Condition of Rivers and Streams in the St. Croix River Basin of Minnesota

Minnesota Pollution Control Agency
Biological Monitoring Program

Scott Niemela
David Christopherson
John Genet
Joel Chirhart
Mike Feist

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Executive Summary

In 1996, the MPCA began a monitoring program designed to assess the condition of rivers and streams in each of the 10 major river basins of Minnesota. To obtain an unbiased estimate of stream condition, the MPCA program used a random site selection process developed by the Environmental Protection Agency, Environmental Monitoring and Assessment Program (EPA/EMAP). The random sampling design allowed for the extrapolation of the monitoring results from approximately 50 sites to the entire population of rivers and streams in the geographical area of interest – in this case, the St. Croix River Basin in Minnesota. Longitudinal surveys were also conducted at targeted locations on the St. Croix River, Kettle River, Snake River, and Rush Creek to further document their condition.

Coordinates for 60 randomly selected sites were provided by EPA/EMAP, and an initial site reconnaissance was conducted by MPCA to determine if the selected sites could be considered part of the target population of streams. The 10 additional sites were requested because the EMAP site selection procedure was based on mapping information that was not always accurate. Therefore, it was necessary to visit each site in advance to ensure that the chosen location was, in fact, an accessible flowing stream. Sites that were dry, inaccessible, had no defined channel, or where a landowner denied permission to access the stream, were not considered part of the target stream population. Other sampling limitations restricted interpretation of the results for some parameters to a subset of the target population.

An integrated monitoring approach that combined measures of habitat, water chemistry, and fish and/or invertebrate community structure was used to assess each site. In addition to the field measurements, GIS technology was used to derive land use percentages for each upstream watershed to quantify human disturbance. A habitat index score was calculated using key variables from the habitat assessment. Water chemistry variables were compared to state water quality standards or ecoregion expectations. Index of biological integrity (IBI) scores were calculated using both fish and invertebrate community data. The IBI scores for fish and invertebrates were used to assess whether or not the site was supporting or non-supporting (i.e. impaired) of its aquatic life uses.

The entire dataset was analyzed using S-plus statistical software and statistical routines provided by EPA/EMAP. The dataset was also divided into two ecoregion groups (Northern Lakes and Forests and North Central Hardwood Forests), stream size groups (1st and 2nd order, and 3rd through 6th order), and watershed disturbance groups (<40% disturbance and >40% disturbance) to determine if any of these factors influenced the estimates. Cumulative distribution functions (CDF's) were created for each continuous variable. The CDF's graphically illustrate the cumulative stream miles for every level of the variable. For example, a CDF may show the cumulative percent of stream miles for all possible IBI scores, which may then be used to find the percent of stream miles in the basin with IBI scores equal to or less than a biologically based impairment threshold. Bar charts were created to view the results of categorical variables.

The majority of land in the St. Croix River Basin is forested with many wetlands and lakes interspersed throughout. Most headwater streams in the basin, particularly in the northern portion of the basin, emanate from these wetland complexes. The connection of most streams to the surrounding wetlands, along with the relatively small amount of watershed disturbance and in-stream habitat alteration, makes streams in this basin some of the most scenic in the state.

The primary form of land use in the basin is from light agricultural practices such as pasturing cattle and hay fields. Other more intensive types of land use, such as row crop agriculture and residential/urban development, are not as common but are intensifying with an expanding human population. The southern portion of the basin, primarily the North Central Hardwood Forests ecoregion, is relatively more developed than the northern portion, due in part to rapid development in and around the Minneapolis/St. Paul metropolitan area.

The habitat assessment results indicated that approximately 74% of all streams in the basin had habitat index scores in the fair to good range (i.e. habitat index scores of at least 4 out of 12). Ecoregional differences were not related to the quality of habitat. However, streams in the NCHF ecoregion tended to

have substrates that were dominated by fine material (i.e. sands and silts). Watershed disturbance (i.e. summation of agriculture, urban, residential, pasture, and mining land use percentages) had was strongly related to habitat quality, with the poorer habitat occurring in streams with higher disturbance. In highly disturbed watersheds the riparian zone within 30 meters of the stream bank tended to be more disturbed, the bottom substrates tended to be smaller, there were fewer riffle/run/pool sequences, bends, and log jams, and the contour of the stream bottom was not as variable.

