survey data:
1. Position each site on the x-axis according to miles or tenths of a mile upstream of the mouth.
2. Plot the values of the four indices for each site as indicated by the common scale.
3. Calculate the mean of the four values and plot the result. This represents the assessed impact for each site.

Example data:

	Station 1		Station 2	
	metric value	10-scale value	metric value	10-scale value
Species richness	20	5.59	33	9.44
Hilsenhoff Biotic Index	5.00	7.40	4.00	8.00
EPT richness	9	6.80	13	9.00
Percent Model Affinity	55	5.97	65	7.60
Average		6.44 (slight)		8.51 (non-)

Sample BAP plot:



Appendix V. Water Quality Assessment Criteria

Non-Navigable Flowing Waters

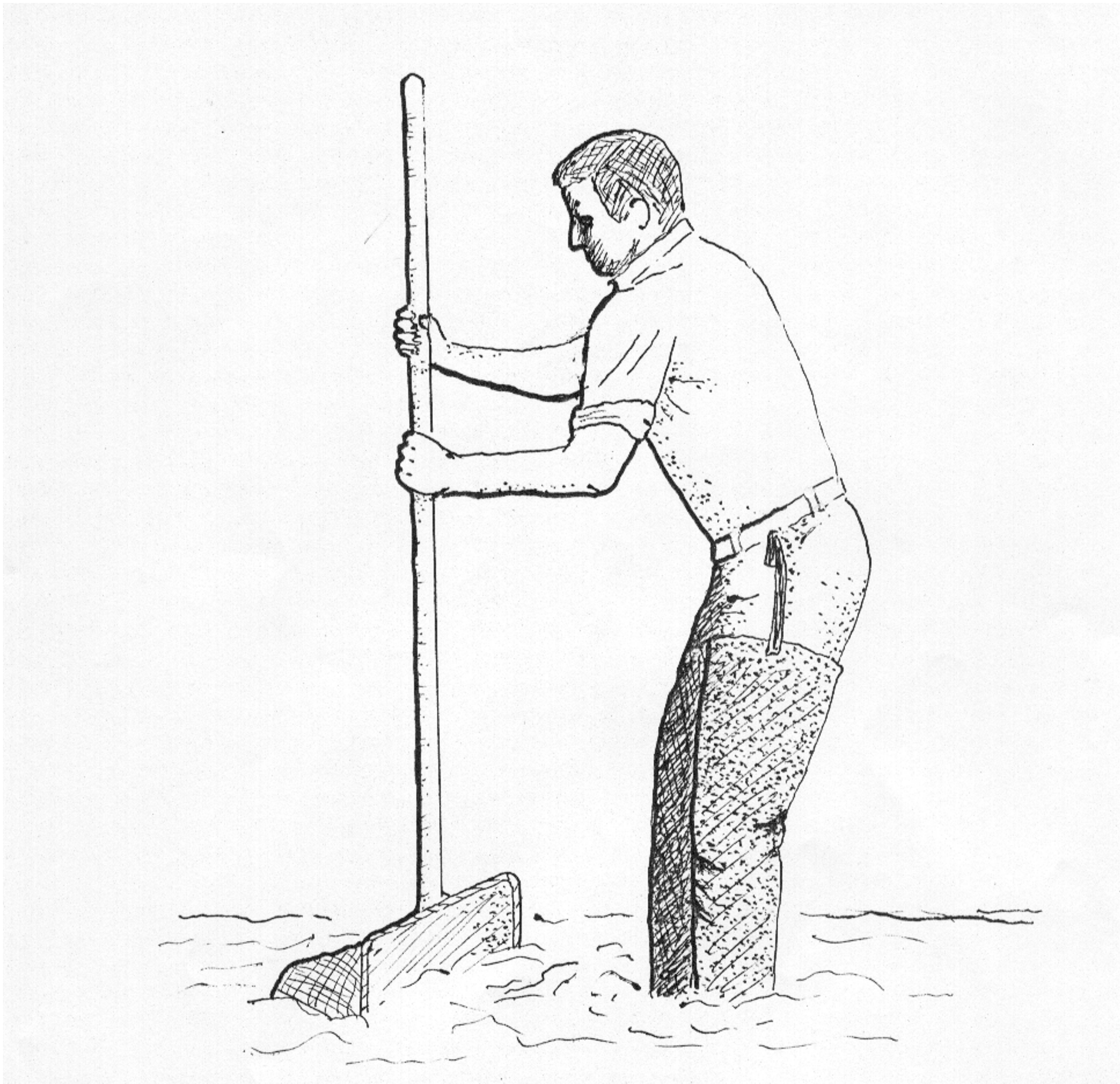
	Species Richness	Hilsenhoff Biotic Index	EPT Value	Percent Model Affinity*	Diversity**
Non-Impacted	>26	0.00-4.50	>10	>64	>4
Slightly Impacted	19-26	4.51-6.50	6-10	50-64	3.01-4.00
Moderately Impacted	11-18	6.51-8.50	2-5	35-49	2.01-3.00
Severely Impacted	0-10	8.51-10.00	0-1	<35	0.00-2.00

* Percent model affinity criteria used for traveling kick samples but not for multiplate samples.
** Diversity criteria are used for multiplate samples but not for traveling kick samples.

