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Water Quality Assessment of Irondequoit Creek using Benthic Macroinvertebrates

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by Nichelle Bailey-Billhardt

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THESIS DEFENSE

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ABSTRACT

The Rochester Embayment of Lake Ontario is one the 43 Great Lakes' Areas of Concern designated by the Environmental Protection Agency (Monroe County 1993). As part of a Remedial Action Plan (RAP), degradation of benthos was one of the 14 use impairments identified for the Rochester Embayment (Monroe County 1993). Stage II of the RAP identified stream health monitoring as a method of identifying existing and future conditions of the Embayment and its tributaries, including Irondequoit Creek. There is much debate in the "world" of stream health biomonitoring using aquatic macroinvertebrates regarding methods of collection, sample size and taxonomic resolution required to obtain accurate stream health assessments. My study compared stream health at three locations in Irondequoit Creek (upstream, midstream and downstream) and in three habitats (gravel, mud and vegetation) and evaluated methods of sampling macroinvertebrates and analyzing stream health used by the Stream Biomonitoring Unit of the New York State Department of Environmental Conservation (Bode et al. 1996). There were few differences between upstream (primarily agricultural or rural land use) and midstream (primarily agricultural and suburban land use) communities, but stream health decreased from upstream to downstream (primarily urban/suburban land use). As expected, community differences were found across habitats (gravel, vegetation, mud) at the same sampling locations. Fixed 100 count methods were compared with entire macroinvertebrate samples in the gravel habitat at the midstream location (Powder Mill Park, Rochester, NY). Although metric values for random and haphazard samples of 100 organisms differed from values for whole samples, stream health assessments did not differ.

DEDICATION

I would like to dedicate this work

in loving memory

of my cousin

Rebecca (Becky) Joe Andre.

Thank you for friendship, support and all the laughter!!!!!!!!

BIOGRAPHY

Nichelle Lynn Bailey Billhardt was born in Oswego, New York in September of 1972. She grew up in Glenfield, NY and graduated from South Lewis Jr./Sr. High School in Turin, NY. She earned her Associates' degree in Liberal Arts: Math/Science from Jefferson Community College, Watertown, NY. Her Bachelor's degree in Biological Sciences (emphasis, environmental science) was earned in 1996 at SUNY College at Brockport. Nichelle continued on at SUNY Brockport to earn her Master's degree in Biology (with an emphasis on aquatic ecology). Nichelle is currently employed as the District Manager of the Orleans County Soil and Water Conservation District. Her hobbies are camping, reading and enjoying the outdoors.

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Introduction

Water quality of the Rochester Embayment declined tremendously after European settlement of the Genesee Valley. The Embayment was used as a disposal system by surrounding towns and municipalities, ultimately resulting in PCB and dioxin contamination, eutrophication, oxygen depletion and fish die-offs (Kappel et al. 1981, Monroe County 1993). As a result of the threat to fish and other wildlife, the Rochester Embayment was designated an Area of Concern (AOC) in the Great Lakes by the Environmental Protection Agency (Monroe County 1993). A Remedial Action Plan (RAP) was developed for the AOC to provide a long-term course of action for environmental cleanup. Stage I of the RAP identified 12 use impairments for Rochester Embayment, which included degradation of fish and wildlife populations, loss of fish and wildlife habitat, and degradation of benthos (Monroe County 1993).

The quality of Rochester Embayment water is indicative of the quality of water of the streams and rivers that flow into it. A proposed method of monitoring stream health, designated by the Stage II RAP, identified species diversity and abundance of benthic and water-column macroinvertebrates as a measure of pollution impact in waters such as the Genesee River (the largest contributor of water and contaminants to the Rochester Embayment) (Monroe County 1997). Irondequoit Creek, an important Embayment tributary that flows into Irondequoit Bay, also required water quality assessment (Johnston and Sherwood 1988). My study used benthic macroinvertebrate indices (Bode et al. 1996) to assess the health of Irondequoit Creek.

Several methods of assessment have been used to measure water quality conditions in the Rochester Embayment. Although physiochemical approaches have proven successful for measuring water pollutant concentrations, these techniques record the chemical makeup of the water only at the time of sampling. Pollutant concentrations can fluctuate greatly within a system over a period of just a few minutes, thus chemical measurement may not be indicative of water conditions over the lifetime of organisms living in a stream (Rosenburg and Resh 1993). "Biological indicators can indicate the occurrence of pollution even if the pollutant is temporarily absent at the time of measurement…" (Brower et al. 1990). Therefore, biological techniques have proven successful in the assessment of water quality over longer periods (Rosenburg and Resh 1993).

