Orange County Department of Planning

Orange County, NY

Quassaick Creek Biomonitoring Project

Report for years 2012 & 2013

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Prepared for

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Background

Quassaick Creek Watershed comprises approximately 56 square miles within Orange and Ulster Counties, New York State. There are 8 sub-watersheds, including one artificially connected sub-watershed (Upper Silver Stream) within its boundary (Figure 1). According to the 2006 National Land Cover Dataset analysis of the Quassaick Creek Watershed, land use categories percentages, grouped, include: developed 14%, forested 43%, wetland 22%, agriculture 19%, and 2% open water. Although approximately 86% of the land use is forested, wetland, open water and agriculture, the 14% developed land is likely having deleterious effects on water quality and aquatic biota.

Developed urbanized land areas are located mainly in the lower southern portion of the watershed and include portions of the City of Newburgh, the Town of New Windsor, and the central/southern portions of the Town of Newburgh. The northern portion of the watershed is mainly comprised of forest, wetland, and agriculture land.

Biological assessment has been widely implemented as a useful, cost-effective approach for providing information on the extent and potential source of impacts to surface waters. Although biological assessments may utilize one or more biological communities, the use of aquatic macroinvertebrate communities has several advantages over other assemblages: Benthic macroinvertebrates are abundant in most streams, relatively easy and inexpensive to sample, and relatively sensitive to a wide range of environmental stressors, both physical and chemical. Their life span is short enough that sensitive life stages will be affected by stressors, but long enough that any impairment is measurable in the assemblage. Because they are relatively stationary, measured differences reliably convey localized conditions, allowing comparison of sites in close proximity to one another.

Changes in a macroinvertebrate community structure are indicative of these localized impacts and frequently provide insight into the type of impact. Benthic communities serve as indicators of overall, integrated water quality, including the effects of intermittent discharges and lapses in treatment, synergistic effects, and effects of substances in lower-than-detectable levels (Smith et al. 2009). Furthermore, macroinvertebrate collection and processing protocols have been standardized, proficiency in taxonomic identification has been established through a Society for Freshwater Science certification process, and state and federal agencies routinely use community metrics. All of these factors contribute to more accurate, reproducible data for making comparison between locations and for determining trends over time. Aquatic macroinvertebrate biological monitoring data may also be used to support documentation to establish a waterbody on the NYS 305(b) priority waterbodies list or 303(d) impaired waterbodies list, or be used in permit compliance.

The most recent Quassaick Creek water quality assessments conducted by the New York State Department of Environmental Conservation (NYS DEC) occurred in 2012 and indicated slightly impacted water quality conditions. As development within the watershed continues, the identification of comprehensive water quality conditions in the

Quassaick Creek and its tributaries becomes imperative. Identifying tributaries impacting the creek will help direct remediation efforts. Recognizing this need, the Orange County Water Authority (OCWA) authorized a biological stream assessment using aquatic macroinvertebrate communities at four locations within the Quassaick Creek Watershed in 2004. Re-assessment of at least one station yearly continued until 2010; one additional station was also added. In 2012, the Orange County Department of Planning (OCDP) initiated further biological stream assessments, expanding the number of sampling locations throughout the watershed to include 9 new stations and 5 previous sampled stations for a total of 18 samples (see Table 2). Of the 18 samples collected, 12 were collected by trained volunteers and 6 were collected by Watershed Assessment Associates (WAA) aquatic biologists. All samples were processed by Society for Freshwater Science certified taxonomists of WAA.

In this study, the sample locations were selected to provide ambient water quality data for sites throughout the Quassaick Creek Watershed in order to provide information for use in the Quassaick Creek Watershed Management Plan, to provide a baseline of data against which future water quality data can be compared, and to monitor water quality changes at sites sampled in previous years by OCWA and NYS DEC. This report documents the approach, methods, and findings of the 2012 and 2013 assessment.

Methods

Site Selection

Sample stations were selected to provide characterization of current water quality conditions in the Quassaick Creek Watershed, and included five previously sampled sites and nine new locations (Figure 1, Table 1). Sample stations were selected by the OCPD in collaboration with a stream monitoring subcommittee comprised of various agency staff as well as citizen volunteer monitors trained in macroinvertebrate collection

See Figure 1 for a map of site locations.

