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2010 ONONDAGA LAKE TRIBUTARIES MACROINVERTEBRATE MONITORING

Significant Findings and Data Summaries

PREPARED FOR:

ONONDAGA COUNTY
DEPARTMENT OF WATER ENVIRONMENT PROTECTION

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July 2011

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1.0 INTRODUCTION

This document presents the significant findings and data summaries of the 2010 Onondaga Lake tributary macroinvertebrate monitoring program. Macroinvertebrates are an important component of the aquatic food web. Because they have limited migration patterns or a sessile mode of life, they are well suited for assessing site-specific impacts of point and nonpoint discharges. Many state agencies, including the New York State Department of Environmental Conservation (NYSDEC), use macroinvertebrate community structure as an indicator of the biological health of surface waters.

Macroinvertebrate sampling is among the requirements of the Amended Consent Judgment signed in January 1998. Onondaga County is required to assess the macroinvertebrate communities of selected Onondaga Lake tributaries (Appendix D, III. 5 ".... Sample the stream's macroinvertebrate communities and calculate the NYSDEC rapid Field Biotic Index throughout the tributaries' length....") and the Lake (Appendix D, IV 4 "Complement the chemical monitoring program with a biological monitoring effort to assess the densities and species composition of phytoplankton, zooplankton, macrophytes, macrobenthos, and fish").

Sampling in the tributaries is conducted every two years and sampling in the lake's littoral zone is conducted every five years under the Ambient Monitoring program (AMP). Macroinvertebrates have been sampled in Onondaga Lake tributaries in 2000, 2002, 2004, 2006, 2008, and 2010. The objectives of monitoring this element of the aquatic ecosystem are to characterize the existence and severity of use impairment and evaluate the effectiveness of improvements to the County’s wastewater collection and treatment infrastructure.

2.0 METHODS

A total of ten sampling sites are located along the three tributaries (Onondaga Creek, Harbor Brook and Ley Creek) affected by combined sewer overflows (CSO). The macroinvertebrate community present at these sites is assessed every two years. Samples from the stream bottom are collected using either kick samples or jab samples. Data are analyzed using 1) NYSDEC Biological Assessment Profiles (BAP), an index of overall impact to the macroinvertebrate community; 2) the Hilsenhoff Biotic Index (HBI), a measure of community impairment due to organic enrichment; and 3) the percent contribution of oligochaetes to the macroinvertebrate community, another measure of organic enrichment from sewage or animal wastes. In addition, the NYSDEC Impact Source Determination (ISD) is calculated at kick sample sites to determine the primary factor(s) contributing to impairment of the macroinvertebrate community. A more detailed description of the methods is provided in the 2010 Onondaga County Department of Water Environment Protections (OCDWEP) Annual Program Submittal, a copy of which is included as part of the 2010 Onondaga Lake AMP Annual Report. Calculation of BAP, HBI, and ISD follow methods presented in NYSDEC (2009).

3.0 SIGNIFICANT FINDINGS

The combination of habitat degradation, non-point source pollution, and CSO discharges influences the community structure of the respective tributary macroinvertebrate communities. As in past years, the macroinvertebrate communities of Onondaga Creek, Ley Creek, and Harbor Brook showed varying levels of impact in 2010. Sites in Ley Creek tended to be the most severely impacted, followed closely by Harbor Brook. Sites in Onondaga Creek tended to be the least impacted. A macroinvertebrate taxa list is provided in Appendix 1. Tables of metric results and BAP designations are provided in Appendix 2. Tables of Impact Source Determinations (ISD) are provided in Appendix 3. Graphics showing community structure are provided in Appendix 4.

3.1 Onondaga Creek

Sites on Onondaga Creek showed a wide range of conditions in 2010 with a trend towards increasing impacts downstream (Figure 1). This downstream trend has been evident since 2000, and is likely related to downstream increases in loading due first to changes from forested to agricultural land use in the upper watershed followed by a shift to urban land use downstream. Impacts to the macroinvertebrate community are generally slight upstream (Sites 1, 2 and 3) of urban areas and CSOs and moderate downstream (Site 4) of urban areas and CSOs.

Site 1 Tully Farms Road

This most upstream site has shown little change since 2000, with BAP scores generally close to the impact demarcation for *non-* and *slightly impacted* (Figure 1). The BAP for this site in 2010 showed a slight decline from the 2008 value, resulting in an overall assessment of slightly impacted. Inspection of the data shows this minor decline to be due to reduced species and EPT richness. These reductions are due to the relatively high abundance of the mayfly genus *Baetis*. This genus is generally considered indicative of good water quality, and its level of abundance is not necessarily a sign of water-quality degradation. However, its dominance in the community resulted in somewhat lower species and EPT richness values, which are reflected in the overall BAP score. The HBI and percent oligochaete scores were both indicative of non-impacted conditions at this site, providing further evidence that the slight drop in BAP score was not due to water-quality degradation. The ISD scores for the Tully Farms Road site show this site is most similar to a stream in natural condition experiencing minimal human impact (Appendix 3).

Site 2 Webster Road

The site at Webster Road has shown consistently lower BAP scores than Site 1 Tully Farms Road, located four miles upstream, since monitoring began in 2000 (Figure 1). Increasing agricultural land use and dairy farming, resulting in increased stream loadings between these two locations, may be contributing to poorer BAP scores at the Webster Road site. Since 2002, the BAP score for this site has remained close to the demarcation for slightly and moderately impacted and was classified as moderately impacted in 2010. The 2010 HBI score was indicative of a slightly impacted condition, but the overall BAP score indicated moderate impact due to a relatively poor Percent Model Affinity (PMA) value. PMA is a measure of the similarity of the community to a model community for a non-impacted water and is based on the distribution of organisms in various taxonomic groups. The PMA value for the Webster Road site in 2010 was relatively low due to a disproportionate percentage (21% vs. 5% for a model community) of oligochaetes and beetles (35% vs. 10% for a model community). Reasons for the increased proportions of oligochaetes and beetles are unclear. The ISD indicated that the community at this site was most similar to that of a natural community with little human impact (Appendix 3). However, the ISD also suggested that the community at this site may also be influenced by municipal/industrial stressors and nonpoint sources of nutrients or other contaminants.

Site 3 Dorwin Avenue

Dorwin Avenue is located at the southern edge of the city of Syracuse where urban runoff is expected to begin impacting the stream. This location is also upstream of all CSOs. The level of impact at Dorwin Avenue has not changed substantially since monitoring began in 2000 (Figure 1). This location has consistently been measured as *slightly impacted* based on BAP scores. HBI and percent oligochaetes results indicate that the level of organic, oxygen demanding, wastes has not changed substantially (positively or negatively) during the monitoring period at this location. The ISD analysis shows that impacts found at this site in 2010 are most likely related to municipal/industrial sources of stress (Appendix 3), which is not unexpected given the level of development in the vicinity of the site.

Site 4 Spencer Street

The most downstream site on Onondaga Creek is located at Spencer Street, which is approximately 6 miles downstream from Site 3, 14 miles from Site 2, and 18 miles from Site 1. The Spencer Street site is downstream of most CSOs and is also impacted by urban runoff from most of the city of Syracuse. As in past years, this site showed the greatest level of impact of the four Onondaga Creek sites in 2010. Like recent years, the 2010 BAP impact designation was *moderately impacted* (Figure 1). Unlike the overall BAP scores, which have remained fairly constant since 2004, HBI and percent oligochaetes scores have shown a general worsening over the past six years. This suggests that organic loading from sewage or animal wastes may be contributing to impacts at this site. The ISD analysis indicates that impoundment influences may be exerting the greatest impact on community structure at this location, followed by organic loading and municipal/industrial stressors (Appendix 3). The impoundment affects may be a result of the low-head dam located less than 200 ft upstream of Spencer Street.