Navigable Flowing Waters

	Species Richness	Hilsenhoff Biotic Index	EPT Richness	Species Diversity
Non-Impacted	>21	0.00-7.00	>5	>3.00
Slightly Impacted	17-21	7.01-8.00	4-5	2.51-3.00
Moderately Impacted	12-16	8.01-9.00	2-3	2.01-2.50
Severely Impacted	0-11	9.01-10.00	0-1	0.00-2.00

Appendix VI. The Traveling Kick Sample



← current

Rocks and sediment in a riffle are dislodged by foot upstream of a net. Dislodged organisms are carried by the current into the net. Sampling continues for five minutes, as the sampler gradually moves downstream to cover a distance of five meters.

Appendix VII-A. Aquatic Macroinvertebrates Usually Indicative of Good Water Quality

Mayfly nymphs are often the most numerous organisms found in clean streams. They are sensitive to most types of pollution, including low dissolved oxygen (less than 5 ppm), chlorine, ammonia, metals, pesticides, and acidity. Most mayflies are found clinging to the undersides of rocks.

MAYFLIES

Stonefly nymphs are mostly limited to cool, well-oxygenated streams. They are sensitive to most of the same pollutants as mayflies, except acidity. They are usually much less numerous than mayflies. The presence of even a few stoneflies in a stream suggests that good water quality has been maintained for several months.

STONEFLIES

Caddisfly larvae often build a portable case of sand, stones, sticks, or other debris. Many caddisfly larvae are sensitive to pollution, although a few are tolerant. One family spins nets to catch drifting plankton, and is often numerous in nutrient-enriched stream segments.

CADDISFLIES

The most common beetles in streams are riffle beetles (adult and larva pictured) and water pennies (not shown). Most of these require a swift current and an adequate supply of oxygen, and are generally considered clean-water indicators.

BEETLES

Appendix VII-B. Aquatic Macroinvertebrates Usually Indicative of Poor Water Quality

Midges are the most common aquatic flies. The larvae occur in almost any aquatic situation. Many species are very tolerant to pollution. Large, red midge larvae called "bloodworms" indicate organic enrichment. Other midge larvae filter plankton, indicating nutrient enrichment when numerous.

MIDGES

Black fly larvae have specialized structures for filtering plankton and bacteria from the water, and require a strong current. Some species are tolerant of organic enrichment and toxic contaminants, while others are intolerant of pollutants.

BLACK FLIES

The segmented worms include the leeches and the small aquatic worms. The latter are more common, though usually unnoticed. They burrow in the substrate and feed on bacteria in the sediment. They can thrive under conditions of severe pollution and very low oxygen levels, and are thus valuable pollution indicators. Many leeches are also tolerant of poor water quality.

WORMS

Aquatic sowbugs are crustaceans that are often numerous in situations of high organic content and low oxygen levels. They are classic indicators of sewage pollution, and can also thrive in toxic situations.

SOWBUGS

Digital images by Larry Abele, New York State Department of Environmental Conservation, Stream Biomonitoring Unit.

Appendix VIII. The Rationale of Biological Monitoring

Biological monitoring refers to the use of resident benthic macroinvertebrate communities as indicators of water quality. Macroinvertebrates are larger-than-microscopic invertebrate animals that inhabit aquatic habitats; freshwater forms are primarily aquatic insects, worms, clams, snails, and crustaceans.

Concept:
Nearly all streams are inhabited by a community of benthic macroinvertebrates. The species comprising the community each occupy a distinct niche defined and limited by a set of environmental requirements. The composition of the macroinvertebrate community is thus determined by many factors, including habitat, food source, flow regime, temperature, and water quality. The community is presumed to be controlled primarily by water quality if the other factors are determined to be constant or optimal. Community components which can change with water quality include species richness, diversity, balance, abundance, and presence/absence of tolerant or intolerant species. Various indices or metrics are used to measure these community changes. Assessments of water quality are based on metric values of the community, compared to expected metric values.

Advantages:
The primary advantages to using macroinvertebrates as water quality indicators are that they:

- are sensitive to environmental impacts
- are less mobile than fish, and thus cannot avoid discharges
- can indicate effects of spills, intermittent discharges, and lapses in treatment
- are indicators of overall, integrated water quality, including synergistic effects
- are abundant in most streams and are relatively easy and inexpensive to sample
- are able to detect non-chemical impacts to the habitat, e.g. siltation or thermal changes
- are vital components of the aquatic ecosystem and important as a food source for fish
- are more readily perceived by the public as tangible indicators of water quality
- can often provide an on-site estimate of water quality
- can often be used to identify specific stresses or sources of impairment
- can be preserved and archived for decades, allowing for direct comparison of specimens
- bioaccumulate many contaminants, so that analysis of their tissues is a good monitor of toxic substances in the aquatic food chain

Limitations:
Biological monitoring is not intended to replace chemical sampling, toxicity testing, or fish surveys. Each of these measurements provides information not contained in the others. Similarly, assessments based on biological sampling should not be taken as being representative of chemical sampling. Some substances may be present in levels exceeding ambient water quality criteria, yet have no apparent adverse community impact.

