BRONX RIVER

Biological Stream Assessment

May 1, 2015

STREAM BIOMONITORING UNIT

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BIOLOGICAL STREAM ASSESSMENT

Bronx River
Bronx and Westchester Counties, New York
Atlantic/Long Island Drainage Basin

Survey date: September 12, 2014
Report date: May 1, 2015

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Table of Contents

Stream: Bronx River

River Basin: Atlantic Ocean / Long Island Sound

Reach: Valhalla to Bronx, NY

Background

      The New York State Department of Environmental Conservation (NYSDEC) Stream Biomonitoring Unit (SBU) conducted a biological assessment of water quality at five locations on the Bronx River, September 12, 2014. The survey was conducted to provide current data for the river and to assess biological condition in comparison to surveys conducted in 1998 and 2003.

      To characterize water quality and assess any impacts to aquatic life, benthic macroinvertebrate communities were collected via traveling kick sample from riffle areas at each location. Methods used are described in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC, 2014) and summarized in the appendices of this document. The contents of each sample were field-inspected to determine major groups of organisms present, and then preserved in alcohol for laboratory inspection of 100-specimen subsamples from each site. Biological assessment of water quality was conducted through calculation of benthic macroinvertebrate community metrics including the Biological Assessment Profile (BAP) score for riffle communities. Expected variability in the results of benthic macroinvertebrate community samples is presented in Smith and Bode (2004).

Results and Conclusions

1. Benthic macroinvertebrate community assessment suggests water quality in the Bronx River remains impaired for aquatic life. All sampling locations were assessed as moderately impacted. This assessment is similar to previous survey reports completed by the SBU in 1998 and 2003.

2. Severely altered habitat conditions resulting from human alteration of the riparian corridor are also influencing the integrity of biological communities in the Bronx River. Habitat improvement projects, focused along the river, can improve riparian corridors by increasing vegetative width, diversity and stability, which in turn will improve in-stream colonization by biological communities. In addition, these improvements will also reduce pollutant loads to the river.

3. Bode et al. (2003) suggested the presence of mayflies in the Bronx River as indicators of water quality improvement. In the present survey mayflies were found at each location although in very low abundance and diversity. Their presence should continue to be monitored and will hopefully increase in number and diversity in the future.

Discussion

The Bronx River in located in southern NY, predominately within Westchester County. The river drains approximately 60 mi^2 of land area, 48 mi^2 of which are highly urbanized and within Westchester County (Westchester County 2007). In the headwater reaches of the watershed there are significant areas of forested land surrounding the Kensico Reservoir, which serves as a water supply for both Westchester County and New York City residents (Westchester County 2007). As a result of the long-standing urbanization in the watershed the Bronx River has been subject to increased stormwater runoff and higher water temperatures (USACE 2006) which have likely contributed to the impaired benthic macroinvertebrate communities in most areas of the Bronx River (Bode et al. 1999, Bode et al. 2003).

On September 12, 2014 the SBU conducted a biological assessment of water quality at five locations on the Bronx River, some of which had been previously reported on in 1998 and 2003 (Table 1, Figures 1, 2-2d). The present survey was conducted to provide current data on the Bronx River and to assess biological condition in comparison to historical surveys. Additionally this more recent assessment may be useful documentation in support of other watershed management and restoration efforts currently ongoing in the Bronx River watershed. For example, the Bronx River Watershed Coalition, a partnership among Westchester County local governments and not-for-profits, has established a comprehensive watershed management plan (Bronx River Watershed Coalition 2014). Some of the work involved in developing this plan included biological assessment of water quality using benthic macroinvertebrates at previous SBU sites and elsewhere. This work was conducted through partnership with the U.S. Army Corps of Engineers (ACE) and others (USACE 2006). Continued documentation of impact to water quality in the Bronx River will be important as management plans in the watershed are implemented.

Water quality in the Bronx River remains relatively unchanged since the most recent historical SBU surveys (Bode et al. 1999, Bode et al. 2003). The results of the 2014 survey by the SBU suggest water quality, based on benthic macroinvertebrate communities, is moderately impacted (Figure 3a). Therefore water quality in the Bronx River does not yet support its designated use for protection of aquatic life. As a result of the moderately impacted conditions the NYSDEC's Waterbody Inventory and Priority Waterbodies list should continue to list the Bronx River, upper (segment #1702-0107), middle (segment #1702-0106), and lower (segment #1702-0006) segments as impaired for aquatic life. The five locations sampled during the 2014 survey represent each of these waterbody segments providing updated assessments for the entire main-stem Bronx River.

Previous reports by Bode et al. (1999 and 2003) suggest moderately impacted water quality at all sites with the exception of the most upstream location, BRNX-01 at Valhalla, NY, which was assessed as slightly impacted (Figure 3b). In the present survey the assessment of water quality at this location is now moderately impacted. This worsening in the condition estimate does not represent a significant change in water quality but rather reflects a change in the SBU's methods of reporting benthic macroinvertebrate condition. In 2012 the SBU began reporting water quality impacts using an additional biological community metric known as the Nutrient Biotic Index for phosphorus (NBI-P) (Smith et al. 2007). This method is summarized in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC, 2014). Adding this fifth metric to the Biological Assessment Profile score (BAP), NYSDEC's multimetric indicator of water quality, generally reduces condition estimates slightly when compared with previous assessment using the BAP excluding the NBI-P. These differences

2

can be seen in the overall condition estimates from the 2015 survey of the Bronx River (Figure 3a) and in comparison with previous reports when the NBI-P has been excluded (Figure 3b). When reporting water quality using this previous method BRNX-01 is again assessed as slightly impacted. However, Smith et al. (2007) suggests the addition of the NBI-P provides a more accurate assessment of benthic community condition as it reflects the influence of increased nutrient concentrations in water.

Impact Source Determination (ISD, Table 2) indicates similar possible sources of water quality impacts to those reported in the 1998 and 2003 reports. At the upstream station at Valhalla, various sources including siltation, non-point source nutrients, and municipal/industrial inputs, some of which may be toxic in nature, are indicated. Further downstream at sampling locations BRNX-02, 03A, and 04 municipal/industrial inputs are suggested as the dominant sources of impact. ISD was inconclusive in identifying a possible source of impact at the most downstream location, BRNX-05, in the Bronx (Tables 1 and 2). The indication of municipal/industrial sources of impact represents the presence of a complex set of wastes including those from industrial processes, waste water treatment facilities, combined sewer overflows, and unspecified urban runoff. Many of the pollution sources characterized by the municipal/industrial ISD category can be related directly to increases in specific conductance of stream water (Riva-Murray et al. 2002). Specific conductance almost triples between BRNX-01 and BRNX-02 from 514 µmhos to 1409 µmhos respectively, remaining elevated but slightly decreasing moving downstream until under 1000 µmhos at the most downstream station, BRNX-05 (Table 3). Along with ISD this suggests the worst impacts to water quality arise in the reach between White Plains and the Bronx. Future water quality improvement projects should focus in this reach and include efforts to track down sources of increased conductance.