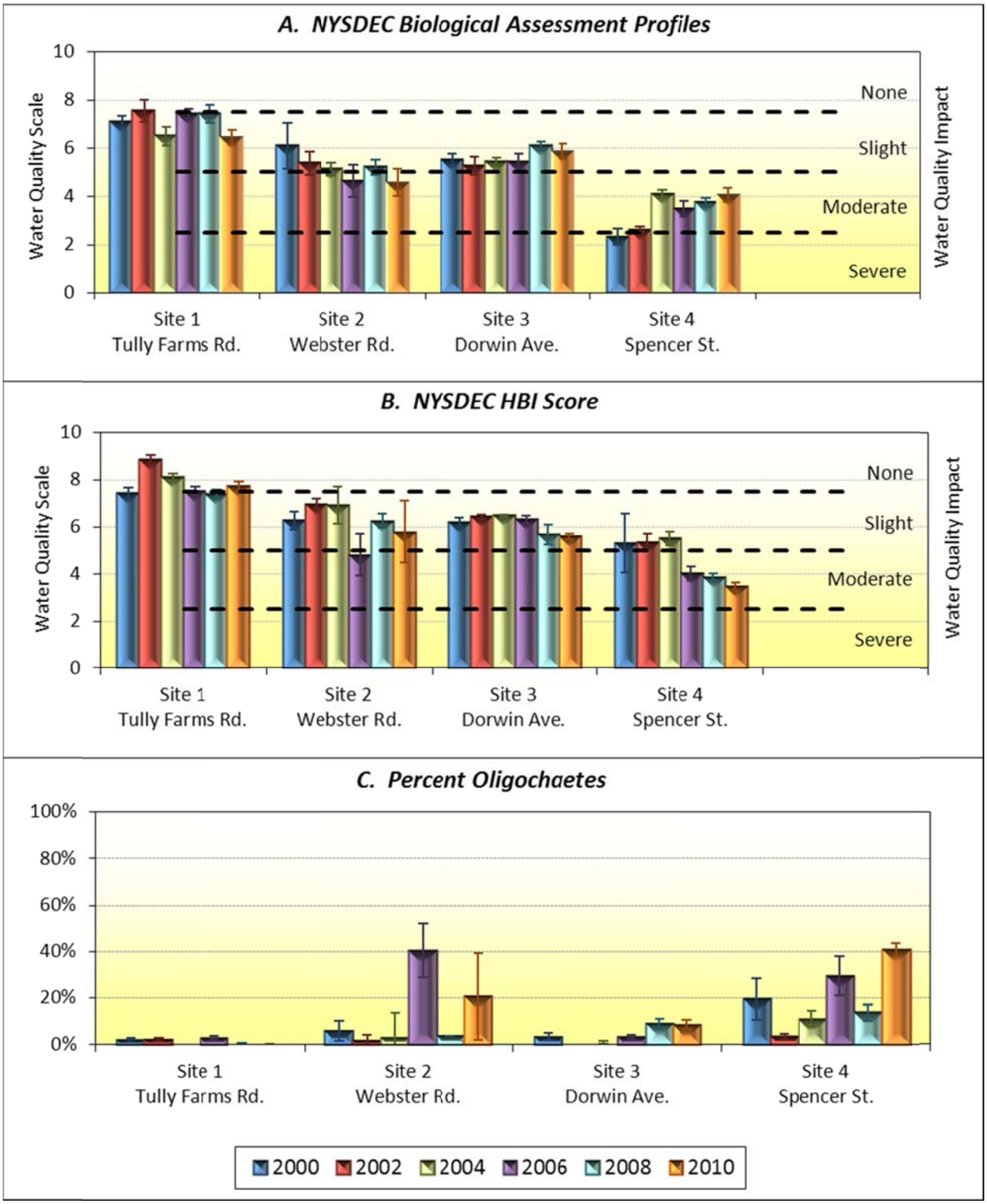


Figure 1. NYSDEC BAP scores (A), NYSDEC HBI scores (B), and percent oligochaetes (C) for sites in Onondaga Creek sampled every two years since 2000. Error bars are standard error.

3.2 Ley Creek

Ley Creek tends to show the greatest degree of overall impact of the three Onondaga Lake tributaries monitored for macroinvertebrates. Sites in Ley Creek have been consistently assessed as *severely impacted* by the NYSDEC BAP and HBI scores, and percent oligochaete values also indicate a high degree of impact (Figure 2). In 2010, some improvement of the HBI score was seen at site 1, but all sites on the stream still show considerable impact to the macroinvertebrate community.

Site 1 Townline Road

With the exception of extremely low values in 2006, the BAP scores for the Townline Road site have been consistently right at the demarcation between *severely impacted* and *moderately impacted* (Figure 2). The HBI score for 2010 was the best yet recorded, and was well into the *moderately impacted* category. Percent oligochaetes was the second lowest (best) value observed during the monitoring program, being only slightly higher than the 2008 value. The ISD analysis for this site indicates that observed impacts are reflective of municipal/industrial stressors (Appendix 3). Community structure also suggests that organic loading from sewage or animal wastes may also be impacting the stream at this location.

Site 2 7th North Street

The 7th North Street sampling location is approximately two and a half miles downstream of the Townline Road site. This location had consistently been assessed as *severely impacted* throughout the duration of the monitoring program. Although data from 2008 showed some minor improvement at this station compared to previous years, the 2010 data showed a return to pre-2008 conditions (Figure 2). The macroinvertebrate community at this site remains dominated by oligochaetes and lacking in taxa considered intolerant of organic enrichment or other environmental perturbation, especially EPT taxa (mayflies, stoneflies, and caddisflies). An ISD analysis could not be performed for this site since jab sampling (rather than kick sampling) was used due to a lack of riffle habitat in this reach of stream. However, the preponderance of oligochaetes and the poor HBI score indicate that organic loading from sewage, animal wastes, and/or fertilizers is likely one of the main stressors acting on the macroinvertebrate community.

Site 3 Park Street

The Park Street sampling location is approximately one mile downstream of the 7th North Street site and is the only site in Ley Creek downstream of CSOs. The overall level of impact at this location appears to be gradually decreasing in recent years, with BAP scores trending slightly upward and into the *moderately impacted* category in 2010 (Figure 2). HBI values have also been in the *moderately impacted* range in 3 of the past 4 sampling periods. Percent oligochaetes was still relatively high (37%) in 2010, but was well below the values of 62-82% seen prior to 2008.

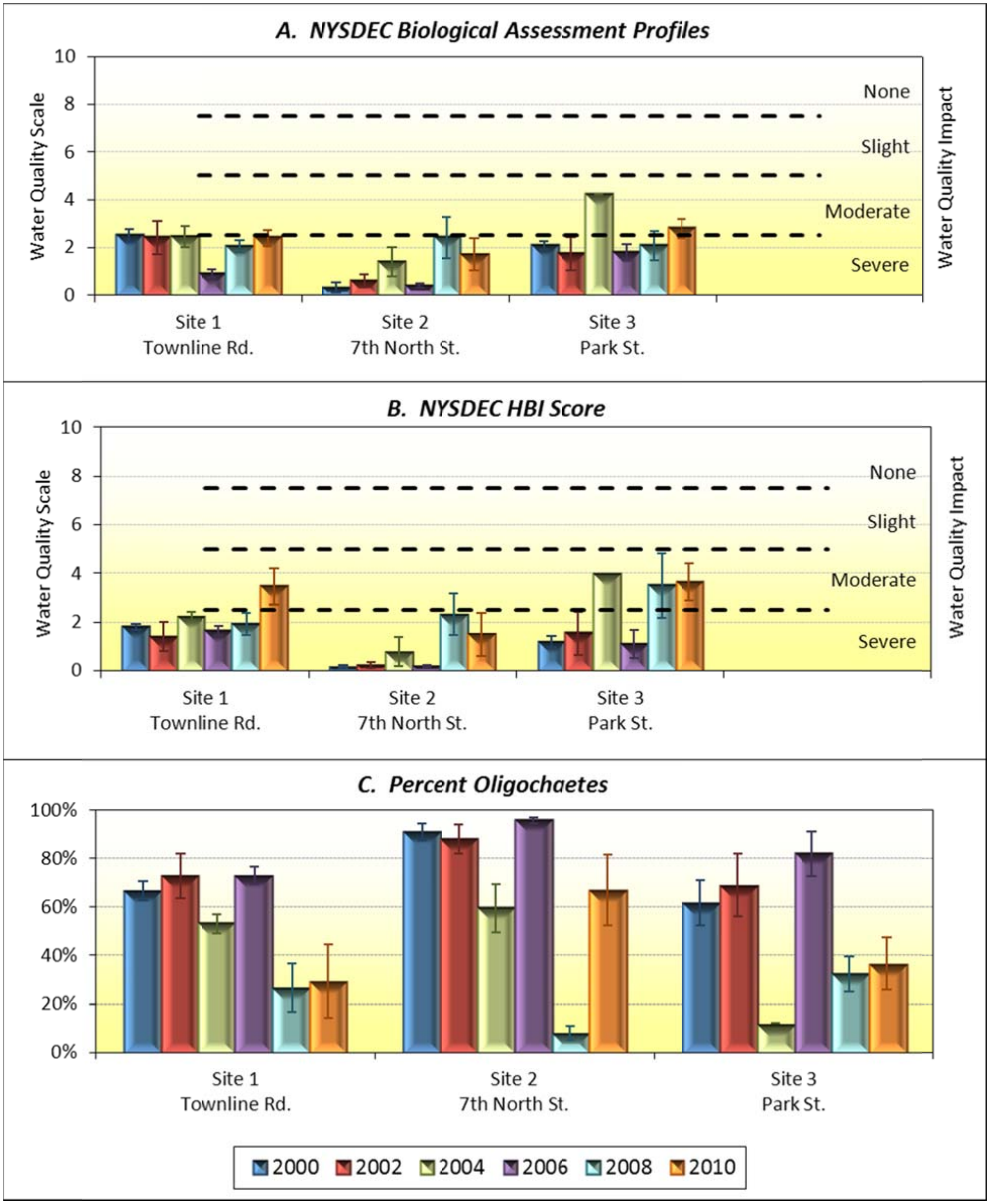


Figure 2. NYSDEC BAP scores (A), NYSDEC HBI scores (B), and percent oligochaetes (C) for sites in Ley Creek sampled every two years since 2000. Error bars are standard error.

3.3 Harbor Brook

Sites on Harbor Brook ranged from *moderately* to *severely impacted* based on BAP scores (Figure 3). The two sites downstream of the most urbanized areas and all CSOs showed a greater degree of impact than the upstream reference site.

Site 1 Velasko Road

This most upstream site in Harbor Brook has had BAP scores consistently in the "*moderate*" impact range for all years sampled (Figure 3). Results for the HBI scores for this time period are disproportionably better then the BAP results, particularly since 2002, indicating that the primary sources of impact are likely not associated with organic, oxygen demanding wastes. The ISD analysis has consistently indicated that impacts at this site are related to impoundment influences and municipal/industrial stressors (Appendix 3). Given that there are no notable impoundments immediately upstream of this site, it is likely that effects of municipal/industrial land uses are exerting the primary impacts observed at this location.