Benthic macroinvertebrates are ideal bioindicators because they are sedentary organisms that play active roles in nutrient and pollutant cycling. These organisms are exposed to physical and chemical fluctuations that occur in lotic waters throughout the entire year. Therefore, only organisms that have the ability to tolerate all of a stream's conditions can inhabit it. Organisms such as macroinvertebrates, mainly aquatic insect larvae, are commonly used to indicate the impact of pollution on bodies of water (Rosenberg and Resh 1993; EPA 1993). Despite difficulties with classification, the relative ease and low cost of sampling attracts researchers to biomonitoring over more expensive physiochemical techniques (Hellawell 1986; Thorne and Williams 1997).

A multimetric approach to assess pollution impacts on streams was originally designed by Karr for use with fish communities (Index of Biotic

Integrity, Barbour et al. 1992) and has been modified for use with macroinvertebrates (Loeb and Spacie 1994). Karr's procedure analyzed different components of the "structure and function of stream and river fish communities in an integrated assessment, using various attributes of ecological systems (Barbour et al. 1992; Rosenberg and Resh 1993; Reice and Wohlenberg 1993)." This multimetric approach has been modified by several researchers, including Hilsenhoff (1982), Plafkin et al. (1989), and Bode et al. (1996), for use with benthic macroinvertebrates. In 1983, New York State's Stream Biomonitoring Unit began developing methods for assessing stream water quality that use benthic macroinvertebrates as a measure of stream pollution (Bode et al. 1991, 1996).

The use of a single metric, such as taxa richness or diversity, provides a more limited representation of the invertebrate community at a particular site than does a multimetric approach. Combining results from different metrics should remove much of the bias a single metric may provide and, in theory, provide a reasonable estimate of water quality (Barbour et al. 1992; Lenz and Miller 1996).

Three categories of metrics are used to delineate stream health: structure, community balance, and functional feeding group metrics (Barbour et al. 1992). Ideally, each metric should provide a distinct view of the community assemblage. Thus a more accurate assessment of impairment can be obtained. Bode et al.'s protocol (1996) was used to examine benthic macroinvertebrates as indicators of water quality in Irondequoit Creek, and consisted of the following metrics (defined below): Taxa Richness, EPT Richness, Hilsenhoff Biotic Index, Percent

Model Affinity, DOM-3, NCO Richness and Shannon-Weiner Diversity. These metrics fall into two of the main categories suggested by Barbour et al. 1992: structure and community balance metrics. The third type of metric, not used in Bode's protocol, involves functional feeding groups that are more useful for assessing stream health using fish communities (Merritt and Cummins 1996; Resh and Jackson 1993).

Structure Metrics

The most common richness metrics used to describe macroinvertebrate communities are total taxa richness (TR) and EPT (Ephemeroptera, Plecoptera, Trichoptera) richness (Lenat and Barbour 1994; Barbour et al. 1992; Reice and Wohlenberg 1993). To these structural metrics Bode et al. (1996) add percent model affinity (PMA) and Non-Chironomid/Non-Oligochaete richness (NCO). Taxa richness establishes the number of distinct species found in a particular sample (Barbour et al. 1996) and depicts the diversity of the aquatic assemblage (Resh et al. 1995). In most cases, as the amount of stream perturbation increases, taxa richness decreases. As Resh et al. (1995) state:

> Increasing diversity correlates with increasing health of the assemblage and suggests that niche space, habitat, and food source are adequate to support survival and propagation of many species. The number of taxa measures the overall variety of the macroinvertebrate assemblage.

Ideally, taxa richness consists of species-level identifications, but this often is not the case due to limited classification keys (e.g., certain tribes of Family Chironomidae). My study was limited to genus identifications in many instances.

Comparisons at the genus level may not reflect the true diversity of a benthic macroinvertebrate community (Merritt and Cummins 1996).

Richness measures can also be specific to certain indicator organisms. One such measure includes EPT richness, which refers to the total number of taxa in the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). According to researchers at North Carolina State University, "this measure was very sensitive to changes in water quality," and it proved to be less variable than total taxa richness in relation to between-year changes in flow (unpublished data from North Carolina's ambient monitoring network; Lenat and Barbour 1994; Bartenhagen 1995). These three orders of insects are generally indicators of good water quality. Absence or low diversity of them may indicate a serious degradation of water quality.