In addition to water quality pollutants running off from the highly urbanized watershed of the Bronx River habitat for biological communities is severely altered from its natural state (Figure 4). The results of habitat assessments at each sampling location suggest the river's urban setting has reduced the presence of natural cover components that would allow for sustained colonization by more sensitive macroinvertebrate taxa. For example, riparian corridors along the Bronx River are narrow, on average between 6-12 meters. As a result vegetation along the river banks is typically unstable. Alteration to the riparian corridor reduces the amount of available in-stream cover and substrate for biological community colonization. Habitat assessments in the Bronx River indicated on average only between 20-40% of in-stream substrates were stable habitats suitable for colonization (Table 5). Improving in-stream cover through restoration and protection of riparian corridors will improve biological community condition when done so in concert with pollutant reductions.

Results of the present survey indicate benthic macroinvertebrate communities in the Bronx River are dominated by tolerant freshwater invertebrates including the non-biting midges (Diptera: Chironomidae), freshwater crustaceans (Amphipoda: Gammaridae), and aquatic worms (Oligochaeta: Haplotaxidae, Enchytraeidae, Tubificidae, Nadidae). Filter feeding caddisflies (Tichoptera: Hydropsychidae), although less tolerant of pollution and indicators of fine particulate organic matter, also make up a significant portion of the community. Increased occurrence of these pollutant tolerant taxa coincided with the increase in specific conductance and ISD categorization of municipal/industrial sources of impact (BRNX-02, 03A, and 04) (Table 5). Bode et al. (2003) highlighted the overall lack of mayflies in samples collected at all sampling locations downstream of Valhalla (BRNX-01) and suggested their presence would be a suitable indicator of improved water quality. In samples collected during 2015 mayflies were present at each sampling location but in very low abundance, at most only 6% of the sample

3

(BRNX-03A), and as low as 1% (BRNX-02 and -05) (Table 5). In addition to their low abundance the specific taxa present, various *Baetis* spp. (Table 5), are some of the more tolerant and ubiquitous mayfly taxa of stream environments. With water quality improvements the mayfly community may continue to improve and become more abundant and diverse.

Conclusions

Based on assessment of benthic macroinvertebrate communities, the Bronx River remains impaired for aquatic life. Condition estimates from 2015 are similar to previous survey reports completed by the SBU in 1998 and 2003. This is also true for possible sources of impact which continue to be driven by municipal/industrial sources from the heavily urbanized landscape. In addition to pollutant sources, biological communities are also impacted by poor habitat conditions resulting from human alteration of the riparian corridor. Focusing water quality and habitat improvement projects in the reach between White Plains and the Bronx would likely provide the greatest benefit to water quality and biological communities. Although benthic macroinvertebrate communities are still impaired in the Bronx River, some more sensitive indicator taxa appear to be present in the entire river, although in very low abundance. Mayflies, as suggested by Bode et al. (2003), can be the barometer for success in Bronx River water quality improvement. Their presence should continue to be monitored and will hopefully increase in number and diversity.