Water quality in the basin was found to be generally good from a chemical perspective. However, single-visit water quality samples from 31% of the streams failed to meet the applicable state water quality standard for at least one chemical parameter. The vast majority of these exceedances were attributed to naturally low dissolved oxygen or pH concentrations in headwater streams influenced by riparian wetlands. Similarly, ecoregion expectations for turbidity, conductivity, TSS, total phosphorus, and nitrogen were often exceeded, even in streams with low watershed disturbance. A reexamination of ecoregion expectations may be warranted, particularly for small streams, given that many of the exceedances occurred in streams that had watersheds with very little disturbance and that the ecoregion expectations were developed using data from larger streams only.

The biological surveys documented the occurrence of a diverse assemblage of fish and invertebrates. Seventy one of the 110 fish species known to occur in the basin were collected during the study. Over 380 invertebrate taxa were collected during the study. The structure of the fish and invertebrate varied by ecoregion, watershed disturbance level and stream size. Three fish species on the state list of special concern species were collected during the survey and were estimated to occur in 11% of the streams in the basin. Several federal- or state-listed mussels and other invertebrates occur in the basin, but no attempt was made to document the distribution of these species during this survey.

The fish and invertebrate IBI scores indicated that streams in the St. Croix River Basin were generally in fair to excellent condition with only a small percentage of streams in poor or very poor condition. The highest quality streams were in the NLF ecoregion (i.e. northern portion of the basin) in watersheds with a lower level of disturbance. On the other hand, nearly all of the poor quality streams were in the NCHF ecoregion in watersheds with a relatively high level of disturbance. Nearly 36% (690 km) of all streams in the basin were estimated to be biologically impaired for fish, invertebrates, or both assemblages. Individually, the assessments based on each assemblage agreed with each other most (72%) of the time. The impaired streams were not evenly distributed throughout the basin. Only 13% of the streams in the NLF ecoregion were impaired, compared to 89% of the streams in the NCHF ecoregion. Likewise, only 11% of the streams with low watershed disturbance were impaired, compared with 100% of the streams with high watershed disturbance.

The results of the longitudinal stream surveys tend to corroborate the results of the random survey. Fair to excellent IBI scores were obtained for every site on the St. Croix, Snake, and Kettle Rivers. Each of these streams are either wholly confined to the NLF ecoregion or have a significant portion of their watersheds in this ecoregion. Rush Creek, located in the NCHF ecoregion, was in poor condition, particularly in the headwater reaches.

While the St. Croix River does not at this time appear to be negatively affected by the impaired tributary streams in the southern portion of the basin, developmental pressures are sure to increase and place even more pressure on this susceptible river. Further monitoring of rivers and streams throughout the basin, particularly the southern portion of the basin, is warranted to help prevent further degradation of the tributary streams and to maintain the excellent condition of the St. Croix River, a most valuable resource. The inclusion of additional biological indicators (e.g. stream periphyton) may help to identify stressors that fish and invertebrates are not particularly sensitive to.

Rivers and streams within the St. Croix River Basin are arguably some of the most scenic in Minnesota. These waterways support a wide variety of recreational activities including fishing, hunting, canoeing, and site seeing. Recognition of the St. Croix River as a unique water body of exceptional quality that is being threatened by human development has led to federal and state protection status. The upper St. Croix River (above Taylors Falls) was one of the first eight rivers to be included in the original National Wild and Scenic Rivers Act of 1968 (Public Law 90-542; 16 U.S.C. 1271-1287) The lower St. Croix River was included in 1972. In addition, Minnesota has designated the St. Croix and Kettle Rivers as an Outstanding Resource Value Water (Minnesota Rule Chapter 7050.0180). This special designation carries with it regulations intended to control the spread of development within the stream corridor and control point source emissions in the St. Croix River itself and its tributaries.

The basin topography was shaped by the advance and retreat of glaciers that scoured some areas and deposited glacial materials in others to form the flat to gently rolling landscape that is present today. The glacial deposits in the northern portion of the basin are generally thin and coarse, resulting in the formation of soils that were agriculturally unproductive. In many places in the northern portion of the basin and close to the major rivers, bedrock is exposed or lies close to the land surface (MPCA 2000). The relatively thick and fine glacial deposits of the southern portion of the basin have produced soil conditions that are more amenable to cultivation.