The TR metric is applied to all sampling methods suggested by Bode et al. (1996). EPT richness metrics are applied to all but ponar (sediment) samples. NCO richness, however, is used specifically for samples collected in slow, sandy streams (Bode et al. 1996). NCO is a measure of richness, similar to EPT, except that it measures the non-Chironomidae and non-Oligochaeta portion of a sample. Organisms in these two groups are generally more pollution tolerant and are found in abundance in degraded habitats, but they are also commonly found in non-degraded benthic habitats of slow moving streams. Other NCO taxa in finer sediments of streams are more commonly less tolerant of degraded habitats, therefore their presence would indicate higher water quality (Bode et al. 1996).

Percent Model Affinity is a third structure metric used by Bode et al. (1996). It measures the similarity of an actual sample to a model non-impacted community based on percent abundance of seven major groups. The model New York stream gravel community is 40% Ephemeroptera, 5% Plecoptera, 10% Trichoptera, 10% Coleoptera, 20% Chironomidae, 5% Oligochaeta, and 10% other; the model mud community is 20% Oligochaeta, 15% Mollusca, 15% Crustacea, 20% Non-Chironomid Insecta, 20% Chironomid and 10% other (Bode et al. 1996).

Community Balance Metrics

The second category of metrics used in Bode et al.'s (1996) protocol measure community balance. These include a percent dominance measure (DOM-3), a diversity measure (Shannon-Wiener) and the modified Hilsenhoff Biotic Index (HBI).

Dominance is a measure of balance, or evenness, of taxa numbers within a community (Bode et al. 1996). This measure captures redundancy of taxa in a community and works on the premise that a "highly redundant community (major abundance by a single taxon) reflects an impaired community" (Barbour et al. 1992). DOM-3 is the combined percentage of the three most numerous taxa. A high DOM-3 percentage indicates a community strongly dominated by one or a few taxa (Bode et al. 1996).

Diversity is a measure that combines taxa richness with community balance. Taxa richness is the measure of the number of taxa in a sample. Community balance, or evenness, refers to the relative abundance of each taxon in a sample. The Shannon-Wiener index of diversity (also known as Shannon-Weaver index) (Bode et al. 1996; Brower et al. 1990) is the method chosen by

Bode et al. (1996) to calculate diversity. A high diversity value is indicative of an even (or balanced) community, whereas low diversity may indicate community impairment (Bode et al. 1996; Brower et al. 1990).

A biotic index includes a list of species commonly occurring in a geographic area and their individual pollution tolerance values (Bartenhagen 1995). Tolerance values, on a scale of one to ten, are assigned to each species depending on their ability to cope with pollutants (low values translate less tolerance to pollutants). In North America, most biotic indices are based on Chutter's (1972) system modified by Hilsenhoff (1982). Hilsenhoff used a large Wisconsin database (2000+ collections) to assign tolerance values to a 0-10 range (Lenat and Barbour 1994). The biotic index for each site, defined by Hilsenhoff, is calculated by multiplying the number of individuals of each species by its assigned tolerance value, summing these products, and dividing by the total number of individuals (Bode et al. 1996). The HBI metric is valuable because it uses detailed knowledge of individual species and it reflects their known sensitivity to the influence of human actions (Loeb and Spacie 1994). "This index weights the relative abundance of each taxon in terms of its pollution tolerance in determining a community score", (Resh and Jackson 1993). Site impairments can be assessed and water quality improvements can then be measured by sampling in subsequent years (Bode et al. 1996).

Biotic indices are popular because they provide an easily understood numerical expression of a biological response (Merritt and Cummins 1996). A disadvantage of using this technique is that it depends on an accurate assessment of pollution tolerances for different taxa (Merritt and Cummins 1996). Also, if the biotic index is not specific to the geographic area being sampled, incorrect tolerances values may be assigned. For example, species A may occur both in the Midwest and the Northeast. However, due to differences in environmental conditions and adaptations, their pollution tolerances may be different. Thus, the overall impact assessment may be inaccurate if it is not species-specific to a geographic region.

Objectives

The first objective of my study was to determine the current degree of community health/impairment at three locations in the Irondequoit Creek watershed using the protocol of Bode et al. (1996). Communities in Irondequoit Creek were compared among locations (upstream, midstream, downstream) and among habitats (gravel, mud, vegetation). These data will serve as a baseline for future studies to determine if the health of Irondequoit Creek is improving as a result of remediations suggested in the Rochester Embayment RAP (Monroe County 1997). The second objective was to examine the reliability of the NYS Department of Environmental Conservation's Rapid Bioassessment Protocol (Bode et al. 1996). Bode's method requires kick sampling of gravel substrate, haphazardly picking 100 invertebrates out of the sample in the field, identifying all 100 organisms and calculating the metrics described above. My study compares results from Bode's method of subsampling (haphazard) with random subsampling and an analysis of all macroinvertebrates in a sample.

