AN EVALUATION OF THE PRESQUE ISLE BAY WATERSHED MACROINVERTEBRATE COMMUNITY AND STREAM HABITAT: 2011

Prepared by:

Karla Kaczmarek[1] and Sean D. Rafferty[2]

[1] Pennsylvania Sea Grant; Tom Ridge Environmental Center; 301 Peninsula Dr., Suite 3; Erie, PA 16505; kmk32@psu.edu

[2] Pennsylvania Sea Grant; Tom Ridge Environmental Center; 301 Peninsula Dr., Suite 3; Erie, PA 16505; sdr138@psu.edu

March 2012

ACKNOWLEDGEMENTS

We would like to thank the United States Environmental Protection Agency's Great Lakes Restorative Initiative for providing the funding necessary to undertake this sampling effort; Jim Grazio and William Andrus (Pennsylvania Department of Environmental Protection), and Dr. Ed Masteller (Natural History Museum at the Tom Ridge Environmental Center) for assisting with the identification of macroinvertebrates; Jake Lybrook and Amy Streeter (Pennsylvania Sea Grant), Matt Pluta (Pennsylvania Department of Environmental Protection) for assisting with the collection of the macroinvertebrate samples and habitat data; and Dr. Michael Campbell (Mercyhurst University) for assisting with the analysis of the data. In addition, we would like to thank Dr. Robert Light (Penn State Behrend and Pennsylvania Sea Grant) for the critical review of this report.

Sea Grant
Pennsylvania

Great Lakes
RESTORATION

TABLE OF CONTENTS

1.0 Abstract

Presque Isle Bay is a 5.7 square mile embayment located in northwestern Pennsylvania on the southern shore of Lake Erie. The bay's watershed drains a highly urbanized area (62.6% imperviousness) of 26.2 square miles, including portions of Millcreek Township, City of Erie, Harborcreek Township, Summit Township, and Greene Township in Erie County, Pennsylvania. Tributaries of the bay include, from west to east, Scott Run, Cascade Creek, and Mill Creek and its tributary Garrison Run. In May and June 2011, macroinvertebrate community and habitat surveys were conducted at 16 sites in tributaries of Presque Isle Bay in an effort to characterize the impact of urbanization on the watershed. EPA's Rapid Bioassessment Protocol for Use in Wadeable Streams and Rivers were used to assess the macroinvertebrate communities and stream habitat. In addition, a macroinvertebrate composite index score was calculated for each site based on analysis of six different metrics including: 1) total number of taxa, 2) number of Ephemeroptera, Plecoptera, and Trichoptera taxa (EPT), 3) number of intolerant taxa, 4) percent EPT, 5) percent intolerant, and 6) Hilsenhoff Biotic Index (HBI). A total of 4,928 individual macroinvertebrates representing 47 taxa were collected within the Presque Isle Bay watershed. Chironomidae and Oligochaeta were the dominant taxa in the watershed, comprising 55.01% and 20.35% of the total catch, respectively. The median composite index score was 13.0 (very poor). The median total habitat score was 124 (suboptimal). There was a significant, positive correlation between the epifaunal substrate/available cover, left bank stability, right bank stability, total bank stability, and total habitat scores and the macroinvertebrate composite index scores. The impaired macroinvertebrate community in the watershed is likely due to habitat alterations as a result of urbanization.

2.0 Introduction

Presque Isle Bay is a 5.7 square mile embayment located in northwestern Pennsylvania on the southern shore of Lake Erie. Prior to 1980, land along Presque Isle Bay was dominated by industrial uses. However, the bayfront began to transition to more tourism and recreational uses in the 1980s. As industry began to fade from the area, environmentally minded citizens banded together with the common goal of restoring and protecting Presque Isle Bay. In 1991, Presque Isle Bay was named the 43rd Area of Concern (AOC) as a result of their efforts. In 2002, as a result of improving conditions in the AOC, Presque Isle Bay was upgraded to an AOC in Recovery. In December 2012, the Pennsylvania Department of Environmental Protection petitioned the United States Environmental Protection Agency to delist Presque Isle Bay.

The bay's watershed drains a highly urbanized area (62.6% imperviousness) of 26.2 square miles, including portions of Millcreek Township, City of Erie, Harborcreek Township, Summit Township, and Greene Township in Erie County, Pennsylvania. Tributaries of the bay include, from west to east, Scott Run, Cascade Creek, and Mill Creek and its tributary Garrison Run (**Map 1**). These tributaries comprise 88.3% of the bay's watershed; the remainder of the watershed (11.7%) is comprised of small, unnamed tributaries and direct runoff to the bay.

It is widely known that urbanization can alter the physical and chemical characteristics of streams, which can lead to significant decreases in invertebrate communities (Cuffney et al. 2010). As urbanization increases, so does run-off during storm events, which increases sedimentation, scouring, and flushes out critical habitat (Wang et al. 2001). The objective of this study was to evaluate the macroinvertebrate communities and stream habitat at the 16 sites previously assessed by Campbell (2002) and Diz and Johnson (2002).

3.0 Methods

3.1 Sampling Locations

In May and June 2011, macroinvertebrate community and habitat surveys were conducted at 16 sites in tributaries of Presque Isle Bay (**Map 2**; **Table 1**). In addition, three reference sites outside of the watershed were surveyed (**Map 3**). The latitude and longitude of the downstream limit were recorded at each site using a Garmin GPSMAP® 60CSX handheld GPS unit. All sites were previously sampled by Diz and Johnson (2002) and Campbell (2002).