Field Collection

Benthic surveys were conducted in accordance with the NYSDEC Stream Biomonitoring Unit (NYS DEC SBU) sampling season (July–September). The protocols established by NYS DEC SBU for the collection of benthic macroinvertebrates, physical habitat evaluation, and collection of basic water quality parameters for kick (riffle) (Smith et al. 2009) were followed. For kick riffles, an aquatic kick net was positioned in the water about 0.5 m downstream and the stream bottom was disturbed by foot so that the dislodged organisms were carried into the net. Sampling was continued for 5 minutes for a distance of 5 meters in a diagonal transect of the stream. The net contents were emptied into a pan of stream water and larger debris, once devoid of organisms, was removed. The contents of the pan was sieved with a US number 30 standard sieve and transferred to a jar for preservation with ethyl alcohol.

Volunteer monitors, trained by WAA, performed macroinvertebrate collection following the same protocols, for identification by WAA taxonomists.

A single replicate sample was collected from each station.

The following parameters were obtained from each station collected by professional biologists (WAA), using a YSI 556™ probe following the manufacturer calibration guidelines: water temperature (accuracy ± 0.15°C); specific conductance (range 0 -200,000 µS/cm with an accuracy of ± 0.5% of reading); pH, with a range of 0 to 14 units (accuracy ± 0.2 units); dissolved oxygen, with a range of 0 to 50 mg/L (accuracy ± 0.2 mg/L); and percent oxygen saturation, with a range of 0-500% (accuracy ± 2%).

The following physical habitat attributes were documented at stations collected by WAA: estimated stream width, depth, velocity, substrate embeddedness, and substrate composition.

See Appendix for description of rationale.

Sorting and Organism Identification

Sample sorting and identification adhered to the NYS DEC SBU laboratory methods (Smith et al. 2009). The samples were rinsed with tap water in a U.S. number 40 standard sieve to remove fine particles and then examined under a dissecting microscope to separate 100 organisms from the sample matrix. All specimens were identified to genus/species, or lowest practical taxonomic level, and enumerated using a dissecting microscope. Oligochaetes and Chironomids were slide-mounted in CMCP-10 mounting medium and viewed using a compound microscope.

See Appendix for description of rationale.

Habitat Assessment

Each site sampled by WAA was evaluated for current speed; percent of rock, rubble, gravel, sand, and silt; embeddedness of substrate; epifaunal substrate/available cover; velocity/depth regime; sediment deposition; channel flow status; channel alteration; channel sinuosity; bank stability; vegetative protection; and riparian vegetative wetted width. The depth and width of the stream were also measured.

Macroinvertebrate Community Metrics

Standard NYS DEC SBU standard kick community metrics [species richness, EPT richness, biotic index (BI), and percent model affinity (PMA)] were calculated for each subsample (Smith et al. 2009; Table 1).

The metric values were scaled to a common value between 0-10 and averaged to calculate the standard NYS biological assessment profile (BAP) score.

BAP indicates the water quality condition in response to low oxygen saturation, organic enrichment, and industrial pollutants based on four impact categories: non-impact (BAP 10 – 7.51), slight impact (BAP 7.5 – 5.01), moderate impact (BAP 5 – 2.51), and severe impact (BAP 2.5 – 0). The boundary between the slight and moderate impact category is considered the decision threshold for designated use impairment based on biological data (NY DEC SBU 2008).

See Table 3 for a descriptive summary of metrics used and Table 5 for a summary of water quality categories.

Impact Source Determination

Impact Source Determination (ISD) compares the sample community structure to a series of benthic model communities indicative of various impact sources to help identify a likely source of impact affecting the sample community (Table 4). The model that exhibits the highest similarity to the sample community denotes the likely impact source; if sample community scores fall within 5 percent of each other, however, multiple impacts may be affecting the community. Alternatively, the sample community may be most similar to a "natural" or non-impacted community. If the sample community does not exhibit greater than 50% similarity to any model community, the determination is inconclusive (Novak and Bode, 1992).

ISD is applicable to benthic samples collected from wadeable stream systems only; the methods were developed for data derived from 100-organism subsamples of traveling kick samples from riffles of NYS streams.

Results

Macroinvertebrate Community Metrics

Among stations sampled, benthic macroinvertebrate community metrics indicated non- to moderately impacted water quality (Table 1). EPT richness ranged from 2 to 11; biotic index values ranged from 2.8 to 6.7; species richness ranged from 9 to 28; percent model affinity ranged from 42 to 81%. Biological assessment profile scores ranged from 3.8 to 7.7. Tables 3 and 5 detail the significance of each of the above metrics.

