Warwick Brook

Orange County, NY

Stream Biological Impairment Criteria Analysis

Sample Date: March 25, 2012
Report Date: April 6, 2012

Prepared for
Village of Tuxedo Park
80 Lorillard Road
P.O. Box 31
Tuxedo Park, NY 10987

Prepared by

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Background and Summary

The Village of Tuxedo Park requested that Watershed Assessment Associate, LLC (WAA) conduct a stream biological criteria assessment of Warwick Brook, Orange County, NY due to concerns about degraded water conditions. Warwick Brook originates in Sterling Forest State Park; the main channel travels primarily through forested land prior to emptying into Wee Wah Lake in the Village of Tuxedo Park. Wee Wah Lake is used for primary contact recreation and is a back-up drinking water source for the Village of Tuxedo Park. Area residents recently observed that the water appeared cloudy with pockets of orange foam and had become malodorous, particularly upstream; a fish kill was also discovered at Four Corners Pond. There is concern that runoff from a large mulch facility may be adversely impacting Warwick Brook water quality. WAA was asked to provide professional assessment of the biological condition of the stream and appropriate recommendations for further study.

The fish kill, according to the Tuxedo Town Supervisor, likely occurred March 13 – 14, 2012. A 500 acre beaver pond located upstream from Four Corners Pond (and downstream from the Tuxedo mulch facility) was breached during March 6 – 8, 2012, with the rapid release of a large volume of water into Warwick Brook.

WAA performed habitat assessment and collected biological samples from Warwick Brook in both the Village of Tuxedo Park and Town of Tuxedo and from the Indian Kill (used as a reference site) on March 25, 2012. Benthic macroinvertebrate communities were examined to determine if biological impairment of Warwick Brook has occurred downstream of the mulch facility. Determination of biological impairment adhered to NYS methodology (Smith et al. 2009 and Bode et al. 1990).

Results of this study indicate that test sites downstream from the mulching facility are biologically impaired. The impairment is most likely due to excessive nutrients originating upstream from the sampling sites, resulting in an excessive growth of microbial organisms (algae and bacteria). This is likely producing wide diurnal swings in stream oxygen levels inconducive to aquatic invertebrate life. The recent fish kill may have resulted from an exacerbation of these conditions secondary to the increased volume of runoff (breaching of the beaver dam) and/or the recent warm weather conditions.

Methods

Upstream/Reference Site Selection

Ideally, a reference site should be located upstream of the potential impact source. Where upstream conditions are located underneath bridges or within recently disturbed areas (e.g. construction, farming), in areas of dense macrophyte growth, within one mile of an impoundment release, or in near-shore areas, a reference site may be selected in a comparable watershed (Bode et al. 1990).

The reference and suspected impact sites must meet habitat comparability criteria. The median substrate particle size between the two sites cannot deviate by more than 3 phi units; substrate embeddedness cannot differ by more than 50%; current velocity should be within 30-150 cm/s and velocity cannot differ by more than 50% between the sites; and canopy cover cannot differ by more than 50% between the sites. In addition, both sites must be sampled using the same collection method (Bode et al. 1990).

Field Collection

Details of the assessment methods are described in the Standard Operating Procedure for Biological Monitoring of Surface Waters in New York State (Smith et al. 2009) and Biological Impairment Criteria for Flowing Waters in New York State (Bode et al. 1990). Samples are field inspected to determine major groups of benthic macroinvertebrates present and then preserved in ethyl alcohol for laboratory identification and enumeration of a 100 specimen subsample from each sample.

Sorting and Organism Identification

Sample sorting and identification follows NYS DEC laboratory methods (Smith et al. 2009). The subsamples are rinsed with tap water in a U.S. number 40 standard sieve to remove fine particles and the remaining material is placed in a Petri dish with water. Samples are then examined under a dissecting microscope to separate organisms from debris and macroinvertebrates are placed in vials containing 70% alcohol. This sorting procedure is repeated for each subsample until 100 organisms are removed. Organisms are identified to lowest taxonomic resolution as outlined in the NYS DEC SBU Quality Assurance Work Plan (QAWP) (Smith et al. 2009), unless specimens are immature or damaged, and enumerated using a dissecting microscope. Oligochaetes and chironomids are slide-mounted in CMCP-10 mounting medium and viewed using a compound microscope.

Replicate Similarity

For replicate samples there must be a 50% similarity between the replicates (Bode et al. 1990). A Bray-Curtis cluster analysis is performed on taxa community structure (square root transformed) to reveal similarities between replicates and between stations. A dendrogram is generated using the Bray-Curtis cluster analysis. A Similarity Profile (SIMPROF) test is applied to the data to determine significant relationships between samples (Figure 1).

Macroinvertebrate Parameters and Impairment Criteria Analysis

The following parameters are calculated for each replicate and then averaged for comparison: species richness, biotic index, species dominance, EPT richness, and percent model affinity (see Appendix for further details).

Violation of one or more of the criteria (based on averaged metric results – see Appendix) between the suspected impacted site and reference site indicates provisional impairment. If provisional impairment is indicated, a Student's T-test is performed to determine if the results

are statistically significant (α=0.05). If the statistical test results are significant, then biological impairment is indicated (Bode et al. 1990).

Results

Upstream/Reference Site Selection

A reference site meeting the habitat criteria could not be identified above the site of concern, and therefore a reference site was selected using a watershed similar in size within proximity to the Warwick Brook watershed. The Warwick Brook watershed drains 4.5 square miles, is 95% forested, and has an average basin slope of 834 feet/mile. Its confluence with Wee Wah Lake is in the Village of Tuxedo Park. The Indian Kill Watershed, just north of and adjacent to the Warwick Brook Watershed, was selected for use as the reference station. The Indian Kill drains 5 square miles, is 92% forested, and has an average basin slope of 985 feet/mile. Its confluence is with the Ramapo River (see Figure 1 in the Appendix).

Patterson Brook Watershed was also sampled at the request of the Village; although this watershed is adjacent to the Warwick Brook watershed, the surface waters appear to remain separate. It has a similar average basin slope to the Indian Kill watershed (879 feet/mil), and is similarly covered by forest (96%), but the size of the watershed is significantly less than the Indian Kill (0.5 square miles).

The habitat criteria comparability criteria were satisfied for all stations (Table 1).