Study Area

Irondequoit Creek is located in Monroe and Ontario Counties, NY east and south of the City of Rochester. Tributary streams that form Irondequoit Creek's headwaters originate in the Mendon - West Bloomfield corners of Monroe and Ontario Counties. Land uses surrounding the headwaters are primarily rural and agricultural (small farms, country homes, and villages) (Sutton 1998). Proceeding north for 19 miles (30.6 Km), Irondequoit Creek is joined by Trout Creek (upstream from Village of Mendon), Thomas Creek (near Whitney Road, East Rochester), and Allen's Creek (between Route 441 and Penfield Road) before entering Irondequoit Bay at Empire Blvd (Figure 1) (Sutton 1998). What is considered "lower" Irondequoit Creek receives runoff from surrounding residential areas, small villages, golf courses, parks, and some commercial developments (Sutton 1998). As a result of pollution discharge and runoff from the surrounding watershed, Irondequoit Creek has been identified as a major source of pollution contributing to the eutrophication of Irondequoit Bay (Johnston and Sherwood 1988).

Historically, the surrounding land was cleared for agriculture in the 1800s. The creek was used as a source of water power for the Lawless Paper Mill in 1886 (Sutton 1998). Prior to the installation of a wastewater-treatment facility in 1979, sewage was directly discharged into the creek and its tributaries (Johnston and Sherwood 1988). Although sewage diversion has improved water quality, other sources of pollution, such as sediment and nonpoint-source pollution, persist (Sutton 1998). Land uses are rapidly changing as populations are moving out of the city into outlying towns such as Pittsford, Perinton, Penfield and Mendon (Johnston and Sherwood 1988). While agricultural land-use is declining, residential land-use is on the rise in the Irondequoit Creek basin. Therefore, while surface runoff of pesticides and fertilizers from agriculture is decreasing, runoff (especially stormwater) is on the rise from housing and commercial development (Johnston and Sherwood 1988).

Sample Sites

Sites were chosen that represented expected differences in types and degrees of impact. Samples were collected at Cheese Factory Road (upstream, rural/agricultural land use), Powder Mill Park (midstream, suburban/agricultural land use), and Ellison Park (downstream, suburban/urban land use) (Figure 1). Although the headwaters of Irondequoit Creek, located on Cheese Factory Road, are affected by agricultural runoff, this site was the least anthropogenically influenced and, therefore, was considered a "control" site. The two downstream sites were in Powder Mill Park (near Bergundy Basin) and Ellison Park (south of Blossom Road). In addition to being representative of the upper, middle, and lower portions of the creek, the three sampling locations were chosen because they were accessible, wadeable and had mixtures of gravel, vegetation, and mud habitats.

Methods

Physical and Chemical Parameters

To ensure habitat comparability among locations, certain physical, chemical and biological parameters were compared (Bode et al. 1991). Dissolved oxygen, pH, conductivity, temperature, and current speed were measured once at the upper- and lowermost stations at each location. Substrate particle size, percent embeddedness, percent canopy cover, width and depth, and presence of aquatic vegetation were recorded for all five stations at each sampling location (Bode et al. 1991).

Sampling

With the exception of the Ellison Park downstream site (Figure 1), five replicate samples of invertebrates were collected in gravel, mud and vegetation habitats in April of 1997. Mud and vegetation samples (five replicates each) were collected just downstream in 1996 (Haynes and McNamara 1998).

Mud samples were collected with an Ekman grab sampler. A site was chosen within the sampling station where there was adequate silt and mud habitat. The grab sampler was set, plunged into the silt/mud substrate, and the jaws were triggered. The sampler was pulled out of the substrate, placed over a mesh sieve and a bucket and much of the silt and mud were washed through into the bucket while retaining the organisms on the sieve. Organisms on the sieve were then washed off with water into a collecting jar.

Vegetation stations were chosen where vegetation was growing at the water's surface, hanging from bank edges or where trapped but floating vegetation existed. Samples were collected by passing an aquatic dip net through vegetative habitat until the net was half full. Once removed from the water, the dip net was inverted into a bucket and contents washed clean from the net. The sample was then poured from the bucket into a collecting jar.

