MINNEHAHA CREEK WATERSHED DISTRICT
QUALITY OF WATER QUALITY OF LIFE

Memo

To: Board of Managers

From: Kelly Dooley, Yvette Christianson

CC: David Mandt, Craig Dawson

Date: October 9, 2014

Re: 2013 Macroinvertebrate Assessment of Minnehaha Creek and Upper Watershed Streams

The following report is the results of the 2013 macroinvertebrate survey that was completed on Minnehaha Creek, Long Lake Creek, Gleason Creek, Classen Creek, Schutz Creek, Six Mile Creek, and Painters Creek. These were the same sites done by Interfluve, Inc. in 2003.

The report compares the 2003 and 2013 MCWD studies and the 2013 MPCA Assessment of the watershed. Data was also compared to work done by the MN DNR at 4 locations in 2008 and 7 locations done in 2010.

The 2013 results show that urbanization and stream channelization have heavily impacted many of the streams. Six Mile Creek showed the best biological community in the upper watershed streams, though the impact of urbanization is evident. Minnehaha Creek shows fair habitat and diversity near the upper part of the creek with declines in biological community as it flow through Minneapolis.

2013

Macroinvertebrate Assessment

Minnehaha Creek

Upper Watershed Streams

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Report Date:	July 31, 2014
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Subject:	Macroinvertebrate Assessment of Minnehaha Creek and Upper Watershed Streams
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Acknowledgements:	Dr. Leonard C. Ferrington, Jr., University of Minnesota: fieldwork, Chironomidae genus identification and taxon quality control verification Joel Chirhart, Minnesota Pollution Control Agency: IBI calculations

Table of Contents Page

Executive Summary

In 2013, aquatic macroinvertebrates were colleced in Minnehaha Creek from Lake Minnetonka to the Mississippi River, and five tributary streams to Lake Minnetonka (Figures 2-3). These same sites were monitored in 2003. The overall conclusions are very comparable between the 2003 and 2013 MCWD studies and the 2013 MPCA Assessment of the watershed.

The 2013 results show that many of the streams are heavily impacted by urbanization and stream channelization, including Long Lake Creek, Painter Creek, Gleason Creek, and Classen Creek. Long Lake Creek and Painter Creek are listed as impaired by the MPCA (Figure 1). Six Mile Creek showed the best biological community of the Upper Watershed streams, but is still impacted by urbanization.

Minnehaha Creek shows fair habitat and biological community diversity in the first 6 sites after Lake Minnetonka, and as it flows through Minneapolis the biological community declines. This shows the effect of urbanization on the creek and it's biological community. Minnehaha Creek is listed as impaired for chloride, fecal coliform, dissolved oxygen, and macroinvertebrate and fish IBIs (Figure 1).

The combination of degraded habitat and poor water quality have affected the biological community in these streams. Stream restoration projects in these areas could show improvement in the biological community. It is helpful to have these data sets as a "before" condition to any future improvements.

MPCA Assessment 2013

The Minnesota Pollution Control Agency completed the Mississippi River – Twin Cities Watershed Monitoring and Assessment Report in September 2013. The Minnehaha Creek Subwatershed Summary can be found on pages 85-98 (MPCA 2013).

This assessment found Long Lake Creek exceeding impairment standards for macroinvertebrate IBI, Fish IBI and dissolved oxygen. Painter Creek was found to exeed impairment standards for dissolved oxygen in the upper reach and both dissolved oxygen and *E.coli* in the lower reach. For Long Lake Creek, Six Mile Creek, Gleason Creek the aquatic life assessments have been deferred until the adoption of Tiered Aquatic Life Uses due to the stream being predominatnly (>50%) channelized or having biological data limted to a station occurring on a channelized portion of the stream (MPCA 2013).

Schutz Lake Creek was found to meet aquatic life indicator criteria and be fully supporting to aquatic life. Six Mile Creek was found to be fully supporting for aquatic recreation (MPCA 2013).

Minnehaha Creek, from Lake Minnetonka to the Mississippi River, was found to exceed the criteria for macroinvertebrate IBIs with a potential severe impairment. It also has existing impariments for Fish IBI, dissolved oxygen, chloride and bacteria. Minnehaha Creek is listed as non-suporting for aquatic life and aquatic recreation (MPCA 2013).

Non-assessed biological stations on channelized streams included Painter Creek, which was listed as poor for invertebrate IBI and Minnehaha Creek, which was listed as Fair (4) for invertebrate IBI (MPCA 2013).

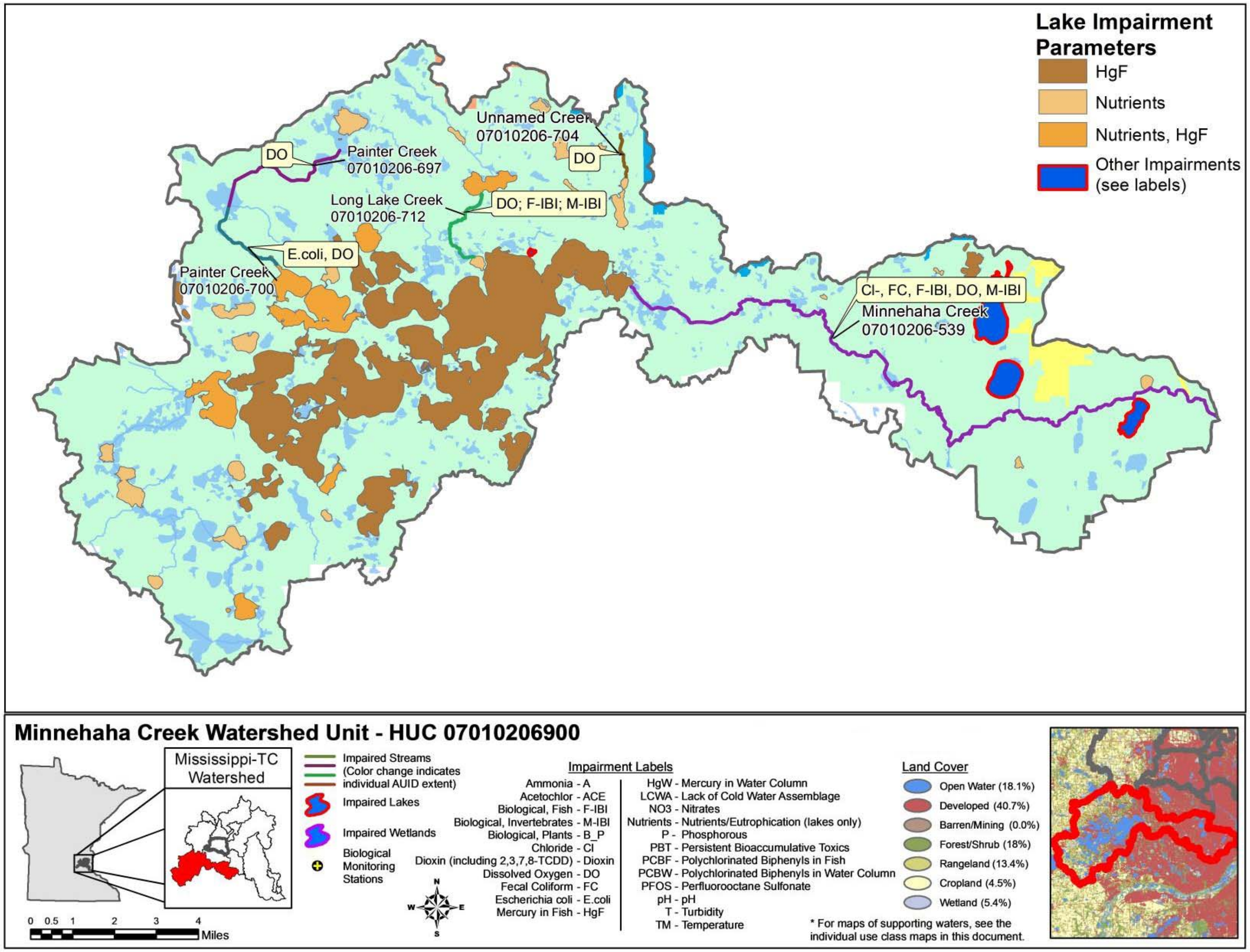

Figure 1. MPCA assessments for the Minnehaha Creek Watershed, 2013. This map was created by the MPCA (MPCA 2013).

Methods

Sample Sites

In 2003, MCWD contracted with Interfluve to conduct macroinvertebrate monitoring in the upper watershed of Lake Minnetonka and Minnehaha Creek. The same sites from the 2003 study were monitored in this study, with a total of 27 sites in the Upper Watershed and 22 sites along Minnehaha Creek (Figures 2-3). The Minnesota Pollution Control Agency has also monitored sites in these watersheds (Figures 2-3).