Table 1. Habitat comparability criteria results of Indian Kill (INDI 01A) reference station, Warwick Brook (WARI 01A, 01, and 02) and Patterson Brook (PATT 01)

In-stream parameters	INDI 01A	WARI 01A	WARI 01	WARI 02	PATT 01
Current (cm/sec)	55	65	50	55	45
Canopy (%)	85	85	85	85	70
Embeddedness (%)	40	50	40	55	50
Rock (%)	20	25	20	20	20
Rubble (%)	20	25	20	20	20
Gravel (%)	25	20	20	25	20
Sand (%)	25	20	15	20	30
Silt (%)	10	10	25	15	10
Phi Value	INDI 01A	WARI 01A	WARI 01	WARI 02	PATT 01
-8	-1.6	-2	-1.6	-1.6	-1.6
-6.5	-1.3	-1.625	-1.3	-1.3	-1.3
-3	-0.75	-0.6	-0.6	-0.75	-0.6
2	0.5	0.4	0.3	0.4	0.6
6.5	0.65	0.65	1.625	0.975	0.65
Median particle size	-2.50	-3.18	-1.58	-2.28	-2.25
Difference	**Ref**	**0.67**	**0.93**	**0.23**	**0.25**

Field Collection

Samples of benthic macroinvertebrates were collected in replicate at five stations (three on Warwick Brook, one on the Indian Kill, and one on Patterson Brook).

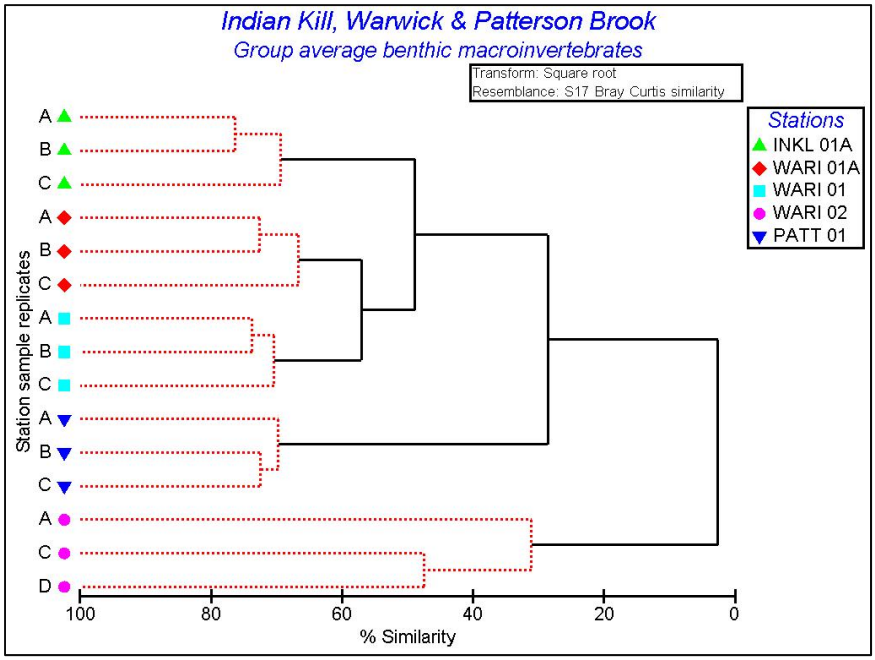
Sorting and Organism Identification

Organisms were identified to lowest taxonomic resolution as outlined in the NYS DEC SBU QAWP (Smith et al. 2009), unless specimens were immature or damaged.

Replicate Similarity

Similarity between replicate samples at the sites was >50% (Figure 1) except at station WARI 02, which was due to low taxa richness. To ensure that collector variability or aberrant effort did not affect replicate similarity at this station, the data was examined in PRIMER: Community structure for all replicates from all stations was significantly similar by SIMPROF analysis (Figure 1).

Figure 1. Bray-Curtis dendrogram of the community structure at genus/species level for all replicates. Dashed red lines indicate a statistically significant similarity between replicates (SIMPROF test).



Macroinvertebrate Parameters and Impairment Criteria Analysis

The following parameters were calculated for each replicate and then averaged for comparison: species richness, biotic index, species dominance, EPT richness, and percent model affinity (Table 2). Warwick Brook station WARI 01 violated one of the impairment criteria (EPT richness), WARI 02 violated all five impairment criteria, and Patterson Brook station PATT 01 violated one impairment criteria (PMA) (Table 2), indicating provisional impairment at these

stations. Further analysis of these results utilizing the Student's T-test demonstrated that all violated impairment criteria with statistical significance (α =0.05), indicating biological impairment at station WARI 01, WARI 02, and PATT 01.

Table 2 a-d. Summary of the average community metric results and provisional impairment violations for the Indian Kill, Warwick Brook, and Patterson Brook.

Table 2a. Waterbody	**Indian Kill**	**Warwick Brook**	
Station	**INKL 01A**	**WARI 01A**	Violation
Taxa richness	23	24	No
Biotic index	3.21	2.69	No
EPT richness	13	12	No
Percent model affinity	70	74	No
Species dominance	23	22	No

Table 2b. Waterbody	**Indian Kill**	**Warwick Brook**	
Station	**INKL 01A**	**WARI 01**	Violation
Taxa richness	23	19	No
Biotic index	3.21	3.03	No
EPT richness	13	8	Yes
Percent model affinity	70	61	No
Species dominance	23	26	No

Table 2c. Waterbody	**Indian Kill**	**Warwick Brook**	
Station	**INKL 01A**	**WARI 02**	Violation
Taxa richness	23	4	Yes
Biotic index	3.21	6.11	Yes
EPT richness	13	0.33	Yes
Percent model affinity	70	5	Yes
Species dominance	23	45	Yes

Table 2d. Waterbody	**Indian Kill**	**Patterson Brook**	
Station	**INKL 01A**	**PATT 01**	Violation
Taxa richness	23	29	No
Biotic index	3.21	4.88	No
EPT richness	13	9	No
Percent model affinity	70	48	Yes
Species dominance	23	12	No

Ambient Water Quality Parameters

Dissolved oxygen, dissolved oxygen saturation, specific conductivity and salinity were remarkably different among the Warwick Brook stations. The dissolved oxygen and dissolved oxygen percent saturation dropped appreciably from the most downstream station WARI 01A to the upstream station WARI 02. Specific conductance and salinity rose appreciably from the most downstream station WARI 01A to the upstream station WARI 02 (Table 3).