Site 2 Hiawatha Blvd.

The Hiawatha Blvd. sampling location is approximately two miles downstream of the Velasko Road site of which about one mile is composed of an underground culvert. BAP and HBI scores at this site have shown considerable variation over the course of the monitoring program and, with one exception (HBI in 2008) have consistently been within the severely impacted range since 2006 (Figure 3). In 2010, the BAP, HBI, and percent oligochaetes values were the second poorest recorded to date. The ISD analysis indicates that the macroinvertebrate community structure at this site is strongly reflective of municipal/industrial impacts. The high abundance of oligochaetes and the low HBI score suggest that organic loading also is impacting the community at this location.

Site 3 Rt. 690

The Rt. 690 sampling location is approximately one-half mile downstream of the Hiawatha Blvd. site. Prior to 2010, the level of impact at this location had remained relatively stable over the course of the monitoring program remaining near the demarcation of *severely* and *moderately* impacted. In 2010, the BAP and HBI scores and percent oligochaetes all improved considerably (Figure 3). The BAP and HBI scores placed this site in the middle of the moderately impacted range. Previously this site had never scored better than the lower end of the moderately impacted range and had been classified as severely impacted in both 2006 and 2008. An ISD analysis could not be performed for this site since jab sampling (rather than kick sampling) was used due to a lack of riffle habitat in this reach of stream. However, the reduction in HBI score and percent oligochaetes suggests that there has been some decline in organic loading at this site since 2008.

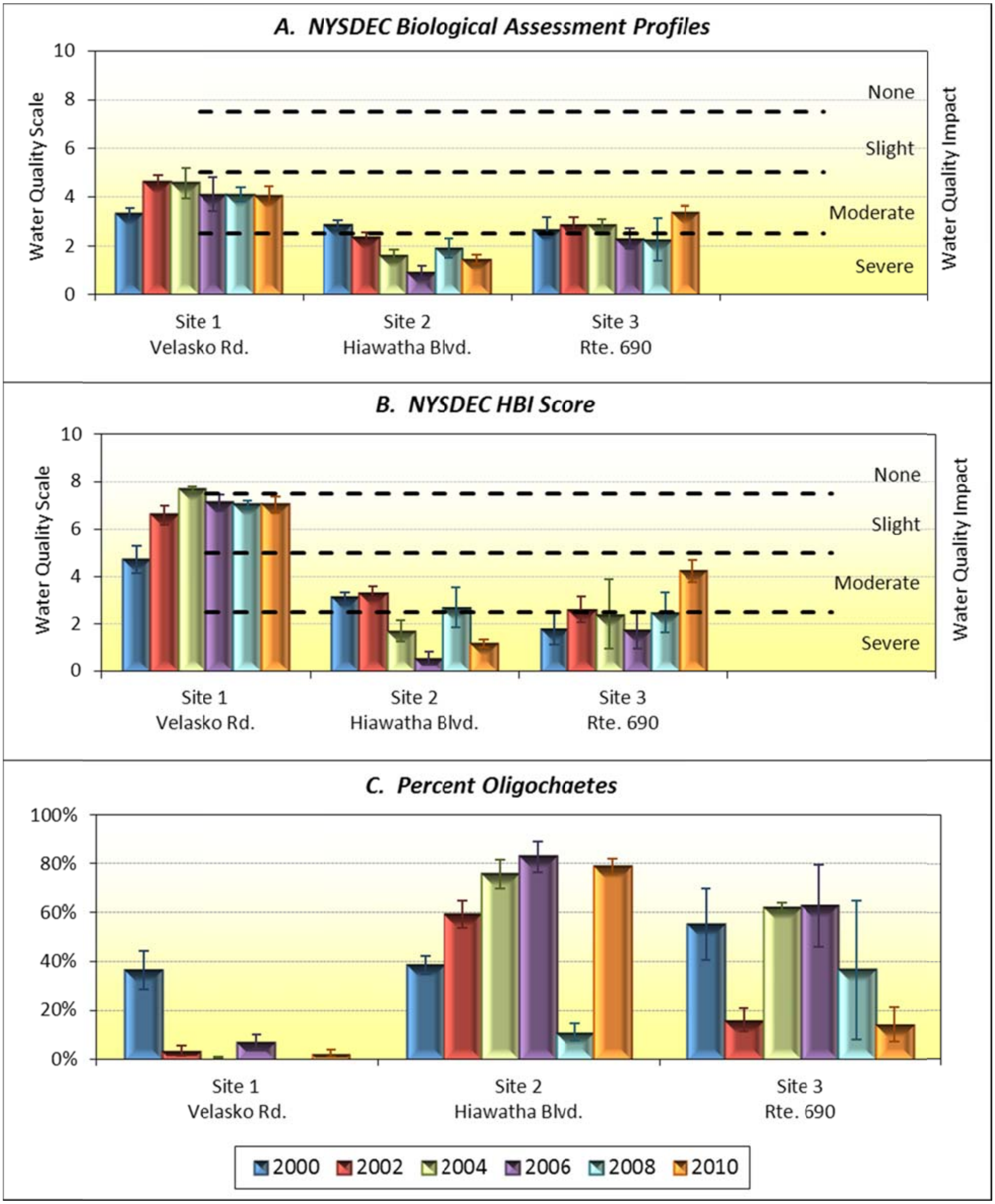


Figure 3. NYSDEC BAP scores (A), NYSDEC HBI scores (B), and percent oligochaetes (C) for sites in Harbor Brook sampled every two years since 2000. Error bars are standard error

4.0 INCIDENCE OF CHIRONOMID DEFORMITIES

Chironomidae (non-biting midges) is a family of flies with aquatic larvae that are widespread and tolerant of a wide range of environmental perturbation. The incidence and frequency of deformities (a departure in the morphology of a structure from normal phenotype in size, shape, or structure as a result of exposure to a toxic pollutant) in mouth parts and antennae of some taxa of Chironomidae have been used as a means of biomonitoring sediment toxicity (e.g., elevated levels of metals) and organic loading in freshwaters (Lenat 1993; Hudson and Ciborowski 1996; Diggins and Stewart 1998; Bisthoven and Gerhardt 2005). Chironomidae in samples taken as part of the 2010 Onondaga Lake tributary monitoring program were examined for incidences on deformities as a secondary means of assessing water and sediment quality at the sampling locations.

Populations of sensitive taxa (*Chironomus* and *Procladius*) at “clean” reference sites have been found to contain around 3 percent deformities. For a doubling of deformity incidence over 3 percent background levels to be considered significant, a sample size of 125 from each site would be required (Hudson and Ciborowski 1996). The maximum number of Chironomidae found in any of the 2010 tributary samples with deformed Chironomidae was 48 (Ley Creek, Site 2), and the majority of samples with deformed Chironomidae had 15 or fewer total Chironomidae. Thus, sample size was too small to make definitive conclusions regarding the level of environmental impact based on the incidence of Chironomidae deformities; however, the preliminary findings of this analysis are present here.

Percent chironomid deformities was low at all sites in Onondaga Creek, ranging from 1.7% at the Tully Farms Road site to 6.1% at the Webster Road site (Table 1). There was no longitudinal pattern to incidence of deformities in this stream. Lenat (1993) used just 15-25 specimens of *Chironomus* per site to compare sites in North Carolina streams and found clean water sites averaged about 5% deformities, moderately impaired sites averaged 24%, and severely impaired sites averaged 44 percent. Based on this, the range of deformities found in Onondaga Creek is indicative of non-impacted conditions with regard to sediment toxicity.

Percent chironomid deformities was quite low at all sites in Harbor Brook, ranging from 0.0% at the Velasko Road and Hiawatha Blvd. sites to 3.1% at the Route 690 site (Table 1). Deformities were found only at the most downstream site on this stream, and the low incidence of deformities suggests the Harbor Brook sites are non-impacted with regard to sediment toxicity.

Percent chironomid deformities in Ley Creek ranged from 6.9% at the Townline Road site to 21.6% at the 7th North Street site (Table 1). There was no longitudinal pattern to incidence of deformities in this stream, though the lowest incidence level was found at the most upstream site. The levels of chironomid deformities found at the Park Street and 7th North Street sites suggest that these stations are slightly and moderately impacted, respectively, by sediment toxicity. Again, it should be understood that the results of the chironomid deformities analysis presented here are based on small sample sizes that are statistically insufficient to allow for making definitive assessments of water quality or sediment toxicity at the sites sampled. These data are presented herein as a preliminary analysis only.

Table 1. Incidence of deformities in Chironomidae at Onondaga Lake tributary sites sampled in 2010.

Sampling Location	Mean % Deformities
Onondaga Creek	
Tully Farms	1.7
Webster Road	6.1
Dorwin Avenue	2.5
Spencer Street	3.1
Harbor Brook	
Velasko Road	0.0
Hiawatha Blvd	0.0
Route 690	3.1
Ley Creek	
Townline Road	6.9
7th North Street	21.6
Park Street	15.6

5.0 SUMMARY

Results of the 11-year macroinvertebrate monitoring program indicate no consistent trends toward improving conditions in the monitored portions of the watershed. Some individual sites have shown varying levels of change, both positive and negative, with no apparent relation to combined sewer overflows. All sites sampled show some level of impact, though those in the upper portions of the watersheds are generally less impaired than those in the lower portion of the watersheds. Impairment is greatest in the lower portions of Ley Creek and Harbor Brook. ISD analyses indicate that the primary causes of impairment are related to excessive organic loading, primarily from sewage or animal wastes, and influences from municipal/industrial development.