Station 4200_002. The upper most station on the Quassaick Creek received BAP scores of 7.3 in 2012 and 7.2 in 2013, corresponding to a slight impact classification (Table 1). ISD indicated natural conditions in 2012 and results were inconclusive in 2013.

Station 4600_001. Quassaick Creek station received a BAP score of 7.7 in 2012, corresponding to a BAP classification of non-impact. This station was sampled by OCWA in 2005, 2008, and 2009 with BAP scores of 4.8, 6.72, and 5.33, respectively, corresponding to slight impact classifications (Table 1). The 2012, the ISD was inconclusive.

Station 4600_004. Quassaick Creek station received a BAP score of 6.4 in 2012, corresponding to a BAP of slight impact. This station was sampled by OCWA in 2004, receiving a BAP score of 6.3, slight impact classification (Table 1). The 2012 ISD results indicated natural conditions and nonpoint source inputs.

Station 4600_005. Quassaick Creek station received a BAP score of 5.1 in 2013 and 5.4 in 2013, corresponding to a BAP impact classification of slight impact. This station was sampled by OCWA in 2004, receiving a BAP score of 7.3, slight impact classification (Table 1). The 2012 and 2013 ISD results were inconclusive.

Station 1100_001. Quassaick Creek station was sampled only in 2012, receiving a BAP score of 6.5, corresponding to a slight impact classification (Table 1). ISD results were inconclusive.

Station 4600_007. Gidneytown Creek station received a BAP score of 7.1 in 2012 and 6.9 in 2013, corresponding to a BAP impact classification of slight impact. This station was sampled by OCWA in 2004, receiving a BAP score of 9.2, non-impact (Table 1). The 2012 ISD indicated natural conditions and impoundment effects. The 2013 ISD was inconclusive.

Station 4600_010. Gidneytown Creek station was sampled only in 2012, receiving a BAP score of 6.4, corresponding to a slight impact classification (Table 1). ISD results were inconclusive.

Station 4600_012. Bushfield Creek station was sampled only in 2012, receiving a BAP score of 7.4, corresponding to a slight impact classification (Table 1). ISD indicated natural conditions and non-point source nutrient inputs.

Station 4600_013. Bushfield Creek station received BAP scores of 7.0 in 2012 and 6.9 in 2013, corresponding to slight impact classifications (Table 1). In 2012, ISD indicated natural conditions and impoundment effects; in 2013, ISD indicated natural conditions, as well as non-point source and toxic inputs.

Station 4600_016. Patton Brook received a BAP 4.6 in 2013, corresponding to moderately impact classification (Table 1). ISD indicated toxic inputs.

Station 4600_015. Quassaick Creek station, sampled only in 2013, received a BAP score of 6.5, corresponding to a slight impacted classification (Table 1). ISD indicated natural conditions.

Station 4800_013. Quassaick Creek station, sampled in 2013, received a BAP score of 4.8, moderate impact (Table 1). ISD indicated nonpoint source, organic, complex, siltation and impoundment effects. This station was also sampled by OCWA and NYS DEC SBU in 1987, 1992, 1997, 1998, 1999, 2002, 2005 – 2010, 2012. BAP scores were similar to the 2013 results, and water quality impact classification has remained in the moderate impact category since 2006.

Station 4800_014. Silver Stream station, sampled only in 2013, received a BAP score of 4.2, corresponding to a moderate impact classification (Table 1). ISD indicated organic and complex inputs.

Station 4800_015. Silver Stream station, sampled only in 2013, received a BAP score of 3.8, corresponding to a moderate impact classification (Table 1). ISD indicated organic and toxic inputs.

Nine kick samples were collected in 2012 and 2013 at stations not previously sampled (Table 2). Physical habitat, chemical parameters and biological samples were collected at seven of the stations by WAA; biological samples only were collected by OCPD volunteer monitors at the remaining stations (Table 1). Of note is that the Bushfield Creek sub-watershed did not lend itself to water quality assessment by stream biomonitoring methodology, as it is extensively comprised of wetland habitat.

Biological community metrics indicate the Quassaick Creek water quality ranges from moderately impact to non-impact (Table 1). Biological assessment profile (BAP) scores ranged from 3.8 (Station 4800_015, Silver Stream) to 7.7 (Station 4600_001, Quassaick Creek) (Table 1). Overall, one station was non-impacted, thirteen stations were slightly impacted and four were moderately impacted (Table 1).