Table 3. Summary of ambient water quality parameters (see Appendix, Rational for Data Collected, for further details)

Station	INDI 01A	WARI 01A	WARI 01	WARI 02	PATT 01
Temperature °C	9.73	10.41	10.59	9.24	8.41
Dissolved oxygen mg/l	10.87	9.94	7.49	4.91	10.98
Dissolved oxygen % saturation	95.8	88.9	71.3	42.7	92.9
Specific conductance µm/cm	174	250	261	539	153
pH	8.27	7.61	7.74	7.33	7.92
Salinity ppm	0.08	0.12	0.13	0.26	0.07

Discussion

The intent of this study was to determine if biological impairment has occurred to Warwick Brook below the Town of Tuxedo mulch facility.

As part of this study the Village of Tuxedo Park requested sampling of Patterson Brook, where some surface foam had been noted by concerned citizens. Patterson Brook Watershed is not within the drainage area of the Warwick Brook Watershed, and an impact at Warwick Brook should not directly affect Patterson Brook. While there was a percent model affinity (PMA) violation at Patterson Brook, this is likely a function of the watershed's size, not a water quality issue. Of note is that the average taxa richness (diversity) at Patterson Brook was 29 different taxa, which was more than the Indian Kill reference station (23 different taxa). In general, sites with a greater diversity of organisms are less impacted. Additionally, since Patterson Brook is a headwater stream, by NYS DEC metric standards, its PMA score may actually be higher. It was not a candidate for use as a reference stream for Warwick Brook because of its smaller size. For these reasons, the remainder of this discussion will focus on findings at Warwick Brook and the Indian Kill.

There were notable differences in dissolved oxygen, dissolved oxygen percent saturation, specific conductance and salinity between Warwick Brook Watershed and Indian Kill Watershed, and among stations on Warwick Brook. Specific conductance and salinity more than doubled between stations WARI 01A and WARI 02, whereas dissolved oxygen and dissolved oxygen percent saturation dropped by more than half between these stations. Specific

conductance may be used as an indicator of anthropogenic-source impacts; the higher the specific conductance reading, the more dissolved ions in the water. Dissolved oxygen levels tend to fluctuate widely with excessive plant growth, rising during the day (with photosynthesis) and dropping at night (with plant respiration). Percent oxygen saturation, the maximum level of dissolved oxygen present at a specific temperature in the absence of other influences, drops when something other than temperature (such as dissolved solids or bacterial decomposition) affects oxygen levels. A healthy stream contains near 100 percent oxygen saturation. A drop in oxygen concentration and percent saturation is lethal to some types of sensitive macroinvertebrates (due to their inability to migrate away from changing conditions); a gradual change in oxygen saturation will cause sensitive fish to migrate from affected areas, whereas an abrupt change may be lethal.

Data from this study is indicative of severe nutrient enrichment originating above Warwick Brook WARI 02, as evidenced by the heavy growth of filamentous algae, weeds, and slimes over the entire substrate at this station (see cover photo) and significant algae growth at stations WARI 01A and 01. It is reasonable to conjecture that such enrichment might also result in excessive growth and diminished oxygen levels within Four Corners Pond, though such evaluation was beyond the scope of this analysis.

The growth documented at station WARI 02 is often referred to as sewage fungus. Sewage fungus is comprised of filamentous algae, bacteria, fungi, and protozoa. With the amount of sewage fungus at WARI 02, wide diurnal swings in dissolved oxygen are expected, which can be incompatible with invertebrate life. The daytime dissolved oxygen level recorded at this station in late morning only reached 4.91 mg/l, which is a critically low level for this type of habitat. Due to plant respiration during the night hours, a pre-dawn dissolved oxygen reading would most likely be even lower. The benthic macroinvertebrate community at WARI 02 may be reflective of critically low oxygen levels, as it is nearly devoid of benthic macroinvertebrates.

Photo depicts the ventral view of Perlidae stoneflies from Warwick Brook and Indian Kill. The top stonefly is from WARI 01 and is covered in dark organic growth; the healthy stonefly on the bottom is from INDI 01.

While DO levels were higher at WARI 01A and 01, the macroinvertebrates were nevertheless covered in a heavy organic growth (see photo above) that also covered the entire substrate at each station (see Appendix station photos). The invertebrates at these stations will likely die from a combination of asphyxiation and other physical habitat stressors, such as lack of natural food resources. Nevertheless, the impact at these stations may not reach the same degree of impact that has occurred at station WARI 02.

The results of this study indicate that Warwick Brook station WARI 02 and WARI 01 are biologically impaired and the impairment is most likely the result of excessive nutrient enrichment that is originating upstream from station WARI 02. The extent to which the beaver

dam breach has contributed to water quality conditions in Warwick Brook is unknown; inundation by a large volume of nutrient-laden or poorly oxygenated water could acutely impact the brook, but water quality data is not available on the water that was released by the breaching of the dam.

Additional stressors that may exacerbate water quality impact are increased runoff (such as occurs during rain events), which can increase the nutrient load to a system; and warm weather, which promotes growth of vegetation and algal blooms, with subsequent changes in water oxygen levels. A period of warm ambient temperature occurred in the weeks preceding the fish kill, but the extent of its contribution to this particular event is unknown.

Ambient temp. in Orange County, NY (°F) 2012		
Week of	Maximum	Mean
March 4	71	58
March 11	75	62
March 18	79	64

The potential direct and indirect affects of the impact documented at these sites extends beyond the aquatic realm: Benthic macroinvertebrates are a food resource for birds and amphibians, mammals use the stream and ponds as a water resource, and people use the water for recreational activities. It may be advisable to investigate whether health concerns exist for primary and secondary contact recreation.

Recommendations

Longitudinal study of Warwick Brook is warranted to document the full extent of the impairment, whether chronic nutrient loading is occurring (and if so, the origin of the nutrients), and evidence of recovery. Additionally, extending the evaluation to include Four Corners Pond, Wee Wah Lake, and Tuxedo Lake will help to determine what impact, if any, is occurring in these associated waterbodies.