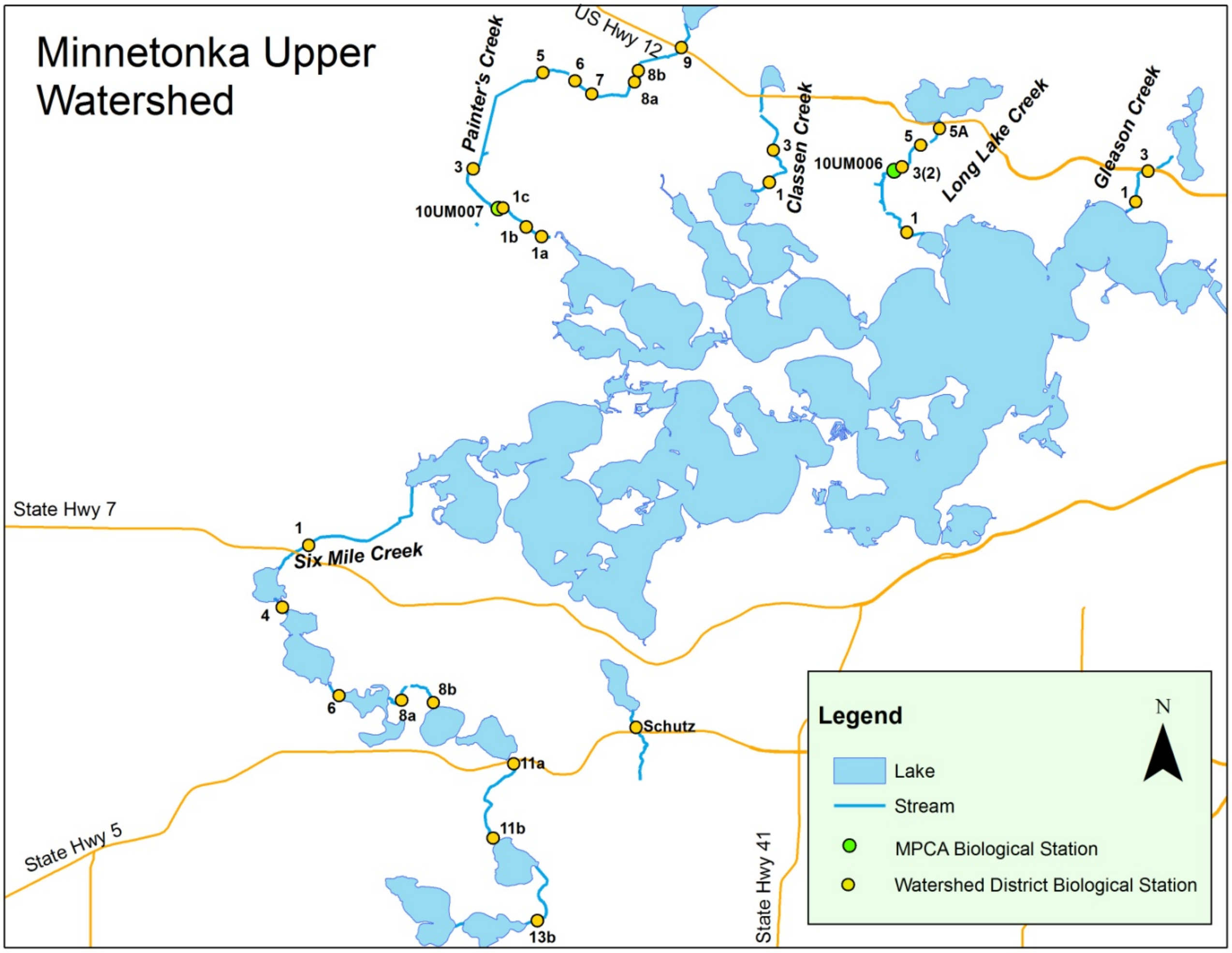

Figure 2. Macroinvertebrate monitoring sites in the Upper Watershed of Lake Minnetonka.

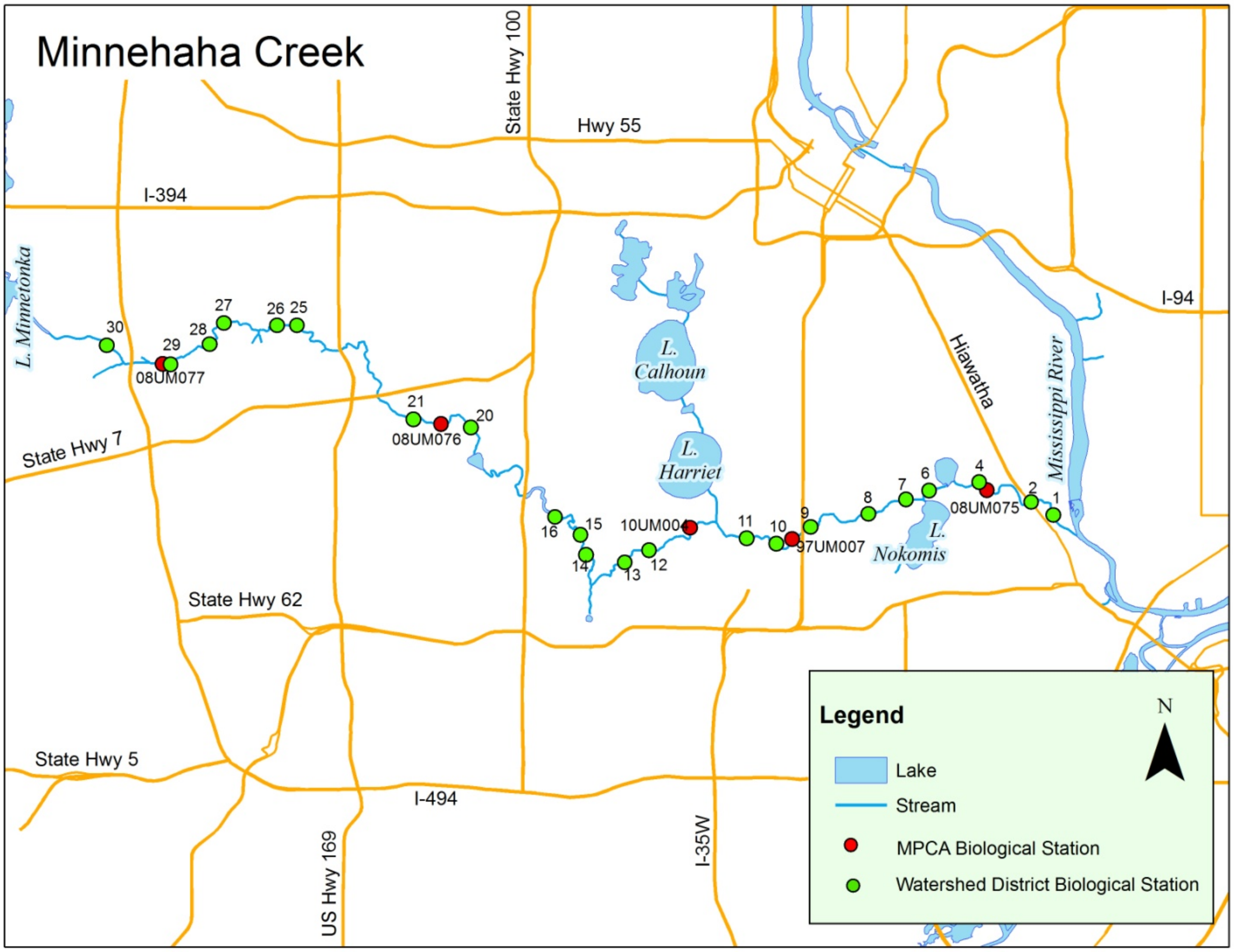

Figure 3. Macroinvertebrate monitoring sites on Minnehaha Creek.

Sample Collection
Aquatic macroinvertebrate samples were collected with a D-frame net following the MPCA's protocols for multi-habitat collection of stream invertebrates (MPCA), which is similar to the USEPA Rapid Bioassessment Protocols for Use in Streams and Rivers (USEPA 1997).

Sample Processing
Macroinvertebrate samples were hand-delivered to RMB Environmental Laboratories (RMBEL) in Detroit Lakes for processing. Taxa were identified to genus where possible and enumerated. The chironomidae family was identified to genus by Dr. Leonard C. Ferrington, Jr. at the University of Minnesota.

Quality control measures as outlined in the scope of work were strictly adhered to. Samples were picked to a 95% efficiency at RMBEL and each identified taxon was verified by Dr. Leonard C. Ferrington, Jr. at the University of Minnesota. RMBEL identifications met a 95% efficiency, and the couple mis-identified taxa were corrected in the results.

Data Management and Assessment
After the quality control, the final data was entered into a Microsoft Excel database. The data were sent to Joel Chirhart at the MPCA to be run through their Index of Biological Integrity (IBI) database developed for the State of

Minnesota. These data were graphed and included in tables in this report. They were also compared to data collected by the MPCA at the same sites.

The 2013 results were also condensed to family level and run through the Family Biotic Index to enable comparison to the 2003 results (Hilsenhoff 1988).

Results

Overall Metrics

Overall, 139 taxa were recorded for this project (Appendix 2). The most taxon rich site was Schutz Creek 1. Six Mile Creek sites had the next highest richness of the Upper Watershed Streams. Painter Creek had the lowest richness of the whole project, with less than 17 total taxa at all sites (Table 1). In Minnehaha Creek, the sites closest to the headwaters (Lake Minnetonka) had the highest taxon richness. All Minnehaha Creek sites but five had taxon richness higher than 22 (Table 2).

Table 1. Richness metrics of Upper Watershed Streams sorted by the most rich to the least rich site.