3.2 Macroinvertebrate Assessment

The macroinvertebrate community was assessed using EPA's Rapid Bioassessment Protocol for Use in Wadeable Streams and Rivers (Barbour et al. 1999). At each site, a 100-meter section of the stream, representing all habitats (riffle, run, pool, and snag) if possible, was sampled. The 100-meter section was divided into corresponding percentages based on habitat type (**Table 2**). A total of 10 kicks were performed at each site. The kicks were distributed proportionally to the habitat type [e.g. 50% riffles (five kicks), 30% runs (three kicks), 10% pools (one kick), and 10% snags(one kick)]. A 500-micron D-Frame net was used to collect each sample. Each kick was performed for one minute in approximately a one square-meter section of substrate upstream from the net. After kicking, large rocks, sticks, and other debris within the one square-meter sampling section were rinsed-off in the net. Snags were treated by jabbing the D-Frame net into the snag for one minute. The net was then emptied into a half-gallon plastic jar labeled with the location and date, with 70% alcohol, and returned to the laboratory for analysis. In the laboratory, each sample was rinsed in a 500-micron sieve and transferred to a large, shallow white pan with fresh alcohol. The benthic material was removed from the pan and placed into a petri dish. The macroinvertebrates were then separated from the debris using a stereo microscope. All macroinvertebrates were identified to the lowest practicable taxonomic level and enumerated (**Form A**). In the case of an overabundance of a species, the number of specimens was approximated.

The macroinvertebrate community at each site was analyzed using a composite index score. Six different metrics were computed for each site, including: 1) total number of taxa, 2) number of Ephemeroptera, Plecoptera, and Trichoptera taxa (EPT), 3) number of intolerant taxa, 4) percent EPT, 5) percent intolerant, and 6) Hilsenhoff Biotic Index (HBI). Intolerant taxa were determined to be any macroinvertebrate receiving a Hilsenhoff Biotic Index score of less than 6.0. Each metric was then given a standardization score from 1 to10 based on stream order (**Tables 3-5**). A composite index score was calculated by summing each of the six metrics. Composite index scores have a potential range of 6 to 60, with 6 representing minimal biotic diversity and 60 representing optimal conditions (**Table 6**).

3.3 Habitat Assessment

Sites were assessed using the visual-based habitat assessment methodology described by Barbour et al. 1999. USEPA's Rapid Bioassessment Protocol for evaluating habitat provides a way for quantifying the condition of existing habitat. At each location, a 100-meter stream segment was assessed. The visual-based assessment evaluated and scored 10 parameters on a range of 0 to 20 (**Form B**) and classified each parameter as optimal (16-20), suboptimal (11-15), marginal (6-10), or poor (0-5). The individual parameter scores were then summed to get a total habitat score for each location. Total habitat scores were classified as optimal (160-200), suboptimal (110-159), marginal (60-109), or poor (< 60).

3.4 Correlation Analysis

The relationship between the habitat parameters and macroinvertebrate composite index scores was tested using the Spearman rank correlation test. The null hypothesis (H_o) tested was that there is no relationship between the parameters ($\rho = 0$; $p > 0.05$) and the alternative hypothesis (H_a) was that there is a relationship between the parameters ($\rho \neq 0$; $p < 0.05$). All rho (ρ) calculations were performed using the Spearman Rank Correlation – Free Statistics Software (Wessa 2012).

4.0 Results

4.1 Macroinvertebrate Assessment

A total of 4,928 individual macroinvertebrates representing 47 taxa were collected within the Presque Isle Bay watershed (**Table 7**). Chironomidae and Oligochaeta were the dominant taxa in the watershed, comprising 55.01% and 20.35% of the total catch, respectively. Chironomidae was the only taxon present at all sites. *Acentrella* (1.7%), *Baetis* (6.98%), *Caecidotea* (1.83%), *Cheumatopsyche* (1.26%), *Optioservus* (1.81%), *Simulium* (2.62%), and *Stenelmis* (1.93%) were the only other taxa that comprised more than 1% of the total catch. Sites CC3 and MC4 had the fewest taxa present, two taxa were observed. Site CC1 had the fewest total individuals, 17 individuals were observed. Site MC5 had the most taxa present, 23 taxa were observed. The median number of taxa was 7.5. Site MC6 had the most total individuals, 1,091 individuals were observed. A total of 1,329 individuals representing 24 taxa were collected at the reference sites. Chironomidae was the dominant taxon among the reference sites, comprising 86.68% of the total catch. The only other taxa to comprise more than 1% of the total catch were *Acentrella* (1.66%), *Baetis* (2.48%), *Ephemeroptera* (1.35%), and *Simulium* (3.76%). Each of the reference sites had 11 taxa present.

Composite index scores in the Presque Isle Bay watershed ranged from a low of 6 (minimal biotic diversity) at sites CC5, MC4, and GR1 to a high of 34 (slightly degraded) at site MC5 (**Table 8**). The median composite index score was 13.0 (very poor). Site MC5 had the most EPT and intolerant taxa, 11 and 13 taxa respectively (**Table 9**). Sites SR1, CC1, CC3, CC4, CC5, MC4, and GR1 had no EPT taxa present. Sites CC1, CC3, CC5, MC4, and GR1 had no intolerant taxa present. The median number of EPT and intolerant taxa was 1. Composite index scores in the reference sites ranged from a low of 14 (very poor) at site 12M to a high of 19 (poor) at site 7M2. All three reference sites had two EPT taxa present. Sites 7M1 and 7M2 had three intolerant taxa present, and site 12M had one intolerant taxa present.

4.2 Habitat Assessment

Total habitat scores in the Presque Isle Bay watershed ranged from a low of 68 (marginal) at site CC5 to a high of 145 (suboptimal) at site MC2 (**Table 10**). The median total habitat score was 124 (suboptimal). Of the 16 Presque Isle Bay watershed sites assessed, none were poor, 11 were marginal, five were suboptimal, and none were optimal. All three reference sites were rated as suboptimal.