Appendix IX. Glossary

Anthropogenic: caused by human actions

Assessment: a diagnosis or evaluation of water quality

Benthos: organisms occurring on or in the bottom substrate of a waterbody

Bioaccumulate: accumulate contaminants in the tissues of an organism

Biomonitoring: the use of biological indicators to measure water quality

Community: a group of populations of organisms interacting in a habitat

Drainage basin: an area in which all water drains to a particular waterbody; watershed

Electrofishing: sampling fish by using electric currents to temporarily immobilize them, allowing capture

EPT richness: the number of taxa of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) in a sample or subsample

Eutrophic: high nutrient levels normally leading to excessive biological productivity

Facultative: occurring over a wide range of water quality; neither tolerant nor intolerant of poor water quality

Fauna: the animal life of a particular habitat

Impact: a change in the physical, chemical, or biological condition of a waterbody

Impairment: a detrimental effect caused by an impact

Index: a number, metric, or parameter derived from sample data used as a measure of water quality

Intolerant: unable to survive poor water quality

Longitudinal trends: upstream-downstream changes in water quality in a river or stream

Macroinvertebrate: a larger-than-microscopic invertebrate animal that lives at least part of its life in aquatic habitats

Mesotrophic: intermediate nutrient levels (between oligotrophic and eutrophic) normally leading to moderate biological productivity

Multiplate: multiple-plate sampler, a type of artificial substrate sampler of aquatic macroinvertebrates

Non Chironomidae/Oligochaeta (NCO) richness: the number of taxa neither belonging to the family Chironomidae nor the subclass Oligochaeta in a sample or subsample

Oligotrophic: low nutrient levels normally leading to unproductive biological conditions

Organism: a living individual

PAHs: Polycyclic Aromatic Hydrocarbons, a class of organic compounds that are often toxic or carcinogenic.

Rapid bioassessment: a biological diagnosis of water quality using field and laboratory analysis designed to allow assessment of water quality in a short turn-around time; usually involves kick sampling and laboratory subsampling of the sample

Riffle: wadeable stretch of stream usually with a rubble bottom and sufficient current to have the water surface broken by the flow; rapids

Species richness: the number of macroinvertebrate taxa in a sample or subsample

Station: a sampling site on a waterbody

Survey: a set of samplings conducted in succession along a stretch of stream

Synergistic effect: an effect produced by the combination of two factors that is greater than the sum of the two factors

Tolerant: able to survive poor water quality

Trophic: referring to the biological productivity of a stream

Appendix X. Methods for Calculation of the Nutrient Biotic Index

Definition: The Nutrient Biotic Index (Smith et al., 2007) is a diagnostic measure of stream nutrient enrichment identified by macroinvertebrate taxa. The frequency of occurrences of taxa at varying nutrient concentrations allowed the identification of taxon-specific nutrient optima using a method of weighted averaging. The establishment of nutrient optima is possible based on the observation that most species exhibit unimodal response curves in relation to environmental variables (Jongman et al., 1987). The assignment of tolerance values to taxa based on their nutrient optimum provided the ability to reduce macroinvertebrate community data to a linear scale of eutrophication from oligotrophic to eutrophic. Two tolerance values were assigned to each taxon, one for total phosphorus, and one for nitrate (listed in Smith, 2005). This provides the ability to calculate two different nutrient biotic indices, one for total phosphorus (NBI-P), and one for nitrate (NBI-N). Study of the indices indicates better performance by the NBI-P, with strong correlations to stream nutrient status assessment based on diatom information.

Calculation of the NBI-P and NBI-N: Calculation of the indices [2] follows the approach of Hilsenhoff (1987).

$$\text{NBI Score}_{(\text{TP or NO3}^-)} = \sum (a \times b) / c$$

Where ***a*** is equal to the number of individuals for each taxon, ***b*** is the taxon's tolerance value, and ***c*** is the total number of individuals in the sample for which tolerance values have been assigned.

Classification of NBI Scores: NBI scores have been placed on a scale of eutrophication with provisional boundaries between stream trophic status.

Index	Oligotrophic	Mesotrophic	Eutrophic
NBI-P	< 5.0	> 5.0 - 6.0	> 6.0
NBI-N	< 4.5	> 4.5 - 6.0	> 6.0

Jongman, R. H. G., C. J. F. ter Braak and O. F. R. van Tongeren. 1987. Data analysis in community and landscape ecology. Pudoc Wageningen, Netherlands, 299 pages.

Smith, A.J., R. W. Bode, and G. S. Kleppel. 2007. A nutrient biotic index for use with benthic macroinvertebrate communities. Ecological Indicators 7(200):371-386.