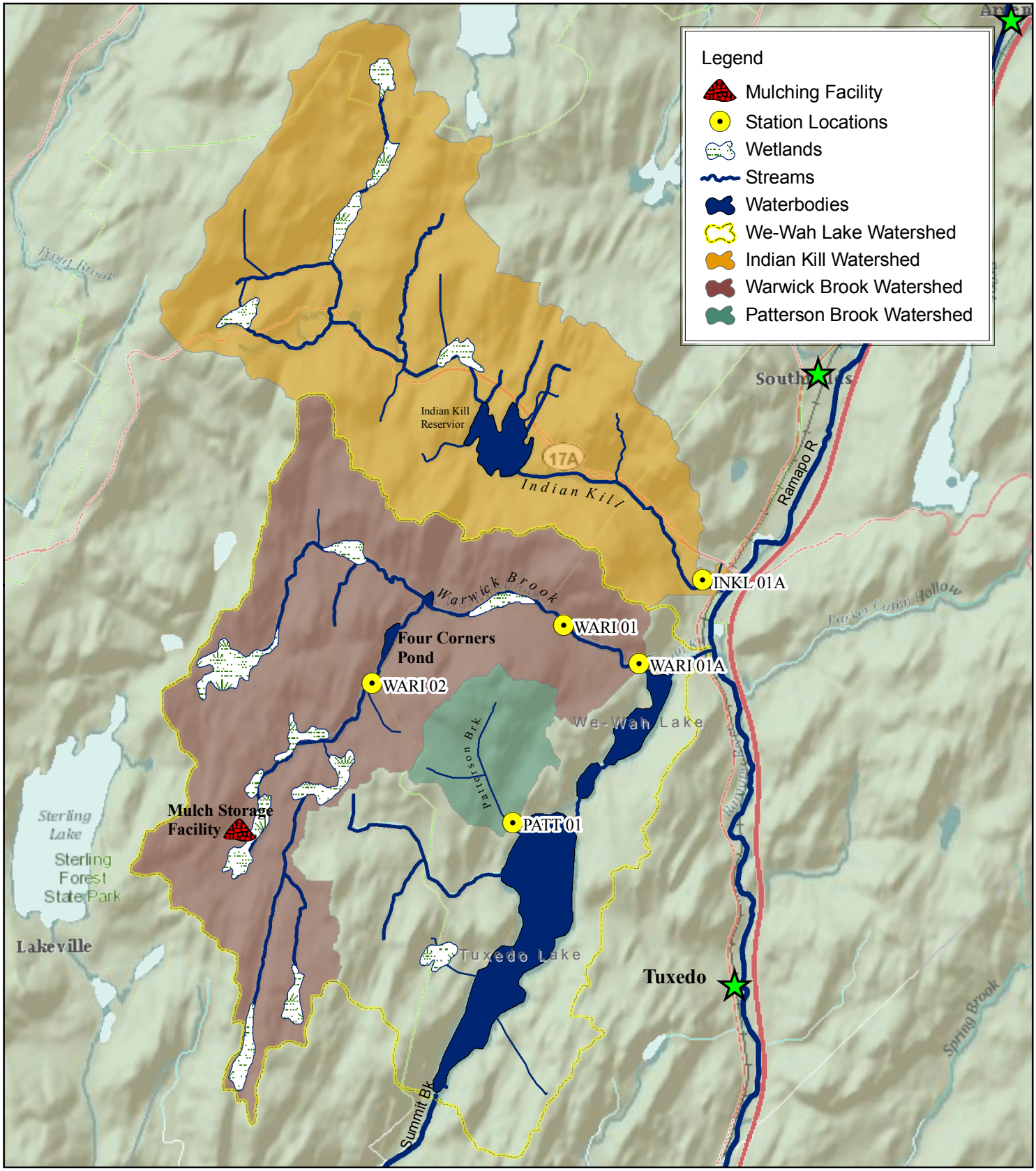
To this end, we recommend the following measures:

1. Continued monitoring of the benthic macroinvertebrate community.
    a. A reasonable sampling schedule for benthic macroinvertebrates would be to collect replicated samples at all four stations on the Indian Kill and Warwick Brook in early July and in mid- to late September 2012 following the Biological Impairment Criteria for Flowing Waters in New York State (Bode et al. 1990).
    b. A screening survey for benthic macroinvertebrate samples should be conducted at tributaries that may have a subsurface hydrologic connection to the upper Warwick Brook and feed into Tuxedo Lake.
2. Collect water chemistry samples concurrently with biological samples to document total phosphorus, total Kjeldahl nitrogen (TKN), nitrate, pH, alkalinity, total suspended solids (TSS), turbidity, true color, apparent color, and E. coli.
3. Conduct a fish survey of Warwick Brook.
4. Monitor for algal blooms in Four Corners Pond and Wee Wah Lake during the summer months.
5. Perform a baseline biological assessment at both Wee Wah Lake and Tuxedo Lake.

Appendix

Descriptions of the metrics calculated for each replicate sample and criteria required to indicate impairment

Metric	Description	Impairment Criteria (difference between reference and impacted sites)
Taxa Richness	Species richness is the total number of species or taxa found in the subsample. Higher species richness values are mostly associated with undisturbed sediment conditions.	-8
EPT Richness	EPT richness is the total number of taxa represented by Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These groups are composed largely of mostly clean water taxa and their presence usually indicates good water quality conditions.	-4
Biotic Index	Biotic Index, or the Hilsenhoff Biotic Index (Hilsenhoff 1987), is calculated by multiplying the number of individuals of each species or taxa by its assigned tolerance value, summing these products, and dividing the total number of individuals. Tolerance values range from intolerant (0) to tolerant (10). High biotic index values are suggestive of organically enriched condition, while low values indicate naturally occurring, ambient communities.	+1.5
Percent model affinity	Percent model affinity measures the similarity to a model non-impacted community based on the abundance of 7 taxa groups (Bode et al. 2002). Kick sample model community is composed of 40% Ephemeroptera, 5% Plecoptera, 10% Trichoptera, 10% Coleoptera, 20% Chironomidae, 5% Oligochaeta, and 10% Other.	-20
Species dominance	Species dominance is a measure of community balance, or how evenly the most numerous species contribute to the community. High dominance values indicate unbalanced communities strongly dominated by one or more numerous species.	+15



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0 1 Miles

Figure 1
We-Wah Lake & Indian Kill Watershed

Village of Tuxedo Park
80 Lorillard Rd
P.O. Box 31
Tuxedo Park, NY 10987

Field Data Summary

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Waterbody: **Indian Kill**
River Basin: **Ramapo**
County: **Orange**
State: **NY**

Station: **INKL 01A**
Coll Date: **3/25/2012**
Site description: **Aprox 125 meters above Rt 17**

Latitude: **41.22761**
Longitude: **-74.1874**
Field Crew: **jkn, cmf**

Physical Characteristics	
Depth (meters):	**0.2**
Width (meters):	**6**
Current (cm/sec):	**55**
Canopy (%):	**85**
Substrate	
Rock (%):	**20**
Rubble (%):	**20**
Gravel (%):	**25**
Sand (%):	**25**
Silt (%):	**10**
Embeddedness (%):	**40**

Chemical Measurements	
DO (mg/L):	**10.87**
DO sat. (%):	**95.8**
Temperature (C):	**9.73**
Spec. Conduct. (umhos):	**174**
Baro pressure:	**746.9**
pH:	**8.27**
Salinity (PSS):	**0.08**