4.3 Relationship between Habitat and Composite Index Scores

A Spearman's correlation was run to determine the relationship between the habitat parameters and macroinvertebrate composite index scores. There was a significant, positive correlation between the epifaunal substrate/available cover ($\rho = 0.51$, $p < 0.05$), left bank stability ($\rho = 0.49$, $p < 0.05$), right bank stability ($\rho = 0.54$, $p < 0.05$), total bank stability ($\rho = 0.55$, $p < 0.05$), and total habitat scores ($\rho = 0.57$, $p < 0.05$) and the macroinvertebrate composite index scores (**Table 11**).

5.0 Discussion

The streams in the Presque Isle Bay watershed were dominated by pollution-tolerant taxa, particularly Chironomidae and Oligochaeta individuals, which comprised 75.36% of the total catch. Only 10.15% of the total catch was comprised of intolerant individuals, including intolerant EPT individuals, which comprised 4.06% of the catch. Stepenuck et al. (2002) observed a negative relationship between urban land use and impervious cover and percent intolerant EPT individuals in urban streams in Wisconsin. Walsh et al. (2005), in a review of the literature, indicated that in nearly all studies, sensitive species were absent or less abundant in streams draining urbanized areas. The low median composite index score (13.0) indicates that the macroinvertebrate community in the Presque Isle Bay watershed as a whole is in very poor condition. Assessing the communities in the individual streams revealed Garrison Run has minimal biological diversity, Scott Run and Cascade Creek are in very poor condition, and Mill Creek is in poor condition. Campbell (2002) observed similarly impaired macroinvertebrate communities in the Presque Isle Bay tributaries.

The impaired macroinvertebrate community in the watershed is likely due to habitat alterations as a result of urbanization. The Presque Isle Bay watershed is comprised of 77% urban land uses. The degradation of physical habitat, as a result of urbanization, has been shown to result in a reduction in the richness or number of intolerant macroinvertebrates in streams (reviewed by Roy et al. 2003). The median total habitat score (124.0) indicates that the Presque Isle Bay streams as a whole are in suboptimal condition. None of the stream locations received an optimal rating. There was a significant relationship between total habitat scores and composite index scores. This suggests that as stream and riparian habitats are altered, the macroinvertebrate community will respond negatively. Assessing data from 296 stream sites in Idaho, Mebane (2001) observed higher invertebrate scores at sites with higher habitat scores than sites with lower habitat scores.

Efforts have been and continue to be made in the Presque Isle Bay watershed to improve habitats to restore aquatic biota. For example, since 2004 in the Cascade Creek watershed, 4,030 feet of stream has been stabilized; 5,500 square feet of impervious cover has been removed; 212,125 square feet of riparian buffer has been established; and 395 tons of sediment per year has been eliminated from the stream as a result of habitat restoration. Miller et al. (2010), in reviewing 24 separate studies, showed that habitat improvements had significant, positive effects on macroinvertebrate richness. Efforts to address urbanization and stream habitat should continue to be implemented to restore fish and macroinvertebrate communities in the Presque Isle Bay watershed.

6.0 References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Campbell, J. Michael. 2002. Assessment of Benthic Macroinvertebrate Communities in the Presque Isle Bay Watershed. Unpublished report submitted to the Erie County Conservation District, June 14, 2002.

Cuffney, T., Brightbill, R., May, J., Waite, R. 2010. Responses of Benthic Macroinvertebrates to Environmental Changes Associated with Urbanization in Nine Metropolitan Areas. *Ecological Applications* 20(5): 1384-1401.

Kaplan, et al. Protecting Headwaters: The scientific Basis for Safeguarding Stream and River Ecosystems. Stroud Water Research Center.

McCafferty, W. 1983. Aquatic Entomology: The Fishermen's and Ecologist Illustration Guide to Insects and their Relatives.

Mebane, C.A. 2001. Testing bioassessment metrics: macroinvertebrate, sculpin, and salmonid responses to stream habitat, sediment, and metals. *Environmental Monitoring and Assessment* 67: 293-322.

Merritt, R., Cummins, K., Berg, M. 2008. An introduction to the Aquatic Insects of North America. Fourth Edition.

Peckarsky, P., Fraissinet, P., Penton, M., Conklin, D. 1990. Freshwater Macroinvertebrates of Northeastern North America.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. *Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish.* U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA 440-4-89-001.

Rafferty, S., Lybrook, J., Kaczmarek, K., Lethaby, M., and Wellington, R. 2012. An Evaluation of the Presque Isle Bay Watershed Fish Community. The Pennsylvania State University.

Stepenuck, K.F., Crunkilton, R.L., and Wang, L. 2002. Impacts of urban land use on macroinvertebrate communities in Southeastern Wisconsin streams. *Journal of the American Water Resources Association* 38: 1041-1051.

Walsh, C.J., Roy, A.H., Feminella, J.W., Cottingham, P.D., Groffman, P.M., and Morgan, R.P. 2005. The urban stream syndrome: current knowledge and the search for a cure. *Journal of the North American Benthological Society* 24: 706-723.

Wang, L., Lyons, J. and Kanehl, P. 2001. Impacts of urbanization on stream habitat and fish across multiple scales. *Environmental Management* 28(2): 255-266.