In 1929-1930 Francis J. Marschner, a research assistant in the USDA Bureau of Agricultural Economics, constructed a map of historical vegetation based on the notes of the Public Land Survey, 1847-1907 (Brady 2003, Fig. 2). Marschner's map indicated that over 11% of the basin vegetation was once dominated by white and red pine stands. Most of the remaining vegetation was dominated by mixed forest types (aspen, maple, basswood, oak, etc). While the map gives the most complete information regarding historical vegetative cover in the basin, the data probably reflects changes in vegetative cover that were already underway due to logging practices.

Today, logging and agricultural land use practices have almost entirely eliminated the large pine stands. A diverse mixture of second-growth mixed-hardwood forests, open fields, and cropland now dominates in the basin (Figs. 2 and 3). Logging in the basin began with the opening of the first sawmill in Stillwater in 1844. The Snake and Kettle Rivers were among the first major watersheds to be exploited for their abundance of virgin white pines (Waters 1977). By the 1890's logging in the St. Croix River Basin was at its peak. Over 3.5 million logs were floated down the river in 1890 (Waters 1977). Around 1914, when almost all of the virgin timber within the basin had been harvested, logging operations ceased.

Agriculture supported the early settlers and loggers during the logging era and intensified as the harvestable timber was depleted and the logging industry collapsed. However, in many cases farms were abandoned because of poor soil conditions, particularly in the northern portion of the basin where soils were marginal at best. The farming practices that survived included a mix of row-crop agriculture, small-grain farming, and beef, dairy, and poultry operations. In the latter half of the 1900's, residential and commercial development began to transform the landscape once again, particularly in the southern portion of the basin, where the Twin Cities metropolitan area emerged as a major regional economic center.

The majority of agricultural land occurs in the southern half of the basin, coinciding with an ecoregional divide that runs roughly through the center of the basin in an east-west direction (Fig. 1). Ecoregions are areas of land that have similar land-surface form, soils, potential natural vegetation, and land use patterns (Omernik 1987). The divide separates the two major ecoregions of the basin: the Northern Lakes and Forests (NLF) ecoregion in the north and the North Central Hardwood Forests (NCHF) ecoregion in the south. Two other ecoregions, the Western Corn Belt Plains and Driftless Area, comprise a very small portion of the southern tip of the basin.

a relatively small number of sites to the entire population of rivers and streams within the basin. The same concept is used in political polling, where the results of a small number of randomly selected interviews can represent the opinions of a much larger population.

Because the results are based on a sub-sample of all streams in the basin, it is necessary to incorporate an error term when reporting the results. The error term, often expressed as a 95% confidence limit, indicates the reliability of a reported result. For example, we may conclude that the average water temperature that was measured in streams of the St. Croix River Basin was $21^{o}C \pm 4^{o}C$. This means that we are 95% confident that the true average temperature of all streams in the basin will fall within $4^{o}C$ of the average measured temperature, between $17^{o}C$ and $25^{o}C$.

The results of this survey provide, for the first time, a statistically valid picture of the overall condition of the rivers and streams in the St. Croix River basin, showing what portion of the total waters are impaired. Future surveys will focus on other basins of the state. The first assessment in each basin will provide a baseline of current conditions; future rounds will allow the analysis of basin-wide and state-wide water quality trends, providing a picture of long-term problems as well as of the effectiveness of water quality programs.

In addition to the randomly selected sites, the MPCA conducted longitudinal surveys (i.e. a series of surveys at different locations on a stream) on three major rivers – the St. Croix, Snake, Kettle Rivers, as well as Rush Creek to develop an understanding of the longitudinal trends in water quality within each stream. Because these sites were not selected randomly the data was not used in the basin assessment.

Methods

Upstream land use in the watershed served as an indicator of potential human disturbance. Watersheds with a high degree of land use disturbance were assumed to have an increased level of environmental stressors. Upstream land use in the watershed of each site was characterized using the most recent GIS land use coverages. The land use coverage was overlaid on a watershed drainage area coverage to produce a land use coverage identical in shape and size to the watershed drainage area coverage. Land uses were then summed across the entire drainage area and divided by the total area to produce percentages for each land use. The percent watershed disturbance was calculated by adding together the percentages that were agricultural, urban or residential, grassland associated with pastured areas, and mines.