6.0 LITERATURE CITED

Bisthoven, L. J. de and A. Gerhardt. 2005. A critical appraisal of morphological deformities in midge larvae (Insecta, Nematocera: Chironomidae): clues for biomonitoring the sediment quality of freshwater ecosystems. Trends in Comparative Biochemistry & Physiology 11:27-36.

Diggins, T. P. and K. M. Stewart. 1998. Chironomid deformities, benthic community composition, and trace elements in the Buffalo River (New York) area of concern. Journal of the North American Benthological Society 17:311-323.

Hudson, L.A. and J.J.H. Ciborowski. 1996. Spatial and taxonomic variation in incidence of mouthpart deformities in midge larvae (Diptera: Chironomidae: Chironomini). Canadian Journal of Fisheries and Aquatic Sciences 53:297-304.

Lenat, D. R. 1993. Using mentum deformities of *Chironomus* larvae to evaluate the effects of toxicity and organic loading in streams. Journal of the North American Benthological Society 12:265-269.

NYSDEC. 2009. Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State. New York State Department of Environmental Conservation, Division of Water. 159 pp.

APPENDIX 1.

Tributary Macroinvertebrate Taxa List (2000-2010)

Macroinvertebrate taxa collected from tributaries of Onondaga Lake , 2000-2010

PHYLUM/DIVISION	CLASS	ORDER	FAMILY	SUBFAMILY	Species	2000	2002	2004	2006	2008	2010
Annelida	Clitellata	Haplotaxida	Enchytraeidae		Enchytraeidae		x	x	x	x	x
					Enchytraeus	x					
					Lumbricillis	x					
			Lumbricidae		Allolobophora chlorotica	x					
					Eiseniella tetraedra	x		x	x		
					Lumbricidae	x	x	x	x		
			Naididae		Dero digitata	x		x	x	x	
					Nais bretscheri				x		
					Nais communis			x	x		x
					Nais elinguis	x					
					Nais variabilis		x	x			x
					Ophidonais serpentina	x	x	x	x	x	
					Paranais			x	x		
					Paranais litoralis					x	
					Pristina jenkinae				x		x
					Uncinais uncinata						x
					Dero					x	
			Tubificidae		Aulodrilus limnobius					x	x
					Aulodrilus pigueti	x	x			x	x
					Bothrioneurum						x
					Ilyodrilus templetoni	x	x	x	x		x
					Limnodrilus		x				
					Limnodrilus cervix	x	x	x	x	x	x
					Limnodrilus claparedeianus	x					
					Limnodrilus claparedianus					x	
					Limnodrilus hoffmeisteri	x	x	x	x	x	x
					Limnodrilus profundicola	x					
					Limnodrilus udekemianus	x	x	x	x	x	x
					Potamothrix bavaricus	x	x	x	x	x	x
					Potamothrix bedoti	x					x
					Potamothrix moldaviensis	x		x	x	x	x
					Potamothrix vejdovskyi				x		
					Quistadrilus multisetosus	x					

Macroinvertebrate taxa collected from tributaries of Onondaga Lake , 2000-2010

PHYLUM/DIVISION	CLASS	ORDER	FAMILY	SUBFAMILY	Species	2000	2002	2004	2006	2008	2010
Annelida (cont.)	Clitellata (cont.)	Haplotaxida (cont.)	Tubificidae (cont.)		Tub.: hair + pectinate chaetae				x	x	x
					Tubifex tubifex	x	x	x	x	x	x
					Tubificid immature: bifids	x	x	x			
					Tubificid immature: h+p	x	x	x			
					Tubificinae: bifid chaetae				x	x	x
		Lumbriculida	Lumbriculidae		Lumbriculidae	x	x				x
	Hirudinea	Arhynchobdellida	Erpobdellidae		Erpobdella						x
					Erpobdella fervida						x
					Erpobdellidae			x			
				Erpobdellinae	Mooreobdella		x			x	
					Mooreobdella fervida	x					
					Mooreobdella microstoma	x		x			
		Rhynchobdellida	Glossiphoniidae		Helobdella stagnalis	x					
			Piscicolidae	Piscicolinae	Piscicola		x				
Arthropoda	Arachnida	Acariformes			Acariformes (deuteronymph)		x				
			Hygrobatidae		Hygrobates	x				x	
			Torrenticolidae		Torrenticola	x					
		Trombidiformes	Sperchonidae		Sperchon					x	x
	Crustacea	Amphipoda			Amphipoda		x				
			Crangonyctidae		Crangonyx			x		x	x
					Crangonyx pseudogracilis	x		x			x
					Crangonyx pseudogracilis cmplx				x		
			Gammaridae		Gammarus				x		
					Gammarus (immature/damaged)	x	x	x		x	x
					Gammarus fasciatus	x	x	x	x	x	x
					Gammarus pseudolimnaeus	x	x	x	x	x	x
		Decapoda	Cambaridae		Cambaridae			x			
		Isopoda	Asellidae		Caecidotea				x	x	x
					Caecidotea (immature/female)	x	x	x			
					Caecidotea racovitzai	x	x	x	x	x	x
	Insecta	Coleoptera	Dytiscidae		Agabus		x			x	
					Dytiscidae		x				
					Hydroporinae						x

Macroinvertebrate taxa collected from tributaries of Onondaga Lake , 2000-2010

PHYLUM/DIVISION	CLASS	ORDER	FAMILY	SUBFAMILY	Species	2000	2002	2004	2006	2008	2010
Arthropoda (cont.)	Insecta (cont.)	Coleoptera (cont.)	Elmidae		Dubiraphia	x	x	x	x	x	x
					Macronychus			x	x	x	
					Optioservus	x	x	x	x	x	x
					Promoresia	x	x		x	x	x
					Stenelmis	x	x	x	x	x	x
			Gyrinidae		Dineutus		x				
			Hydrophilidae		Tropisternus		x				
			Psephenidae		Ectopria		x			x	
					Psephenus herricki		x		x		
		Diptera	Athericidae		Atherix	x	x	x	x	x	x
			Ceratopogonidae		Bezzia/Palpomyia						x
					Ceratopogon				x	x	
					Sphaeromais					x	
			Chironomidae		Chironomidae pupae	x	x	x			
					Nanocladius					x	
					Nanocladius distinctus/minimus						x
				Chironominae	Chironomini						x
					Chironomus	x	x	x	x	x	x
					Cladopelma	x				x	
					Cladotanytarsus	x	x	x	x	x	x
					Cryptochironomus	x	x	x	x	x	x
					Cryptotendipes	x				x	x
					Demicryptochironomus			x			
					Dicrotendipes		x		x	x	x
					Dicrotendipes fumidus		x				
					Dicrotendipes modestus	x	x	x	x	x	x
					Dicrotendipes neomodestus			x	x	x	x
					Endochironomus			x			
					Micropsectra	x	x	x	x	x	x
					Microtendipes pedellus grp.	x	x	x	x	x	x
					Microtendipes rydalensis grp.		x				
					Nilothauma			x	x	x	
					Parachironomus					x	

Macroinvertebrate taxa collected from tributaries of Onondaga Lake , 2000-2010

PHYLUM/DIVISION	CLASS	ORDER	FAMILY	SUBFAMILY	Species	2000	2002	2004	2006	2008	2010
Arthropoda (cont.)	Insecta (cont.)	Diptera (cont.)	Chironomidae (cont.)	Chironominae (cont.)	Parachironomus frequens			x			
					Paracladopelma		x				
					Paralauterborniella					x	
					Paratanytarsus			x	x	x	
					Paratendipes			x		x	x
					Phaenopsectra					x	
					Phaenopsectra obediens grp.	x	x	x	x		x
					Phaenopsectra punctipes				x		
					Polypedilum				x	x	x
					Polypedilum aviceps	x	x	x	x	x	x
					Polypedilum cf. angulum				x		
					Polypedilum fallax	x	x	x			
					Polypedilum flavum		x	x	x	x	x
					Polypedilum halterale					x	x
					Polypedilum halterale grp.	x	x	x			
					Polypedilum illinoense					x	
					Polypedilum illinoense grp.	x	x	x	x		x
					Polypedilum laetum	x	x	x	x	x	x
					Polypedilum scalaenum grp.	x	x	x	x	x	x
					Polypedilum tritum		x	x		x	
					Rheotanytarsus	x			x	x	x
					Rheotanytarsus (exiguus grp.)			x			
					Stempellinella	x	x	x		x	x
					Stempellinella fimbriata					x	
					Stictochironomus	x	x	x	x	x	x
					Sublettea		x		x	x	
					Sublettea coffmani					x	
					Tanytarsini						x
					Tanytarsus	x	x		x	x	x
					Tribelos					x	
				Diamesinae	Diamesa	x	x	x	x	x	x
					Diamesinae		x				
					Pagastia	x	x	x	x	x	x