Site	POET* Richness	Chironomidae Richness	Total Richness
Schutz Creek 1	5	17	45
Six Mile Creek 8B	7	17	34
Six Mile Creek 6	4	13	32
Six Mile Creek 8A	7	9	29
Six Mile Creek 11A	4	14	27
Six Mile Creek 11B	2	17	27
Gleason Creek 3	0	14	26
Painter Creek 9	0	11	26
Six Mile Creek 4	3	12	26
Six Mile Creek 1	3	10	25
Classen Creek 1	2	13	24
Classen Creek 3	1	12	21
Gleason Creek 1	2	7	20
Long Lake Creek 1	1	14	19
Long Lake Creek 3(2)	3	12	19
Long Lake Creek 5	2	10	19
Painter Creek 6	1	9	17
Six Mile Creek 13B	0	10	17
Long Lake Creek 5A	2	8	16
Painter Creek 5	0	8	15
Painter Creek 1A	0	6	12
Painter Creek 1C	0	5	12
Painter Creek 7	3	7	12
Painter Creek 1B	0	5	9
Painter Creek 3	1	1	8
Painter Creek 8B	0	3	8
Painter Creek 8A	0	2	5

**POET = Taxa richness of Plecoptera, Odonata, Ephemeroptera, & Trichoptera (Baetid taxa treated as one taxon)*

Table 2. Richness metrics of Upper Watershed Streams sorted by the most rich to the least rich site.

Site	POET* Richness	Chironomidae Richness	Total Richness
Minnehaha Creek 25	9	13	34
Minnehaha Creek 27	10	8	34
Minnehaha Creek 2	5	10	33
Minnehaha Creek 28	8	10	32
Minnehaha Creek 26	8	5	29
Minnehaha Creek 7	6	9	29
Minnehaha Creek 8	5	13	27
Minnehaha Creek 11	6	9	26
Minnehaha Creek 21	4	9	26
Minnehaha Creek 29	10	8	26
Minnehaha Creek 9	2	10	25
Minnehaha Creek 14	4	7	24
Minnehaha Creek 16	4	9	24
Minnehaha Creek 10	4	6	23
Minnehaha Creek 15	5	8	23
Minnehaha Creek 6	5	7	23
Minnehaha Creek 12	3	6	22
Minnehaha Creek 13	4	6	19
Minnehaha Creek 1	2	7	18
Minnehaha Creek 30	5	7	17
Minnehaha Creek 20	4	7	16
Minnehaha Creek 4	3	6	14

**POET = Taxa richness of Plecoptera, Odonata, Ephemeroptera, & Trichoptera (Baetid taxa treated as one taxon)*

Index of Biological Integrity (IBI)

An IBI is a tool used to identify and classify water pollution problems. An IBI associates anthropogenic influences on a water body with biological health in the water body. It usually runs on a scale from 1-100, with 100 being a pristine habitat and fully functioning ecosystem, and a 1 being a severely impacted and unhealthy ecosystem.

The MPCA developed an IBI database for the State of Minnesota (MPCA 2014). This database takes into account the stream type and location in the state. All the MCWD sites fell under stream classification 5 – Southern Streams Riffle/Run or 6 – Southern Streams Glide/Pool. What determined the site classification is if riffle habitat was present at the site or not (Tables 3-4).

Table 3. Upper Watershed site descriptions and invertebrate class assignments.

Site Name	Invertebrate Class (MPCA)	Site Description
Classen Creek 1	5 - Southern Streams Riffle/Run	riffle/run with gravel and woody debris
Classen Creek 3	6 - Southern Streams Glide/Pool	glide/pool with woody debris and sand
Gleason Lake Creek 1	6 - Southern Streams Glide/Pool	mostly impounded wetland areas, low gradient
Gleason Lake Creek 3	6 - Southern Streams Glide/Pool	mostly impounded wetland areas, low gradient
Long Lake Creek 1	6 - Southern Streams Glide/Pool	lentic backwater of Lake Minnetonka
Long Lake Creek 3(2)	5 - Southern Streams Riffle/Run	riffle/run with cobble and woody debris
Long Lake Creek 5	5 - Southern Streams Riffle/Run	riffle/run with cobble and woody debris
Long Lake Creek 5A	5 - Southern Streams Riffle/Run	riffle/run with cobble and woody debris
Painter Creek 1A	6 - Southern Streams Glide/Pool	low gradient stream with wetlands
Painter Creek 1B	6 - Southern Streams Glide/Pool	low gradient stream with wetlands
Painter Creek 1C	6 - Southern Streams Glide/Pool	low gradient stream with wetlands
Painter Creek 3	6 - Southern Streams Glide/Pool	low gradient stream with wetlands
Painter Creek 5	6 - Southern Streams Glide/Pool	low gradient stream with wetlands
Painter Creek 6	6 - Southern Streams Glide/Pool	low gradient stream with wetlands
Painter Creek 7	6 - Southern Streams Glide/Pool	low gradient stream with wetlands
Painter Creek 8A	6 - Southern Streams Glide/Pool	low gradient stream with wetlands
Painter Creek 8B	6 - Southern Streams Glide/Pool	low gradient stream with wetlands
Painter Creek 9	6 - Southern Streams Glide/Pool	low gradient stream with wetlands
Schutz Creek 1	5 - Southern Streams Riffle/Run	low gradient stream with wetlands
Six Mile Creek 1	6 - Southern Streams Glide/Pool	wetland/marsh areas located between lakes
Six Mile Creek 11A	6 - Southern Streams Glide/Pool	wetland/marsh areas located between lakes
Six Mile Creek 11B	6 - Southern Streams Glide/Pool	wetland/marsh areas located between lakes
Six Mile Creek 13B	6 - Southern Streams Glide/Pool	wetland/marsh areas located between lakes
Six Mile Creek 4	6 - Southern Streams Glide/Pool	wetland/marsh areas located between lakes
Six Mile Creek 6	5 - Southern Streams Riffle/Run	wetland/marsh areas located between lakes
Six Mile Creek 8A	5 - Southern Streams Riffle/Run	wetland/marsh areas located between lakes
Six Mile Creek 8B	6 - Southern Streams Glide/Pool	wetland/marsh areas located between lakes

Table 4. Minnehaha Creek site descriptions and invertebrate class assignments.

Site Name		Invertebrate Class (MPCA)	**Site Description**
Minnehaha Creek	1	5 - Southern Streams Riffle/Run	riffle/run with cobble and gravel
Minnehaha Creek	2	5 - Southern Streams Riffle/Run	riffle/run with cobble, gravel and boulder
Minnehaha Creek	4	5 - Southern Streams Riffle/Run	riffle/run with gravel and sand
Minnehaha Creek	6	6 - Southern Streams Glide/Pool	glide/pool with gravel
Minnehaha Creek	7	6 - Southern Streams Glide/Pool	glide/pool with gravel and cobble
Minnehaha Creek	8	6 - Southern Streams Glide/Pool	glide/pool with gravel and woody substrate
Minnehaha Creek	9	6 - Southern Streams Glide/Pool	glide/pool with cobble and woody substrate
Minnehaha Creek	10	6 - Southern Streams Glide/Pool	glide/pool with cobble and woody substrate
Minnehaha Creek	11	6 - Southern Streams Glide/Pool	glide/pool with cobble and woody substrate
Minnehaha Creek	12	5 - Southern Streams Riffle/Run	riffle/run with cobble and woody substrate
Minnehaha Creek	13	5 - Southern Streams Riffle/Run	riffle/run with boulder and woody substrate
Minnehaha Creek	14	5 - Southern Streams Riffle/Run	riffle/run with boulder and woody substrate
Minnehaha Creek	15	6 - Southern Streams Glide/Pool	glide/pool with gravel and woody substrate
Minnehaha Creek	16	5 - Southern Streams Riffle/Run	riffle/run with cobble and woody substrate
Minnehaha Creek	20	6 - Southern Streams Glide/Pool	glide/pool with gravel and rooted vegetation
Minnehaha Creek	21	5 - Southern Streams Riffle/Run	riffle/run with cobble and woody substrate
Minnehaha Creek	25	6 - Southern Streams Glide/Pool	glide/pool with boulder, wood, and veg.
Minnehaha Creek	26	5 - Southern Streams Riffle/Run	riffle/run with boulder, wood, and veg.
Minnehaha Creek	27	5 - Southern Streams Riffle/Run	riffle/run with boulder, wood and veg.
Minnehaha Creek	28	6 - Southern Streams Glide/Pool	glide/pool with cobble, wood and veg.
Minnehaha Creek	29	5 - Southern Streams Riffle/Run	riffle/run with boulder, wood and veg.
Minnehaha Creek	30	6 - Southern Streams Glide/Pool	glide/pool with gravel, wood and veg.

In the Upper Watershed Streams, IBIs were highest in Six Mile Creek and lowest in Painter Creek (Figure 3). For Minnehaha Creek, IBIs were generally higher upstream (near Lake Minnetonka) and lower downstream (near the Mississippi River). There was a significant declining trend in IBIs from upstream to downstream sites (Figure 4). The trend was determined using Mann Kendall Trend Statistic.