Wessa P. 2012. Spearman Rank Correlation (v1.0.1) in Free Statistics Software (v1.1.23-r7), Office for Research Development and Education, http://www.wessa.net/rwasp_spearman.wasp/

APPENDIX A: FORMS

2011 Presque Isle Bay Watershed Macroinvertebrate Sampling Data Sheet

Sampling Location:_____
Date sample was collected:_____
Date sample was IDed:_____
IDed by:_____

	Taxa	Number of individuals	Total
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			

Return to Page 2

Form B: Habitat Assessment Data Sheet

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regimes	All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (slow is < 0.3 m/s, deep is > 0.5 m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity / depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (< 20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills > 75% of the available channel; or < 25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yrs.) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream < 7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of > 25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. < 5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone > 18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone < 6 meters; little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

HABITAT SCORES	VALUE
OPTIMAL	160 – 200
SUB-OPTIMAL	110 – 159
MARGINAL	60 – 109
POOR	< 60

Return to Page 2

APPENDIX B: TABLES

Table 1. Macroinvertebrate sampling locations

Stream	Site	Stream Order	Date	Latitude	Longitude
Presque Isle Bay Watershed Sites					
Scott Run	SR1	1	5/18/2011	42.1106	-80.15531
Cascade Creek	CC1	2	5/18/2011	42.12647	-80.11275
Cascade Creek	CC2	2	5/23/2011	42.11678	-80.11729
Cascade Creek	CC3	2	5/23/2011	42.11368	-80.11626
Cascade Creek	CC4	1	5/23/2011	42.11129	-80.12069
Cascade Creek	CC5	1	5/23/2011	42.10588	-80.13155
Cascade Creek	CC6	1	5/23/2011	42.10175	-80.13082
Mill Creek	MC1	3	5/23/2011	42.10571	-80.07307
Mill Creek	MC2	3	6/16/2011	42.09315	-80.07096
Mill Creek	MC3	2	6/16/2011	42.08557	-80.07143
Mill Creek	MC4	1	6/16/2011	42.07721	-80.05157
Mill Creek	MC5	2	6/16/2011	42.09208	-80.05582
Mill Creek	MC6	2	6/16/2011	42.10314	-80.02643
Mill Creek	MC7	1	6/16/2011	42.10325	-80.02766
Mill Creek	MC8	2	6/16/2011	42.09078	-80.01598
Garrison Run	GR1	2	6/16/2011	42.14098	-80.07226
Reference Sites					
Sevenmile Creek	7M1	2	6/16/2011	42.18249	-79.97916
Sevenmile Creek	7M2	3	6/16/2011	42.1512	-79.93947
Twelvemile Creek	12M	3	6/16/2011	42.20889	-79.91494

Return to Page 2

Table 2. Habitat type by site

	Habitat Type (%)			
Site	Riffle	Pool	Run	Snag
SR1	70	0	20	10
CC1	30	0	60	10
CC2	50	0	50	0
CC3	70	0	30	0
CC4	30	0	65	15
CC5	20	0	80	0
CC6	20	0	80	0
MC1	20	10	30	0
MC2	30	10	60	0
MC3	55	5	40	0
MC4	20	10	70	0
MC5	80	0	20	0
MC6	60	10	30	0
MC7	15	0	80	5
MC8	30	10	60	0
GR1	50	40	10	0
7M-1	70	10	20	0
7M-2	70	20	10	0
12M	50	10	40	0

Return to Page 2

Table 3. Composite index scoring criteria for 1st order streams

	Metric Value					
Score	Total Taxa	EPT Taxa	Intolerant Taxa	% EPT	% Intoler-ant	PA Hilsenhoff
1	0-3	0-1	0-2	0-7	0-8	8.644-10
2	4-6	2-3	3-4	8-14	9-16	7.966-8.643
3	7-9	4-5	5-6	15-20	17-24	7.288-7.965
4	10-12	6	7-8	21-27	25-32	6.61-7.289
5	13-16	7-8	9-10	28-34	33-40	5.932-6.6
6	17-19	9-10	11-12	35-41	41-48	5.254-5.931
7	20-22	11	13	42-47	49-56	4.576-5.253
8	23-25	12-13	14-15	48-54	57-64	3.898-4.575
9	26-28	14	16-17	55-61	65-72	3.22-3.897
10	≥ 29	≥ 15	≥ 18	≥ 62	≥ 73	2.542-3.21

Return to Page 2

Table 4. Composite index scoring criteria for 2nd order streams

	Metric Value					
Score	Total Taxa	EPT Taxa	Intolerant Taxa	% EPT	% Intoler-ant	PA Hilsen-hoff
1	0-4	0-2	0-3	0-7	0-8	9.31-10
2	5-8	3-4	4-5	8-15	9-16	8.62-9.30
3	9-12	5-6	6-8	16-22	17-24	7.93-8.61
4	13-16	7-8	9-10	23-30	25-32	7.24-7.92
5	17-19	9-10	11-13	31-37	33-40	6.55-7.23
6	20-23	11-12	14-15	38-44	41-48	5.86-6.54
7	24-27	13-15	16-18	45-52	49-57	5.17-5.85
8	28-31	16-17	19-20	53-59	58-65	4.48-5.16
9	32-35	18-19	21-23	60-67	66-73	3.79-4.47
10	≥ 36	≥ 20	≥ 24	≥ 68	≥ 74	< 3.1-3.78

Return to Page 2

Table 5. Composite index scoring criteria for 3rd order streams

Score	Metric Value					
	Total Taxa	EPT Taxa	Intolerant Taxa	% EPT	% Intoler-ant	PA Hilsen-hoff
1	0-3	0-2	0-2	0-9	0-9	9.27-10
2	4-7	3-4	3-5	10-17	10-18	8.53-9.26
3	8-11	5-6	6-7	18-26	19-27	7.80-8.52
4	12-15	7-9	8-10	27-34	28-35	7.06-7.79
5	16-19	10-11	11-13	35-43	36-44	6.33-7.05
6	20-22	12-13	14-15	44-51	45-53	5.60-6.32
7	23-26	14-16	16-18	52-60	54-62	4.86-5.59
8	27-30	17-18	19-20	61-68	63-71	4.13-4.85
9	31-34	19-20	21-23	69-77	72-80	3.39-4.12
10	≥ 35	≥ 21	≥ 24	≥ 77	≥ 81	≤ 3.38

Return to Page 2

Table 6. Composite index score classifications

Classification	Score (1st Order)	Score (2nd Order)	Score (3rd Order)
Minimal Biotic Diversity	6	6	6
Very Poor	7-13	7-15	7-15
Poor	14-21	16-24	16-25
Slightly Degraded	22-28	25-34	26-35
Fair	29-36	35-43	36-45
Good	37-48	44-51	46-52
Very Good	49-59	52-59	53-59
Optimum Condition	60	60	60