Gravel samples were collected using the 2-min kick sampling method and an aquatic net (Bode et al. 1996). The 2-min kick sampling method was used in my study, as opposed to the 5-min method (according to Bode et al. 1990, index values derived from the 2-min and 5-min kick samples are comparable). A 5-m chain was placed diagonally across the riffle portion of the stream and substrate was dislodged, using a sweeping motion with the feet, for a 2-min period while traveling downstream to upstream. Once the dip net was removed from the water the sample was poured into a sieve. Small substrate was washed through the sieve while large substrate and organisms were retained on the sieve. Again, the contents of the sieve were washed into a collecting jar.

Samples were preserved in the field in 5% formalin. After 24 hours each sample was transferred to a solution of 70% ethanol with rose bengal dye. Organisms were separated from debris and placed into smaller sample jars. Second sorts were done on each sample to ensure the retrieval of most organisms, and they were added to the first counts.

Subsampling

For three locations (upstream, midstream, downstream) and three habitats (gravel, vegetation, mud) 100 organisms were randomly chosen from a gridded sorting pan by drawing random letters and numbers to determine quadrats in the pan to sample (RNB-Nichelle Bailey-Billhardt's random sample). Whole samples (WNB) were then sorted, identifications made and metrics were calculated along with the random samples (RNB).

For midstream (Powder Mill Park) gravel samples, three sampling methods were compared in order to determine if different sampling methods would yield similar community and structure metrics and similar stream health assessments. Using new samples collected from the same stream reach in Powder Mill Park in May 1998, 100 organisms were chosen from a gridded sorting pan haphazardly at the discretion of the sampler (haphazard samples, HCC, done by research assistant Christine Cody). Then, after replacement, 100 organisms were taken randomly (RCC- Cody's random sample). Metrics (TR, EPT, HBI, PMA) were calculated for 100 counts (HCC, RCC and RNB) and compared with metrics for the whole sample (WNB-Nichelle Bailey-Billhardt's whole sample) for the Powder Mill Park gravel habitat.

Invertebrates were identified to the lowest possible taxonomic level using keys by Merritt and Cummins (1996), Peckarsky et al. (1990), Wiggins (1977), Pennak (1989) and confirmed by W. Bollman 1998; Rhithron Biological Associates, Missoula, MT, personal communication).

Methods used by Bode et al. (1996) require a fixed count of 100 organisms to calculate each metric. However, chironomids were removed from my samples for another thesis project (Cook 1998) prior to obtaining 100 organisms. Therefore, metrics used for stream health assessment were calculated using whole samples, which include a detailed list of chronomid taxa provided by Cook (1998) (Appendix A). Haphazard and random counts include chironomids keyed only to the family level and, for consistency, they were compared to whole counts that included chironomids as one taxon.

Experimental Design and Statistical Analyses

Comparing Stream Reaches and Habitats

I used one-way ANOVA to test the null hypotheses that there were no differences in biotic indices among the upstream, midstream and downstream locations or the vegetation, mud and gravel habitats of Irondequoit Creek. Both raw metric values and metrics converted to the modified O'Brien plot (or scaled values; Figures 2-4) (Bode et al. 1996) were compared. I predicted that the results would show increasing impact farther downstream (e.g., more development) and differences among habitats (e.g., one would expect mud to support fewer taxa with higher "pollution" tolerance than gravel). When differences among treatments were significant, a Student Newman Keuls (Studentized Q; Sokal and Rolff 1981) test was used to determine which means were different.

Comparing 100 (Haphazard and Random) and Whole Samples

I used one-way ANOVA to test the null hypotheses that there were no differences in the biotic indices among 100 haphazard and 100 random samples (drawn and identified by C. Cody) and 100 random and whole samples collected and identified by me. When differences among treatments were significant, a Student Newman Keuls (Studentized Q; Sokal and Rolff 1981) test was used to distinguish means. Because samples were collected a month apart in different years (but in the same stream reach), it was possible that results of her random counts and mine would differ. If they did not differ, I could be confident that comparing my whole samples to her haphazard samples would be a valid methodology.

Because the number of taxa found is likely related to the number of organisms examined (in the sense of a species/sampling intensity curve, Figure 2), I predicted that the indices that depended on taxa counts (taxa richness, EPT, HBI) would be different for whole vs. 100 count samples, whereas the Percent Model Affinity index should be uninfluenced by the number organisms examined.