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Figure 1. Overview map, the Bronx River watershed and 2014 sampling locations.
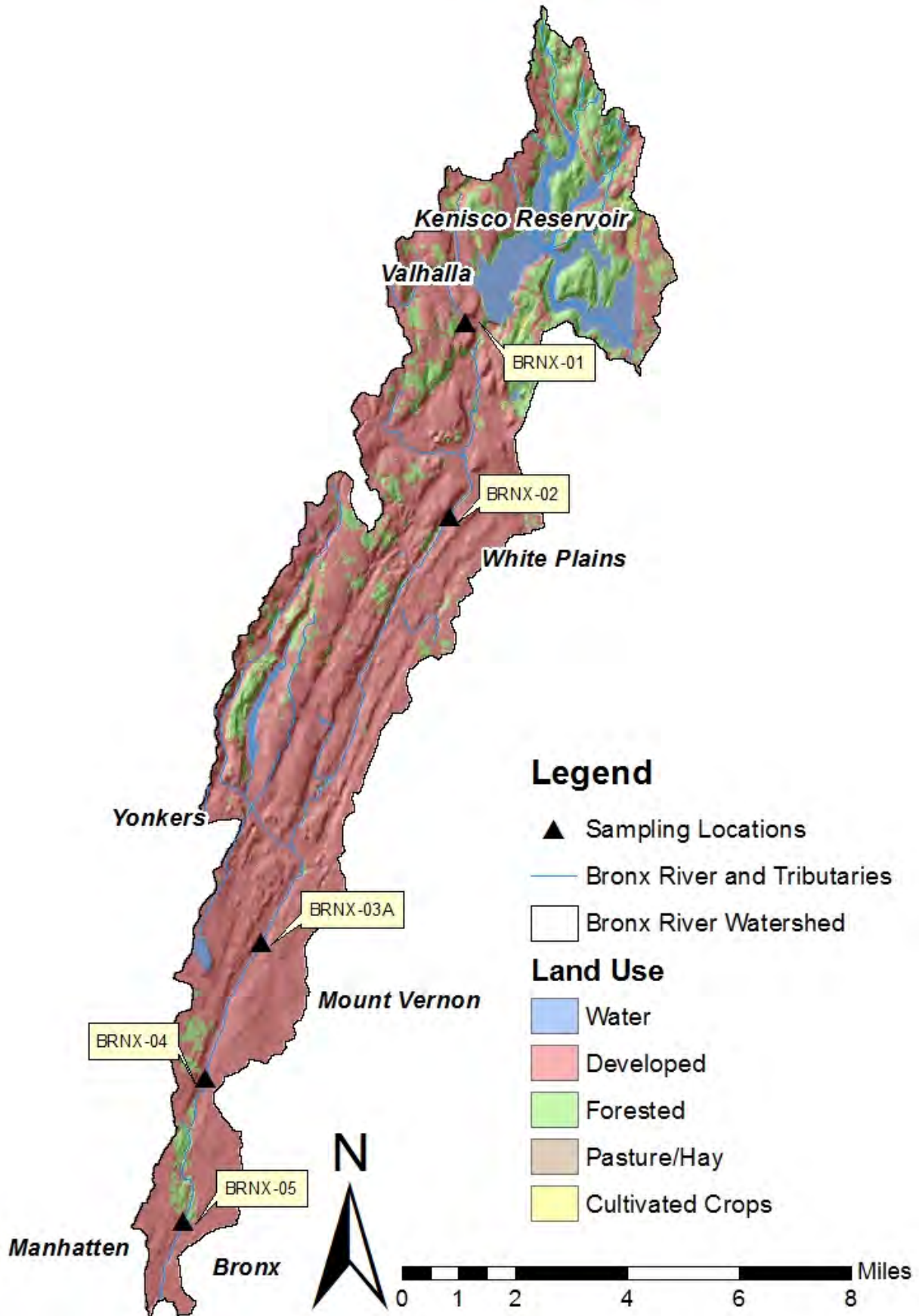
Figure 2. Site location map, the Bronx River, Station 01.
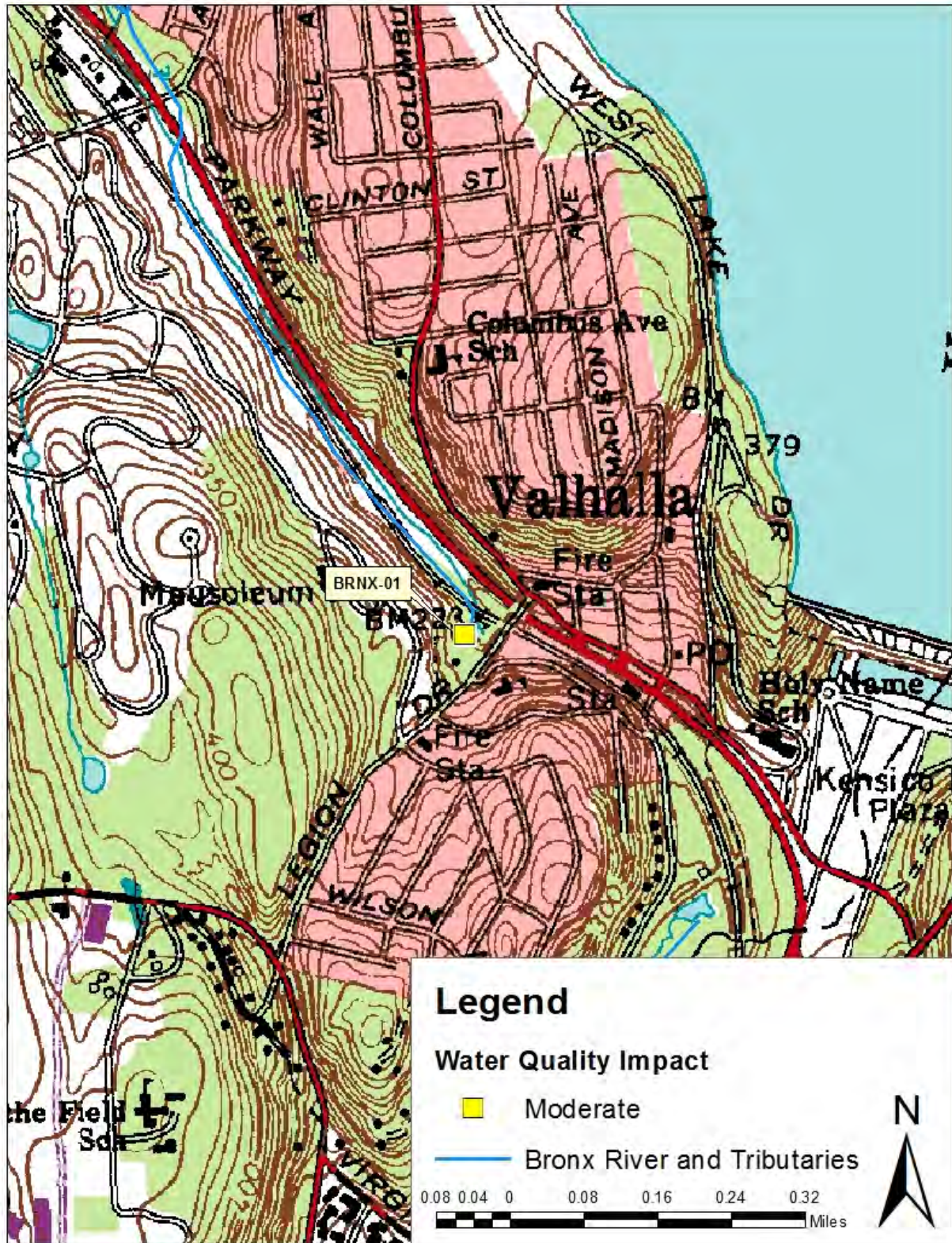
Figure 2a. Site location map, the Bronx River, Station 02.
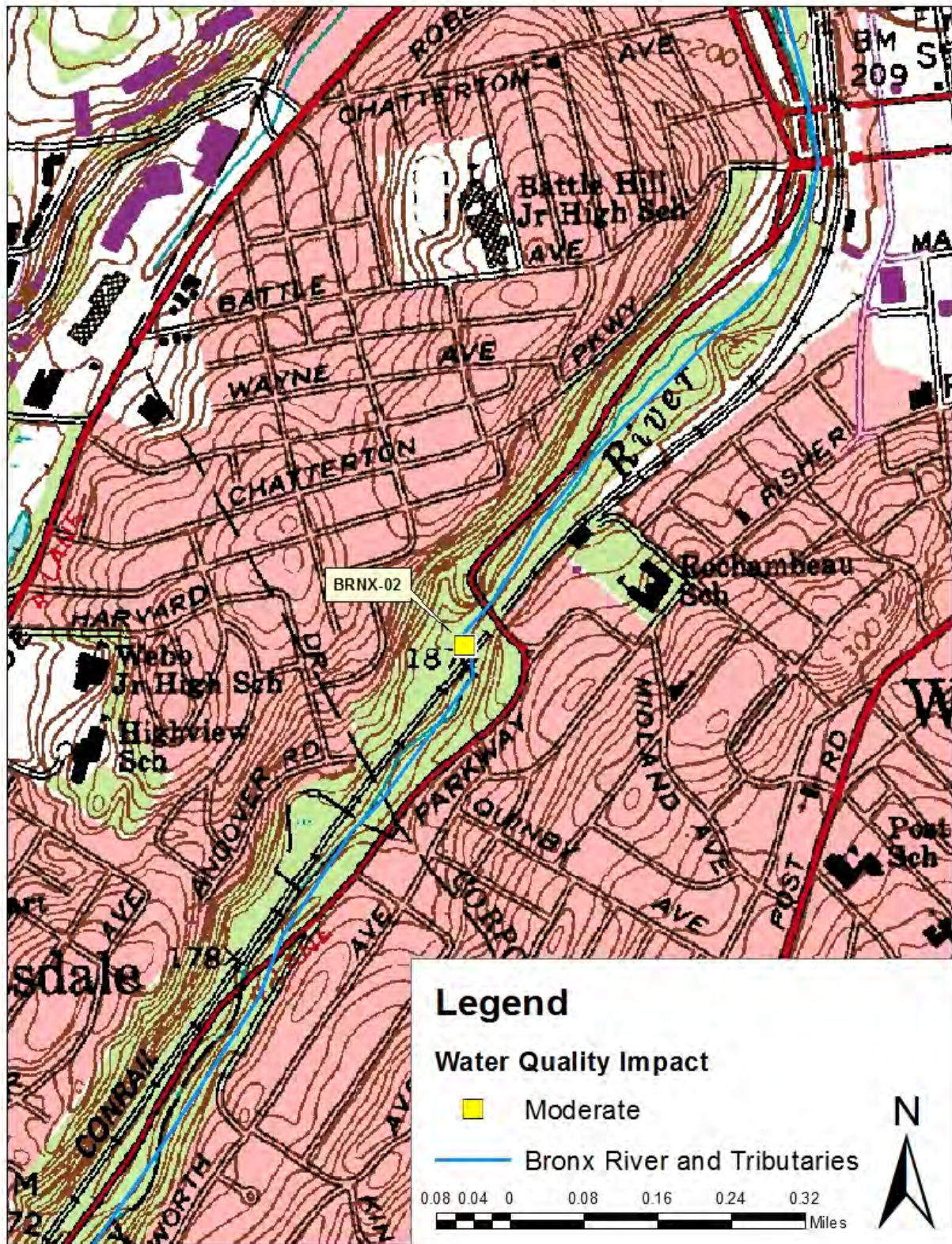