The majority of stations are slightly impacted and the ISD for the majority of these stations indicates natural conditions or natural and non-point source inputs (or are inconclusive). The 2012 and 2013 flow rates, however, were higher than in previous sampling years (2004 – 2010) due to increased precipitation; increased flow may dilute the impact of point sources, which are expected in this urban watershed. It is possible that water quality during such a high flow state is the highest attainable water quality these stations will achieve under current land use conditions. Longitudinal assessment will aid in determining of the types of anthropogenic influences on this watershed.

Station 4600_001 (Quassaick Creek) was assessed as non-impacted. The benthic macroinvertebrate community was diverse, with a total of 28 different taxa, including 5 different mayfly species. This station's community structure can be used as a benchmark threshold of what other stations' water quality could achieve in the absence of anthropogenic influences.

The assessment performed for this report used screening methodology, which provides useful information on overall water quality, water quality trends, and potential impact sources, but is limited, by design, in its ability to provide detailed information about specific impacts or recommendations for remediation and preservation. Continued sampling of the current stations using this methodology will determine whether significant water quality changes occur and better define how flow is affecting Quassaick Creek water quality. Expansion of current monitoring protocols will provide more detailed data on impact sources and potential remedial actions to improve water quality.

Specific recommendations are:

- Conduct a stream walk led by an aquatic biologist or other qualified expert to document potential impact sources (e.g. bank failure, old garbage sites, illicit discharge pipes). The assessment should include photographic/video documentation (with GPS location) of possible water quality impacts and specific sites where remedial efforts can be implemented. The approach should be by sub-basin, perhaps divided over a two year period to allow detailed attention to each sub-basin.
- Sample the stream stations for pathogens following protocol set by NYS DEC to better determine the impact of these pathogens on water quality and then establish an enterococcus monitoring program to assist in impact source tracking.
- Consider replicate benthic macroinvertebrate sampling following NYS DEC sampling for impairment criteria (Bode et. al., 1990) to firmly establish water quality; this provides more detailed analysis than the current methodology, which is considered a screening tool.
- Conduct lake sampling of benthic macroinvertebrates to establish baseline conditions for future assessment at Lake Washington, Orange Lake, Chadwick Lake, and perhaps Browns Pond. The NYS DEC and the EPA are currently establishing metrics for lake assessment to augment water quality analysis in NYS.
- Produce GIS sub-basin watershed maps and determine land use percentages within each sub-watershed to better understand water quality issues and potential impact sources.
- For the Bushfield Creek watershed and other heavily wetland areas, collect benthic macroinvertebrates for biodiversity assessment. This will establish the current community structure, which will be useful for both future trend analysis and to provide a measurement of the success of future remedial actions.
- Consider conducting fish surveys of the main branch of the Quassaick and at each of the sub-basins to establish both water quality and baseline community diversity, which will be useful for both future trend analysis and to provide a measurement of the success of future remedial actions.

Figure 1. Map of 2012 & 2013 sampling locations in the Quassaick Creek Watershed, including biological assessment profile (BAP) categories.