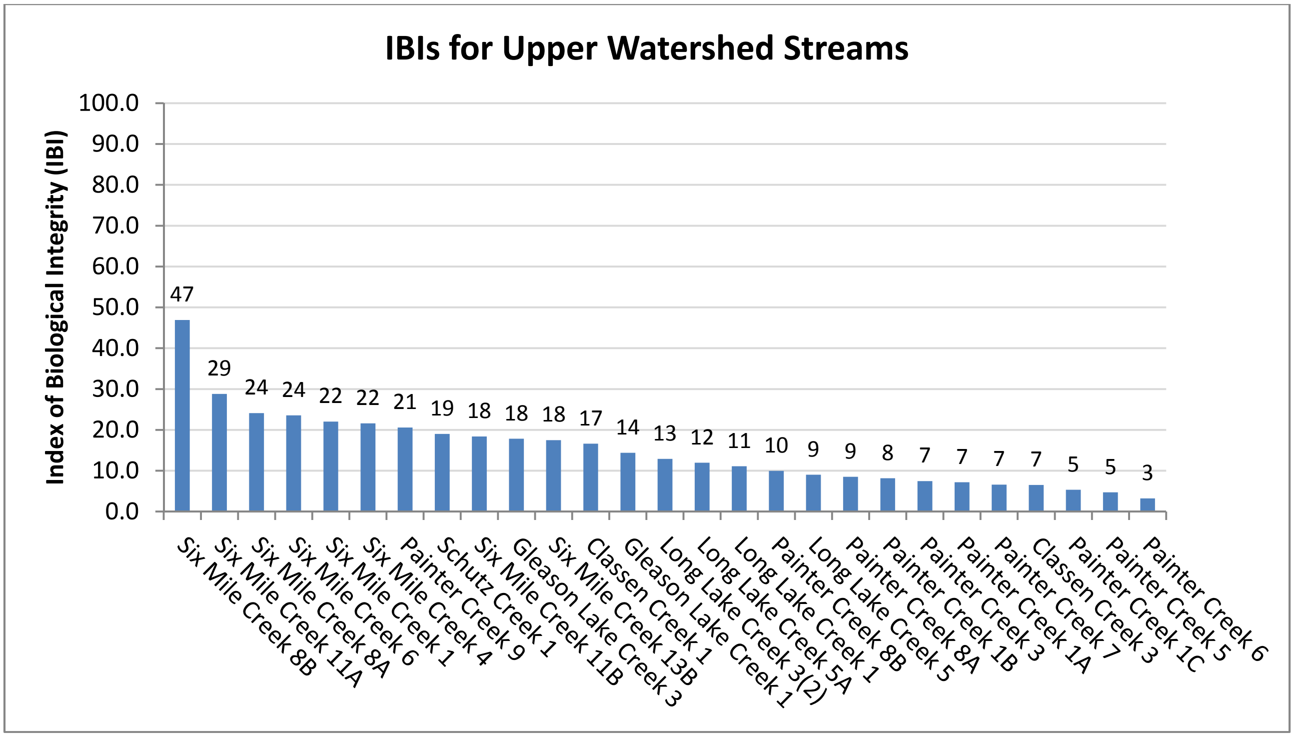

Figure 4. IBIs for Upper Watershed Streams ranked in order from highest to lowest IBI.

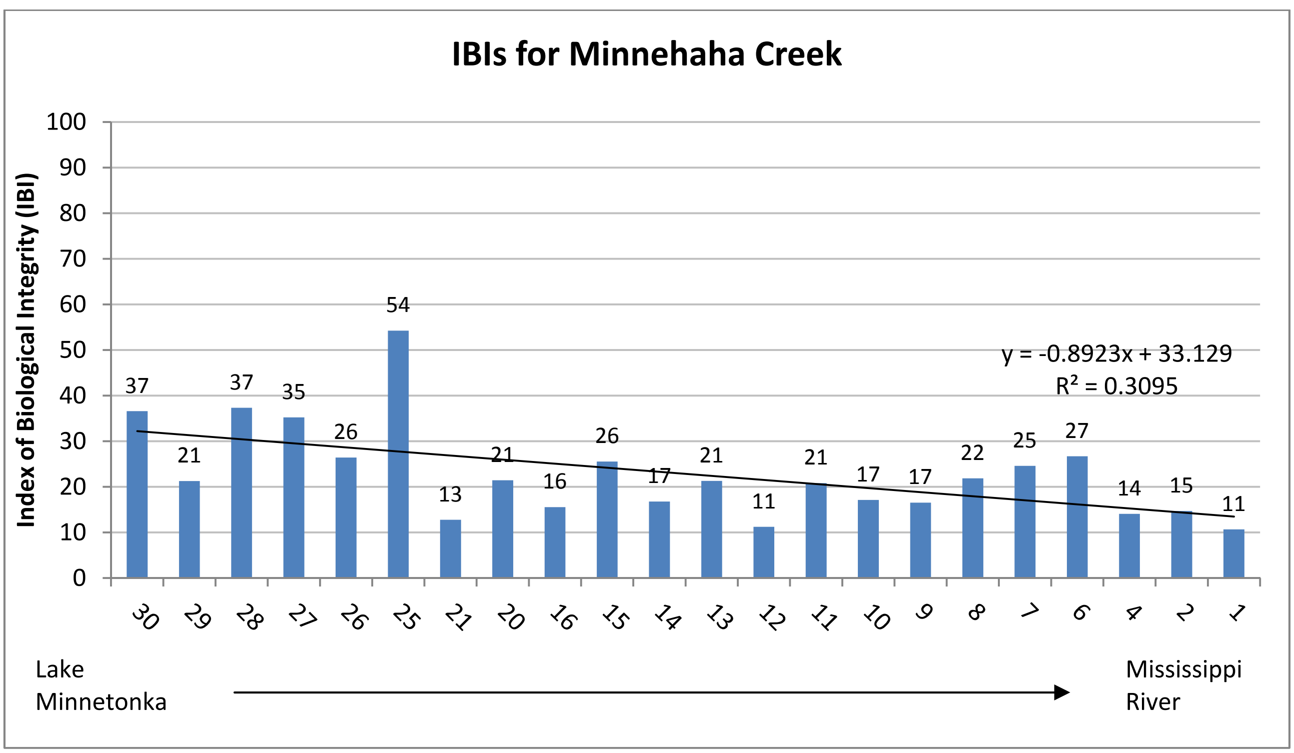

Figure 5. IBIs for Minnehaha Creek in order from the headwaters at Lake Minnetonka to the Mississippi River. There is a significant declining trend (95% probability).

Tiered Aquatic Life Uses

The MPCA has developed new standards for biological assessment of streams in Minnesota (Table 5) (MPCA 2014). These standards help apply the IBIs to understand the stream health better and compare it to what it was before human influence.

The results from this study were compared to the different use categories. The Modified Use category was developed for streams that have been channelized and altered so that the habitat is unable to support a full biological community. When properly managed (i.e. maintaining buffers, etc), these sites should strive to meet the Modified Use goal (MPCA 2014).

In this study, most of the Upper Watershed sites and about half of the Minnehaha Creek sites did not meet the Modified Use IBI goal. Some sites in Six Mile Creek and the Minnehaha Creek sites near Lake Minnetonka met the Modified Use goal (Figures 6-9).

Table 5. Tiered Aquatic Life Uses as determined by the MCPA (MPCA 2014).

Use Category	**Description**
Exceptional Use	Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance; ecosystem level functions fully maintained.
General Use	Overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes.
Modified Use	Sensitive taxa markedly diminished; conspicuously unbalanced distribution of major taxonomic groups; ecosystem function shows reduced complexity and redundancy.