Figure 2b. Site location map, the Bronx River, Station 03A.
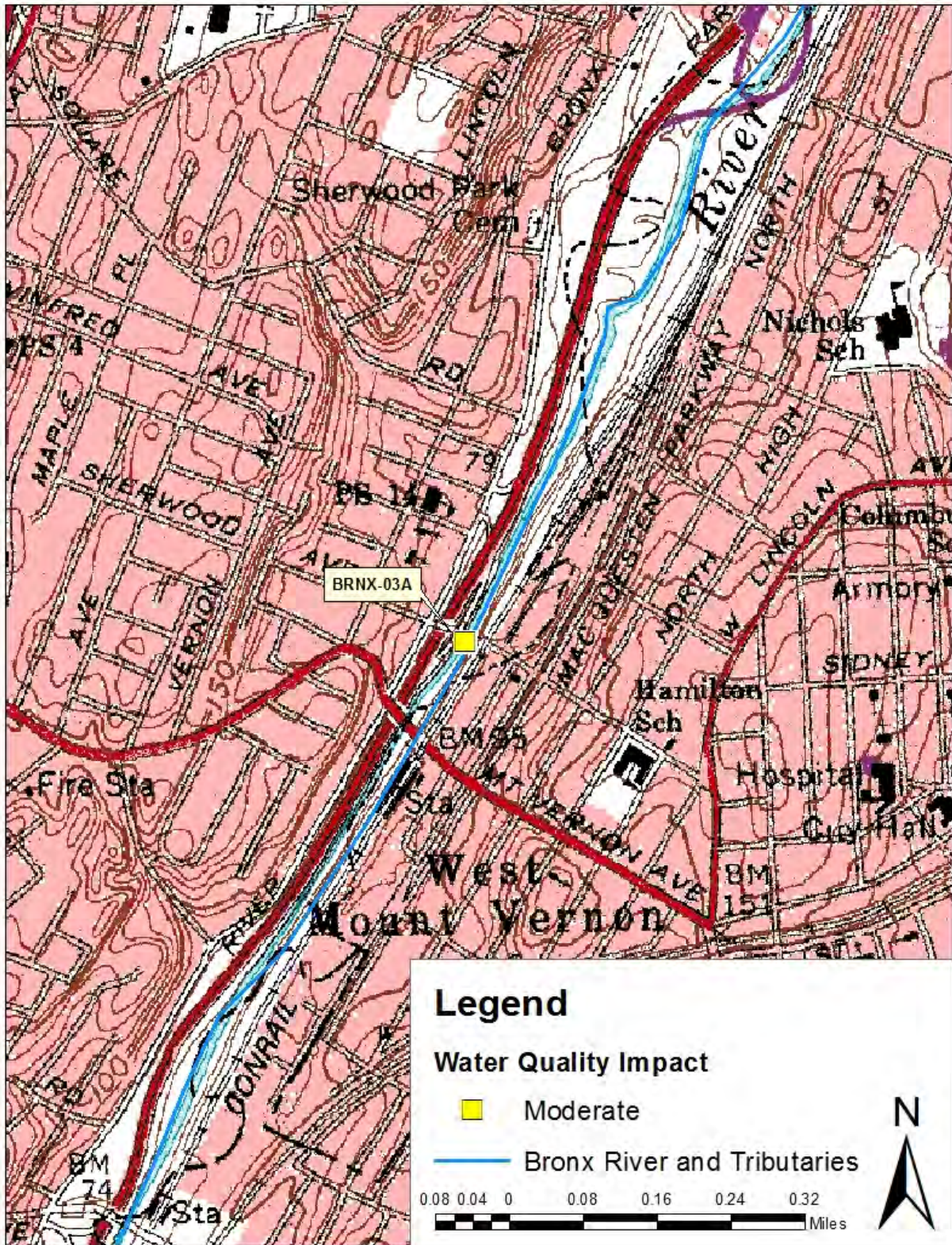
Figure 2c. Site location map, the Bronx River, Station 04.
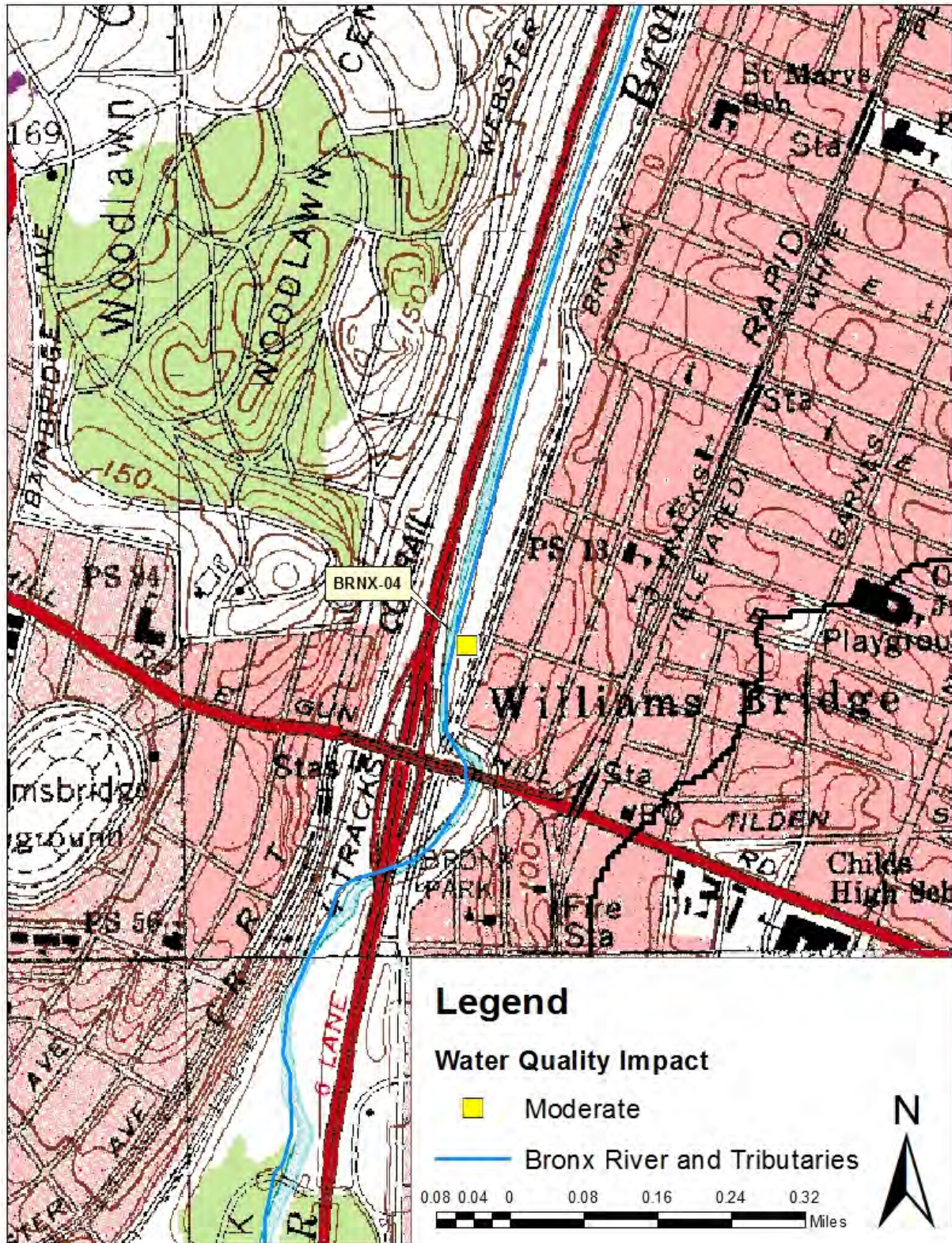
Figure 2d. Site location map, the Bronx River, Station 05.
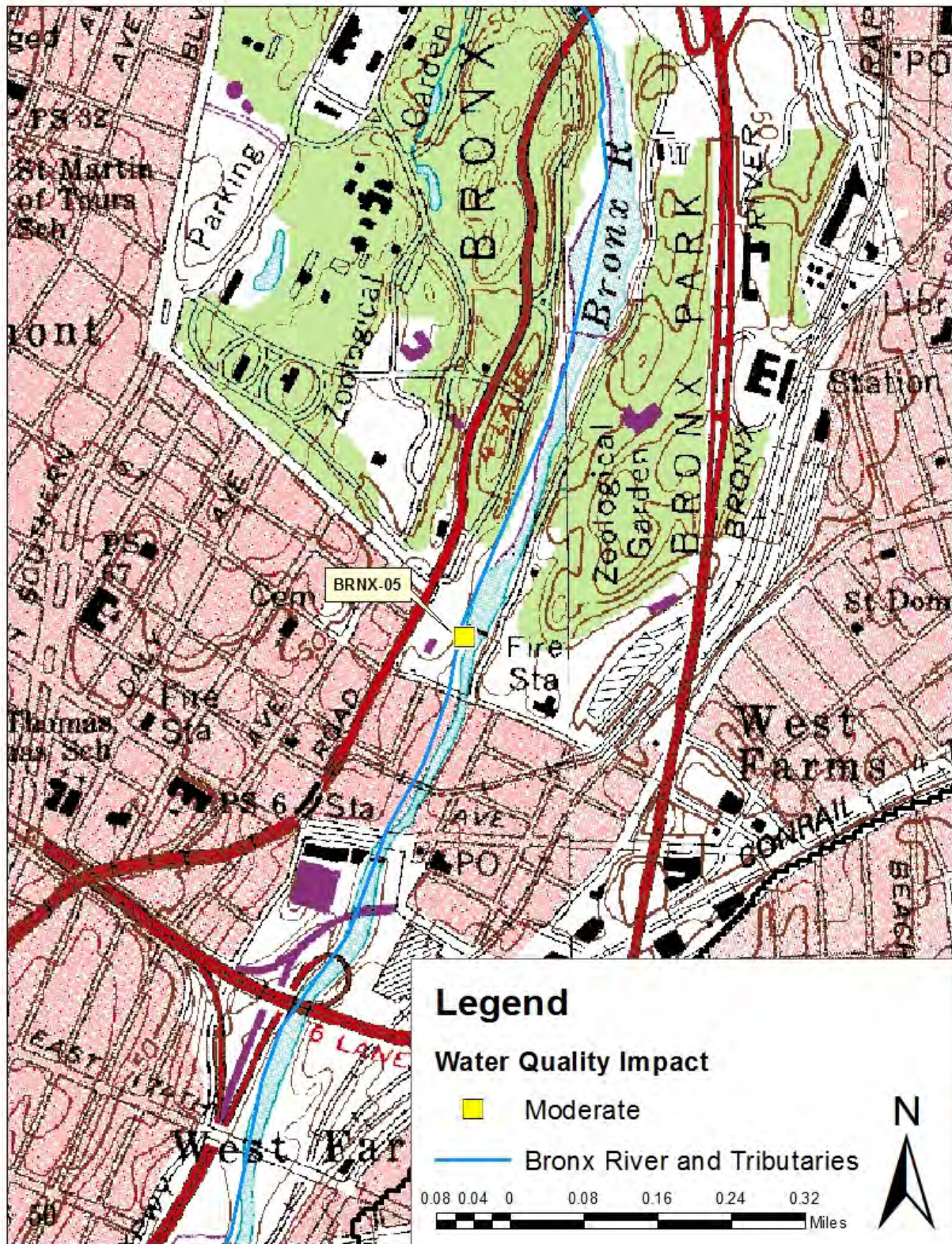
Table 1. Survey locations on the Bronx River, 2014.