Biological Attributes	
Aquatic vegetation	
Macrophytes:	**Y**
Diatoms:	**Y**
Algae-suspended:	
Algae-filamentous:	
Occurance of macroinvertebrates	
Ephemeroptera:	**Y**
Plecoptera:	**Y**
Trichoptera:	**Y**
Coleoptera:	
Megaloptera:	
Odonata:	
Chironomidae:	
Simuliidae:	
Decapoda:	**Y**
Gammaridae:	
Mollusca:	
Oligochaeta:	
Other macro's:	
Field Faunal Condition:	**Very good**

Flow

Flow

Lab Data Summary

Watershed Assessment Associates
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DATE SAMPLED: Indian Kill Station INKL 01A
LOCATION: Orange, NY Aprox. 125 meters above Rt. 17
DATE: 3/25/2012
SAMPLE TYPE: Kick

		Replicate	A	B	C
ARTHROPODA					
INSECTA					
DIPTERA	Chironomidae	Cricotopus sp.	6	7	4
		Eukiefferiella claripennis gr.	~	~	1
CRUSTACEA					
AMPHIPODA	Crangonyctidae	Crangonyx sp.	1	1	1
INSECTA					
EPHEMEROPTERA	Ameletidae	Ameletus sp.	1	1	~
DIPTERA	Chironomidae	Tvetenia sp.	6	2	3
		Polypedilum aviceps	1	1	~
EPHEMEROPTERA	Baetidae	Heterocloeon sp.	17	25	28
DIPTERA	Chironomidae	Sublettea coffmani	1	~	~
EPHEMEROPTERA	Ephemerellidae	Eurylophella funeralis	1	3	~
PLECOPTERA	Leuctridae	Leuctra sp.	1	~	1
	Nemouridae	Amphinemura sp.	9	7	14
		Prostoia sp.	1	1	2
COLEOPTERA	Psephenidae	Ectopria sp.	1	1	~
		Psephenus herricki	~	~	1
TRICHOPTERA	Philopotamidae	Chimarra aterrima	2	1	1
	Hydropsychidae	Cheumatopsyche sp.	9	9	6
		Diplectrona sp.	6	1	7
		Hydropsyche betteni	2	2	~
		Hydropsyche sparna	3	~	2
	Rhyacophilidae	Rhyacophila carolina	1	~	~
		Rhyacophila fuscula	9	6	9
DIPTERA	Tipulidae	Antocha sp.	~	4	~
	Simuliidae	Prosimulium sp.	6	7	7
		Simulium sp.	~	~	4
	Empididae	Undetermined Empididae	2	~	~
	Chironomidae	Thienemannimyia gr. spp.	~	2	~
		Diamesa sp.	5	11	6
		Sympotthastia sp.	2	2	~
		Cardiocladius obscurus	2	2	1
		Tanytarsus sp.	2	~	~
PLECOPTERA	Perlidae	Acroneuria abnormis	1	3	1
		Paragnetina media	~	~	1
	Perlodidae	Isoperla sp.	2	~	~
	Pteronarcidae	Pteronarcys biloba	~	1	~

Field Data Summary

Watershed Assessment Associates
Environmental Services / Biomonitoring / Invertebrate Taxonomy / Professional Training

Waterbody: **Warwick Brook**
River Basin: **Ramapo**
County: **Orange**
State: **NY**

Station: **WARI 01A**
Coll Date: **3/25/2012**
Site description: **Just above Wee Wah Rd. Bridge**

Latitude: **41.2206**
Longitude: **-74.1946**
Field Crew: **jkn, cmf**

Physical Characteristics	
Depth (meters):	**0.25**
Width (meters):	**5**
Current (cm/sec):	**0.5**
Canopy (%):	**85**
Substrate	
Rock (%):	**20**
Rubble (%):	**20**
Gravel (%):	**20**
Sand (%):	**15**
Silt (%):	**25**
Embeddedness (%):	**40**

Chemical Measurements	
DO (mg/L):	**9.94**
DO sat. (%):	**88.9**
Temperature (C):	**10.41**
Spec. Conduct. (umhos):	**250**
Baro pressure:	**745.9**
pH:	**7.61**
Salinity (PSS):	**0.12**

Biological Attributes	
Aquatic vegetation	
Macrophytes:	
Diatoms:	**Y**
Algae-suspended:	
Algae-filamentous:	**Y**
Occurance of macroinvertebrates	
Ephemeroptera:	**Y**
Plecoptera:	**Y**
Trichoptera:	**Y**
Coleoptera:	
Megaloptera:	
Odonata:	
Chironomidae:	
Simuliidae:	
Decapoda:	**Y**
Gammaridae:	
Mollusca:	
Oligochaeta:	
Other macro's:	
Field Faunal Condition:	**Very good**

Flow

Flow

Lab Data Summary

Watershed Assessment Associates
Environmental Services / Biomonitoring / Invertebrate Taxonomy / Professional Training

DATE SAMPLED: Warwick Brook Station WARI 01A
LOCATION: Orange, NY Just above Wee Wah Rd. bridge
DATE: 3/25/2012
SAMPLE TYPE: Kick

		Replicate	A	B	C
ARTHROPODA					
INSECTA					
DIPTERA	Chironomidae	Cricotopus sp.	3	3	8
		Eukiefferiella gracei gr.	1	~	2
CRUSTACEA					
AMPHIPODA	Gammaridae	Gammarus sp.	2	1	~
INSECTA					
EPHEMEROPTERA	Ameletidae	Ameletus sp.	~	1	2
	Isonychiidae	Isonychia sp.	~	~	1
DIPTERA	Chironomidae	Nanocladius distinctus	1	~	~
		Parametriocnemus sp.	1	2	2
		Rheocricotopus sp.	~	~	1
		Stilocladius sp.	~	~	1
		Tvetenia sp.	15	3	11
		Polypedilum aviceps	2	1	1
EPHEMEROPTERA	Baetidae	Heterocloeon sp.	18	23	19
DIPTERA	Chironomidae	Tribelos/Phaenopsectra Co	~	~	1
EPHEMEROPTERA	Heptageniidae	Epeorus sp.	1	4	4
		Stenonema sp.	~	1	~
	Ephemerellidae	Ephemerella dorothea	4	14	7
PLECOPTERA	Nemouridae	Amphinemura sp.	4	2	~
		Prostoia sp.	~	1	1
TRICHOPTERA	Philopotamidae	Chimarra aterrima	2	3	5
	Polycentropodidae	Polycentropus sp.	1	2	~
	Hydropsychidae	Diplectrona sp.	2	~	5
		Hydropsyche sparna	~	1	~
	Rhyacophilidae	Rhyacophila carolina	2	~	3
		Rhyacophila fuscula	8	9	2
DIPTERA	Tipulidae	Tipula sp.	1	~	~
	Simuliidae	Prosimulium sp.	25	21	13
		Simulium sp.	~	1	4
	Empididae	Undetermined Empididae	~	~	2
	Chironomidae	Diamesa sp.	3	1	2
		Brillia sp.	1	1	~
		Cardiocladius obscurus	~	1	1
PLECOPTERA	Perlidae	Acroneuria abnormis	~	1	~
		Paragnetina media	2	2	1
	Pteronarcidae	Pteronarcys biloba	1	1	1