The key comparisons in this part of my study were between index values for the 100 haphazardly and randomly drawn organisms and between 100 haphazardly drawn organisms and whole samples. Invertebrate identification is incredibly labor-intensive and, to a lesser degree, so is random sampling, especially in the field. If there is no significant difference in indicators of stream health between 100 haphazardly drawn organisms and randomly drawn or whole samples, then the methods of Bode et al. (1996) really do offer a reliable, low cost way to assess stream health.

Results

Physical and Chemical Parameter Comparison

In order to ensure that invertebrate communities were sampled from similar stream habitats, the following physical and chemical parameters were recorded at the upper and lowermost stations at each location: depth, width, current, percent canopy cover, percent substrate embeddedness, temperature, conductivity, dissolved oxygen, pH and substrate particle size (Table 1). Of these parameters, the key habitat comparability criteria set by Bode et al. (1990) are substrate particle size, percent embeddedness, current speed, and canopy cover (Tables 2 and 3). Physiochemical parameters were recorded separately for different habitats (gravel, vegetation, mud), depending on where the sample was taken, and they were compared within the same habitat across locations to assess habitat similarity before collecting. At some locations, measurements were the same for more than one habitat.

Among habitats being compared, particle size should not differ by more than 3 phi units in gravel habitats or by more than 50% in mud habitats (Bode et al. 1990). In the gravel habitat, the upstream and downstream locations differed by 3.4 units (Table 2), slightly more than the recommended criterion. Particle sizes in the mud habitat did not differ by more than 50% among the three sampling locations (Table 3).

Differences in percent embeddedness should not exceed 50% unless the values are within 20 percentage units (Bode et al. 1990). In the gravel and mud habitats embeddedness did not differ by more than 50% (Tables 2 and 3).

Differences in current speed should not to exceed 50% unless they are within 20 cm/sec (Bode et al. 1990). For the gravel habitat, differences in current speeds were not greater than 50% among the three sample locations (Table 2). The upstream mud habitats did differ from other locations by more than 50% (Table 3).

Canopy cover should not to exceed a 50% difference unless the values are within 20 percentage units (Bode et al. 1990). The canopy cover above the upstream gravel habitat differed by more than 50% from the mid- and downstream values (Table 2). The upstream location was post-agricultural, dominated by vegetation in an early successional stage of tree growth, which explains the lower canopy cover values. The canopy cover above the midstream mud habitat differed from the other two locations by more than 50% (Table 3).

In sum, there were few consistent physical differences in the gravel and mud habitats sampled in upper, middle and lower Irondequoit Creek. Bode et al. (1990) do not provide distinguishing criteria for vegetated habitats. Therefore, it is unlikely that any differences found in benthic macroinvertebrate communities across locations would be due to physical habitat differences in the sections sampled in Irondequoit Creek.

Benthic Community Comparisons Among Locations Within Each Habitat

The TR (Taxa Richness), EPT (Ephemeroptera-Plecoptera-Trichoptera), HBI (Hilsenhoff Biotic Index) and PMA (Percent Model Affinity) metrics were used to compare benthic macroinvertebrate communities in gravel habitats, the TR, HBI, EPT and NCO (Non-Chironomid and Oligochaeta) metrics were used to compare communities in vegetation habitats, and the TR, DIV (Simpson's Diversity), HBI, DOM-3 (percent of community comprised by the three most abundant taxa), PMA and NCO metrics were used to compare mud habitat communities (Bode et al. 1996). Although NCO is not included in Bode's biological assessment profile of index values for soft sediments, nor is the formula available for scaled conversion, it is a valid metric for invertebrate communities in mud habitats (Bode 2001, NYSDEC Stream Biomonitoring Unit Albany, NY, personal communication). A 1-way ANOVA was performed on all raw and scale-converted metrics (Tables 4-6), and if ANOVAs were significant analysis continued with Student Newman-Keuls tests to distinguish significant differences among treatment means (Tables 7-13; Raw data is found in Appendix B).

Gravel Habitat Comparisons Across Locations

Raw and scale-converted metrics applicable to the gravel habitat (TR, EPT, HBI, PMA) were compared among the upstream (Cheese Factory Road), midstream (Powder Mill Park) and downstream (Ellison Park) locations (Figure 1). In the gravel habitat, there were significant differences across locations in raw and scaled values for the TR, EPT and PMA indices (Tables 4, 7, 8 and 10). For raw and scaled values, the higher TR, HBI and PMA indices indicated improving water quality from downstream to upstream (Table 4, 7 and 10). While there were no differences in the HBI across locations (P=0.076, Table 4), the trend for the HBI also suggests improving water quality from downstream to upstream. Raw and scaled EPT richness values, however, indicate that the midstream community had the highest water quality followed by the upstream and then the downstream community (Tables 4 and 8). Overall, water quality declined from upstream to downstream in the gravel habitats.