Macroinvertebrate taxa collected from tributaries of Onondaga Lake , 2000-2010

PHYLUM/DIVISION	CLASS	ORDER	FAMILY	SUBFAMILY	Species	2000	2002	2004	2006	2008	2010
Arthropoda	Insecta	Diptera	Chironomidae	Diamesinae (cont.)	Potthastia gaedii grp.		x	x	x		x
(cont.)	(cont.)	(cont.)	(cont.)	Orthocladiinae	Brillia flavifrons	x					
					Cardiocladius obscurus						x
					Chaetocladius				x	x	
					Cricotopus		x	x		x	
					Cricotopus (Isocladius)	x					
					Cricotopus absurdus					x	
					Cricotopus bicinctus	x	x	x	x	x	x
					Cricotopus cf. intersectus			x	x		
					Cricotopus cf. triannulatus		x	x	x		x
					Cricotopus cf. vierriensis		x	x	x		
					Cricotopus intersectus					x	
					Cricotopus sylvestris gp.	x	x		x	x	x
					Cricotopus triannulatus	x				x	
					Cricotopus trifascia	x	x	x	x	x	x
					Cricotopus trifasciatus					x	
					Cricotopus vierriensis					x	
					Cricotopus/Orthocladius	x	x		x	x	x
					Eukiefferiella (early instar)	x					
					Eukiefferiella brehmi grp.	x	x		x		
					Eukiefferiella claripennis grp.	x	x				
					Eukiefferiella coerulescens grp.			x			
					Eukiefferiella devonica grp.	x	x	x	x		
					Eukiefferiella gracei grp.				x		
					Heleniella		x				
					Orthocladius		x		x		
					Parakiefferiella		x				
					Parakiefferiella sp A of Epler				x		
					Parametriocnemus		x	x	x	x	x
					Psectrocladius	x		x			
					Rheocricotopus	x	x	x	x	x	
					Thienemanniella		x			x	
					Thienemanniella cf. xena	x					

Macroinvertebrate taxa collected from tributaries of Onondaga Lake , 2000-2010

PHYLUM/DIVISION	CLASS	ORDER	FAMILY	SUBFAMILY	Species	2000	2002	2004	2006	2008	2010
Arthropoda (cont.)	Insecta (cont.)	Diptera (cont.)	Chironomidae (cont.)	Orthocladiinae (cont.)	Tvetenia				x	x	
					Tvetenia bavarica			x	x		
					Tvetenia bavarica grp.	x					x
					Tvetenia discoloripes grp.	x					x
					Tvetenia paucunca		x	x	x		
					Tvetenia vitracies		x	x	x	x	
				Prodiamesinae	Prodiamesa	x	x	x	x	x	x
				Tanypodinae	Ablabesmyia					x	
					Alotanypus		x				
					Bethbilbeckia					x	
					Clinotanypus						x
					Krenopelopia					x	
					Larsia	x					x
					Natarsia	x	x	x	x	x	
					Procladius		x	x	x	x	
					Procladius (H)						x
					Procladius (Holotanypus)	x					
					Psectrotanypus		x				
					Tanypodinae					x	
					Tanypus		x			x	x
					Telopelopia					x	
					Thienemannimyia grp.	x	x	x	x	x	x
					Zavrelimyia		x				
					Nanocladius cf. minimus			x			
					Nanocladius cf. rectinervus			x			
			Empididae		Chelifera	x		x			
					Hemerodromia	x		x			
					Neoplasta					x	x
				Hemerodromiinae	Hermerodromia						x
			Ephydridae		Ephydridae						x
			Muscidae		Muscidae	x		x	x	x	x
			Psychodidae		Pericoma	x					
					Psychoda	x	x				

Macroinvertebrate taxa collected from tributaries of Onondaga Lake , 2000-2010

PHYLUM/DIVISION	CLASS	ORDER	FAMILY	SUBFAMILY	Species	2000	2002	2004	2006	2008	2010
Arthropoda (cont.)	Insecta (cont.)	Diptera (cont.)	Psychodidae (cont.)		Psychodidae pupae	x	x	x			
			Sciaridae		Sciaridae						x
			Simuliidae		Simulium	x	x	x	x	x	x
			Stratiomyidae		Caloparyphus		x				
					Euparyphus			x			
					Stratiomyidae			x			
					Stratiomys		x				
			Tabanidae		Chrysops	x	x	x	x	x	
			Tipulidae		Antocha	x	x	x	x	x	x
					Dicranota	x	x	x	x	x	x
					Hexatoma	x	x	x	x	x	x
					Pseudolimnophila			x			
					Tipula	x		x	x	x	x
					Tipulidae pupae			x			
				Limoniinae	Gonomyia		x				
		Ephemeroptera	Baetidae		Baetidae		x	x	x	x	
					Baetis	x	x	x	x	x	x
					Diphetor hageni						x
					Procloeon	x					
			Ephemerellidae		Attenella					x	
					Dannella		x			x	
					Ephemerellidae				x	x	
					Timpanoga (Dannella)				x		
			Heptageniidae		Epeorus	x	x			x	
					Heptagenia	x	x		x		x
					Heptageniidae					x	
					Leucrocuta			x			
			Leptohyphidae		Tricorythodes	x	x	x	x	x	x
			Leptophlebiidae		Leptophlebiidae			x			x
					Paraleptophlebia	x	x		x		
		Hemiptera	Corixidae		Corixidae		x	x			
					Hesperocorixa		x			x	
					Trichocorixa		x				

Macroinvertebrate taxa collected from tributaries of Onondaga Lake , 2000-2010

PHYLUM/DIVISION	CLASS	ORDER	FAMILY	SUBFAMILY	Species	2000	2002	2004	2006	2008	2010
Arthropoda (cont.)	Insecta (cont.)	Hemiptera (cont.)	Notonectidae		Notonecta					x	
			Veliidae		Rhagovelia		x				
		Megaloptera	Corydalidae		Nigronia serricornis	x	x	x	x		x
					Nigronia					x	
			Sialidae		Sialis	x	x	x	x	x	x
		Odonata	Aeshnidae		Boyeria	x					
					Boyeria vinosa				x		x
			Calopterygidae		Calopteryx					x	
			Coenagrionidae		Coenagrion/Enallagma		x				
					Coenagrionidae				x		x
					Coenagrionidae immature	x					
					Ischnura					x	x
			Cordulegastridae		Cordulegaster						x
					Cordulegaster obliqua				x		
					Cordulegastridae					x	
			Gomphidae		Lanthus parvulus	x					
		Plecoptera	Chloroperlidae		Alloperla		x				
					Chloroperlidae		x				
					Sweltsa	x	x				
					Sweltza					x	x
			Leuctridae		Leuctra	x	x	x	x	x	x
					Leuctridae		x				
			Perlidae		Acroneuria	x	x				
					Agnetina	x	x	x	x	x	x
					Perlidae		x	x			
			Perlodidae		Perlodidae	x	x			x	
			Pteronarcidae		Pteronarcys	x	x				
		Trichoptera	Glossosomatidae		Glossosoma	x		x	x	x	
			Helicopsychidae		Helicopsyche borealis		x				
			Hydropsychidae		Cheumatopsyche	x	x	x	x	x	x
					Hydropsyche				x	x	x
					Hydropsyche betteni	x	x	x			
					Hydropsyche bronta	x	x	x	x	x	x

Macroinvertebrate taxa collected from tributaries of Onondaga Lake , 2000-2010

PHYLUM/DIVISION	CLASS	ORDER	FAMILY	SUBFAMILY	Species	2000	2002	2004	2006	2008	2010
Arthropoda (cont.)	Insecta (cont.)	Trichoptera (cont.)	Hydropsychidae (cont.)		Hydropsyche slossonae	x	x	x	x	x	x
					Hydropsyche sparna	x	x	x	x	x	x
					Hydropsychidae					x	x
					Hydropsyche (early instar)	x	x	x			
					Hydropsyche cf. scalaris				x		
					Hydropsychidae (v. e. instars)			x			
					Hydropsychidae pupae	x	x				
			Hydroptilidae		Hydroptila	x		x	x	x	x
			Leptoceridae		Ceraclea		x				
					Oecetis (Pseudosetodes) avara grp.	x	x				
			Limnephilidae		Pycnopsyche			x			
			Philopotamidae		Dolophilodes	x	x			x	x
			Rhyacophilidae		Rhyacophila		x			x	
	Malacostraca	Amphipoda	Hyalellidae		Hyalella azteca						x
Mollusca	Bivalvia	Veneroida	Pisidiidae		Musculium	x					
					Pisidium		x			x	
					Pisidium casertanum	x					
					Pisidium compressum	x		x			
					Pisidium dubium	x					
					Sphaerium		x	x			
	Gastropoda	Basommatophora	Ancylidae		Ferrissia rivularis			x			
			Lymnaeidae		Fossaria	x					
			Physidae		Physa		x				
					Physa cf. heterostropha	x					
		Heterostropha	Valvatidae		Valvata piscinalis			x			
		Neotaenioglossa	Hydrobiidae		Hydrobiidae						x
Nemata					Nematoda					x	x
Nemertea	Enopla	Hoplonemertea	Tetrastemmatidae		Prostoma						x
Platyhelminthes	Turbellaria	Tricladida	Dugesiidae		Cura foremanii						x
			Planariidae		Dugesia tigrina	x					
					Planariidae		x			x	
					Planariidae (damaged)	x					

APPENDIX 2.

Metric Results and BAP Designations

Mean index value and corresponding mean NYSDEC biological assessment profiles (BAP) score and designations from monitoring sites in Onondaga Creek in all sampled years.