Field Data Summary

Watershed Assessment Associates
Environmental Services / Biomonitoring / Invertebrate Taxonomy / Professional Training

Waterbody: **Warwick Brook**
River Basin: **Ramapo**
County: **Orange**
State: **NY**

Station: **WARI 01**
Coll Date: **3/25/2012**
Site description: **Just off Warwick Brook Rd**

Latitude: **41.2239**
Longitude: **-74.203**
Field Crew: **jkn, cmf**

Physical Characteristics	
Depth (meters):	**0.25**
Width (meters):	**6**
Current (cm/sec):	**65**
Canopy (%):	**85**
Substrate	
Rock (%):	**25**
Rubble (%):	**25**
Gravel (%):	**20**
Sand (%):	**20**
Silt (%):	**10**
Embeddedness (%):	**50**

Chemical Measurements	
DO (mg/L):	**7.49**
DO sat. (%):	**71.3**
Temperature (C):	**10.59**
Spec. Conduct. (umhos):	**261**
Baro pressure:	**742.6**
pH:	**7.74**
Salinity (PSS):	**0.13**

Biological Attributes	
Aquatic vegetation	
Macrophytes:	**Y**
Diatoms:	**Y**
Algae-suspended:	
Algae-filamentous:	**Y**
Occurance of macroinvertebrates	
Ephemeroptera:	**Y**
Plecoptera:	**Y**
Trichoptera:	**Y**
Coleoptera:	
Megaloptera:	**Y**
Odonata:	
Chironomidae:	**Y**
Simuliidae:	**Y**
Decapoda:	
Gammaridae:	
Mollusca:	
Oligochaeta:	
Other macro's:	
Field Faunal Condition:	**Very good**

Flow

Flow

Lab Data Summary

Watershed Assessment Associates
Environmental Services / Biomonitoring / Invertebrate Taxonomy / Professional Training

DATE SAMPLED:	Warwick Brook	Station WARI 01
LOCATION:	Orange, NY	Off Warwick Brook Rd
DATE:	3/25/2012	
SAMPLE TYPE:	Kick	

		Replicate	A	B	C
ARTHROPODA					
INSECTA					
DIPTERA	Chironomidae	Cricotopus sp.	8	9	8
EPHEMEROPTERA	Ameletidae	Ameletus sp.	~	~	1
DIPTERA	Chironomidae	Orthocladius sp.	2	2	~
		Parametriocnemus sp.	2	2	~
		Rheocricotopus sp.	3	5	1
		Tvetenia sp.	4	6	8
		Microtendipes pedellus gr.	~	1	~
		Polypedilum aviceps	2	1	6
EPHEMEROPTERA	Baetidae	Heterocloeon sp.	7	4	10
DIPTERA	Chironomidae	Micropsectra sp.	~	1	6
EPHEMEROPTERA	Heptageniidae	Epeorus sp.	1	~	~
	Ephemerellidae	Ephemerella dorothea	7	15	13
		Eurylophella funeralis	~	3	1
COLEOPTERA	Psephenidae	Psephenus herricki	~	1	~
MEGALOPTERA	Sialidae	Sialis sp.	~	1	~
TRICHOPTERA	Philopotamidae	Chimarra aterrima	~	~	1
	Polycentropodidae	Polycentropus sp.	~	1	~
	Hydropsychidae	Cheumatopsyche sp.	~	~	1
		Diplectrona sp.	~	~	1
	Rhyacophilidae	Rhyacophila fuscula	9	3	6
DIPTERA	Simuliidae	Prosimulium sp.	35	21	21
		Simulium sp.	1	2	2
	Chironomidae	Thienemannimyia gr. spp.	~	1	~
		Diamesa sp.	15	18	11
		Brillia sp.	2	~	1
PLECOPTERA	Perlidae	Acroneuria abnormis	~	~	1
	Peltoperlidae	Tallaperla sp.	1	~	~
	Perlodidae	Isoperla sp.	1	1	1
	Pteronarcidae	Pteronarcys biloba	~	2	~

Field Data Summary

Watershed Assessment Associates
Environmental Services / Biomonitoring / Invertebrate Taxonomy / Professional Training

Waterbody: **Warwick Brook**
River Basin: **Ramapo**
County: **Orange**
State: **NY**

Station: **WARI 02**
Coll Date: **3/25/2012**
Site description: **Just off Warwick Brook Rd**

Latitude: **41.2191**
Longitude: **-74.2245**
Field Crew: **jkn, cmf**

Physical Characteristics	
Depth (meters):	**0.2**
Width (meters):	**4**
Current (cm/sec):	**55**
Canopy (%):	**85**
Substrate	
Rock (%):	**20**
Rubble (%):	**20**
Gravel (%):	**25**
Sand (%):	**20**
Silt (%):	**15**
Embeddedness (%):	**60**

Chemical Measurements	
DO (mg/L):	**4.91**
DO sat. (%):	**42.7**
Temperature (C):	**9.24**
Spec. Conduct. (umhos):	**539**
Baro pressure:	**738.1**
pH:	**7.33**
Salinity (PSS):	**0.26**

Biological Attributes	
Aquatic vegetation	
Macrophytes:	**Y**
Diatoms:	**Y**
Algae-suspended:	**Y**
Algae-filamentous:	**Y**
Occurance of macroinvertebrates	
Ephemeroptera:	
Plecoptera:	
Trichoptera:	
Coleoptera:	
Megaloptera:	
Odonata:	
Chironomidae:	
Simuliidae:	
Decapoda:	
Gammaridae:	
Mollusca:	
Oligochaeta:	
Other macro's:	
Field Faunal Condition:	**Very poor**

Flow

Flow

Lab Data Summary

Watershed Assessment Associates
Environmental Services / Biomonitoring / Invertebrate Taxonomy / Professional Training