Vegetation Habitat Comparisons Across Locations

Metrics applicable to the vegetation habitat (TR, HBI, EPT and NCO) were compared among the three stream locations, but no definitive trends were found. Raw community TR values did not differ significantly (P=0.057) among the three communities sampled in the vegetation habitat (Tables 5 and 7), although the trend suggests better water quality at the up- and midstream than at the downstream locations (Table 5). There were differences across locations for the scaled TR and for the raw and scaled EPT and HBI indices (Tables 5, 7, 8 and 9). The TR and EPT indices denote better water quality at the midstream location, followed by the up- and downstream locations (Table 5, 7 and 8). A low scaled HBI value indicates a slight impact on water quality in the midstream community compared to the up- and downstream communities in the vegetation habitat. No significant differences were found among raw and scaled NCO indices (Tables 5 and 11).

Mud Habitat Comparisons Across Locations

Metrics applicable in the mud habitat (TR, HBI, PMA, DIV, DOM3 and NCO) were compared among the upstream, midstream and downstream locations. There were no significant differences among the three mud communities in raw and scaled values for the TR, HBI, PMA and NCO indices (Tables 6, 7, 9, 10 and 11). For the mud habitat, only the raw NCO richness values were calculated (there is no formula available for scaled values) (Bode 2001, personal communication). Raw and scaled DIV (Simpson's Diversity) and DOM-3 indices indicated improving water quality from downstream to upstream (Tables 6, 12 and 13).

Benthic Community Comparisons Among Habitats Within Each Location

Comparisons among all habitats within the same location are limited to the Taxa Richness (TR) and the Hilsenhoff Biotic Index (HBI) metrics. Ephemeroptera-Plecoptera-Trichoptera richness (EPT) is applicable only for comparing gravel and vegetation habitats, Percent Model Affinity (PMA) is applicable only to the gravel and mud habitats, and NCO (non-Chironomid, non-Oligochaeta) richness is applicable only to the vegetation and mud habitats. DIV (Shannon-Wiener Diversity) and DOM3 (percentage of the three most abundant taxa in the community) were not used for habitat comparisons because these metrics are only used for the mud habitat. For each location (upstream, midstream, downstream) each applicable metric was analyzed using 1-way ANOVA's followed by Student-Newman Keuls (SNK) tests, if appropriate (Tables 14-18; Raw data is found in Appendix C).

Upstream Location (Cheese Factory Road)

At the upstream location (Figure 1), there were significant differences in index values among the three habitats for the TR, EPT, and HBI indices (Table 14). Raw TR was higher in the gravel habitat than in the mud and vegetation habitats (Tables 14 and 17), raw EPT richness was greater in the gravel habitat than in the vegetation habitat (Table 14), and the raw HBI metric indicated a healthier benthic community in the vegetation habitat than in the mud and gravel habitats (Tables 14 and 18). Raw PMA values did not differ between the gravel and mud communities, and raw NCO values suggest better water quality in the vegetation habitat than in the mud habitat ($P = 0.052$, Table 14). For scaled values, only the HBI index remained significantly different among the three habitats, with the gravel community having higher HBI diversity than the mud and vegetation communities (Tables 14 and 18). Overall, once adjusted by scaled values for inherent differences in habitat quality for benthic macroinvertebrates (gravel ≥ vegetation > mud), there were no apparent water quality-related differences among the gravel, mud and vegetation communities at the upstream location.

Midstream Location (Powder Mill Park)

At the midstream location, raw values were significantly different among habitats for the TR, HBI, and NCO indices (Tables 15, 17, and 18). Raw TR and HBI values were higher and lower, respectively, in the gravel and vegetation habitats than in the mud habitat (Tables 15 and 17), and NCO was higher in the vegetation habitat than in the mud habitat (Table 15). There were no significant differences for the raw EPT and PMA indices (Table 15). Scaled EPT richness was higher in vegetation than in gravel, and scaled PMA was significantly higher in gravel than in mud (Table 15), but scaled values were not significantly different for the TR and HBI indices (Tables 15, 17, and 18). TR and HBI are the two indices that allow comparisons across all three habitats, so it is reassuring to see that these indices, when scaled, show no differences among benthic communities at the midstream location. The PMA scaled index suggests that the gravel habitat has greater affinity with a model gravel community than the mud habitat does with a model mud community. Overall, once adjusted by scaled values for inherent differences in habitat quality for macroinvertebrates (gravel ≥ vegetation > mud), there were few water quality-related differences among the gravel, vegetation and mud communities at the midstream location.