Tolerance values assigned to taxa for calculation of the Nutrient Biotic Index

TAXON	TP T-Value	NO3 T-Value
Acentrella sp.	5	5
Acerpenna pygmaea	0	4
Acroneuria abnormis	0	0
Acroneuria sp.	0	0
Agnetina capitata	3	6
Anthopotamus sp.	4	5
Antocha sp.	8	6
Apatania sp.	3	4
Atherix sp.	8	5
Baetis brunneicolor	1	5
Baetis flavistriga	7	7
Baetis intercalaris	6	5
Baetis sp.	6	3
Baetis tricaudatus	8	9
Brachycentrus appalachia	3	4
Caecidotea racovitzai	6	2
Caecidotea sp.	7	9
Caenis sp.	3	3
Cardiocladius obscurus	8	6
Cheumatopsyche sp.	6	6
Chimarra aterrima?	2	3
Chimarra obscura	6	4
Chimarra socia	4	1
Chimarra sp.	2	0
Chironomus sp.	9	6
Cladotanytarsus sp.	6	4
Corydalus cornutus	2	2
Cricotopus bicinctus	7	6
Cricotopus tremulus gr.	8	9
Cricotopus trifascia gr.	9	9
Cricotopus vierriensis	6	5
Cryptochironomus fulvus gr.	5	6
Diamesa sp.	10	10
Dicranota sp.	5	10
Dicrotendipes neomodestus	10	4
Dolophilodes sp.	4	3
Drunella cornutella	4	4
Ectopria nervosa	10	9
Epeorus (Iron) sp.	0	0
Ephemerella sp.	4	4
Ephemerella subvaria	4	1
Ephoron leukon?	1	1
Eukiefferiella devonica gr.	9	9
Ferrissia sp.	9	5
Gammarus sp.	8	9
Glossosoma sp.	6	0
Goniobasis livescens	10	10
Helicopsyche borealis	1	2
Hemerodromia sp.	5	6
Heptagenia sp.	0	0
Hexatoma sp.	0	1
Hydropsyche betteni	7	9
Hydropsyche bronta	7	6
Hydropsyche morosa	5	1
Hydropsyche scalaris	3	3
TAXON	TP T-Value	NO3 T-Value
Hydropsyche slossonae	6	10
Hydropsyche sp.	5	4
Hydropsyche sparna	6	7
Hydroptila consimilis	9	10
Hydroptila sp.	6	6
Hydroptila spatulata	9	8
Isonychia bicolor	5	2
Lepidostoma sp.	2	0
Leucotrichia sp.	6	2
Leucrocuta sp.	1	3
Macrostemum carolina	7	2
Macrostemum sp.	4	2
Micrasema sp. 1	1	0
Micropsectra dives gr.	6	9
Micropsectra polita	0	7
Micropsectra sp.	3	1
Microtendipes pedellus gr.	7	7
Microtendipes rydalensis gr.	2	1
Nais variabilis	5	0
Neoperla sp.	5	5
Neureclipsis sp.	3	1
Nigronia serricornis	10	8
Nixe (Nixe) sp.	1	5
Ophiogomphus sp.	1	3
Optioservus fastiditus	6	7
Optioservus ovalis	9	4
Optioservus sp.	7	8
Optioservus trivittatus	7	6
Orthocladius nr. dentifer	3	7
Pagastia orthogonia	4	8
Paragnetina immarginata	1	2
Paragnetina media	6	3
Paragnetina sp.	1	6
Paraleptophlebia mollis	2	1
Paraleptophlebia sp.	2	3
Parametriocnemus lundbecki	8	10
Paratanytarsus confusus	5	8
Pentaneura sp.	0	1
Petrophila sp.	5	3
Phaenopsectra dyari?	4	5
Physella sp.	8	7
Pisidium sp.	8	10
Plauditus sp.	2	6
Polycentropus sp.	4	2
Polypedilum aviceps	5	7
Polypedilum flavum	9	7
Polypedilum illinoense	10	7
Polypedilum laetum	7	6
Polypedilum scalaenum gr.	10	6
Potthastia gaedii gr.	9	10
Promoresia elegans	10	10
Prostoma graecense	2	7

Psephenus herricki	10	9	*Psephenus sp.*	3	4

NBI tolerance values (cont'd)

TAXON	TP T-Value	NO3 T-Value	TAXON	TP T-Value	NO3 T-Value
Psychomyia flavida	1	0	*Synorthocladius nr. semivirens*	6	9
Rheocricotopus robacki	4	4	*Tanytarsus glabrescens gr.*	5	6
Rheotanytarsus exiguus gr.	6	5	*Tanytarsus guerlus gr.*	5	5
Rheotanytarsus pellucidus	3	2	*Thienemannimyia gr. spp.*	8	8
Rhithrogena sp.	0	1	*Tipula sp.*	10	10
Rhyacophila fuscula	2	5	*Tricorythodes sp.*	4	9
Rhyacophila sp.	0	1	*Tvetenia bavarica gr.*	9	10
Serratella deficiens	5	2	*Tvetenia vitracies*	7	6
Serratella serrata	1	0	Undet. Tubificidae w/ cap. setae	10	8
Serratella serratoides	0	1	Undet. Tubificidae w/o cap. setae	7	7
Serratella sp.	1	1	Undetermined Cambaridae	6	5
Sialis sp.	5	6	Undet. Ceratopogonidae	8	9
Simulium jenningsi	6	2	Undet. Enchytraeidae	7	8
Simulium sp.	7	6	Undet. Ephemerellidae	3	6
Simulium tuberosum	1	0	Undetermined Gomphidae	2	0
Simulium vittatum	7	10	Undet. Heptageniidae	5	2
Sphaerium sp.	9	4	Undetermined Hirudinea	9	10
Stenacron interpunctatum	7	7	Undetermined Hydrobiidae	6	7
Stenelmis concinna	5	0	Undetermined Hydroptilidae	5	2
Stenelmis crenata	7	7	Undet. Limnephilidae	3	4
Stenelmis sp.	7	7	Undet. Lumbricina	8	8
Stenochironomus sp.	4	3	Undet. Lumbriculidae	5	6
Stenonema mediopunctatum	3	3	Undetermined Perlidae	5	7
Stenonema modestum	2	5	Undetermined Sphaeriidae	10	8
Stenonema sp.	5	5	Undetermined Turbellaria	8	6
Stenonema terminatum	2	3	*Zavrelia sp.*	9	9
Stenonema vicarium	6	7			
Stylaria lacustris	5	2			
Sublettea coffmani	3	5			