			Species Richness		EPT Richness		HBI		PMA		NYSDEC	
Year	Site	Description	*Index Mean*	*NYSDEC BAP Mean*	*Index Mean*	*NYSDEC BAP Mean*	*Index Mean*	*NYSDEC BAP Mean*	*Index Mean*	*NYSDEC BAP Mean*	**Mean BAP Score**	**BAP Impact Designation**
2000	1	Tully Farms Rd.	20.0	5.6	9.0	6.9	4.5	7.4	74%	8.5	**7.1**	**Slight**
	2	Webster Rd.	24.5	7.0	5.5	4.7	5.5	6.3	60%	6.5	**6.1**	**Slight**
	3	Dorwin Ave.	19.5	5.4	5.3	4.9	5.5	6.2	52%	5.4	**5.5**	**Slight**
	4	Spencer Street	7.3	1.0	0.3	0.3	6.2	5.3	35%	2.7	**2.3**	**Severe**
2002	1	Tully Farms Rd.	21.5	6.0	10.8	7.8	3.2	8.8	66%	7.5	**7.5**	**None/Slight**
	2	Webster Rd.	21.5	6.0	3.8	3.8	4.9	7.0	47%	4.7	**5.4**	**Slight**
	3	Dorwin Ave.	18.0	5.0	5.0	4.8	5.3	6.4	48%	4.8	**5.3**	**Slight**
	4	Spencer Street	12.0	3.0	0	0	6.2	5.4	33%	2.2	**2.6**	**Moderate**
2004	1	Tully Farms Rd.	21.3	6.0	6.8	5.7	3.9	8.1	58%	6.2	**6.5**	**Slight**
	2	Webster Rd.	18.3	5.0	3.5	3.9	4.9	6.9	47%	4.6	**5.1**	**Slight**
	3	Dorwin Ave.	18.0	4.9	4.5	4.5	5.3	6.5	54%	5.8	**5.4**	**Slight**
	4	Spencer Street	19.0	5.2	1.8	2.6	6.1	5.5	38%	3.1	**4.1**	**Moderate**
2006	1	Tully Farms Rd.	23.0	6.5	9.0	6.9	4.5	7.5	78%	8.8	**7.4**	**Slight**
	2	Webster Rd.	19.8	5.5	3.8	4.0	6.6	4.8	44%	4.2	**4.6**	**Moderate**
	3	Dorwin Ave.	18.0	5.0	6.3	5.6	5.5	6.3	48%	4.7	**5.4**	**Slight**
	4	Spencer Street	21.8	6.1	0.8	1.1	7.3	4.0	36%	2.7	**3.5**	**Moderate**
2008	1	Tully Farms Rd.	24.5	6.8	9.5	7.2	4.6	7.4	73%	8.4	**7.4**	**Slight**
	2	Webster Rd.	21.5	6.0	4.5	4.5	5.5	6.3	44%	4.1	**5.2**	**Slight**
	3	Dorwin Ave.	27.0	7.7	5.5	5.1	6.0	5.7	54%	5.8	**6.1**	**Slight**
	4	Spencer Street	18.0	5.0	1.8	2.6	7.4	3.9	40%	3.5	**3.7**	**Moderate**
2010	1	Tully Farms Rd.	16.5	4.4	6.8	5.7	4.3	7.7	68%	7.9	**6.4**	**Slight**
	2	Webster Rd.	17.8	4.9	5.3	4.9	5.8	5.8	36%	2.7	**4.6**	**Moderate**
	3	Dorwin Ave.	22.8	6.4	5.3	4.9	6.0	5.6	59%	6.5	**5.8**	**Slight**
	4	Spencer Street	23.3	6.6	2.8	3.5	7.7	3.5	36%	2.7	**4.1**	**Moderate**

Mean index value and corresponding mean NYSDEC biological assessment profiles (BAP) score and designations from monitoring sites in Ley Creek in all sampled years.

			Species Richness		EPT Richness		HBI		PMA		NCO		NYSDEC	
			Index	*NYSDEC*	*Index*	*NYSDEC*	*Index*	*NYSDEC*	*Index*	*NYSDEC*	*Index*	*NYSDEC*	**Mean**	**BAP Impact**
Year	**Site**	**Description**	*Mean*	*BAP Mean*	*Mean*	*BAP Mean*	*Mean*	*BAP Mean*	*Mean*	*BAP Mean*	*Mean*	*BAP Mean*	**BAP Score**	**Designation**
2000	1	Townline Road	11.0	2.3	0.25	0.38	8.1	3.2	--	--	3.3	3.8	**2.5**	**Moderate/Severe**
	2	7th North Street	6.5	0.4	0	0	9.8	0.3	--	--	0	0	**0.3**	**Severe**
	3	Park Street	11.0	2.2	0	0	8.6	2.3	--	--	2.0	2.7	**2.1**	**Severe**
2002	1	Townline Road	12.0	2.7	0	0	8.5	2.5	--	--	4.3	3.7	**2.4**	**Severe**
	2	7th North Street	6.0	0	0	0	9.7	0.6	--	--	1.3	1.8	**0.6**	**Severe**
	3	Park Street	9.5	1.4	0.25	0.38	8.3	2.8	--	--	2.3	2.6	**1.7**	**Severe**
2004	1	Townline Road	16.3	4.4	0.50	0.76	8.7	2.2	0.34	2.42	--	--	**2.5**	**Moderate/Severe**
	2	7th North Street	11.3	1.9	0	0	9.4	0.8	--	--	1.3	1.4	**1.4**	**Severe**
	3	Park Street	18.0	5.9	1.00	1.50	7.6	4.0	--	--	6.0	5.5	**4.2**	**Moderate**
2006	1	Townline Road	9.5	1.9	0	0	9.0	1.6	0.16	0.05	0	0	**0.9**	**Severe**
	2	7th North Street	8.5	0.8	0	0	9.9	0.2	0	0	0.5	0.6	**0.4**	**Severe**
	3	Park Street	11.0	2.3	0	0	9.3	1.1	0	0	3.3	3.8	**1.8**	**Severe**
2008	1	Townline Road	13.3	3.4	0.25	0.31	8.8	1.9	0.35	2.60	0	0	**1.4**	**Severe**
	2	7th North Street	14.5	4.2	0	0	8.6	2.3	0	0	3.0	3.1	**2.4**	**Severe**
	3	Park Street	9.8	2.1	0	0	7.9	3.5	0	0	2.3	2.7	**2.1**	**Severe**
2010	1	Townline Road	13.0	3.4	0.50	0.63	7.7	3.5	0.32	2.17	0	0	**2.4**	**Severe**
	2	7th North Street	11.3	2.4	0	0	9.1	1.5	0	0	2.8	3.0	**1.7**	**Severe**
	3	Park Street	12.5	3.0	0	0	7.8	3.6	0	0	4.5	4.5	**2.8**	**Moderate**

Note:

Due to habitat changes, samples at Site 1 were collected with kick samples in 2004 and 2006 and jab samples in 2000 and 2002.

According to NYSDEC guidance PMA is calculated for kick sample sites and NCO for jab sites.

Site 3, Park Street, in 2004 had fewer organisms in all four replicates (22, 19, 30 and 12) than is needed to calculate NYSDEC metrics (100). As a result, replicates were combined into a single sample of 83 organisms to approach the 100 organisms needed.

A single replicate at Site 2, 7th North Street, in 2004 and Site 3 Park Street in 2006 also had few organism, these replicates were not used in the analysis.

Mean index value and corresponding mean NYSDEC biological assessment profiles (BAP) score and designations from monitoring sites in Harbor Brook in all sampled years.

			Species Richness		EPT Richness		HBI		PMA		NCO		NYSDEC	
Year	**Site**	**Description**	*Index Mean*	*NYSDEC BAP Mean*	*Index Mean*	*NYSDEC BAP Mean*	*Index Mean*	*NYSDEC BAP Mean*	*Index Mean*	*NYSDEC BAP Mean*	*Index Mean*	*NYSDEC BAP Mean*	**Mean BAP Score**	**BAP Impact Designation**
2000	1	Velasko Road	16.0	4.3	1.5	2.2	6.7	4.7	32%	2.1	--	--	**3.3**	**Moderate**
	2	Hiawatha Blvd.	20.0	5.6	0.3	0.3	8.1	3.1	35%	2.6	--	--	**2.9**	**Moderate**
	3	Rt. 690	15.0	4.3	0.3	0.4	9.0	1.8	--	--	4.0	4.2	**2.7**	**Moderate**
2002	1	Velasko Road	18.8	5.2	2.3	2.9	5.2	6.6	42%	3.8	--	--	**4.6**	**Moderate**
	2	Hiawatha Blvd.	15.3	4.0	0.3	0.3	7.9	3.3	30%	1.8	--	--	**2.4**	**Severe**
	3	Rt. 690	16.8	5.3	--	--	8.4	2.6	--	--	3.0	3.6	**2.9**	**Moderate**
2004	1	Velasko Road	11.8	2.8	2.8	3.5	4.3	7.7	46%	4.5	--	--	**4.6**	**Moderate**
	2	Hiawatha Blvd.	15.5	4.1			9.0	1.7	23%	0.7	--	--	**1.6**	**Severe**
	3	Rt. 690	15.0	4.4	0.5	0.8	8.6	2.4	--	--	3.5	3.9	**2.9**	**Moderate**
2006	1	Velasko Road	13.8	3.5	2.3	2.9	4.8	7.1	37%	2.9	0	0	**3.4**	**Moderate**
	2	Hiawatha Blvd.	12.5	3.0	0	0	9.7	0.6	17%	0.1	0	0	**0.9**	**Severe**
	3	Rt. 690	13.3	3.4	0	0	9.0	1.7	--	--	4.0	4.2	**2.3**	**Severe**
2008	1	Velasko Road	14.3	3.8	2.5	3.0	4.9	7.0	35%	2.5	--	--	**3.5**	**Moderate**
	2	Hiawatha Blvd.	11.0	2.5	0.3	0.3	8.2	2.7	32%	2.1	--	--	**1.4**	**Severe**
	3	Rt. 690	10.5	2.1	0.5	0.8	8.5	2.5	--	--	4.0	3.7	**2.3**	**Severe**
2010	1	Velasko Road	13.5	3.4	4.0	4.2	4.8	7.0	29%	1.6	0	0	**4.0**	**Moderate**
	2	Hiawatha Blvd.	16.5	4.5	0	0	9.3	1.2	20%	0	0	0	**1.4**	**Severe**
	3	Rt. 690	14.5	4.1	0	0	7.5	4.2	0	0	5.8	5.2	**3.4**	**Moderate**

Note:

Site 1 and 2 use kick samples and Site 3 utilizes jab samples. According to NYSDEC guidance PMA is calculated for kick sample sites and NCO for jab sites.