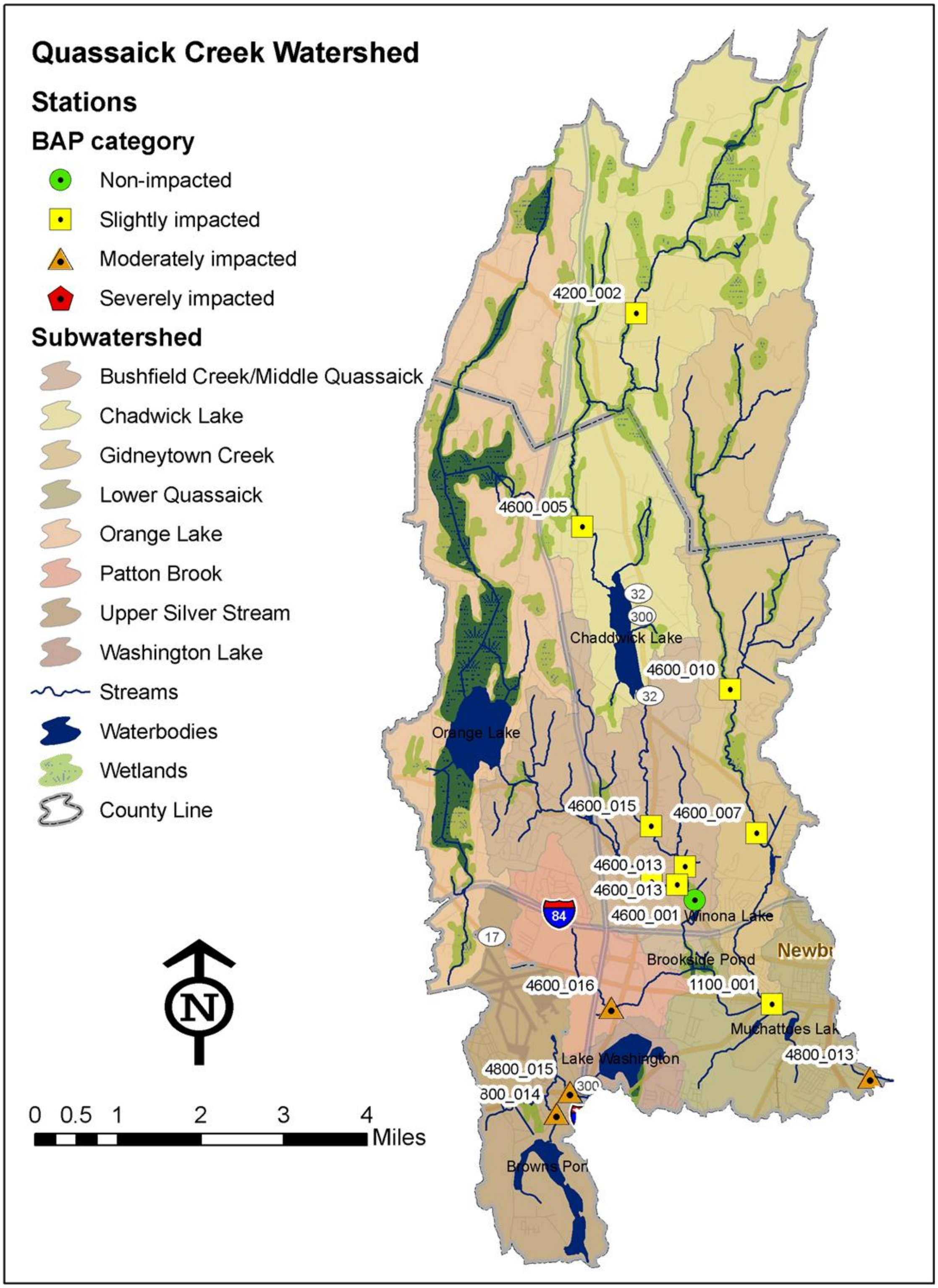

Table 1. Benthic macroinvertebrate metric scores and impact source determination percentages for the sites sampled in 2012 & 2013 throughout Quassaick Creek Watershed. Bolded numbers indicate the most likely source of impact to the stream community. TR= taxa richness; BI= biotic index; EPT = Ephemeroptera-Plecoptera-Trichoptera taxa; PMA= percent model affinity; BAP = Biological Assessment Profile; WQA= water quality assessment category; NAT=natural; NPN = non-point nutrient; ORG = organic inputs; COMPLEX= municipal/industrial; SILT = siltation; IMP= impoundment. ISD Percentages less than 50% are inconclusive. *Samples collected by Quassaick Creek volunteers.