Return to Page 2

Table 7. Presque Isle Bay watershed and reference site macroinvertebrate community (2011)

	Sites																			
Taxa	SR1	CC1	CC2	CC3	CC4	CC5	CC6	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	GR1	7M1	7M2	12M	All Sites
Acentrella	0	0	0	0	0	0	0	0	1	0	0	73	10	0	0	0	7	15	0	106
Agabus	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Ameletus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Amphinemura	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Ancylidae	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Antocha	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	0	0	0	4
Baetis	0	0	0	0	0	0	0	0	22	19	0	181	120	0	2	0	14	9	10	377
Baetidea	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Caecidotea	0	0	0	0	1	0	9	0	0	0	0	1	0	76	3	0	0	0	0	90
Caenis	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	2
Cambaridae	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Ceratopsyche	0	0	0	0	0	0	0	2	1	0	0	29	0	0	0	0	0	0	0	32
Cheumatopsyche	0	0	0	0	0	0	0	3	1	2	0	39	4	13	0	0	0	0	3	65
Chironomidae	78	15	44	7	11	22	323	9	183	162	8	232	810	394	382	31	400	124	628	3863
Dasyhelea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Dicranota	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Diplectrona	0	0	0	0	0	0	0	0	2	0	0	5	0	0	0	0	0	5	0	12
Dolophilodes	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	9
Dubiraphia	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
Ephemeroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	18
Gammarus	2	1	1	0	5	0	7	0	14	0	0	0	0	5	1	0	0	0	0	36
Haliplus	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Hirudinea	0	0	0	0	0	0	10	0	0	0	0	0	0	5	0	0	0	0	0	15
Hydracarina	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Hydrobiidae	0	2	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4
Hydroptila	0	0	2	0	0	0	0	0	0	0	0	2	10	0	0	0	0	0	0	14
Hydropsychidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4
Hydropsyche	0	0	0	0	0	0	0	0	0	1	0	0	1	3	0	0	0	0	1	6
Leptophlebiidae	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4
Leuctra	0	0	0	0	0	0	0	0	0	0	0	7	41	0	0	0	0	2	0	50
Limnophila	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	2

Return to Page 3

Table 7. Presque Isle Bay watershed and reference site macroinvertebrate community (2011) (*continued)*

	Sites																			
Taxa	SR1	CC1	CC2	CC3	CC4	CC5	CC6	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	GR1	7M1	7M2	12M	All
Limonia	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
Lymnaeidae	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Nigronia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Ochrotrichia	0	0	0	0	0	0	2	0	7	0	0	0	0	0	0	0	0	0	0	9
Oligochaeta	23	37	67	10	21	161	50	27	251	27	19	33	0	37	8	232	0	0	13	1016
Optioservus	0	0	0	0	0	0	0	2	2	0	0	6	20	52	7	0	1	3	0	93
Paraleptophlebia	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	10
Physidae	0	0	0	0	0	0	0	0	1	0	0	0	0	31	0	0	0	0	0	32
Planorbidae	0	1	0	0	16	0	0	0	0	1	0	0	0	1	0	1	0	0	2	22
Polycentropus	0	0	0	0	0	0	0	2	0	1	0	4	11	0	3	0	0	0	0	21
Probezzia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Psephenus	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	2
Psychodidae	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	5
Rhagovelia	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Simuliidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Simulium	0	0	0	0	0	0	17	0	0	13	0	67	32	0	0	0	15	14	21	179
Sphaerium	0	0	2	0	3	2	0	0	0	0	0	0	0	4	1	0	0	2	0	14
Stenelmis	0	0	2	0	2	0	0	1	3	0	0	11	10	66	0	0	4	0	1	100
Stratiomyidae	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Tipula	3	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	5
Tipulidae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	2
Valvata	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Valvatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Total Individuals	106	57	127	17	60	185	418	47	493	229	27	703	1091	693	408	265	467	178	684	6255

Return to Page 3

Table 8. Composite index scores, metric scores, and summary classification for all sites (2011)

Site	Stream Order	Metric Score: Total Taxa	EPT Taxa	Intolerant Taxa	% EPT Taxa	% Intolerant Taxa	PA Hilsenhoff Score	Composite Score	Summary Classification
SR1	1	2	1	1	1	1	4	10	Very Poor
CC1	2	2	1	1	1	1	2	8	Very Poor
CC2	2	2	1	1	1	1	3	9	Very Poor
CC3	2	1	1	1	1	1	3	8	Very Poor
CC4	1	3	1	1	1	1	2	9	Very Poor
CC5	1	1	1	1	1	1	1	6	Minimal Biotic Diversity
CC6	1	3	1	1	1	1	5	12	Very Poor
MC1	3	3	2	2	2	2	3	14	Very Poor
MC2	3	5	4	4	1	1	3	18	Poor
MC3	2	3	2	1	2	1	6	15	Very Poor
MC4	1	1	1	1	1	1	1	6	Minimal Biotic Diversity
MC5	2	6	6	5	7	3	7	34	Slightly Degraded
MC6	2	4	5	4	3	2	7	25	Slightly Degraded
MC7	1	6	2	3	1	4	5	21	Poor
MC8	2	3	1	1	1	1	6	13	Very Poor
GR1	2	1	1	1	1	1	1	6	Minimal Biotic Diversity
7M1	2	3	2	3	2	1	6	17	Poor
7M2	3	3	2	3	2	2	7	19	Poor
12M	3	3	2	1	1	1	6	14	Very Poor

Return to Page 3

Table 9. Composite index score metric analysis for all sites (2011)