Appendix XI. Impact Source Determination Methods and Community Models

Definition: Impact Source Determination (ISD) is the procedure for identifying types of impacts that exert deleterious effects on a waterbody. While the analysis of benthic macroinvertebrate communities has been shown to be an effective means of determining severity of water quality impacts, it has been less effective in determining what kind of pollution is causing the impact. ISD uses community types or models to ascertain the primary factor influencing the fauna.

Development of methods: The method found to be most useful in differentiating impacts in New York State streams was the use of community types based on composition by family and genus. It may be seen as an elaboration of Percent Model Affinity (Novak and Bode, 1992), which is based on class and order. A large database of macroinvertebrate data was required to develop ISD methods. The database included several sites known or presumed to be impacted by specific impact types. The impact types were mostly known by chemical data or land use. These sites were grouped into the following general categories: agricultural nonpoint, toxic-stressed, sewage (domestic municipal), sewage/toxic, siltation, impoundment, and natural. Each group initially contained 20 sites. Cluster analysis was then performed within each group, using percent similarity at the family or genus level. Within each group, four clusters were identified. Each cluster was usually composed of 4-5 sites with high biological similarity. From each cluster, a hypothetical model was then formed to represent a model cluster community type; sites within the cluster had at least 50 percent similarity to this model. These community type models formed the basis for ISD (see tables following). The method was tested by calculating percent similarity to all the models and determining which model was the most similar to the test site. Some models were initially adjusted to achieve maximum representation of the impact type. New models are developed when similar communities are recognized from several streams.

Use of the ISD methods: Impact Source Determination is based on similarity to existing models of community types (see tables following). The model that exhibits the highest similarity to the test data denotes the likely impact source type, or may indicate "natural," lacking an impact. In the graphic representation of ISD, only the highest similarity of each source type is identified. If no model exhibits a similarity to the test data of greater than 50 percent, the determination is inconclusive. The determination of impact source type is used in conjunction with assessment of severity of water quality impact to provide an overall assessment of water quality.

Limitations: These methods were developed for data derived from subsamples of 100-organisms each that are taken from traveling kick samples of New York State streams. Application of these methods for data derived from other sampling methods, habitats, or geographical areas would likely require modification of the models.

ISD Models

	NATURAL												
	A	B	C	D	E	F	G	H	I	J	K	L	M
PLATYHELMINTHES	-	-	-	-	-	-	-	-	-	-	-	-	-
OLIGOCHAETA	-	-	5	-	5	-	5	5	-	-	-	5	5
HIRUDINEA	-	-	-	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	-	-	-	-	-	-
SPHAERIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-
ASELLIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-
GAMMARIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-
Isonychia	5	5	-	5	20	-	-	-	-	-	-	-	-
BAETIDAE	20	10	10	10	10	5	10	10	10	10	5	15	40
HEPTAGENIIDAE	5	10	5	20	10	5	5	5	5	10	10	5	5
LEPTOPHLEBIIDAE	5	5	-	-	-	-	-	-	5	-	-	25	5
EPHEMERELLIDAE	5	5	5	10	-	10	10	30	-	5	-	10	5
Caenis/Tricorythodes	-	-	-	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	5	5	-	5	5	15	5	5	5	5
Psephenus	5	-	-	-	-	-	-	-	-	-	-	-	-
Optioservus	5	-	20	5	5	-	5	5	5	5	-	-	-
Promoresia	5	-	-	-	-	-	25	-	-	-	-	-	-
Stenelmis	10	5	10	10	5	-	-	-	10	-	-	-	5
PHILOPOTAMIDAE	5	20	5	5	5	5	5	-	5	5	5	5	5
HYDROPSYCHIDAE	10	5	15	15	10	10	5	5	10	15	5	5	10
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	5	5	-	-	-	20	-	5	5	5	5	5	-
SIMULIIDAE	-	-	-	5	5	-	-	-	-	5	-	-	-
Simulium vittatum	-	-	-	-	-	-	-	-	-	-	-	-	-
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-
TIPULIDAE	-	-	-	-	-	-	-	-	5	-	-	-	-
CHIRONOMIDAE													
Tanypodinae	-	5	-	-	-	-	-	-	5	-	-	-	-
Diamesinae	-	-	-	-	-	-	5	-	-	-	-	-	-
Cardiocladius	-	5	-	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	5	5	-	-	10	-	-	5	-	-	5	5	5
Eukiefferiella/ Tvetenia	5	5	10	-	-	5	5	5	-	5	-	5	5
Parametriocnemus	-	-	-	-	-	-	-	5	-	-	-	-	-
Chironomus	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-	20	-	-	10	20	20	5	-
Polypedilum (all others)	5	5	5	5	5	-	5	5	-	-	-	-	-
Tanytarsini	-	5	10	5	5	20	10	10	10	10	40	5	5
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100