A quantitative habitat assessment was completed at each site following procedures modified from Simonson et al. (1994). The assessment provided information concerning flow, morphology, substrate, cover, and riparian land use. A habitat score was calculated for each wadeable site using a modified version of a habitat index developed as described by Niemela and Feist (2000). Because, for reference sites, both the IBI scores and the variables used to calculate the habitat index scores were correlated with stream size, regression residuals, rather than the raw values of the variables themselves, were used to calculate the habitat index scores. The residuals were taken from LOWESS (locally-weighted scatterplot smoothing) regressions of the habitat variables against (log of) mean stream width. The residuals were used for number of stream features per 100 meters, number of substrate types, percent coarse substrates, coefficient of variation of depth, and sinuosity. Residuals were not used for percent disturbed land use within 30 meters because, for reference sites, the variable should not be affected by stream size. The resulting habitat index scores range from 0 (very poor habitat) to 12 (excellent habitat).

During each site visit, grab samples of stream water were taken for chemical analysis. Water chemistry parameters included dissolved oxygen, turbidity, conductivity, temperature, pH, total suspended solids, nitrite/nitrate, total phosphorus, and total ammonia. Water chemistry results were compared to the applicable state water quality standard or ecoregion expectation (McCollor and Heiskary 1993)

Fish were collected using electrofishing techniques following procedures described in Niemela and Feist (2000) and invertebrates were collected following procedures described in Chirhart (2003). IBI scores for fish and invertebrates were calculated for each sampling event using IBI's developed specifically for streams in the St. Croix River Basin (Niemela and Feist 2000, Chirhart 2003). IBI scores ranged from 0 to

significantly by level of watershed disturbance. Streams with more-disturbed watersheds had fewer coarse substrates and stream features and less bottom contour variability.

These habitat differences suggest that stressors associated with a higher level of watershed disturbance are influencing stream habitat by decreasing the abundance of key habitat parameters thought to be important to fish populations. The lack of habitat heterogeneity in more-disturbed watersheds may also have a negative influence on other aquatic organisms that are sensitive to habitat changes or that have more specific habitat requirements.

Relationships between habitat index and IBI scores in the St. Croix River Basin were statistically significant for fish (Spearman's Rank Correlation, $p<.05$, Appendix 2) and nearly significant for invertebrates. For the individual variables used to compute the habitat index scores, (the residuals for) number of stream features per 100 meters, percent coarse substrates, and coefficient of variation of depth had statistically significant correlations with fish IBI's; the latter two individual variables had statistically significant correlations with invertebrate IBI's. The number of substrate types, sinuosity, and percent disturbed land use within 30 meters were not statistically correlated with the fish or invertebrate IBI score. The lack of relationships for some of the habitat factors may reflect a need for further development of the habitat index.

Water Chemistry

Approximately 31% of all streams (770 km) did show exceedances of a water chemistry standard, meaning that they had at least one single-sample chemical measurement that failed to meet the water quality standard for at least one of the four measured parameters – dissolved oxygen, pH, un-ionized ammonia, or turbidity – for which standards exist (Fig. 11). The large majority of these exceedances, however, were on small, low-gradient, wetland-influenced streams with fine substrates and no riffles, where low dissolved-oxygen and pH levels are likely the result of natural conditions rather than human-induced changes.

With regard to ecoregions, water chemistry measurements were generally better in the NLF than in the NCHF, with statistically significant differences in CDF's found for conductivity, ammonia, and turbidity (Mean-Eigenvalue-Corrected CDF Test, $p<0.05$, Fig. 12). However, the one-time water chemistry samples of most streams – approximately 73% in the NCHF and 88% in the NLF – failed to meet ecoregion expectations (McCollor and Heiskary 1993) for least-impacted streams for at least one of the measured parameters. The fact that 82% of the streams in the basin with low (<40%) watershed disturbance levels exceeded ecoregion expectations, yet had generally good water quality as evidenced by the basin-wide fish and invertebrate IBI scores, suggests that NCHF and NLF ecoregion expectations may merit reexamination.