BRNX-01	Valhalla, NY 10 m above Legion Rd. culvert Latitude: 41.074170 Longitude: -73.776390	
BRNX-02	White Plains, NY 100 m below Bronx River Pkwy bridge Latitude: 41.024170 Longitude: -73.783060	
BRNX-03A	West Mt. Vernon, NY Sherwood Ave. Latitude: 40.915000 Longitude: -73.849000	
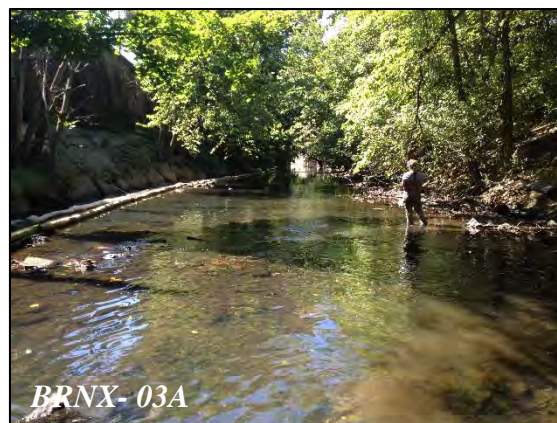
Table 1 Cont'd. Survey locations on the Bronx River, 2014.

BRNX-04	Bronx, NY 150 m above East Gun Hill Rd. bridge Latitude: 40.880000 Longitude: -73.868610

BRNX-05	Bronx, NY Immediately downstream of 182nd St. dam in tail race Latitude: 40.843223 Longitude: -73.876689