DATE SAMPLED:	Warwick Brook	Station WARI 02
LOCATION:	Orange, NY	Just off Warwick Brook Rd., above 4 Corners Pond
DATE:	3/25/2012	
SAMPLE TYPE:	Kick	

		Replicate	A	C	D
ARTHROPODA					
INSECTA					
DIPTERA	Chironomidae	Diplocladius cultriger	1	1	1
MOLLUSCA					
PELECYPODA					
VENEROIDEA	Sphaeriidae	Pisidium sp.	3	~	~
ARTHROPODA					
INSECTA					
DIPTERA	Chironomidae	Polypedilum tritum	~	~	1
ANNELIDA					
OLIGOCHAETA					
LUMBRICULIDA	Lumbriculidae	Undetermined Lumbriculidae	~	2	1
TUBIFICIDA	Enchytraeidae	Undetermined Enchytraeidae	1	~	~
ARTHROPODA					
INSECTA					
COLEOPTERA	Psephenidae	Ectopria sp.	1	~	~
MEGALOPTERA	Sialidae	Sialis sp.	1	1	~
TRICHOPTERA	Hydropsychidae	Cheumatopsyche sp.	~	~	1
DIPTERA	Chironomidae	Undetermined Tanypodinae	~	~	1

Field Data Summary

Watershed Assessment Associates
Environmental Services / Biomonitoring / Invertebrate Taxonomy / Professional Training

Waterbody: **Patterson Brook**
River Basin: **Ramapo**
County: **Orange**
State: **NY**

Station: **PATT 01**
Coll Date: **3/25/2012**
Site description: **Just off Patterson Rd**

Latitude: **41.20727**
Longitude: **-74.2089**
Field Crew: **jkn, cmf**

Physical Characteristics	
Depth (meters):	**0.2**
Width (meters):	**2.5**
Current (cm/sec):	**45**
Canopy (%):	**70**
Substrate	
Rock (%):	**20**
Rubble (%):	**20**
Gravel (%):	**20**
Sand (%):	**30**
Silt (%):	**10**
Embeddedness (%):	**50**

Chemical Measurements	
DO (mg/L):	**10.98**
DO sat. (%):	**92.9**
Temperature (C):	**8.41**
Spec. Conduct. (umhos):	**153**
Baro pressure:	**742.9**
pH:	**7.92**
Salinity (PSS):	**0.07**

Biological Attributes	
Aquatic vegetation	
Macrophytes:	**Y**
Diatoms:	**Y**
Algae-suspended:	
Algae-filamentous:	
Occurance of macroinvertebrates	
Ephemeroptera:	
Plecoptera:	
Trichoptera:	**Y**
Coleoptera:	
Megaloptera:	
Odonata:	
Chironomidae:	**Y**
Simuliidae:	
Decapoda:	
Gammaridae:	
Mollusca:	
Oligochaeta:	
Other macro's:	**Diptera**
Field Faunal Condition:	**Good**

Flow

Flow

DATE SAMPLED: Patterson Brook Station PATT 01
LOCATION: Orange, NY Just of Patterson Rd.
DATE: 3/25/2012
SAMPLE TYPE: Kick

		Replicate	A	B	C
ARTHROPODA					
INSECTA					
DIPTERA	Chironomidae	Cricotopus sp.	9	10	10
		Eukiefferiella brevicalcar gr.	1	4	12
		Eukiefferiella claripennis gr.	3	14	3
MOLLUSCA					
PELECYPODA					
VENEROIDEA	Sphaeriidae	Pisidium sp.	1	~	~
ARTHROPODA					
CRUSTACEA					
DECAPODA	Cambaridae	Cambarus sp.	~	1	1
INSECTA					
DIPTERA	Chironomidae	Orthocladius lignicola	~	~	1
		Parametriocnemus sp.	3	2	1
		Rheocricotopus sp.	2	1	1
		Tvetenia sp.	7	10	13
EPHEMEROPTERA	Ephemerellidae	Eurylophella funeralis	5	1	2
ANNELIDA					
OLIGOCHAETA					
LUMBRICULIDA	Lumbriculidae	Undetermined Lumbriculidae	3	1	1
ARTHROPODA					
INSECTA					
PLECOPTERA	Leuctridae	Leuctra sp.	1	~	~
COLEOPTERA	Psephenidae	Ectopria sp.	3	1	2
	Elmidae	Oulimnius latiusculus	1	~	2
MEGALOPTERA	Corydalidae	Nigronia serricornis	1	3	1
	Sialidae	Sialis sp.	3	1	~
TRICHOPTERA	Polycentropodidae	Polycentropus sp.	1	2	3
	Hydropsychidae	Cheumatopsyche sp.	9	10	10
		Diplectrona sp.	3	6	8
		Hydropsyche betteni	3	7	5
	Rhyacophilidae	Rhyacophila carolina?	~	~	2
		Rhyacophila nigrita	3	1	~
NEMERTEA					
ENOPLA					
HOPLONEMERTEA	Tetrastemmatidae	Prostoma graecense	1	2	~
ARTHROPODA					
INSECTA					
TRICHOPTERA	Brachycentridae	Micrasema sp.	~	1	1
	Uenoidae	Neophylax sp.	3	4	3

Continued next page

Lab Data Summary

Watershed Assessment Associates
Environmental Services / Biomonitoring / Invertebrate Taxonomy / Professional Training

DATE SAMPLED:	Patterson Brook	Station PATT 01
LOCATION:	Orange, NY	Just of Patterson Rd.
DATE:	3/25/2012	
SAMPLE TYPE:	Kick	

		Replicate	A	B	C
	Limnephilidae	Pycnopsyche sp.	4	3	~
	Lepidostomatidae	Lepidostoma sp.	2	~	~
	Leptoceridae	Mystacides sepulchralis	1	~	~
DIPTERA	Tipulidae	Antocha sp.	2	~	2
		Tipula sp.	4	2	1
	Simuliidae	Prosimulium sp.	9	3	3
	Empididae	Clinocera sp.	4	4	4
		Hemerodromia sp.	1	2	~
		Neoplasta sp.	~	1	~
	Chironomidae	Larsia sp.	1	~	~
		Thienemannimyia gr. spp.	5	~	4
		Potthastia longimana gr.	~	~	1
		Sympotthastia sp.	~	~	2
		Brillia sp.	1	2	1
		Chaetocladius sp.	~	1	~

Rationale for Data Collected

Physical

The *physical survey* is essential to a stream study because aquatic fauna often have specific habitat requirements independent of water composition, and alterations in these conditions affect the overall quality of a water body (Giller and Malmqvist, 1998). Additionally, the physical characteristics of a stream affect stream flow, volume of water within the channel, water temperature, and absorbed radiant energy from the sun.