					Biotic Metrics						Impact Source Determination (ISD)						
Stream Name	**Watershed**	**Station**	**Collect Date**	**Sample Type**	**TR**	**BI**	**EPT**	**PMA**	**BAP**	**WQA**	**NAT**	**NPN**	**TOXIC**	**ORGANIC**	**COMPLEX**	**SILT**	**IMP**
Quassaick Creek	Quassaick	4200_002	9/24/2012	Kick	25	4.5	8	74	7.3	slt	**53**	44	29	38	25	43	47
Quassaick Creek	Quassaick	4200_002	7/24/2013	Kick*	21	3.4	10	62	7.2	slt	45	34	26	31	21	28	36
Quassaick Creek	Quassaick	4600_001	7/6/2012	Kick*	28	5	10	74	7.7	non	47	45	40	43	33	48	48
Quassaick Creek	Quassaick	4600_004	7/6/2012	Kick*	17	4.1	9	57	6.4	slt	**62**	**63**	41	43	36	48	47
Quassaick Creek	Quassaick	4600_005	7/10/2012	Kick*	26	6.7	5	42	5.1	slt	17	17	30	25	28	13	19
Quassaick Creek	Quassaick	4600_005	7/24/2013	Kick*	18	6	7	51	5.4	slt	41	43	42	46	42	47	41
Quassaick Creek	Quassaick	1100_001	7/30/2012	Kick*	21	5.4	8	63	6.5	slt	42	36	38	34	31	35	41
Gidneytown Creek	Quassaick	4600_007	7/10/2012	Kick*	23	3.7	8	62	7.1	slt	**50**	49	25	26	48	31	**53**
Gidneytown Creek	Quassaick	4600_007	8/22/2013	Kick*	15	2.8	9	67	6.9	slt	44	25	18	19	19	29	26
Gidneytown Creek	Quassaick	4600_010	9/24/2012	Kick	12	3	8	63	6.4	slt	48	31	22	25	21	30	26
Bushfield Creek	Quassaick	4600_012	9/24/2012	Kick	20	4.4	11	74	7.4	slt	**65**	52	46	42	42	52	56
Bushfield Creek	Quassaick	4600_013	9/24/2012	Kick	18	3.8	9	69	7	slt	**56**	47	32	29	40	39	51
Bushfield Creek	Quassaick	4600_013	8/22/2013	Kick*	21	4.8	6	81	6.9	slt	**56**	50	58	50	42	48	48
Patton Brook	Quassaick	4600_016	8/13/2013	Kick	16	6.3	3	50	4.6	mod	25	40	**62**	36	29	29	49
Quassaick Creek	Quassaick	4600_015	8/13/2013	Kick	14	2.9	7	63	6.5	slt	**52**	33	30	32	28	37	28
Quassaick Creek	Quassaick	4800_013	8/30/2013	Kick*	15	5.9	5	49	4.8	mod	39	54	49	**52**	**53**	**52**	**53**
Silver Stream	Quassaick	4800_014	7/9/2013	Kick*	11	5.9	2	50	4.2	mod	32	48	53	**60**	**65**	52	50
Silver Stream	Quassaick	4800_015	7/9/2013	Kick*	9	5.5	2	43	3.8	mod	27	55	**68**	**67**	62	59	58

Table 2. Biological Assessment Profile (BAP) scores for all stations sampled within the Quassaick Creek Watershed by either NYSDEC SBU, OCWA, or OCPD.

Reported BAP Scores for Sampled Streams in the Quassaic Creek Watershed: 1987 through 2013 (Note: Samples from both OCWA and NYSDEC Included)																	
Program	**Stream Name**	**Station ID**	**1987**	**1992**	**1997**	**1998**	**1999**	**2002**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2012**	**2013**
Orange County Dept. of Planning	Quassaick Creek	4200_002														7.3	7.2
	Quassaick Creek	1100_001														6.5	
	Gidneytown Creek	4600_010														6.4	
	Bushfield Creek	4600_012														7.4	
	Bushfield Creek	4600_013														7	6.9
	Patton Brook	4600_016															4.6
	Quassaick Creek	4600_015															6.5
	Silver Stream	4800_014															4.2
	Silver Stream	4800_015															3.8
Sampled by OCDP OCWA	Quassaick Creek	4600_001														7.7	
										4.8			6.72	5.33			
Sampled by OCDP OCWA	Quassaick Creek	4600_004														6.4	
									6.3								
Sampled by OCDP OCWA	Quassaick Creek	4600_005														5.1	5.4
									7.3								
Sampled by OCDP OCWA	Gidneytown Creek	4600_007														7.1	6.9
									9.2								
OCWA	Quassaick Creek	1100_001							6.7								
Sampled by OCDP, OCWA, NYS DEC	Quassaick Creek	4800_013															4.8
	Quassaick Creek	4800_013								5.1	4.4	4.21		4.73	4.02		
	Quassaick Creek	QUAS 03	2.58	6.18	5.15	4.49	5.54	4.51				4.33	4.95			6.59	
NYS DEC SBU	Quassaick Creek	QUAS 01	7.15													7.31	
	Quassaick Creek	QUAS 02	4.55				5.13										
	Quassaick Creek	QUAS 04N	2.9														
	Quassaick Creek	QUAS 04S	1.42														
	Gidneytown Creek	GIDN01														7.62	

Table 3. Descriptions of the common NYS metrics calculated (adapted from Smith et al. 2009).