Figure 3. Biological Assessment Profile (BAP) of index values, Bronx River, 2014 including the NBI-P (a.) and BAP scores excluding the NBI-P for 1998, 2003, and 2014 (b.). Values are plotted on a normalized scale of water quality. The BAP represents the mean of the five values for each site, representing species richness (Spp), Ephemeroptera, Plecoptera, Trichoptera richness (EPT), Hilsenhoff's Biotic Index (HBI), Percent Model Affinity (PMA), and the Nutrient Biotic Index for phosphorus (NBI-P). See Appendix IV for a more complete explanation.
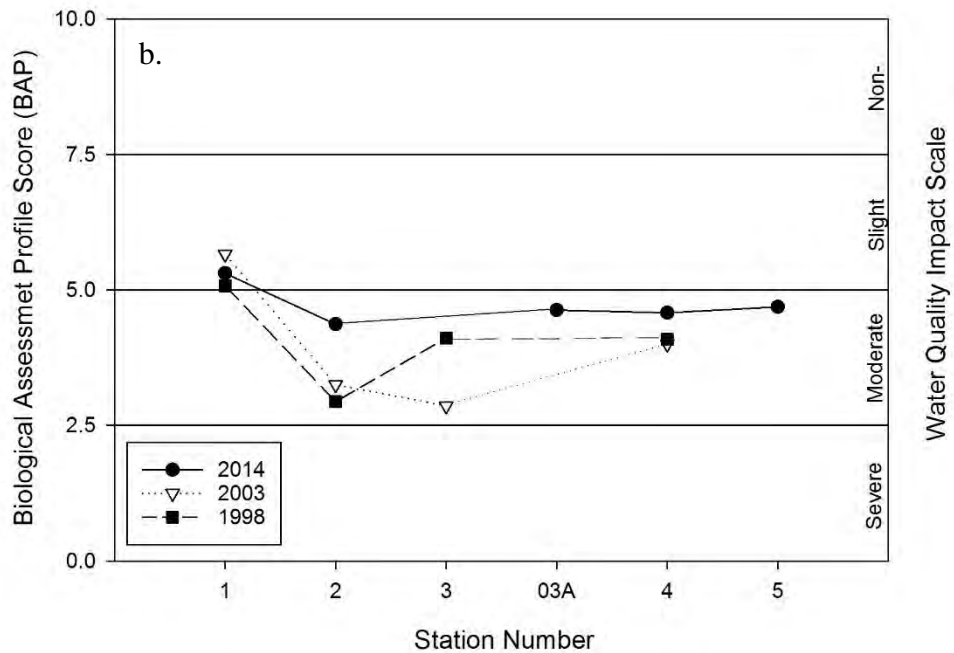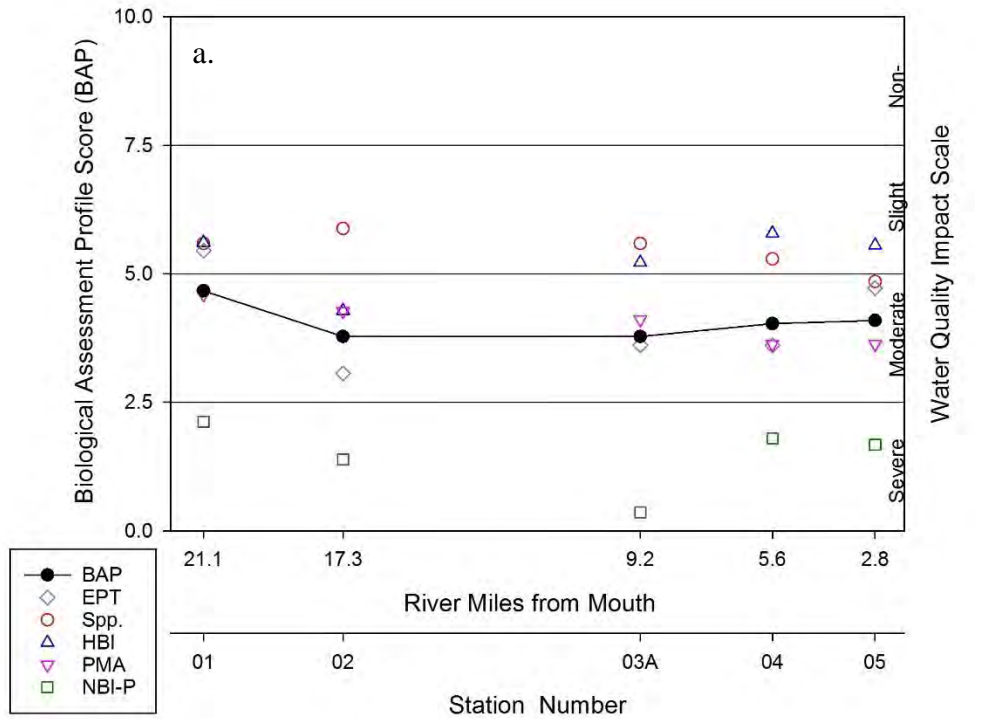
Table 2. Summary of Impact Source Determination (ISD) results for the Bronx River, 2014. Category abbreviations are Mun./Ind.= Municipal/Industrial sources, Non-point = Non-point source nutrient runoff, Sew./An. Wastes = Sewage effluent and animal waste sources. Further detail on ISD is found in Appendix X. Shaded values represent ≥50% similarity to ISD model communities indicating a significant result. Values ≤50% represent inconclusive results.

Station	Mun./Ind.	Non-point	Sew./An. Wastes	Siltation	Toxic
BRNX-01	53	56	48	51	53
BRNX-02	50	32	41	42	41
BRNX-03A	67	28	41	41	40
BRNX-04	55	46	48	50	53
BRNX-05	48	38	38	49	41

Table 3. Summary of physical attributes measured at each sampling location on the Bronx River, 2014.

Station	Depth (m)	Width (m)	Current (cm/sec)	Embed. (%)	Temp. (°C)	Conduct. (µmhos)	pH	DO (mg/L)	DO Sat. (%)
BRNX-01	0.4	15	100	25	19	514	8.4	9.7	106
BRNX-02	0.3	10	10	25	21	1409	8.3	8.8	100
BRNX-03A	0.6	13	50	30	20	1201	8.2	6.7	74
BRNX-04	0.8	15	60	40	19	1089	8.1	6.7	73
BRNX-05	0.3	17	110	40	20	917	8.5	9.1	100

Figure 4. Habitat assessment scores for each sampling location on the Bronx River, 2014.
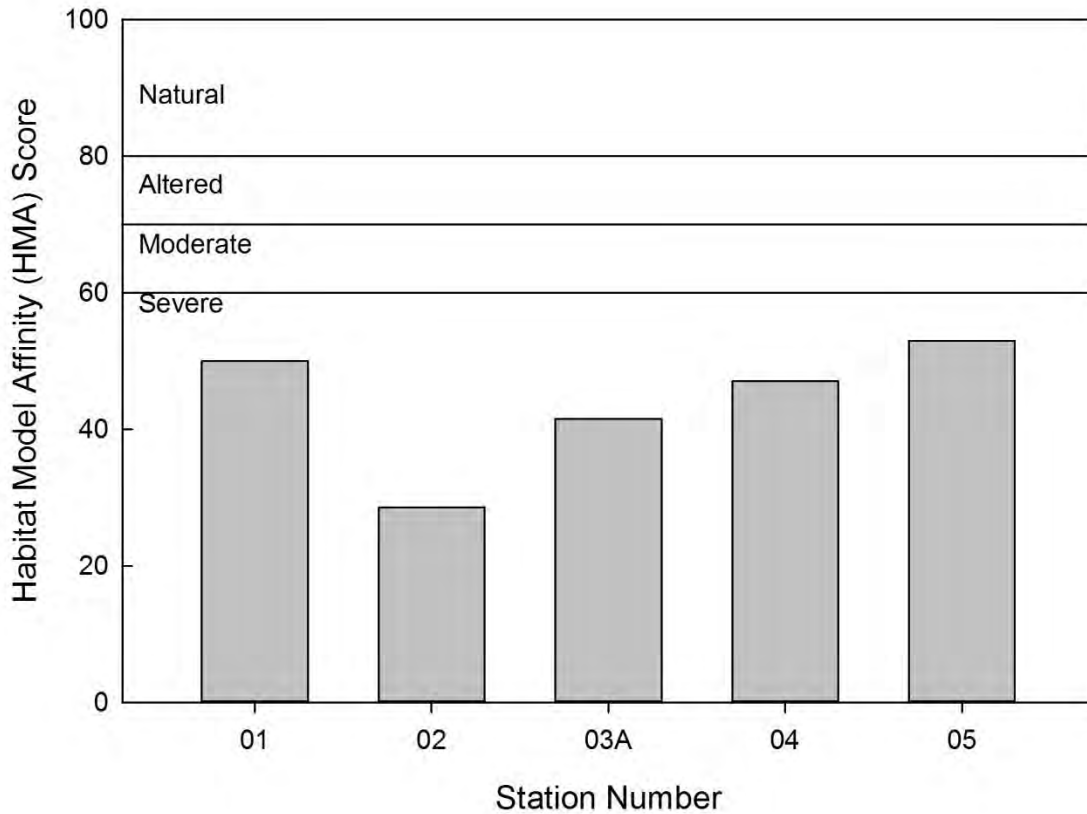
Table 4. Summary of physical habitat attribute scores* used in calculating the Habitat Model Affinity (Figure 5) at locations on the Bronx River, 2014.