With regard to stream order, water chemistry measurements were generally better in larger streams than in smaller streams, with statistically significant differences in CDF's found for dissolved oxygen, ammonia, turbidity, and total suspended solids (Mean-Eigenvalue-Corrected CDF Test, $p<0.05$, Fig. 13). Again, the low dissolved oxygen levels observed in smaller order streams may reflect the fact that many of the basin's headwater streams are low-gradient and wetland-influenced, with fine substrates and few riffles.

With regard to watershed disturbance, water chemistry measurements were generally better in streams with less-disturbed watersheds. There were significant differences in CDF's for turbidity and dissolved oxygen, (Mean-Eigenvalue-Corrected CDF Test, $p<0.05$, Fig. 14). Conductivity and phosphorus concentrations were generally lower in watersheds with a lower level of disturbance, but these differences were not statistically significant.

Relationships between water chemistry and IBI's in the St. Croix River Basin were not particularly strong (Appendix 2). Weak but statistically significant correlations were found between fish IBI scores and turbidity, total suspended solids, conductivity, and total phosphorus (Spearman's Rank Correlation, $p<0.05$). Significant correlations were found between invertebrate IBI scores and conductivity. The lack of strong relationships probably reflects the generally good water quality found in the basin. A greater range of chemistry measurements would likely show greater correlation.

Table 1. Median values for the fish IBI and its metrics. Values in bold indicate that the CDF's (for the two categories of ecoregion or stream order or disturbance level) are statistically significantly different ($p<0.05$).

IBI Score and Fish Community Attributes	All Streams		Ecoregion: Northern Lakes and Forests		Ecoregion: North Central Hardwood Forests		Stream Order: 1st and 2nd		Stream Order: 3rd through 6th		Watershed Disturbance Level: Low (0-39%)		Watershed Disturbance Level: High (40-100%)	
	median	95% CI	median	95% CI	median	95% CI	median	95% CI	median	95% CI	median	95% CI	median	95% CI
IBI Score	63.5	57.4-69.3	65.9	58.3-71.7	52.5	40.1-64.1	59.0	52.1-70.5	68.2	61.9-73.9	**66.8**	**59.9-72.1**	**41.8**	**11.3-59.7**
Fish IBI Metrics														