Metric	Description	Sample Type	Predicted response to impact
Species Richness (SR)	Species richness is the total number of unique species or taxa found in the subsample. Higher species richness indicates higher water quality.	Kick	Decrease
Ephemeroptera-Trichoptera-Plecoptera (EPT) Richness	EPT Richness is the total number of taxa of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) found in a subsample. These are considered to be mostly clean-water organisms, and their presence may indicate good water quality.	Kick	Decrease
Hilsenhoff's Biotic Index (BI)	Biotic index is calculated by multiplying the number of individuals of each species or taxa by its assigned tolerance value, summing these products, and dividing by 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.	Kick	Increase
Percent Model Affinity (PMA)	This is a measure of similarity to a model non-impacted community based on percent abundance in 7 major groups to measure similarity to a kick sample community of 40% Ephemeroptera, 5% Plecoptera, 10% Trichoptera, 10% Coleoptera, 20% Chironomidae, 5% Oligochaeta, and 10% Other. The lower the similarity value the greater the impact.	Kick	Decrease
Standard NYS Biological Assessment Profile (BAP)	BAP is the assessed impact for each station. The BAP score is the mean value of the above metrics after converting each metric score to a common scale of 0-10. The higher the BAP score, the better the assessed impact category. There are four impact categories in NYS: non-, slight, moderate, or severe impact.	Kick	Decrease

Table 4. NYS DEC Impact Source Determination (ISD) Category Definitions

ISD Class	Description
Natural	Minimal human impacts. Includes pristine stream segments and those receiving discharges that minimally affect the biota.
Nonpoint nutrients	Mostly nonpoint agricultural and sources with similar impacts. Includes row crop runoff, golf course runoff, well-treated sewage effluent, and urban runoff. May include pesticide effects.
Toxic	Industrial, municipal, or urban runoff. May include municipal waste-water treat-ment plant discharges that include industrial wastes, and (or) are characterized by high ammonia or chlorine levels.
Organic	Sewage effluent and (or) animal wastes. Includes conventional waste-water treat-ment plant discharges, livestock waste inputs, and failing septic systems.
Complex	Municipal and (or) industrial. Includes industrial point sources and municipal waste-water treatment plant discharges that include industrial wastes. May also include combined sewer overflows and urban runoff.
Siltation	Sites affected by moderate to heavy deposition of fine particles.
Impoundment	Includes upstream lake or reservoir releases, dammed stream segments, or stream segments with upstream areas of natural pond, wetland, or sluggish zones.

Table 5. Abridged NYS DEC Water Quality Category Definitions

Abridged NYS DEC Water Quality Category Definitions	
Non-impacted	Indices reflect very good water quality. The macroinvertebrate community is diverse. 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.
Slightly impacted	Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Water quality is usually not limiting to fish survival, but may be limiting to fish propagation, especially sensitive coldwater fish taxa.
Moderately impacted	Indices reflect poor water quality. The macroinvertebrate community is altered to a large degree from the pristine state. Water quality often is limiting to fish propagation, but usually not to fish survival.
Severely impacted	Indices reflect very poor water quality. The macroinvertebrate community is limited to a few tolerant species. 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

Rationale of physical, chemical, and biological data collection and field data summary page for each of the stations sampled was created, including: site location, number, sampling date, physical and chemical data, and site photos. The benthic macroinvertebrate sub- sample taxa list for each station is also included.

Rationale

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.

High gradient sites are evaluated for: epifaunal substrate/available cover, embeddedness, velocity/depth regime, sediment deposition, channel flow status, channel alteration, channel sinuosity, bank stability, vegetative protection, and riparian vegetative one width.

Site photos were taken of the upstream and downstream area and are included with the physical and chemical data.

Water 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 increases 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 240 Celsius (Hynes, 1970). The NYS Department of Environmental Conservation (NYS DEC) does not have a water quality standard for water temperature. Temperature is recorded using an YSI 556TM probe.

Velocity is 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 is determined by timing a floating object a given distance or 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 is measured using an YSI 556™ probe.

Percent oxygen saturation is reported 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 oxygen saturation levels and because the ability of these organisms to migrate away from 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. Conductivity increases when inorganic ions are dissolved in water. 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 556TM 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 556TM 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 for water quality analysis since 1972 but the biological profiles and water quality assessments are not a part of New York 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 several states have done so; NY is not one of these states.