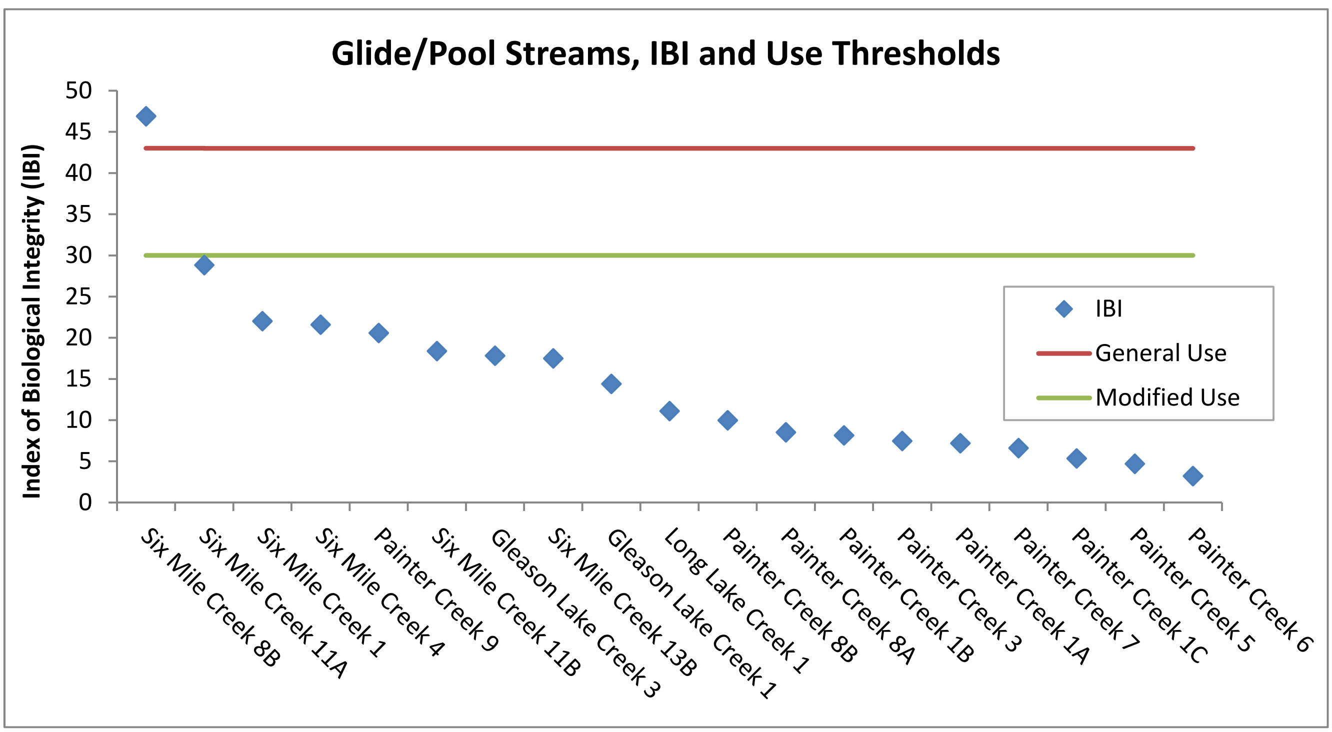

Figure 6.Upper Watershed Stream IBIs compared to the MPCA's Use Thresholds in glide/pool habitats.

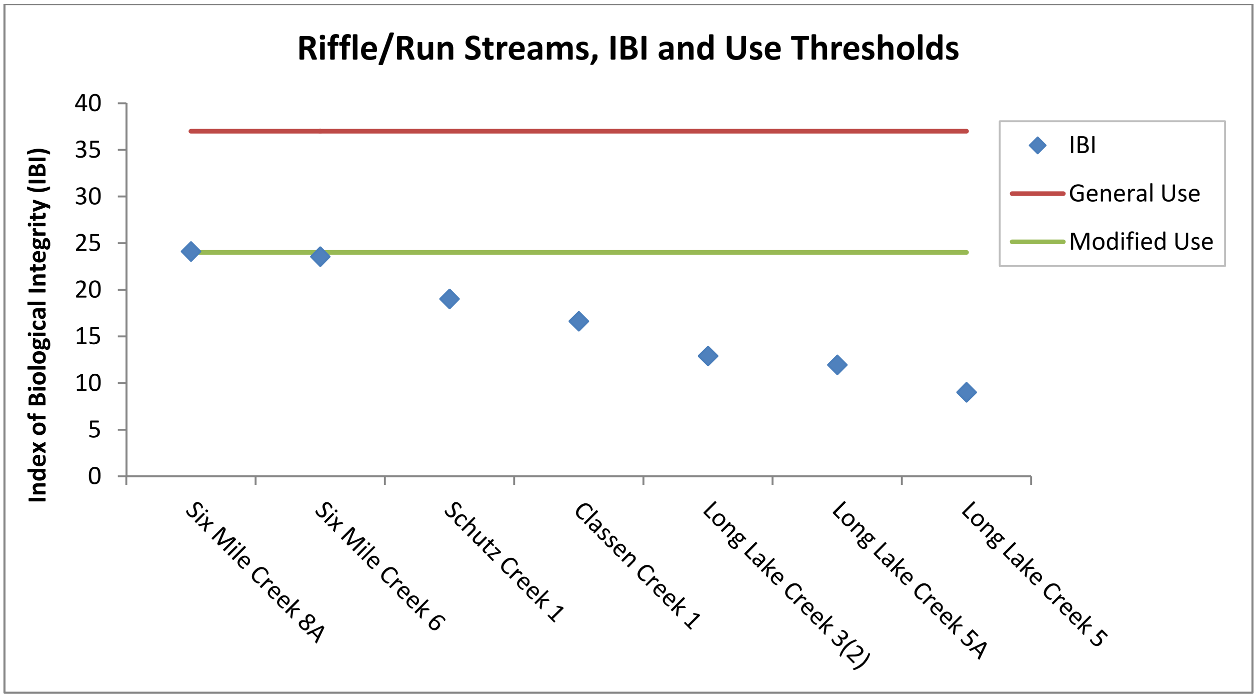

Figure 7.Upper Watershed Stream IBIs compared to the MPCA's Use Thresholds in riffle/run habitats.

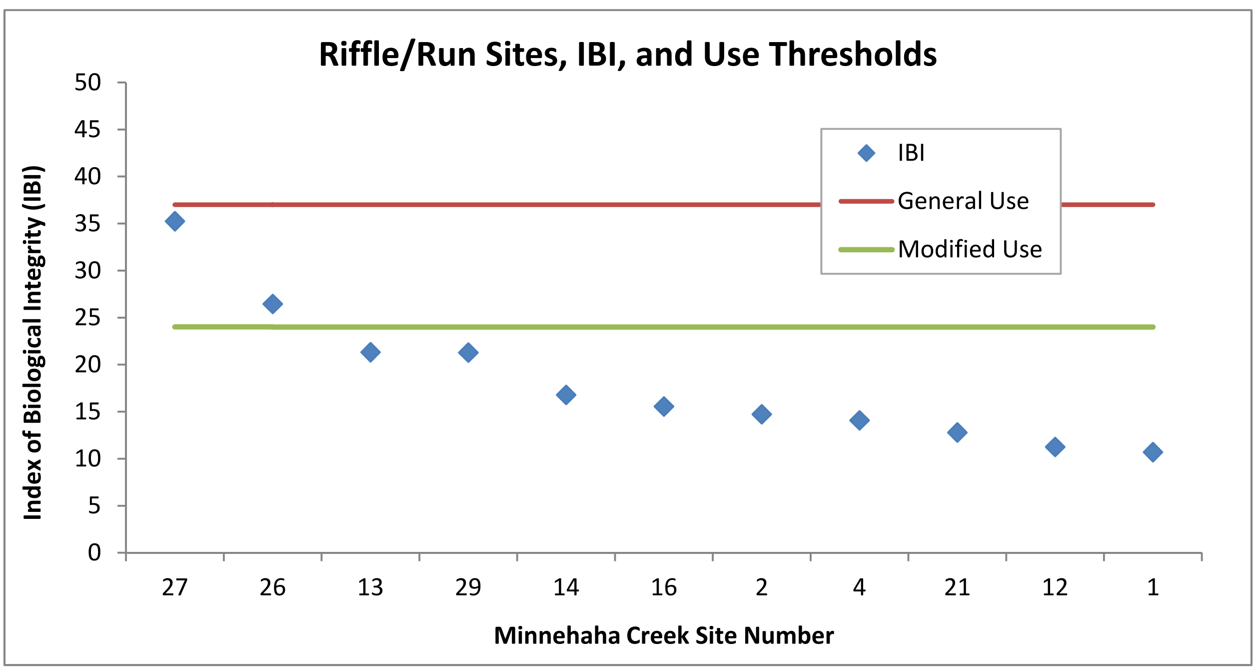

Figure 8. IBIs for Minnehaha Creek compared to the MPCA's Use Thresholds in riffle/run habitats.

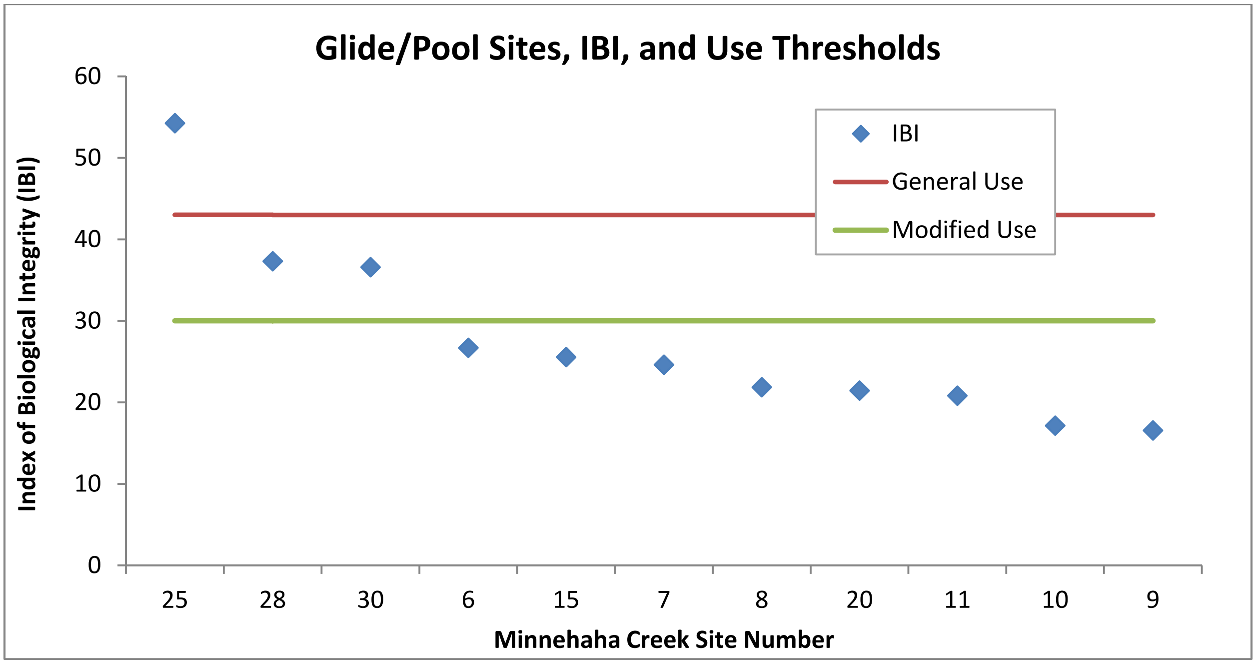

Figure 9. IBIs for Minnehaha Creek compared to the MPCA's Use Thresholds in glide/pool habitats.