APPENDIX 3.

Impact Source Determinations

The NYSDEC Impact Source Determination (ISD) ascertains the primary factor influencing the macroinvertebrate community in stream riffle habitats based on similarity to impacted community models (NYSDEC 2009). The model community that exhibits the highest similarity to the test data indicates the likely impact source type for that site. If data from a site do not match any of the modeled communities (based on a standard of 50% affinity) the determination is "inconclusive".

Impact Source Determination (ISD), Onondaga Creek for years sampled.

ISD Model Group	Site 1 - Tully Farms Road					
	2000	*2002*	*2004*	*2006*	*2008*	*2010*
Natural: minimal human impact	**62**	**64**	**45**	**55**	**56**	**33**
Nonpoint: nutrients, pesticides	35	41	39	*53*	45	*31*
Toxic	27	33	*44*	39	32	*29*
Organic: sewage, animal waste	28	27	31	42	33	21
Municipal/Industrial	23	26	35	31	30	19
Siltation	31	36	33	39	36	24
Impoundment	25	26	30	31	27	17

ISD Model Group	Site 2 - Webster Road					
	2000	*2002*	*2004*	*2006*	*2008*	*2010*
Natural: minimal human impact	51	**53**	*53*	46	48	**53**
Nonpoint: nutrients, pesticides	*57*	*49*	51	*52*	**57**	*50*
Toxic	*56*	44	42	48	45	45
Organic: sewage, animal waste	**60**	41	42	**56**	*53*	46
Municipal/Industrial	42	39	42	44	*53*	*49*
Siltation	54	*51*	46	50	*55*	48
Impoundment	51	42	**57**	**56**	*54*	46

ISD Model Group	Site 3 - Dorwin Avenue					
	2000	*2002*	*2004*	*2006*	*2008*	*2010*
Natural: minimal human impact	42	42	39	38	43	45
Nonpoint: nutrients, pesticides	*63*	*58*	*61*	65	**60**	55
Toxic	53	*58*	**62**	59	*56*	59
Organic: sewage, animal waste	47	*59*	47	**73**	*55*	54
Municipal/Industrial	56	*60*	*58*	**73**	52	**70**
Siltation	**64**	**63**	*61*	59	*56*	59
Impoundment	*62*	*62*	**62**	*68*	51	50

ISD Model Group	Site 4 - Spencer Street					
	2000	*2002*	*2004*	*2006*	*2008*	*2010*
Natural: minimal human impact	13	19	24	20	22	22
Nonpoint: nutrients, pesticides	21	35	29	25	32	34
Toxic	21	**44**	*46*	51	41	43
Organic: sewage, animal waste	*41*	29	*48*	**59**	**46**	58
Municipal/Industrial	*42*	33	**49**	**59**	*46*	56
Siltation	24	30	33	40	37	36
Impoundment	**46**	*43*	*46*	52	*45*	**68**

Note:

Numbers represent maximum similarity to macroinvertebrate community type models for each impact category. The highest similarities (within 5 percentage points of the highest) at each station are highlighted in shades of yellow. Highest similarity (bold text, highlighted yellow with orange border) represents most probable type of impact. Similarities less than 50% are less conclusive.

Impact Source Determination (ISD), Ley Creek, Site 1 for years sampled.

ISD Model Group	Site 1 - Townline Road					
	2000	2002	2004	2006	2008	2010
Natural: minimal human impact	-	-	13	6	17	19
Nonpoint: nutrients, pesticides	-	-	28	16	48	25
Toxic	-	-	35	23	40	37
Organic: sewage, animal waste	-	-	**68**	48	**66**	53
Municipal/Industrial	-	-	58	**73**	40	**68**
Siltation	-	-	33	21	32	34
Impoundment	-	-	52	53	47	49

Note:

ISD can only be calculated for sites sampled with kick sampling, therefore only Site 1 in 2004 and 2006 that were sampled with kick samples have results. Numbers represent maximum similarity to macroinvertebrate community type models for each impact category. The highest similarities (within 5 percentage points of the highest) at each station are highlighted in shades of yellow. Highest points of the highest) at each station are highlighted. Highest similarity (bold text, highlighted yellow with orange border) represents most probable type of impact. Similarities less than 50% are less conclusive.

Impact Source Determination (ISD), Harbor Brook, Sites 1and 2 for years sampled.

ISD Model Group	Site 1 - Velasko Road					
	2000	2002	2004	2006	2008	2010
Natural: minimal human impact	13	28	28	24	17	23
Nonpoint: nutrients, pesticides	22	24	26	22	18	25
Toxic	27	33	27	22	27	18
Organic: sewage, animal waste	46	25	19	25	24	15
Municipal/Industrial	**65**	**51**	*53*	*57*	*47*	51
Siltation	25	36	23	25	18	22
Impoundment	54	45	**57**	**58**	**51**	**65**

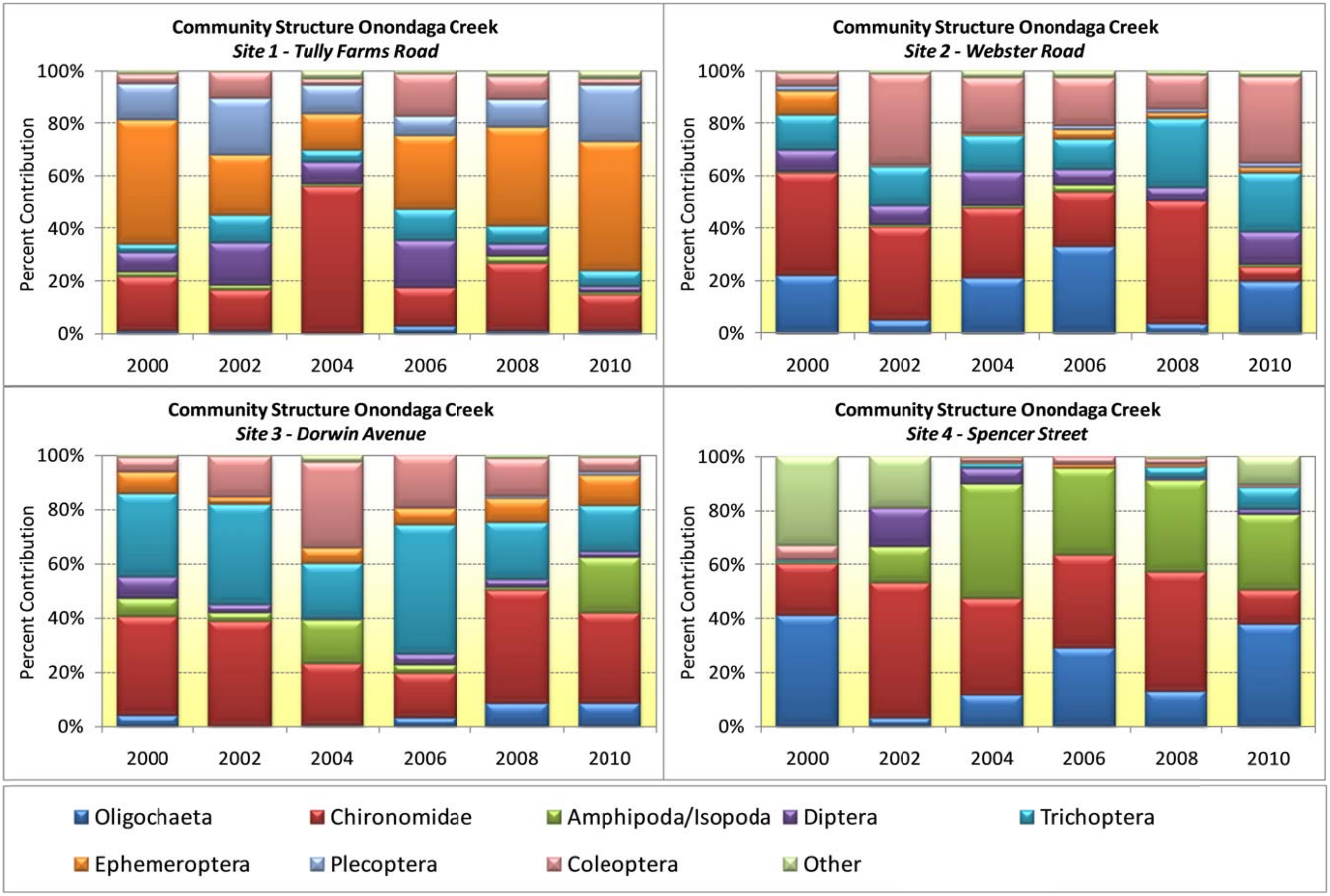
ISD Model Group	Site 2 - Hiawatha Boulevard					
	2000	2002	2004	2006	2008	2010
Natural: minimal human impact	9	25	7	6	6	7
Nonpoint: nutrients, pesticides	24	35	18	22	31	17
Toxic	35	37	25	25	26	27
Organic: sewage, animal waste	**62**	61	49	53	**54**	47
Municipal/Industrial	53	**75**	**74**	**78**	39	**74**
Siltation	24	42	22	21	21	22
Impoundment	*60*	57	54	49	31	50