Site	Stream Order	Metric Analysis							
		Total Taxa	EPT Taxa	Intolerant Taxa	% EPT Taxa	% Intolerant Taxa	PA Hilsenhoff Score	Composite Score	Summary Classification
SR1	1	4	0	1	0	3	6.811	10	Very Poor
CC1	2	6	0	0	0	0	8.772	8	Very Poor
CC2	2	7	1	1	2	2	8.197	9	Very Poor
CC3	2	2	0	0	0	0	8.353	8	Very Poor
CC4	1	8	0	2	0	5	8.017	9	Very Poor
CC5	1	3	0	0	0	0	9.503	6	Minimal Biotic Diversity
CC6	1	7	1	2	0	3	6.495	12	Very Poor
MC1	3	8	4	3	17	11	8.149	14	Very Poor
MC2	3	17	7	9	7	4	7.959	18	Poor
MC3	2	11	4	3	10	1	6.459	15	Very Poor
MC4	1	2	0	0	0	0	8.815	6	Minimal Biotic Diversity
MC5	2	23	11	13	49	20	5.757	34	Slightly Degraded
MC6	2	16	9	10	20	10	5.609	25	Slightly Degraded
MC7	1	17	2	5	2	29	5.971	21	Poor
MC8	2	9	2	3	1	3	6.034	13	Very Poor
GR1	2	4	0	0	0	0	9.525	6	Minimal Biotic Diversity
7M1	2	11	4	6	9	4	5.929	17	Poor
7M2	3	11	4	7	17	16	5.511	19	Poor
12M	3	11	3	2	2	0	6.096	14	Very Poor

Return to Page 3

Table 10. Habitat scores for the Presque Isle Bay watershed and reference sites (2011)

	Habitat Parameter Score																	
Site	Epi	Emb	Vel	Dep	Ch Fl	Ch Alt	Riffle	L-Stab	R-Stab	T-Stab	L-Veg	R-Veg	T-Veg	L-Rip	R-Rip	T-Rip	T-Hab	Rating
SR1	11	11	13	13	16	16	18	2	2	4	7	7	14	8	8	16	132	Suboptimal
CC1	9	11	6	13	16	16	6	5	5	10	5	7	12	9	9	18	117	Suboptimal
CC2	10	15	14	10	15	12	15	7	7	14	7	7	14	2	2	4	123	Suboptimal
CC3	7	10	10	11	15	15	16	3	6	9	2	6	8	2	8	10	111	Suboptimal
CC4	11	5	10	16	16	11	9	7	7	14	8	8	16	9	8	17	125	Suboptimal
CC5	2	4	8	12	16	0	10	8	8	16	0	0	0	0	0	0	68	Marginal
CC6	7	7	7	15	16	13	7	7	7	14	7	7	14	2	2	4	104	Marginal
MC1	11	13	14	10	10	15	15	7	7	14	6	6	12	9	8	17	131	Suboptimal
MC2	10	15	11	16	15	16	16	7	9	16	7	9	16	7	7	14	145	Suboptimal
MC3	11	12	12	10	15	11	13	8	8	16	7	8	15	5	7	12	127	Suboptimal
MC4	10	8	6	6	5	16	11	5	4	9	8	8	16	6	3	9	96	Marginal
MC5	11	11	11	11	10	11	16	8	8	16	8	8	16	6	9	15	128	Suboptimal
MC6	16	11	14	16	16	14	15	8	8	16	8	8	16	4	2	6	140	Suboptimal
MC7	6	5	7	9	14	11	6	5	5	10	4	4	8	3	2	5	81	Marginal
MC8	16	12	12	16	16	14	11	5	6	11	8	8	16	9	9	18	142	Suboptimal
GR1	7	10	10	7	10	4	16	6	6	12	6	6	12	3	2	5	93	Marginal
7M1	12	16	14	12	12	11	15	8	8	16	7	5	12	2	2	4	124	Suboptimal
7M2	13	15	11	15	14	14	16	9	9	18	9	9	18	7	9	16	150	Suboptimal
12M	16	15	16	15	16	13	16	7	7	14	9	9	18	9	2	11	150	Suboptimal

Epi = epifaunal substrate/available cover; Emb = embeddedness; Vel = velocity/depth regime; Dep = sediment deposition; Ch Fl = channel flow status; Ch Alt = channel alteration; Riffle = frequency of riffles; L-Stab = left bank stability; R-Stab = right bank stability; T-Stab = bank stability; L-Veg = left bank vegetative protection; R-Veg = right bank vegetative protection; T-Veg = vegetative protection; L-Rip = left bank riparian vegetative zone width; R-Rip = right bank riparian vegetative zone width; T-Rip = riparian vegetative zone width; T-Hab = total habitat score