Comparison to MPCA Results

The MPCA has monitored some of the same sites as the MCWD and have found similar results for the most part. They have listed these streams as >50% channelized, which affects the biological community. The Long Lake Creek site and some of the Minnehaha Creek sites have lower IBIs in this study than in the MPCA study. One factor that could have impacted the difference was that the summer of 2013 had very high water, and could have affected the biological community.

Table 6. Comparison of MPCA biological monitoring results to the MCWD biological monitoring results.

	MPCA Biological Station ID	**MCWD 2013 IBI**	**MPCA 2010 IBI**	**MPCA 2008 IBI**
Painter Creek	10UM006	5	8	
Long Lake Creek	10UM007	13	41	
Minnehaha Creek	08UM077	21	37	22
Minnehaha Creek	08UM076	21	43	67
Minnehaha Creek	10UM004	21	26	
Minnehaha Creek	97UM007	17	25	22
Minnehaha Creek	08UM075	14	34	36

Invasive Species

Lake Minnetonka is on the MNDNR Infested Waters List as infested for Zebra mussels. Zebra mussels were found at Minnehaha Creek sites 27 and 29. No Zebra mussels were found in the Upper Watershed stream sites.

Discussion

Overall, the majority of the sites monitored in this study had low IBIs and poor habitat conditions. The depressed macroinvertebrate community appears to be due to the lack of habitat variety at these sites and some water quality issues such as low dissolved oxygen. The MPCA lists these sites as heavily channelized and impacted by development, and the macroinvertebrate community reflects this impact. When goal-setting for future water quality, the Modified Use Goal (Table 5) could be considered as a goal for management.

Painter Creek

Painter Creek is listed as impaired by the MPCA for dissolved oxygen and *E.coli* (Figure 1). Painter Creek showed the most impacted biological community, with an IBI ranging from 3-10 out of 100. It also had the lowest taxon richness, ranging from 5-17 taxa. Only three of the Painter Creek sites showed any POET taxa (Plecoptera, Odonata, Ephemeroptera, Trichoptera), which also can indicate poor water quality. Oligochaeta worms and *Chironomus* bloodworms dominated the community in Painter Creek, which shows that these sites have a lot of soft sediment, potential low dissolved oxygen, and low habitat quality. At Painter Creek site 3, only 15 macroinvertebrate specimens were collected in total, including Oligochaeta worms, *Physa* snails, *Pshychoda* flies and Chironomidae flies. Sites 8A and 8B smelled of hydrogen sulfide and possible waste treatment issues, and site 8B had sewage fungus growths on woody substrates. These sites should be tested for *E.coli* to see if there is a waste treatment problem in that area. Painter Creek is listed as impaired for *E.coli* further down in the stream, but not currently in the upper reaches that contain sites 8A and 8B.

Gleason Creek

Gleason Creek is a low gradient stream that runs through various wetlands. The IBIs for Gleason Creek ranged from 14-17 out of 100, which is considered quite low. Both sites on Gleason Creek were highly impacted by urbanization. Water quality and habitat quality could both play a role in the resulting biological community.

Gleason Lake Creek site 1 was 64% Oligochaeta worms, and the POET taxa found were *Caenis* and *Enallagma*, which have relatively high tolerances to urban pollution. *Physa* snails were also common in both Gleason Creek sites, which can be indicators of poor water quality (Barbour 1999).

Classen Creek

Classen Creek has more complex habitat than some of the other streams, with riffles present. The abundance of *Simulium* black flies indicates fast-flowing water. *Polypedilum* chironomids were also common, which are classified in the shredder functional feeding group. The presence of shredders indicates that there is leaf matter present. Baetid mayflies were present at both sites, which have a relatively low tolerance to pollution (tolerance value = 4) (Barbour 1999).

Despite the presence of these taxa, Classen Creek had relatively low IBI scores (17, 7). This could be because this site runs dry in the summer months, which doesn't exactly fit the specifications the MPCA developed the IBIs for.

Long Lake Creek

The MPCA found Long Lake Creek exceeding impairment standards for macroinvertebrate IBI, Fish IBI and dissolved oxygen (Figure 1). The results from this study agreed with the MPCA's findings. All sites show low IBI scores ranging from 9-13 (Figure 4).

Site 1 is a lentic backwater of Lake Minnetonka and was dominated by Oligochaeta worms (38% of the community) and *Chironomus* blood worms (23% of the community), which shows low dissolved oxygen and low flow conditions. Site 3(2) was dominated by black flies, which indicate faster flowing water. The Long Lake Creek sites did have some POET taxa, but they were mainly *Caenis* and *Enallagma*, which have higher tolerance scores (7 and 9 out of 10, respectively) (Barbour 1999). Sites 5 and 5A had large sponge populations in the stream, which can be a clean water indicator.

Six Mile Creek

Six Mile Creek was found by the MPCA to be fully supporting for aquatic recreation (MPCA 2013). All the sites sampled on Six Mile Creek were within wetland/marsh areas located between lakes. Six Mile Creek showed the best biological community of any of the upper watershed streams. The taxon richness ranged from 17 to 34 taxa. Sites 6, 8A, 8B, 11A and 11B showed good overall diversity and good POET diversity. Hydropsychid, Hydroptilid and three different genera of Leptocerid caddisflies were found. Site 6 had Corydalidae present, which are very intolerant to pollution (tolerance value = 0) (Barbour 1999).

Six Mile Creek site 8B met the General Use IBI goal and 8A met the Modified Use IBI goal (Figures 6-7). Sites 11A and 6 were just below the Modified Use IBI goal, and could be focused on to bring up to the Modified Use goal (Figures 6-7).

Six Mile Creek site 13B had the lowest results within Six Mile Creek, with no POET taxa, a taxon richness of 17. This site is the most impacted along the creek. The community at this site was dominated by *Simulium* black flies and *Rheotanytarsus* midges, which indicate fast flowing water. The rest of the community was not diverse; however, with Oligochaeta worms and *Physa* snails.

Schutz Lake Creek

Schutz Lake Creek was found by the MPCA to meet aquatic life indicator criteria and be fully supporting to aquatic life (MPCA 2013). Just one site was monitored on Schutz Lake Creek in this study. This site has high habitat diversity and is forested. It also had the highest taxon richness (45) of all the sites in this study. The IBI (19) was low; however, and much of the diversity was in pollution tolerant taxa including Oligochaeta, Amphipoda, *Physa* snails, and Sphaeridae clams. Some pollution intolerant taxa were also present including Baetidae mayflies, Hydropsychidae caddisflies and Tipulidae flies. A second year of monitoring data would help understand this site better.

Minnehaha Creek

Minnehaha Creek has a relatively fair biological community at its headwaters, with 5 of the first 6 sites meeting the Modified Use IBI goal of 24 for riffle/run habitats. These sites also had high POET richness, ranging from 8-10 taxa. Notable POET taxa included numerous caddisfly genera of Hydropsychidae, Hydroptilidae, Leptoceridae, and mayfly genera of Baetidae and Heptageniidae. Minnehaha Creek site 26 had three Stonefly specimens (Perlidae, *Agnetina*) present, which are excellent water quality indicators. Stoneflies need cold, well-oxygenated water to thrive. There were also Tipulidae crane flies at site 26, which have a tolerance value of 3.

Minnehaha Creek site 25 scored the best IBI of all sites in this study. It contained 2 genera of Hydroptilidae caddisflies, 2 genera of Leptoceridae caddisflies, Tipulidae crane flies, and Heptageniidae mayflies.

Downstream, Minnehaha Creek becomes more urbanized, and the biological community reflects that. There was a significant declining trend in IBI scores from the headwaters of Lake Minnetonka to the pour point of the Mississippi River (Figure 5). Sites 1 and 4 have the lowest taxon richness, 18 and 14 respectively. They also had the lowest IBIs, 11 and 14, respectively.

Minnehaha Creek is listed as impaired by the MPCA for macroinvertebrate IBI, fish IBI, dissolved oxygen, chloride and bacteria. Minnehaha Creek is listed as non-suporting for aquatic life and aquatic recreation (MPCA 2013).

Comparison to the 2003 Data

In 2013, all the collected macroinvertebrates were identified to genus when possible, which is a higher taxonomic resolution than the study in 2003. This higher taxonomic resolution enables the comparison with the MPCA's IBI and TALU (Figures 4-9, Table 6).