ISD Models (cont'd)

NONPOINT NUTRIENTS, PESTICIDES										
	A	B	C	D	E	F	G	H	I	J
PLATYHELMINTHES	-	-	-	-	-	-	-	-	-	-
OLIGOCHAETA	-	-	-	5	-	-	-	-	-	15
HIRUDINEA	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	-	-	-
SPHAERIIDAE	-	-	-	5	-	-	-	-	-	-
ASELLIDAE	-	-	-	-	-	-	-	-	-	-
GAMMARIDAE	-	-	-	5	-	-	-	-	-	-
Isonychia	-	-	-	-	-	-	-	5	-	-
BAETIDAE	5	15	20	5	20	10	10	5	10	5
HEPTAGENIIDAE	-	-	-	-	5	5	5	5	-	5
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	5	-	-
Caenis/Tricorythodes	-	-	-	-	5	-	-	5	-	5
PLECOPTERA	-	-	-	-	-	-	-	-	-	-
Psephenus	5	-	-	5	-	5	5	-	-	-
Optioservus	10	-	-	5	-	-	15	5	-	5
Promoresia	-	-	-	-	-	-	-	-	-	-
Stenelmis	15	15	-	10	15	5	25	5	10	5
PHILOPOTAMIDAE	15	5	10	5	-	25	5	-	-	-
HYDROPSYCHIDAE	15	15	15	25	10	35	20	45	20	10
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-
SIMULIIDAE	5	-	15	5	5	-	-	-	40	-
Simulium vittatum	-	-	-	-	-	-	-	-	5	-
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-
TIPULIDAE	-	-	-	-	-	-	-	-	-	5
CHIRONOMIDAE										
Tanypodinae	-	-	-	-	-	-	5	-	-	5
Cardiocladius	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	10	15	10	5	-	-	-	-	5	5
Eukiefferiella/ Tvetenia	-	15	10	5	-	-	-	-	5	-
Parametriocnemus	-	-	-	-	-	-	-	-	-	-
Microtendipes	-	-	-	-	-	-	-	-	-	20
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	10	10	10	10	20	10	5	10	5	5
Tanytarsini	10	10	10	5	20	5	5	10	-	10
TOTAL	100	100	100	100	100	100	100	100	100	100

ISD Models (cont'd)

	MUNICIPAL/INDUSTRIAL								TOXIC					
	A	B	C	D	E	F	G	H	A	B	C	D	E	F
PLATYHELMINTHES	-	40	-	-	-	5	-	-	-	-	-	-	5	-
OLIGOCHAETA	20	20	70	10	-	20	-	-	-	10	20	5	5	15
HIRUDINEA	-	5	-	-	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	5	-	-	-	5	-	-	-	5
SPHAERIIDAE	-	5	-	-	-	-	-	-	-	-	-	-	-	-
ASELLIDAE	10	5	10	10	15	5	-	-	10	10	-	20	10	5
GAMMARIDAE	40	-	-	-	15	-	5	5	5	-	-	-	5	5
Isonychia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BAETIDAE	5	-	-	-	5	-	10	10	15	10	20	-	-	5
HEPTAGENIIDAE	5	-	-	-	-	-	-	-	-	-	-	-	-	-
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caenis/Tricorythodes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psephenus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Optioservus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Promoresia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenelmis	5	-	-	10	5	-	5	5	10	15	-	40	35	5
PHILOPOTAMIDAE	-	-	-	-	-	-	-	40	10	-	-	-	-	-
HYDROPSYCHIDAE	10	-	-	50	20	-	40	20	20	10	15	10	35	10
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SIMULIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Simulium vittatum	-	-	-	-	-	-	20	10	-	20	-	-	-	5
EMPIDIDAE	-	5	-	-	-	-	-	-	-	-	-	-	-	-
CHIRONOMIDAE														
Tanypodinae	-	10	-	-	5	15	-	-	5	10	-	-	-	25
Cardiocladius	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	5	10	20	-	5	10	5	5	15	10	25	10	5	10
Eukiefferiella/ Tvetenia	-	-	-	-	-	-	-	-	-	-	20	10	-	-
Parametriocnemus	-	-	-	-	-	-	-	-	-	-	-	5	-	-
Chironomus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	-	-	-	10	20	40	10	5	10	-	-	-	-	5
Tanytarsini	-	-	-	10	10	-	5	-	-	-	-	-	-	5
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100

ISD Models (cont'd)