Return to Page 3

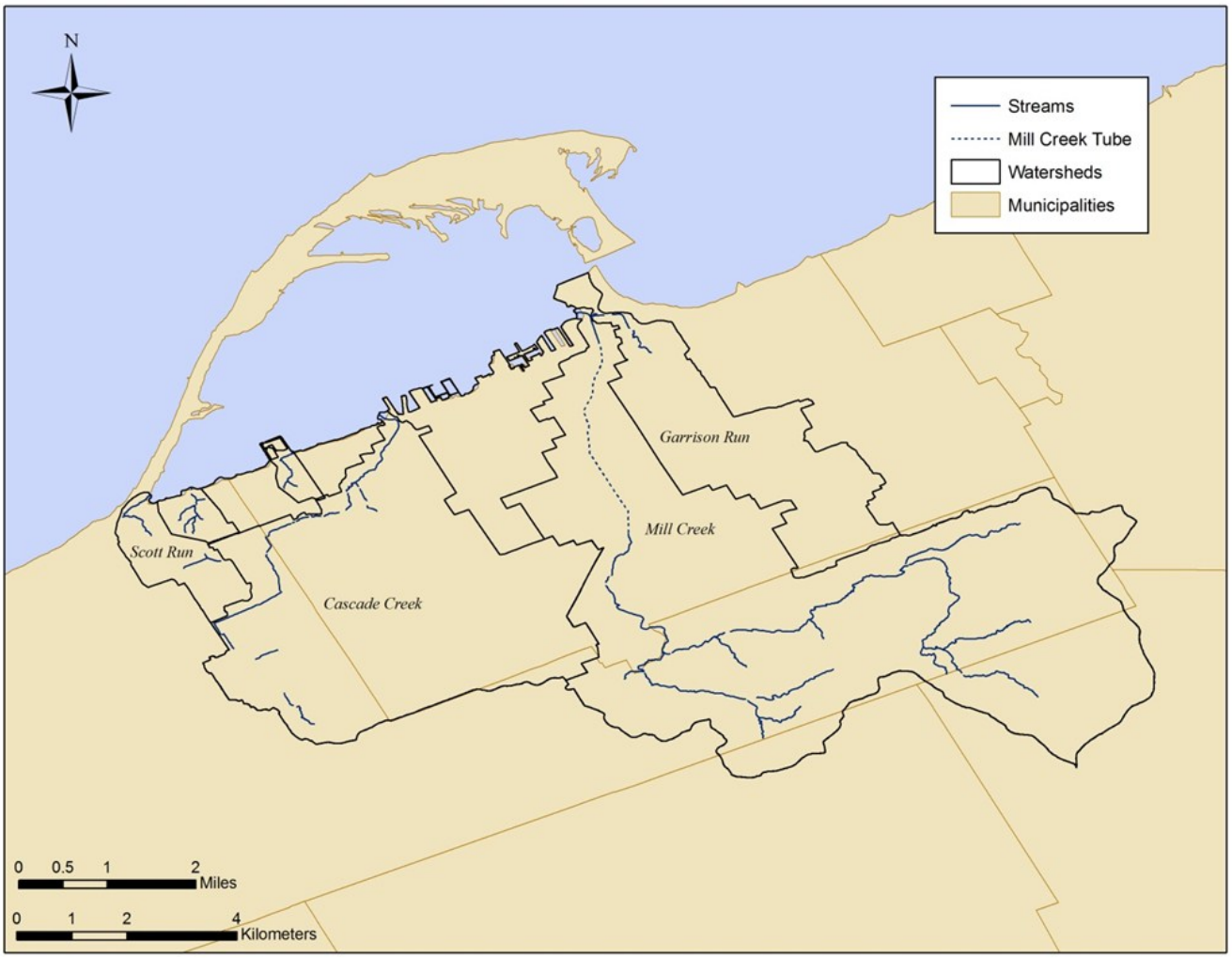
Table 11. Relationship between composite index scores and habitat parameters (2011)

Parameter	Spearman Rank Correlation rho (ρ)	p-value
Epifaunal substrate/available cover	**0.510518158**	**0.025518836**
Embeddedness	0.430677556	0.065654919
Velocity/depth regime	0.43473309	0.062877878
Sediment deposition	0.286417613	0.234511508
Channel flow status	-0.125687571	0.608156443
Channel alteration	-0.042024095	0.864367175
Frequency of riffles	0.19455073	0.424797594
Left bank stability	**0.49247066**	**0.03218766**
Right bank stability	**0.538475033**	**0.017380792**
Bank stability	**0.549778952**	**0.014746388**
Left bank vegetative protection	0.39315063	0.095872066
Right bank vegetative protection	0.352778443	0.138487198
Vegetative protection	0.391165808	0.097711136
Left bank riparian vegetative zone width	0.131258842	0.592215312
Right bank riparian vegetative zone width	0.149438418	0.54145811
Riparian vegetative zone width	0.133774847	0.585073892
Total Habitat	**0.568223812**	**0.011141071**