In 2003, the same sites in the Upper Watershed streams and Minnehaha Creek were biologically assessed, and the Family Biotic Index (FBI) was calculated to compare sites and their water quality (Hilsenhoff 1988) (Table 7). The FBI has some limitations, as the identifications remain at the family level. In addition, the FBI calculation does not include some non-insect macroinvertebrates that can be indicators of organic pollution. Most notably, Oligochaeta worms (tolerance value = 8) and Physa snails (tolerance value = 8) are absent from the FBI calculation. In addition, the FBI gives all Chironomidae a tolerance value of 6, when many of the Chironomini tribe should be 8-9. Hilsenhoff found that the FBI usually indicates less pollution in polluted streams by underestimating the biotic index value (Hilsenhoff 1988).

Table 7. Water quality thresholds for FBI values (Hilsenhoff 1988).

Family Biotic Index Value	Water Quality
0.00 – 3.75	Excellent
3.76 – 4.25	Very Good
4.26 – 5.00	Good
5.01 – 5.75	Fair
5.76 – 6.50	Fairly Poor
6.51 – 7.25	Poor
7.26 – 10.00	Very Poor

The 2013 data were condensed to family level to calculate a Family Biotic Index to compare with the 2003 data. The results were very comparable, with the exception of just a few sites (Figures 10-11). In 2013 the range of FBI values for the Upper Watershed streams was 4.75-7.00, but the median was 6.00, which means most streams were in the Fairly Poor water quality range. Painter Creek had two sites in the Poor Range (site 3 and 9).

In the Upper Watershed streams, the FBI calculations between 2003 and 2013 were nearly identical for most sites (Figure 9). The site that varied the most was Gleason Creek. In 2003 there were not many specimens or taxa found in Gleason Creek and the calculated FBI was 6.89. In 2013, the calculated FBI was 4.75, but this is most likely artificially low. In 2013, 64% of the Gleason Creek site 1 sample was Oligochaeta worms, and they are not included in the FBI calculation. Oligochaeta worms have a tolerance value of 8 (with 10 being most tolerant to pollution). Therefore, the FBI from 2003 was probably more representative to water quality conditions in Gleason Creek (FBI=6.89, Poor).

In 2003, the Classen Creek FBI was 4.89 and in 2013, the FBI was 5.99. Baetid mayflies were found in both 2003 and 2013, which have a low tolerance value of 4. The main difference seems to be that Limniphilidae caddisflies were found in 2003 and not in 2013, which is why the 2003 FBI is lower.

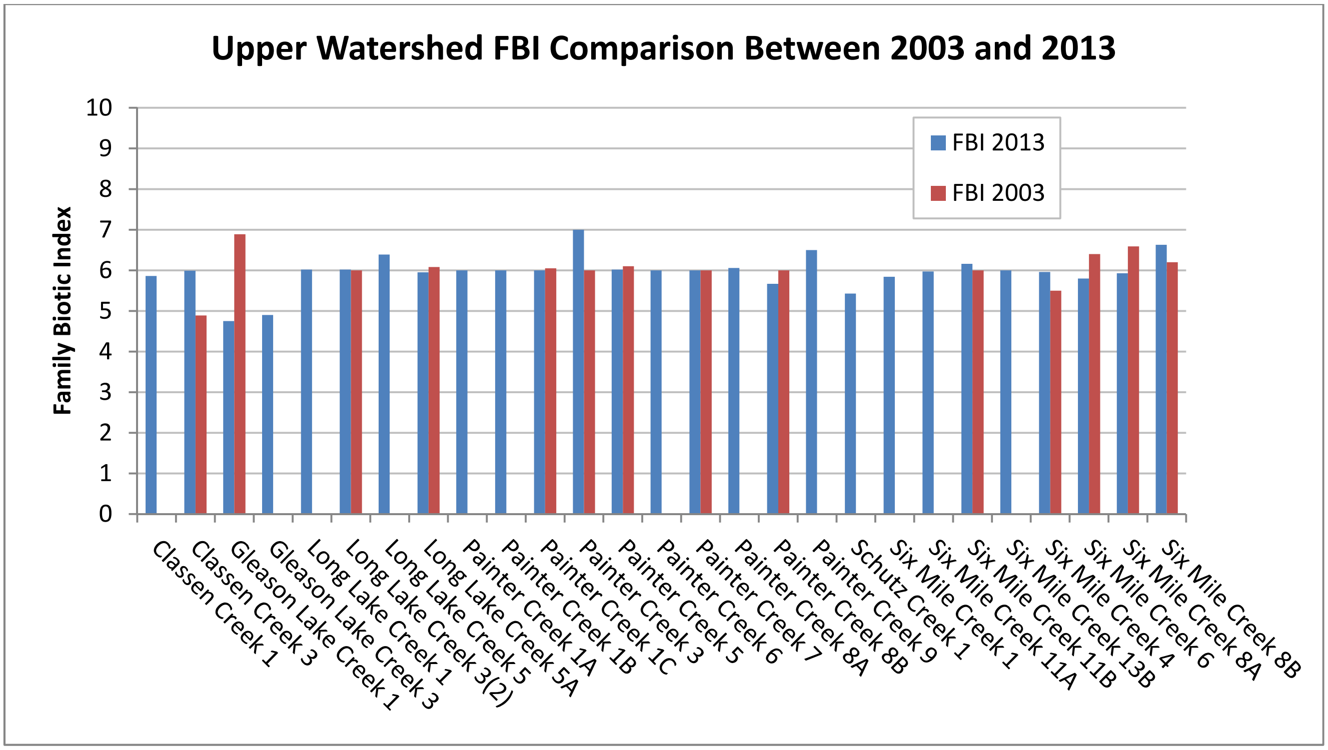

Figure 10. Family Biotic Index (FBI) comparison between 2003 and 2013 for Upper Watershed Streams.

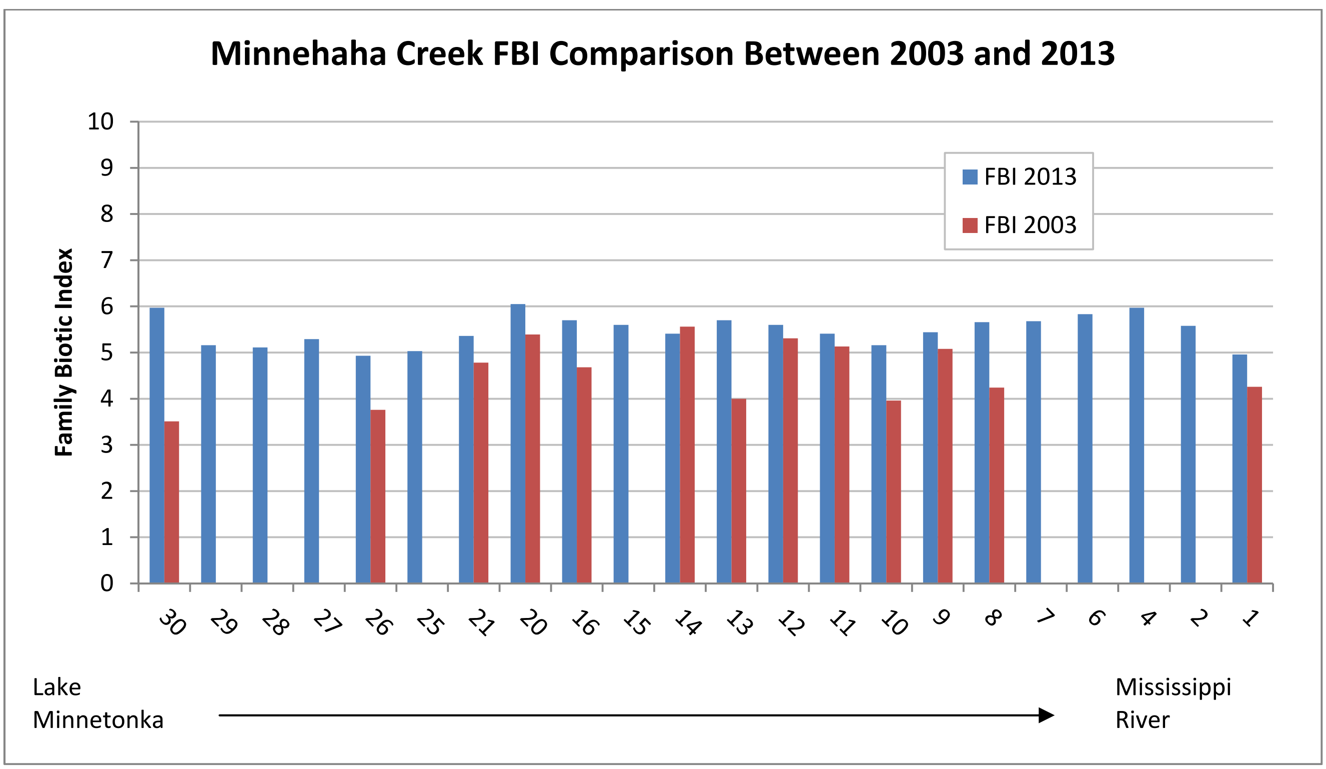

Figure 11. Family Biotic Index (FBI) comparison between 2003 and 2013 for Minnehaha Creek.