Station	Epi. Cover	Embed.	Vel/Dep Reg.	Sed. Dep.	Flow Satus	Chan. Alt.	Rif. Freq.	Bank Stab.	Bank Veg.	Rip. Width
BRNX-01	7	9	10	12	12	11	9	8	10	12
BRNX-02	3	8	6	5	4	10	3	5	9	4
BRNX-03A	8	9	11	9	5	6	7	12	8	8
BRNX-04	4	9	9	9	10	14	12	10	11	6
BRNX-05	2	13	11	11	11	5	11	14	10	18

*   The following attributes are ranked on a scale from 0 (poor) - 20 (optimal). Epi. Cover = Epifaunal substrate cover, Embed. = Embeddedness, Vel/Dep Reg. = Velocity Depth Regime, Sed. Dep. = Sediment Deposition, Flow Status = Channel Flow Status, Chan. Alt. = Channel Alteration, Rif. Freq. = Riffle Frequency, Bank Stab. = Bank Stability, Bank Veg. = Bank Vegetative Cover, Rip. Width = Riparian Corridor Width.

Table 5. Macroinvertebrate species collected in the Bronx River, 2014.

Genus species	Location - Station				
	BRNX-01	BRNX-02	BRNX-03A	BRNX-04	BRNX-05
Ancyronyx sp.			2	1	
Antocha sp.		1			
Baetis flavistriga			2	2	1
Baetis intercalaris		1	4		
Baetis tricaudatus	3				
Cardiocladius obscurus					2
Ceratopsyche sparna	1				5
Cheumatopsyche sp.	3	4		26	10
Chimarra aterrima?	5				
Cladotanytarsus sp.		2			
Conchapelopia sp.		4			
Cricotopus bicinctus			3	2	4
Cricotopus sp.		1			
Cricotopus tremulus gr.					2
Cricotopus trifascia gr.					4
Cricotopus vierriensis			2	1	1
Cryptochironomus fulvus gr.		3			
Dicrotendipes neomodestus			1		
Dicrotendipes sp.		1			
Dolophilodes sp.	1				
Gammarus sp.	31	19	40	25	
Hemerodromia sp.				1	
Hydropsyche betteni	25			8	11
Hydroptila sp.			1		4
Limnodrilus sp.	1				
Microtendipes pedellus gr.	2				
Orthocladius annectens				1	
Orthocladius sp.			2		1
Parametriocnemus sp.		1			
Polypedilum aviceps	1				
Polypedilum flavum		1		3	1
Polypedilum illinoense	2		8	1	1
Pristinella sp.			3		
Rheocricotopus robacki		1	1		
Rheotanytarsus exiguus gr.	2		3		10
Simulium sp.	1				
Stenelmis sp.	10	5		1	
Sublettea coffmani		1			
Tanytarsus glabrescens gr.	1	4		3	1
Tanytarsus guerlus gr.		3			
Tvetenia bavarica gr.	2				

Genus species	Location - Station				
	BRNX-01	BRNX-02	BRNX-03A	BRNX-04	BRNX-05
Undet. Tubificidae w/o cap. setae	1	20	2		
Undetermined Chironomini		3			
Undetermined Enchytraeidae		4	2		
Undetermined Hirudinea	1	11		2	
Undetermined Lumbricina	2		8	4	
Undetermined Naididae			2		
Undetermined Nemertea			1		
Undetermined Physidae				1	
Undetermined Pisidiidae		10	1	1	3
Undetermined Turbellaria	5		12	15	29

Appendix I. Biological Methods for Kick Sampling

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

B. <u>Site Selection</u>: 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. <u>Sampling</u>: 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. <u>Sample Sorting and Subsampling</u>: 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. <u>Organism Identification</u>: 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. <u>Species Richness</u>: 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. <u>EPT Richness</u>: the total number of species of mayflies (<u>E</u>phemeroptera), stoneflies (<u>P</u>lecoptera), and caddisflies (<u>T</u>richoptera) 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. <u>Hilsenhoff Biotic Index</u>: 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. <u>Percent Model Affinity</u>: 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. <u>Nutrient Biotic Index</u>: a measure of stream nutrient enrichment identified by macroinvertebrate taxa. 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 with assigned tolerance values. Tolerance values ranging from intolerant (0) to tolerant (10) are based on nutrient optima for Total Phosphorus (listed in Smith, 2005). Impact ranges are: 0-5.00, non-impacted; 5.01-6.00, slightly impacted; 6.01-7.00, moderately impacted, and 7.01-10.00, severely impacted.

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 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.

Water Quality Scale	SPP	HBI	EPT	PMA	NBI	Water Quality Impact
10.0	35	2.0	15	90	3.0	None
7.5	26	4.5	10	64	5.0	Slight
5.0	18	6.5	5	49	6.0	Moderate
2.5	10	8.5	1	35	7.0	Severe
0.0	5	10.0	0	20	8.0	
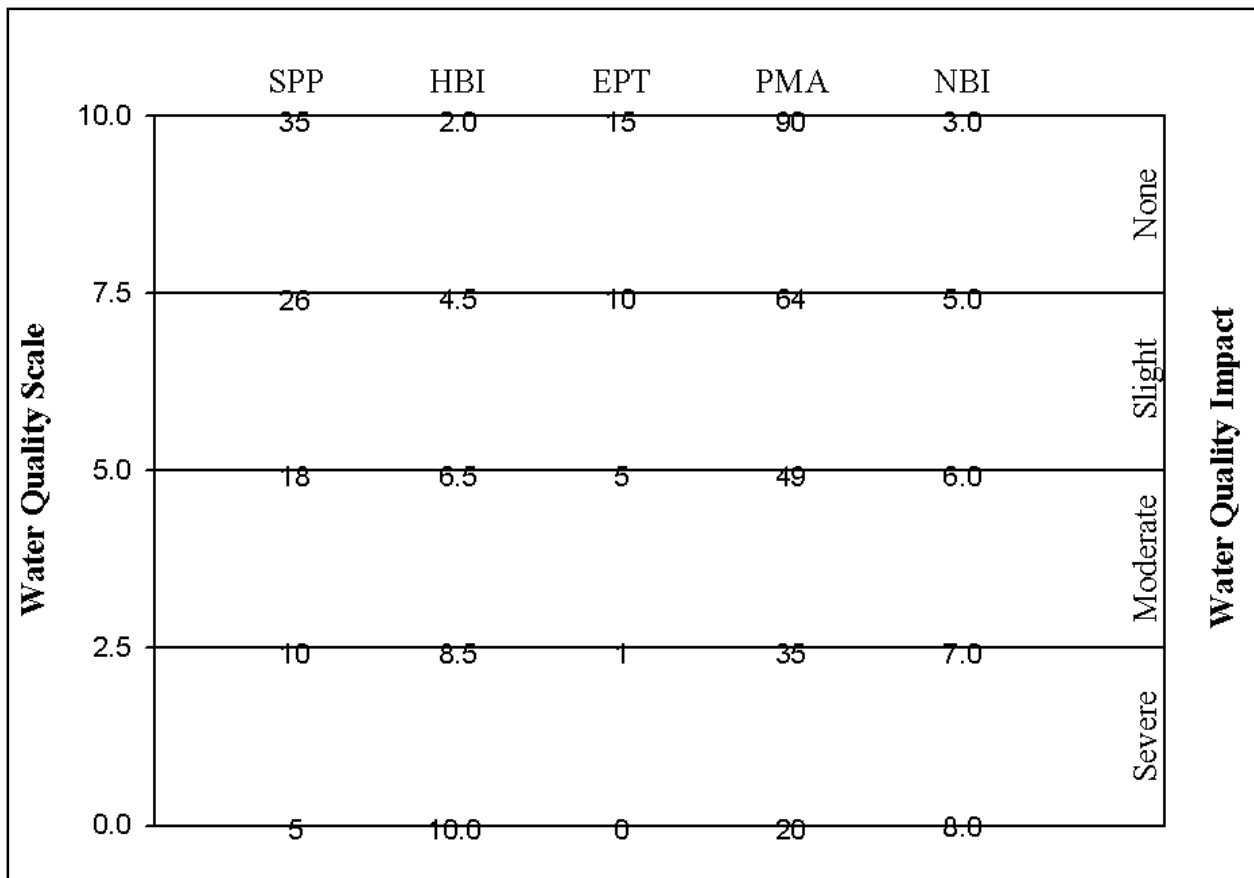
Appendix IV-B. Biological Assessment Profile: Plotting Values