Return to Page 3

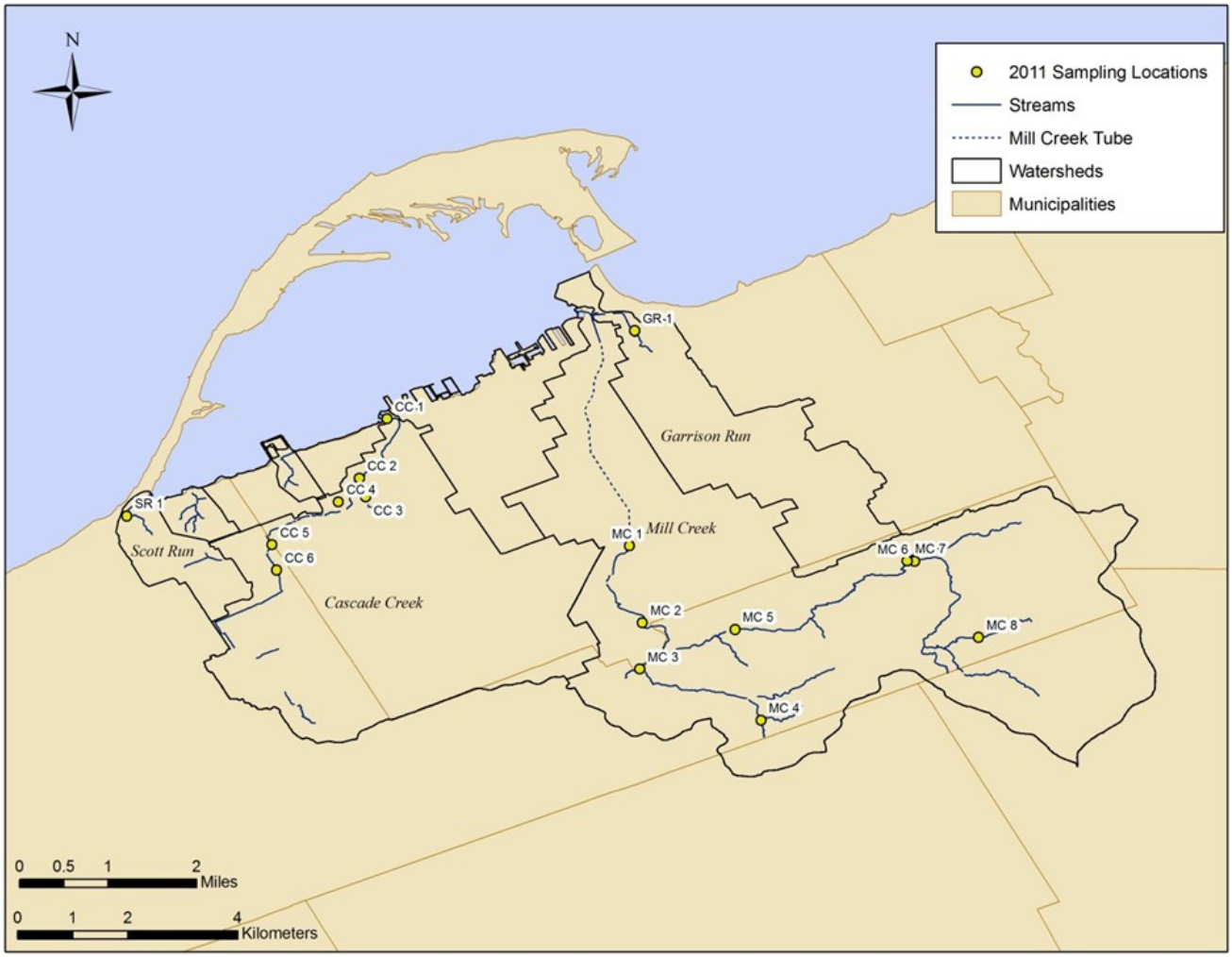
APPENDIX C: MAPS

Map 1: Tributaries of Presque Isle Bay



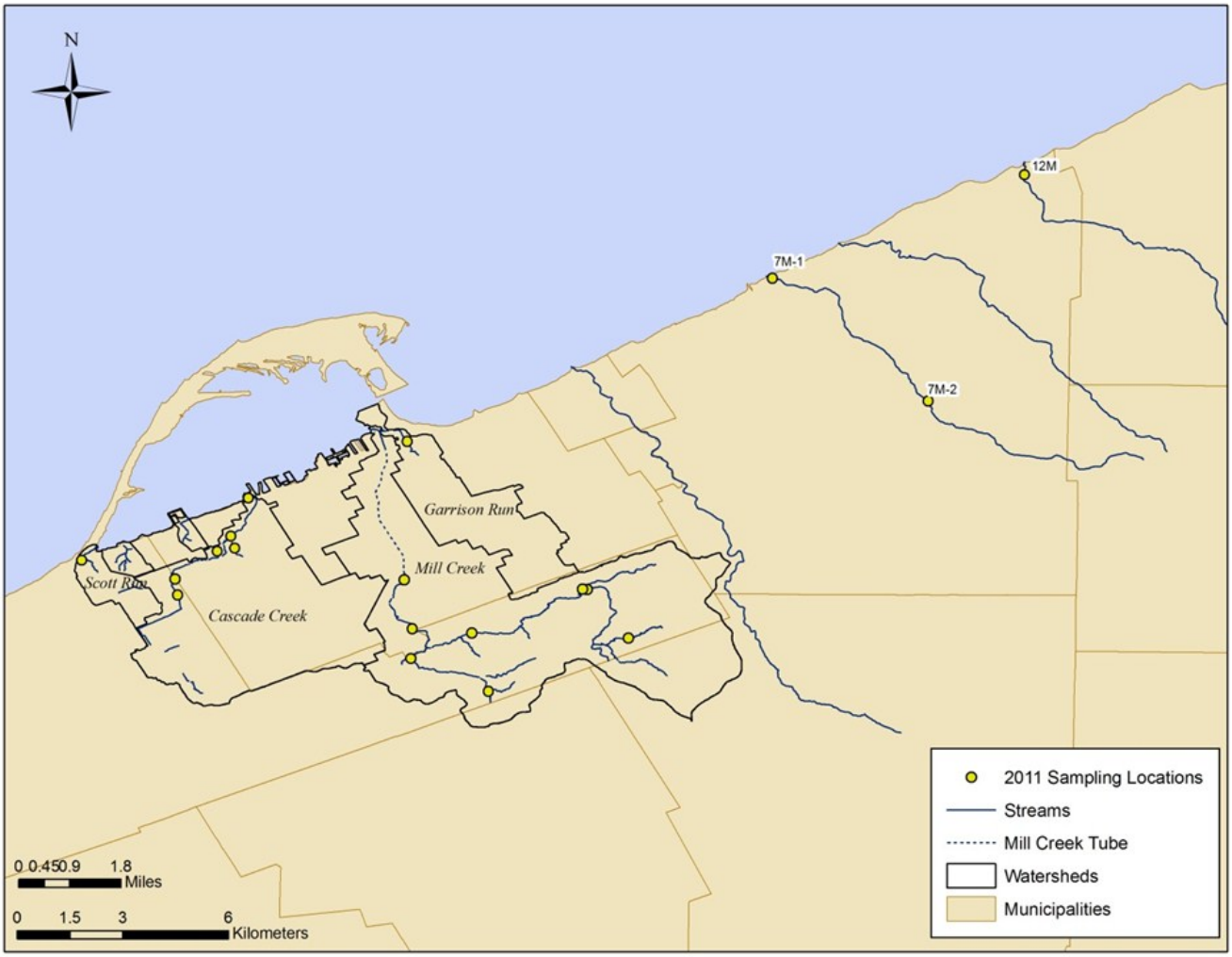
Return to Page 1

Map 2: Presque Isle Bay watershed sampling sites



[Return to Page 2]

Map 3: Reference sampling sites



[Return to Page 2]