In 2013 the range of FBI values for the Minnehaha Creek sites was 4.93-6.05, with a median of 5.51, which means most streams were in the Fair to Fairly Poor water quality range. In Minnehaha Creek, the FBIs were fairly similar between 2003 and 2013 (Figure 10). The two sites that differed by more than 1.7 points were sites 13 and 30. The difference with site 13 can be explained by the presence of Hydropsychidae caddisflies in 2003 but not in 2013. Hydropsychidae caddiesflies have a tolerance value of 4, which brings down the overall average in 2003. The difference at site 30 can be explained by the dominance of Amphipods in 2003. In 2013 there were a greater variety of species; therefore, the FBI from 2013 is more representative of the site (FBI=5.97, Fairly Poor).

Future Project Ideas

Because of the year-to-year differences of the weather, precipitation, water body use, flooding, temperature, water levels, etc., it is helpful to have more than one year of monitoring results when fully understanding a stream's water quality, habitat quality and resulting macroinvertebrate community. Therefore, one more year of data is recommended at these sites before any restoration projects occur. It would be most useful if this data were collected within the next two years, so it is close in time with the 2013 results.

In this project, the Upper Watershed Streams were considered somewhat separately than the Minnehaha Creek sites. Therefore, they wouldn't all need to be monitored in the same year. Upper Watershed streams could be monitored this year or next year, and the Minnehaha Creek sites could be monitored the year after. Comparisons between similar sites, for example in Minnehaha Creek, should all occur in the same year, so it is not recommended to split the Minnehaha Creek sites between different years. Each Upper Watershed stream could be separated as well, as they are not compared to each other, just within streams.

Stream habitat restoration projects could be considered for most of these streams. In addition to restoring varied habitat, any water quality issues must also be identified and fixed. Low dissolved oxygen is one of the water quality parameters that can affect the macroinvertebrate community the most, and many of these stream reaches are impaired for dissolved oxygen. Re-testing the macroinvertebrate community a couple years after a stream restoration project would be a great way to measure the effectiveness of the restoration and quality of the habitat.

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Appendix 1: Hilsenhoff Family Biotic Index (FBI)

The FBI is calculated by multiplying the number in each family by the tolerance value for that family (Table X), summing the products, and dividing by the total arthropods in the sample (Hilsenhoff 1988).

Table 1. Tolerance values for families of stream arthropods in the western Great Lakes region (Hilsenhoff 1988).

Order	Family	Tolerance Value
Plecoptera	Perlidae	1
Ephemeroptera	Baetidae	4
	Caenidae	7
	Heptageniidae	4
	Leptophyphidae	4
Odonata	Aeshnidae	3
	Calopterygidae	5
	Coenagrionidae	9
	Libelluidae	9
Trichoptera	Hydropsychidae	4
	Hydroptilidae	4
	Leptoceridae	4
Megaloptera	Corydalidae	0
Lepidoptera	Pyralidae	5
Coleoptera	Elmidae	4
Diptera	Ceratopogonidae	6
	Chironomini	8
	Chironomidae (other)	6
	Empididae	6
	Psychodidae	10
	Simuliidae	6
	Tabanidae	6
	Tipulidae	3
Amphipoda	Gammaridae	4
Isopoda	Asellidae	8

Hilsenhoff, William L. 1988. Rapid Field Asessment of Organic Pollution with a Family-Level Biotic Index. Journal of the North American Benthological Society, Vol. 7, No. 1, pp. 65-68.

Appendix 1: Project Taxon List

	Taxon	Family	Genus	Species
1	**Amphipoda**			
2	**Bivalvia**	**Sphaeridae**	*Musculium*	
3			*Pisidium*	
4			*Sphaerium*	
5	**Coleoptera**	**Dytiscidae**	*Agabinus*	
6		**Elmidae**	*Dubiraphia*	
7			*Stenelmis*	
8		**Hydraenidae**	*Hydraena*	
9		**Hydrophilidae**	*Cymbiodyta*	
10			*Enochrus*	
11			*Hydrobius*	
12			*Paracymus*	
13	**Collembola**			
14	**Decapoda**	**Cambaridae**		
15	**Diptera**	**Ceratopogonidae**	*Bezzia/Palpomyia*	
16		**Chironomidae**	*Ablabesmyia*	
17			*Acricotopus*	
18			*Apedilum*	
19			*Brillia*	
20			*Cardiocladius*	
21			*Chironomus*	
22			*Cladopelma*	
23			*Cladotanytarsus*	
24			*Conch/Thien*	
25			*Corynoneura*	
26			*Cricotopus*	
27			*Cryptochironomus*	
28			*Dicrotendipes*	
29			*Endochironomus*	
30			*Eukiefferiella*	
31			*Glyptotendipes*	
32			*Goeldichironomus*	
33			*Guttipelopia*	
34			*Labrundinia*	
35			*Larsia*	
36			*Limnophyes*	
37			*Micropsectra*	
38			*Microtendipes*	
39			*Nanocladius*	
40			*Nilotanypus*	
41			*Parachironomus*	
42			*Paracladopelma*	
43			*Parakiefferiella*	
44			*Paralauterborniella*	
45			*Parametriocnemus*	
46			*Paraphaenocladius*	
47			*Paratanytarsus*	
48			*Paratendipes*	
49			*Phaenopsectra*	
50			*Polypedilum*	
51			*Procladius*	
52			*Psectrocladius*	
53			*Pseudochironomus*	
54			*Rheotanytarsus*	
55			*Saetheria*	
56			*Stenochironomus*	
57			*Stictochironomus*	

	Taxon	Family	Genus	Species
58			*Tanypus*	
59			*Tanytarsus*	
60			*Thienemanniella*	
61			*Tvetenia*	
62			*Xenochironomus*	
63			*Zavreliella*	
64		**Culicidae**	*Aedes*	
65			*Psorophora*	
66		**Empididae**	*Hemerodromia*	
67		**Psychodidae**	*Psychoda*	
68		**Sciaridae**		
69		**Simuliidae**	*Simulium*	
70		**Stratiomyidae**	*Caloparyphus*	
71			*Odontomyia*	
72		**Tabanidae**	*Tabanus/Atylotus*	
73		**Tipulidae**	*Dicranota*	
74			*Tipula*	
75	**Ephemeroptera**	**Baetidae**	*Acentrella*	*parvula*
76			*Acentrella*	*sp.*
77			*Acerpenna*	
78			*Baetis*	
79			*Pseudocloeon*	
80		**Caenidae**	*Caenis*	
81		**Heptageniidae**	*Leucrocuta/Ecdyonurus*	
82			*Stenacron*	
83			*Stenonema*	
84		**Leptohyphidae**	*Tricorythodes*	
85	**Gastropoda**	**Ancylidae**		
86		**Dreissenidae**	*Dreissena*	*polymorpha*
87		**Hydrobiidae**	*Amnicola*	
88		**Lymnaidae**	*Lymnea*	
89			*Stagnicola*	
90		**Physidae**	*Aplexa*	
91			*Physa*	
92		**Planorbidae**	*Armiger*	
93			*Gyraulus*	
94			*Helisoma*	
95			*planorbella*	
96			*Promenentus*	
97	**Hemiptera**	**Belostomatidae**	*Belostoma*	
98		**Corixidae**	*Hesperocorixa*	
99			*Neocorixa*	
100			*Trichocorixa*	
101		**Gerridae**	*Metrobates*	
102			*Trepobates*	
103		**Mesovelidae**	*Mesovelia*	
104		**Nepidae**	*Ranatra*	
105		**Notonectidae**	*Notonecta*	
106		**Pleidae**	*Neoplea*	
107		**Veliidae**	*Microvelia*	
108			*Rhagovelia*	
109	**Hirudinea**	**Erpobdellidae**	*Erpobdella*	*punctata*
110			*Mooreobdella*	*fervida*
111		**Glossiphoniidae**	*Actinobdella*	
112			*Alboglossiphonia*	*heteroclita*
113			*Helobdella*	*stagnalis*
114			*Helobdella*	*triserialis*
115	**Hydracarina**			
116	**Isopoda**	**Asellidae**	*Asellus*	
117	**Lepidoptera**	**Pyralidae**		
118	**Megaloptera**	**Corydalidae**	*Chauliodes*	

	Taxon	Family	Genus	Species
119	**Nematomorpha**			
120	**Neuroptera**	**Sisyridae**	*Sisyra*	
121	**Odonata**	**Aeshnidae**	*Aeshna*	
122			*Anax*	*junius*
123		**Calopterygidae**	*Calopteryx*	
124		**Coenagrionidae**	*Enallagma/Coenagrion*	
125		**Libelluidae**	*Sympetrum*	
126	**Oligochaeta**			
127	**Plecoptera**	**Perlidae**	*Agnetina*	
128	**Trichoptera**	**Hydropsychidae**	*Ceratopsyche*	
129			*Cheumatopsyche*	
130		**Hydroptilidae**	*Hydroptila*	
131			*Ochrotrichia*	
132			*Oxyethira*	
133		**Leptoceridae**	*Ceraclea*	
134			*Leptocerus*	
135			*Mysticides*	
136			*Nectopsyche*	
137			*Oecetis*	
138			*Oxyethira*	
139	**Turbellaria**			