Number of fish taxa	9.6	6.8-15.2	9.6	7.2-13.2	6.9	2.0-16.9	**7.0**	**4.4-9.9**	**18.5**	**16.9-21.7**	10.6	7.4-16.3	6.6	2.0-15.3
Number of headwater fish taxa w/o tolerant taxa	0.0	0.0-1.1	**0.5**	**0.0-1.8**	**0.0**	**0.0-1.0**	**1**	**0.0-2.0**	**0.0**	**0.0-0.0**	0.0	0.0-1.3	0.2	0.0-2.1
Number of minnow taxa w/o tolerant taxa	2.3	1.4-2.8	2.5	1.7-3.1	1.9	0.0-3.3	2.2	0.2-3.0	2.5	1.9-3.2	2.4	1.8-2.9	1.3	0.0-3.6
Number of darter taxa	0.2	0.0-1.0	0.2	0.0-1.2	0.2	0.0-1.6	**0.0**	**0.0-0.3**	**2.3**	**1.8-2.8**	**0.8**	**0.0-1.7**	**0.0**	**0.0-0.2**
Number of intolerant fish taxa	0.0	0.0-1.1	0.0	0.0-0.9	0.0	0.0-3.2	**0.0**	**0.0-0.0**	**4.9**	**4.2-5.8**	**0.4**	**0.0-3.4**	**0.0**	**0.0-0.0**
Percent of individual fish that are tolerant taxa	76.4	55.6-88.5	74.9	48.5-86.9	92.9	32.4-99.4	**87.6**	**76.2-93.1**	**17.3**	**10.9-28.7**	**68.1**	**45.3-76.9**	**93.5**	**74.3-99.6**
Percent of ind. fish that are the dominant two taxa	62.6	54.7-76.7	**62.2**	**53.8-67.5**	**85.1**	**40.7-99.5**	**71.3**	**62.3-89.2**	**43.9**	**39.3-47.1**	**58.6**	**51.9-63.5**	**89.4**	**84.0-99.6**
Number of invertivore taxa w/o tolerant taxa	1.8	1.0-4.3	1.7	1.1-4.3	2.7	0.0-7.1	**1.0**	**0.2-1.8**	**8.2**	**7.3-9.0**	**2.6**	**1.2-5.6**	**0.9**	**0.0-3.3**
Number of benthic invertivore fish taxa	0.5	0.0-1.8	0.4	0.0-1.9	1.1	0.0-5.0	**0.0**	**0.0-0.6**	**6.4**	**5.8-6.8**	**1.4**	**0.0-3.4**	**0.0**	**0.0-1.1**
Number of omnivore fish taxa	0.6	0.2-1.0	0.6	0.3-0.9	0.6	0.0-2.0	0.4	0.0-1.1	0.9	0.7-1.2	0.6	0.3-1.0	0.3	0.0-2.5
Percent of individual fish that are piscivores	0.1	0.0-1.7	0.0	0.0-1.3	0.2	0.0-7.2	**0.0**	**0.0-0.1**	**12.3**	**9.5-18.1**	0.4	0.0-2.9	0.0	0.0-3.1
Percent of ind. fish that are lithophilic spawners	19.6	5.0-33.7	21.9	12.6-45.7	2.8	0.0-36.8	**5.2**	**1.2-20.7**	**50.0**	**40.0-59.6**	**33.7**	**20.7-47.7**	**1.1**	**0.0-7.5**
Number of fish per meter w/o tolerant taxa	0.4	0.3-0.6	0.5	0.4-0.7	0.1	0.0-0.8	**0.4**	**0.1-0.5**	**0.6**	**0.4-0.9**	0.5	0.4-0.7	0.1	0.0-0.5
Percent of individual fish with DELT anomalies	0.0	0.0-0.2	0.0	0.0-0.3	0.0	0.0-0.2	**0.0**	**0.0-0.1**	**0.3**	**0.2-0.5**	0.1	0.0-0.3	0.0	0.0-0.0
Other Fish Community Attributes														
Number of game fish taxa	0.0	0.0-1.6	0.0	0.0-0.7	1.4	0.0-4.2	**0.0**	**0.0-0.0**	**4.3**	**3.5-5.1**	0.3	0.0-2.2	0.0	0.0-2.7
Number of special concern fish taxa	0.0	0.0-0.0	0.0	0.0-0.0	0.0	0.0-0.0	0.0	0.0-0.0	0.0	0.0-0.0	0.0	0.0-0.0	0.0	0.0-0.0