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
Nutrient Biotic Index	6.0	5.0	6.0	5.0
Average		6.152 (slight)		7.8 (non-)

Appendix V. Water Quality Assessment Criteria

Non-Navigable Flowing Waters

	Species Richness	Hilsenhoff Biotic Index	EPT Value	Percent Model Affinity*	Nutrient Biotic Index
Non-Impacted	>26	0.00-4.50	>10	>64	<5.00
Slightly Impacted	19-26	4.51-6.50	6-10	50-64	5.01-6.00
Moderately Impacted	11-18	6.51-8.50	2-5	35-49	6.01-7.00
Severely Impacted	0-10	8.51-10.00	0-1	<35	>7.01

* Percent model affinity criteria used for traveling kick samples but not for multiplate 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
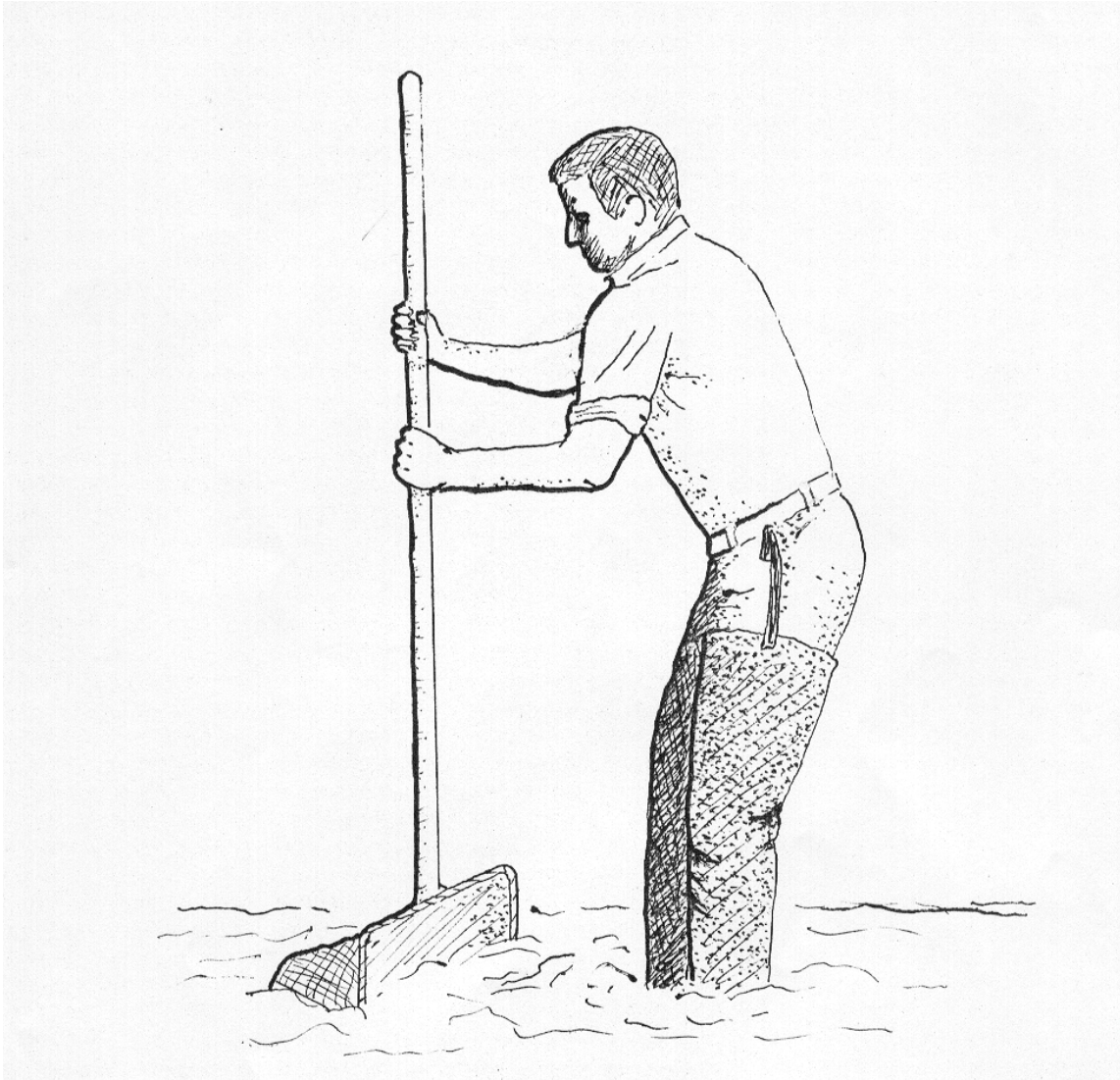
Rocks and sediment in a riffle are dislodged by foot upstream of a net. Dislodged organisms are

⟵ current

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.

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

SOWBUGS

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 productivity

Appendix X. 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, and impoundment. 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.

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)

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<tr><td>PLECOPTERA</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
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<tr><td>CHIRONOMIDAE</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Tanypodinae</td><td>-</td><td>5</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>5</td><td>5</td></tr>
<tr><td>Cardiocladius</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Cricotopus/
 Orthocladius</td><td>-</td><td>10</td><td>15</td><td>-</td><td>-</td><td>10</td><td>10</td><td>-</td><td>5</td><td>5</td></tr>
<tr><td>Eukiefferiella/
 Tvetenia</td><td>-</td><td>-</td><td>10</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Parametriocnemus</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Chironomus</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>10</td><td>-</td><td>-</td><td>60</td></tr>
<tr><td>Polypedilum aviceps</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Polypedilum (all others)</td><td>10</td><td>10</td><td>10</td><td>10</td><td>60</td><td>-</td><td>30</td><td>10</td><td>5</td><td>5</td></tr>
<tr><td>Tanytarsini</td><td>10</td><td>10</td><td>10</td><td>10</td><td>-</td><td>-</td><td>-</td><td>10</td><td>40</td><td>-</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TOTAL</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td><td>100</td></tr>
</tbody>
</table>

ISD Models (cont'd)

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

34