SEWAGE EFFLUENT, ANIMAL WASTES										
	A	B	C	D	E	F	G	H	I	J
PLATYHELMINTHES	-	-	-	-	-	-	-	-	-	-
OLIGOCHAETA	5	35	15	10	10	35	40	10	20	15
HIRUDINEA	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	-	-	-
SPHAERIIDAE	-	-	-	10	-	-	-	-	-	-
ASELLIDAE	5	10	-	10	10	10	10	50	-	5
GAMMARIDAE	-	-	-	-	-	10	-	10	-	-
Isonychia	-	-	-	-	-	-	-	-	-	-
BAETIDAE	-	10	10	5	-	-	-	-	5	-
HEPTAGENIIDAE	10	10	10	-	-	-	-	-	-	-
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	-	5	-
Caenis/Tricorythodes	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-
Psephenus	-	-	-	-	-	-	-	-	-	-
Optioservus	-	-	-	-	-	-	-	-	5	-
Promoresia	-	-	-	-	-	-	-	-	-	-
Stenelmis	15	-	10	10	-	-	-	-	-	-
PHILOPOTAMIDAE	-	-	-	-	-	-	-	-	-	-
HYDROPSYCHIDAE	45	-	10	10	10	-	-	10	5	-
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-
SIMULIIDAE	-	-	-	-	-	-	-	-	-	-
Simulium vittatum	-	-	-	25	10	35	-	-	5	5
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-
CHIRONOMIDAE										
Tanypodinae	-	5	-	-	-	-	-	-	5	5
Cardiocladius	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	-	10	15	-	-	10	10	-	5	5
Eukiefferiella/ Tvetenia	-	-	10	-	-	-	-	-	-	-
Parametriocnemus	-	-	-	-	-	-	-	-	-	-
Chironomus	-	-	-	-	-	-	10	-	-	60
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	10	10	10	10	60	-	30	10	5	5
Tanytarsini	10	10	10	10	-	-	-	10	40	-
TOTAL	100	100	100	100	100	100	100	100	100	100

ISD Models (cont'd)

	SILTATION					IMPOUNDMENT									
	A	B	C	D	E	A	B	C	D	E	F	G	H	I	J
PLATYHELMINTHES	-	-	-	-	-	-	10	-	10	-	5	-	50	10	-
OLIGOCHAETA	5	-	20	10	5	5	-	40	5	10	5	10	5	5	-
HIRUDINEA	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	10	-	5	5	-	-	-	-
SPHAERIIDAE	-	-	-	5	-	-	-	-	-	-	-	-	5	25	-
ASELLIDAE	-	-	-	-	-	-	5	5	-	10	5	5	5	-	-
GAMMARIDAE	-	-	-	10	-	-	-	10	-	10	50	-	5	10	-
Isonychia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BAETIDAE	-	10	20	5	-	-	5	-	5	-	-	5	-	-	5
HEPTAGENIIDAE	5	10	-	20	5	5	5	-	5	5	5	5	-	5	5
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caenis/Tricorythodes	5	20	10	5	15	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psephenus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Optioservus	5	10	-	-	-	-	-	-	-	-	-	-	-	5	-
Promoresia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenelmis	5	10	10	5	20	5	5	10	10	-	5	35	-	5	10
PHILOPOTAMIDAE	-	-	-	-	-	5	-	-	5	-	-	-	-	-	30
HYDROPSYCHIDAE	25	10	-	20	30	50	15	10	10	10	10	20	5	15	20
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
SIMULIIDAE	5	10	-	-	5	5	-	5	-	35	10	5	-	-	15
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHIRONOMIDAE															
Tanypodinae	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-
Cardiocladius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	25	-	10	5	5	5	25	5	-	10	-	5	10	-	-
Eukiefferiella/ Tvetenia	-	-	10	-	5	5	15	-	-	-	-	-	-	-	-
Parametriocnemus	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-
Chironomus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	10	10	10	5	5	5	-	-	20	-	-	5	5	5	5
Tanytarsini	10	10	10	10	5	5	10	5	30	-	-	5	10	10	5
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Appendix XII. Biological Impacts of Waters with High Conductivity

Definition: Conductivity is a measure of the ability of an aqueous solution to carry an electric current. It may be used to estimate salinity, total dissolved solids (TDS), and chlorides. Salinity is the amount of dissolved salts in a given amount of solution. TDS, although not precisely equivalent to salinity, is closely related, and for most purposes can be considered synonymous. EPA has not established ambient water-quality criteria for salinity; for drinking water, maximum contaminant levels are 250 mg/L for chlorides, and 500 mg/L for dissolved solids (EPA, 1995).

Measurement: Conductivity is measured as resistance and is reported in micromhos per centimeter (μmhos/cm), which is equivalent to microsiemens per centimeter (μS/cm). To estimate TDS and salinity, multiply conductivity by 0.64 and express the result in parts per million. For marine waters, salinity is usually expressed in parts per thousand. To estimate chlorides, multiply conductivity by 0.21 and express the result in parts per million. Departures from these estimates can occur when elevated conductivity is a result of natural conditions, such as in situations of high alkalinity (bicarbonates), or sulfates.

Effects on macroinvertebrates: Bioassays on test animals found the toxicity threshold for *Daphnia magna* to be 6-10 parts per thousand salinity (6,000-10,000 mg/L) (Ingersoll et al., 1992). Levels of concern for this species were set at 0.3-6 parts per thousand salinity (300-6,000 mg/L) (U.S. Dept. of Interior, 1998).