Note:

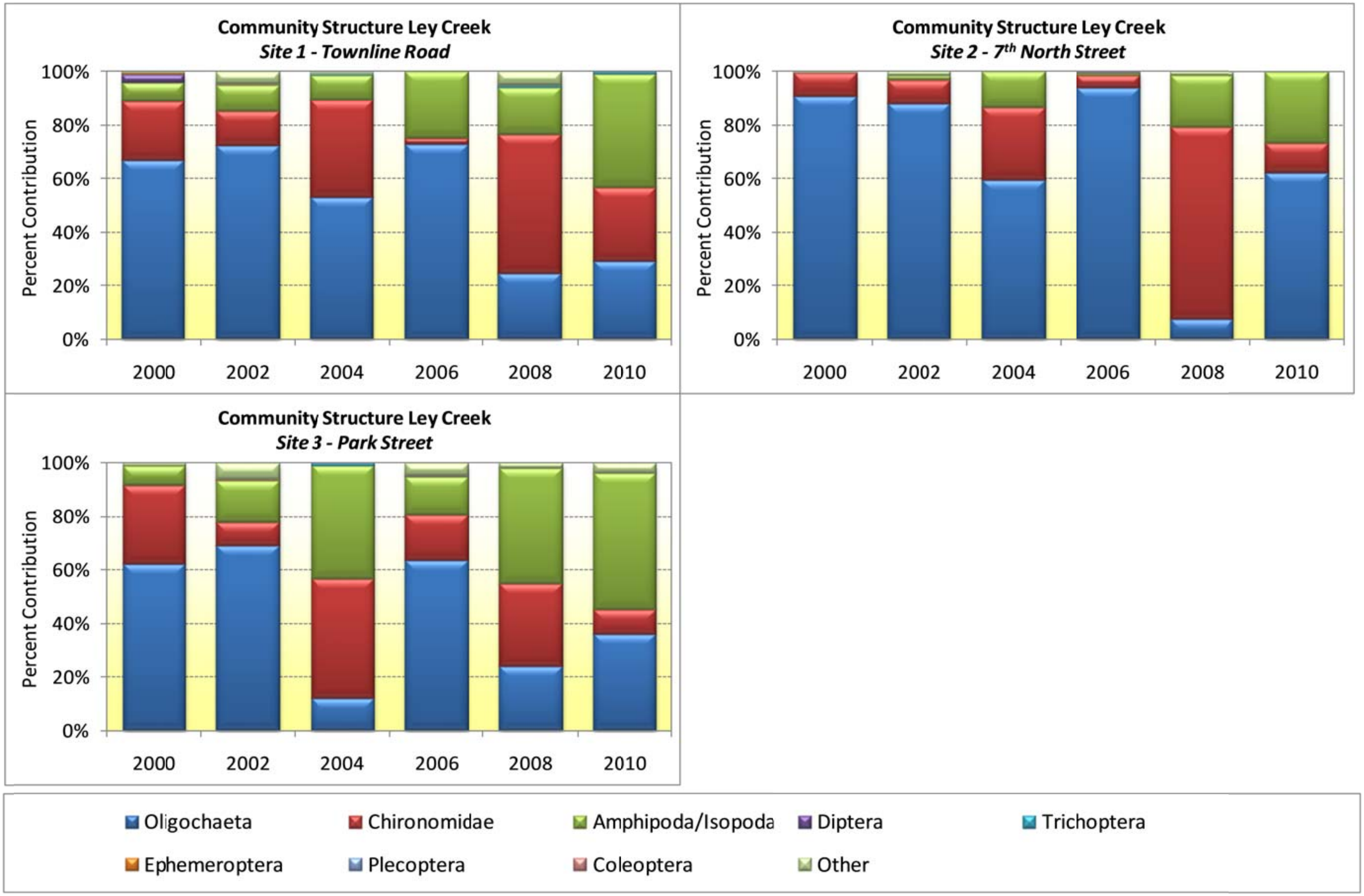
ISD can only be calculated for sites sampled with kick sampling, therefore Site 3 (jab samples) has no results. Numbers represent maximum similarity to macroinvertebrate community type models for each impact category. The highest similarities (within 5 percentage points of the highest) at each station highlighted in shades of yellow. Highest similarity represents probable type of impact and is bolded. highlighted. Highest similarity (bold text, highlighted yellow with orange border) represents most probable type of impact. Similarities less than 50% are less conclusive.

APPENDIX 4.

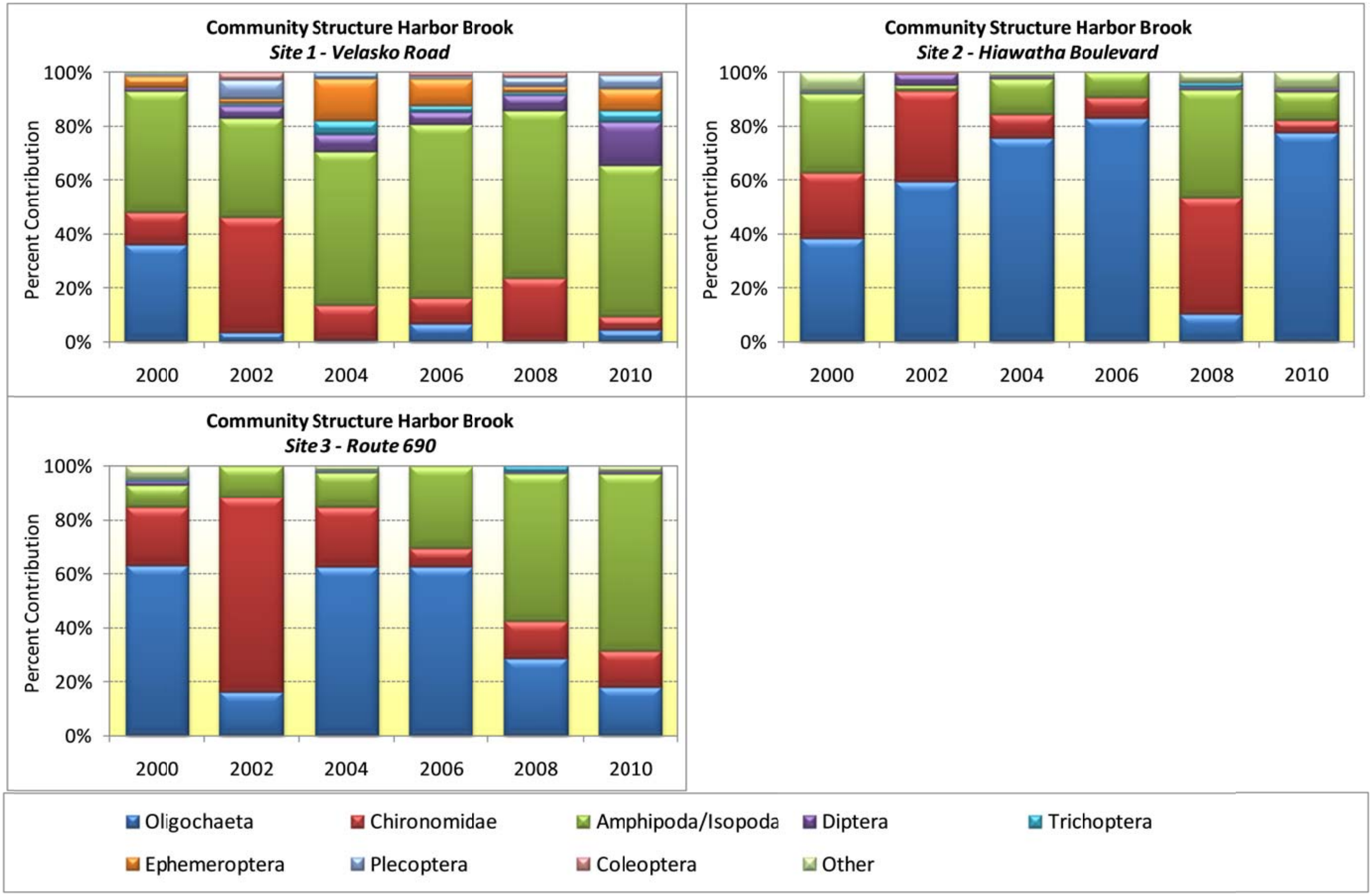
Community Structure



Community structure of macroinvertebrate communities at Onondaga Creek sites surveyed every two years since 2000.



Community structure of macroinvertebrate communities at Ley Creek sites surveyed every two years since 2000.



Community structure of macroinvertebrate communities at Harbor Brook sites surveyed every two years since 2000.