Testing sites are evaluated for: stream depth, width, and current speed; aquatic vegetation; percent substrate and embeddedness; and percent stream canopy cover. Site photos were taken of the upstream and downstream area and are included with the physical and chemical data.

W*ater temperature* directly affects both the nature of aquatic fauna and species diversity; temperature tolerance is organism specific, and the reproductive cycle (including timing of insect emergence and annual productivity) will vary within different temperature ranges. Temperature can also affect organisms indirectly as a consequence of oxygen saturation levels. As water temperature rises, the metabolism of aquatic organisms increases, with an attendant increase in their oxygen requirements. At higher water temperatures, however, the oxygen carrying capacity of water decreases because of a diminished affinity of the water for oxygen.
Optimal water temperature ranges and lethal limits of water temperature vary among different organisms. The ratio of Plecoptera to Ephemeroptera (individuals and numbers of species) has been found to drop as the annual range of temperature increases (Hynes, 1970). The optimal temperature range for Brook trout is 11-16 ^{0} Celsius with an upper lethal limit of 24^{0} Celsius (Hynes, 1970). NYS DEC does not have a water quality standard for water temperature.

Temperature was recorded using a YSI™ 556 probe.

Velocity was calculated at the time of macroinvertebrate collection because an optimal macroinvertebrate collection site has a velocity between 0.45 and 0.75 meter/second. Velocity was determined using a Global Water® Flow Probe.

Chemical

Dissolved Oxygen (DO) level is a function of water turbulence, diffusion, and plant respiration. The EPA recommends that dissolved oxygen levels remain above 11 mg/l during embryonic and larval stages of salmonid production and above 8 mg/l during other life stages (EPA, 1987). The NYS DEC standard for dissolved oxygen for class C(T) and C(TS) stream is 6 mg/L and 7 mg/L respectively.

A significant drop in DO concentration can occur over a 24-hour period, particularly if a waterbody contains a large amount of plant growth. Oxygen is released into the water as a result of plant photosynthesis during daylight; dense plant growth within a stream can therefore elevate the DO level significantly. At night photosynthesis ceases and DO may drop to levels maintained by

diffusion and turbulence. A pre-dawn DO level will, in this case, reflect the lowest DO concentration in a 24 hour period and thus provide important data on the overall health of the system.
DO was measured using a YSI™ 556 probe.

It is also important to consider *percent oxygen saturation*, since dissolved oxygen levels vary inversely with water temperature. Percent saturation is the maximum level of dissolved oxygen that would be present in the water at a specific temperature in the absence of other influences, and is determined by calculating the ratio of measured dissolved oxygen to maximum dissolved oxygen for a given temperature. (The calculation is also standardized to altitude or barometric pressure.) Percent oxygen saturation falls when something other than temperature, such as dissolved solids or bacterial decomposition, affects oxygen levels.

A healthy stream contains near 100 percent oxygen saturation at any given temperature (Hynes, 1970). Trout are particularly sensitive to even a slight drop in oxygen saturation and will migrate away from streams when oxygen saturation falls. Similarly, certain macroinvertebrates are sensitive to varying saturation levels and because the ability of these organisms to migrate away from the changing conditions is limited a drop in saturation can be lethal. NYS DEC has not adopted percent oxygen saturation as a water quality standard.

Specific Conductance or Conductivity is a measure of the ability of an electrical current to pass through a stream; it is dependent on both the concentration of dissolved electrolytes within the water and water temperature. When inorganic ions are dissolved in water, conductivity increases. Organic ions, such as phenols, oil, alcohol and sugar, can decrease conductivity (EPA, 1997). Warmer water is also more conductive and, therefore, conductivity is reported for a standardized water temperature of 25 degrees Celsius. Measurements are reported in microsiemens per centimeter (µS/cm).

In the United States, freshwater stream conductivity readings vary greatly from 50-1,500µS/cm. The conductivity of most streams remains relatively constant, however, unless an extraneous source of contamination is present. A failing septic system would raise conductivity because of its chloride, phosphate, and nitrate content, while an oil spill would lower conductivity.

A YSI™ 556 probe was used to measure conductivity.

The *pH* is a measure of a stream's acidity. A desirable pH for salmonid is 6.5-8.5. A YSI™ 556 probe used to obtain pH. The NYS DEC standard for pH is 6.5-8.5.

Biological

Macroinvertebrates are collected by kick net and the specimens are preserved. Pollution-sensitive *macroinvertebrates*, a food source for trout, require similar chemical parameters as trout. The relative numbers of different macroinvertebrate groups indicate the overall health of an ecosystem. Perhaps more importantly, macroinvertebrate data demonstrate the effects of problems that may not be detected by chemical testing.

The NYS DEC Stream Biomonitoring Unit has utilized stream biological monitoring and water quality analysis since 1972 but the biological profiles and water quality assessments are not a part of the state's standards. They serve as a "decision threshold" to determine the need for further studies.

The Environmental Protection Agency recommends that states and tribes with biomonitoring experience adopt biological criteria into water quality standards to provide a quantitative assessment of a waterway's designated and supportive use. Currently only five states have done so; NY is not one of these states.

Glossary

Anthropogenic: caused by man

Assessment: a diagnosis or evaluation of water quality

Benthic: located on the bottom of a body of water or in the bottom sediments or pertaining to bottom-dwelling organisms

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

Biomonitoring: the use of biological indicators to measure water quality

Diel cycle: referring to the 24 hr day

Eutrophic: very enriched with dissolved nutrients, resulting in increased growth of algae and other microscopic plants.

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

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

Mesotrophic: moderately enriched with dissolved nutrients, resulting in increased growth of algae and other microscopic plants.

Non point source: diffuse pollution sources (i.e., without a single point of origin or not introduced into a receiving stream from a specific outlet)

Oligotrophic: few nutrients and relatively few plants and algae.

Periphyton: are algae that grow on a variety of submerged substrates, such as rocks, plants or debris, in lakes or streams

Point source: a stationary location or fixed facility from which pollutants are discharged or emitted. Also, any single identifiable source of pollution, e.g., a pipe, ditch, ship, ore pit, factory smokestack

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

Station: a sampling site on a waterbody

Stenotherms: organisms having a very narrow thermal tolerance and preferring cooler temperatures

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

Tolerant: able to survive poor water quality

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