Table 2. Median values for the macroinvertebrate IBI and its metrics. Values in bold indicate that the CDF's (for the two categories of ecoregion or stream order or disturbance level) are statistically significantly different ($p<0.05$).

IBI Score and Macroinvertebrate Community Attributes	All Streams		Ecoregion				Stream Order				Watershed Disturbance Level			
			Northern Lakes and Forests		North Central Hardwood Forests		1st and 2nd		3rd through 6th		Low (0-39%)		High (40-100%)	
	median	95% CI	median	95 % CI	median	95% CI	median	95% CI	median	95% CI	median	95% CI	median	95% CI
IBI Score	55.3	44.2 - 66.3	**64.3**	**47.4 - 70.3**	**36.8**	**22.5 - 52.8**	54.5	42.5 - 69.5	56.5	45.6 - 62.6	**67.5**	**59.1 - 71.4**	**42.8**	**17.7 - 53.6**
Invertebrate IBI Metrics														
Number of Chironomidae taxa	15.7	14.7 - 16.7	15.8	14.0 - 18.2	15.6	11.1 - 17.5	15.9	13.8 - 17.5	15.4	13.7 - 17.3	**16.4**	**15.4 - 19.2**	**13.5**	**9.5 - 16.8**
Number of clinger taxa	12.8	8.3 - 16.0	13.5	7.6 - 18.3	8.9	8.2 - 16.3	**8.8**	**6.2 - 13.9**	**20.0**	**16.9 - 23.2**	**15.6**	**12.8 - 18.8**	**8.4**	**5.0 - 16.2**
Number of intolerant taxa	5.0	2.6 - 8.6	**8.3**	**3.2 - 10.8**	**1.6**	**1.0 - 5.6**	**3.0**	**1.7 - 8.0**	**11.3**	**8.4 - 14.2**	**8.6**	**5.0 - 11.2**	**1.0**	**1.0 - 5.2**
Number of Ephemeroptera taxa	2.5	1.8 - 3.3	2.6	1.8 - 3.8	2.3	1.0 - 3.3	**1.8**	**1.2 - 2.5**	**5.2**	**3.5 - 6.4**	**3.2**	**1.9 - 5.2**	**1.0**	**1.0 - 2.7**
Number of Plecoptera taxa	0.0	0.0 - 0.6	0.0	0.0 - 1.4	0.0	0.0 - 0.8	**0.0**	**0.0 - 0.0**	**1.8**	**0.6 - 2.6**	**0.0**	**0.0 - 1.9**	**0.0**	**0.0 - 0.7**
Number of Tricoptera taxa	5.7	4.0 - 7.6	**7.2**	**3.0 - 9.5**	**5.1**	**2.2 - 6.6**	**4.3**	**1.8 - 7.4**	**8.7**	**7.2 - 10.3**	**7.6**	**5.6 - 9.6**	**2.3**	**1.0 - 5.7**
Number of collector-filterer invertebrate taxa	6.7	5.8 - 8.3	7.4	5.9 - 9.2	6.1	3.1 - 8.1	6.3	3.2 - 7.9	8.9	8.1 - 9.7	**8.3**	**6.8 - 9.5**	**5.2**	**1.0 - 6.8**
Number of collector-gatherer invertebrate taxa	17.0	14.1 - 17.8	17.3	14.0 - 19.0	14.7	12.6 - 17.9	16.8	13.3 - 17.9	17.7	15.2 - 19.4	**17.8**	**17.0 - 19.2**	**13.4**	**8.0 - 19.1**
Number of Tanytarsini taxa	3.7	2.7 - 4.3	4.1	2.7 - 4.5	3.1	2.1 - 4.4	**4.1**	**2.4 - 4.6**	**3.3**	**2.8 - 3.8**	4.2	3.2 - 4.6	2.9	2.1 - 4.4
Percent of individuals that are Amphipoda	0.9	0.2 - 2.6	**0.1**	**0.0 - 0.9**	**5.5**	**1.3 - 30.6**	0.9	0.0 - 5.3	1.0	0.6 - 1.7	0.3	0.0 - 1.0	5.4	0.2 - 32.2
Percent of individuals that are dominant two taxa	25.2	21.3 - 29.0	**21.5**	**18.2 - 27.8**	**35.6**	**22.9 - 47.2**	22.8	18.3 - 31.1	27.2	23.5 - 30.4	21.2	17.8 - 26.6	28.9	22.6 - 48.0
Percent of ind. invertebrates that are tolerant	39.2	30.8 - 50.4	**32.2**	**30.1 - 48.8**	**50.5**	**39.0 - 85.7**	48.8	30.6 - 53.2	35.5	29.0 - 39.2	**30.6**	**27.7 - 38.8**	**49.5**	**36.6 - 86.7**
Other Invertebrate Community Attributes														
HBI	5.5	4.9 - 6.2	5.0	4.8 - 6.0	5.8	5.5 - 7.5	5.7	4.9 - 6.5	5.2	4.6 - 5.5	4.9	4.8 - 5.3	6.5	5.6 - 7.5
EPT	9.9	7.8 - 11.5	10.5	8.0 - 11.9	8.3	3.2 - 11.8	**8.3**	**4.3 - 10.7**	**17.0**	**13.7 - 20.4**	**11.4**	**9.9 - 17.2**	**3.3**	**2.0 - 10.5**
Number of scraper taxa	7.2	6.1 - 8.1	7.5	6.0 - 9.4	6.5	4.7 - 8.1	**6.5**	**4.9 - 7.8**	**9.2**	**7.8 - 9.9**	**7.9**	**6.5 - 9.7**	**4.6**	**3.2 - 8.1**
Number of macroinvertebrate taxa -- all Chironomidae taxa included	49.8	44.6 - 55.8	53.0	44.7 - 56.4	45.0	39.2 - 56.5	48.0	40.5 - 55.2	56.7	51.2 - 59.8	**55.6**	**49.0 - 56.8**	**39.3**	**28.0 - 56.5**