Stream Biomonitoring findings: Of 22 New York State streams sampled with specific conductance levels exceeding 800 μmhos/cm, 9% were assessed as severely impacted, 50% were assessed as moderately impacted, 32% were assessed as slightly impacted, and 9% were assessed as non-impacted. Many of the benthic communities in the impacted streams were dominated by oligochaetes, midges, and crustaceans (scuds and sowbugs). Thirty-five percent of the streams were considered to derive their high conductance primarily from natural sources, while the remainder were the result of contributions from point and nonpoint anthropogenic (human caused) sources. For nearly all streams with high conductivity, other contaminants are contained in the water column, making it difficult to isolate effects of high conductance.

Recommendations**:** Conductivity may be best used as an indicator of elevated amounts of anthropogenic-source contaminants. Based on findings that the median impact at sites with specific conductance levels exceeding 800 μmhos/cm is moderate impact, 800 μmhos/cm is designated as a level of concern with expected biological impairments. Eight-hundred umhos/cm corresponds to ~170 mg/L chlorides, ~510 parts per million Total Dissolved Solids, and ~0.51 parts per thousand salinity.

US Dept. of Interior. 1998. Guidelines for interpretation of the biological effects of selected constituents in biota, water, and sediment. National Irrigation Water Quality Program Information Report No. 3.

Ingersoll, C.G., F.J. Dwyer, S.A. Burch, M.K. Nelson, D.R. Buckler, and J.B. Hunn. 1992. The use of freshwater and saltwater animals to distinguish between the toxic effects of salinity and contaminants in irrigation drain water. Environmental Toxicology and Chemistry, 11:503-511.

U.S. EPA. 995. Drinking water regulations and health advisories. U.S. Environmental Protection Agency, Office of Water, Washington, D.C., 11 pages.

Appendix XIII. Methods for Collecting Biological Samples and Assessing Water Quality Using Net Jabs in Slow, Sandy Streams

A. Rationale: The use of the standardized net jab method provides a biological assessment technique that lends itself to rapid assessments of stream water quality in slow, sandy streams where kick sampling does not apply due to a lack of riffle habitat.

B. Site Selection: Sampling sites are selected based on these criteria: (1) The sampling location should be a slow moving stream or river where water levels are typically too deep to wade across, typically more than 1 meter, and a substrate of fine particles, typically sand, silt and clay or some combination. Current speed is usually less than 0.4 meter per second. (2) The site should have comparable current speed, substrate type, embeddedness, and canopy cover to both upstream and downstream sites to the degree possible. (3) Sites are chosen to have a safe and convenient access.

C. Sampling: Macroinvertebrates are sampled using the standardized net jab method. An aquatic net is used to jab at the stream bottom disturbing only the top 1 – 2 inches of substrate. As the stream bottom is disturbed, the net is withdrawn into the water column and swept through the disturbed debris so dislodged organisms are carried into the net. This technique is continued for a period of 5 minutes over a 5-meter transect of stream. The contents of the net are emptied into a pan of stream water. The contents are then examined, and the major groups of organisms are recorded, usually on the ordinal level (e.g., stoneflies, mayflies, caddisflies). Larger rocks, sticks, and plants may be removed from the sample if organisms are first removed from them. The contents of the pan are poured into a U.S. No. 30 sieve and transferred to a quart jar. The sample is then preserved by adding 95% ethyl alcohol.

D. Sample Sorting and Subsampling: In the laboratory, the sample is rinsed with tap water in a U.S. No. 40 standard sieve to remove any fine particles left in the residues from field sieving. The sample is transferred to an enamel pan and distributed homogeneously over the bottom of the pan. A small amount of the sample is randomly removed with a spatula, rinsed with water, and placed in a petri dish. This portion is examined under a dissecting stereomicroscope and 100 organisms are randomly removed from the debris. As they are removed, they are sorted into major groups, placed in vials containing 70 % alcohol, and counted. The total number of organisms in the sample is estimated by weighing the residue from the picked subsample and determining its proportion of the total sample weight.

E. Organism Identification: All organisms are identified to the species level whenever possible. Chironomids and oligochaetes are slide-mounted and viewed through a compound microscope; most other organisms are identified as whole specimens using a dissecting stereomicroscope. The number of individuals in each species and the total number of individuals in the subsample are recorded on a data sheet. All organisms from the subsample are archived (either slide-mounted or preserved in alcohol). If the results of the identification process are ambiguous, suspected of being spurious, or do not yield a clear water quality assessment, additional subsampling may be required.

Appendix XIII (cont'd.)

F. Water Quality Assessment: For net jabs from slow sandy streams, the indices used in calculating the BAP and determining overall water quality are: SPP (species richness), HBI (Hilsenhoff Biotic Index), EPT (EPT richness), and NCO (NCO richness) (Appendix II). NCO replaces the metric known as Percent Model Affinity used in the assessment of samples using the travelling kick method. Values from the four indices are converted to a common 0-10 scale as shown in Figure 11. The mean scale value of the four indices represents the assessed impact for each site. Ten scale conversion formulae for these individual metrics follow.