Downstream Location (Ellison Park)

At the downstream location raw values were different for all indices (Table 16). Raw TR for the gravel habitat was higher than for the vegetation and mud habitats (Tables 16 and 17), and raw HBI values for the vegetation, gravel and mud habitats ranged from lower to higher, respectively (Tables 16 and 18). Raw EPT richness was higher in the gravel habitat than in the vegetation habitat, raw PMA was higher for the mud than the gravel community, and the raw NCO index was higher for the vegetation than the mud community (Table 16). Scaled values were different for the EPT and HBI indices, and they approached significance for TR ($P = 0.07$, Table 16), with the gravel habitat appearing to have greater TR than the mud and vegetation habitats (Table 16). The scaled HBI suggests better water quality in the gravel and mud habitats than in the vegetation habitat (Tables 16 and 18), and the scaled EPT index suggests better water quality in the gravel than in the vegetation habitat (Table 16). Thus, in lower Irondequoit Creek the indices used give a confusing picture of water quality impacts.

Haphazard versus Random versus Whole Count Metrics

Except for the PMA index, raw and scaled metrics for haphazard and random samples of 100 organisms and whole-sample analyses were different, with whole counts consistently providing higher scaled scores, indicative of better water quality, for the TR and EPT indices (Tables 19 and 20; raw data is found in Appendix D). Except for the HBI metric, there were no differences between haphazard and random values for samples of 100 organisms or between the values obtained with different random samples from the same midstream reach in Powder Mill Park (Tables 19 and 20). These results suggest that haphazard subsampling provides the same quality of information as the random subsampling, but that whole samples provide much additional information. Consistent within- and between- investigator results for the TR and EPT indices are a good indicator of methodological soundness. However, the significant difference in HBI values between investigators is troubling. C. Cody (May 1998) and N. Bailey-Billhardt (April 1997) did analyze different samples from the same stream section in Powder Mill park, but why there is a dramatic difference between their HBI values and not their TR and EPT values is unknown.

Discussion

Importance of Comparable Physical and Chemical Habitat Parameters

Sampling multiple habitats at the same location is an excellent way to assess stream health. However, one must be careful when comparing raw community and structure metrics derived from different habitats. Bode et al.'s (1996) protocol ensures habitat comparability by establishing acceptable limits for specified chemical and physical parameters that result in minimal differences in community health metrics due to habitat differences (Bode et al. 1990). In my study, samples were taken in gravel, vegetation and mud habitats. Due to differing biological requirements of species, the benthic invertebrate community in each habitat was expected to be different. Substrate characteristics, particularly particle size, are believed to be one of the most important habitat factors that determine macroinvertebrate community structure (Richards and Host 1994; Mackay 1992). Substrate differences will result in distinct community assemblages, while the same substrate at a different location likely will yield the same community assemblage (Brown and Brussock 1991; McCulloh 1986; Jenkins et al. 1984). Therefore, when raw metrics were compared across habitats at the same location in my study, the differences seen in my data were expected.

Bode et al.'s protocol (1996) takes into account inter-habitat variation by converting raw metrics to habitat-specific scaled metrics. If community differences across habitats were not taken into account, "inter-habitat variation" could be mistaken for ecological impairment (Parson and Norris 1996). In my study, raw metric data differed much more frequently when comparing habitats within locations than did scaled metrics for the same samples. Thus, it appears that the scaled metrics did a good job of removing inter-habitat variability from my data.

Biological Stream Health Assessment Across Locations and Habitats

The first objective of my study was to determine invertebrate community health in Irondequoit Creek based on Bode et al.'s protocol (1996). Individual metrics were calculated for the gravel, vegetation and mud habitat at each stream location (upstream, midstream and downstream) and converted by formulae (Bode 2001, personal communication) to scaled values between one and ten (Figures 3-5). These scaled metrics were then averaged to determine the degree of water quality impact at each location and habitat. Figures 6, 7 and 8 compare scaled metric values within the three habitats (gravel, vegetation, mud) among the three stream locations. When comparing similar habitats across locations, the trend is that there were few differences in scaled community metrics between the up- and midstream locations while the downstream location is often different than the middle and upper reaches of Irondequoit Creek. While there is some variation among the metrics regarding their predictions of impact, the average of the metrics for the benthic macroinvertebrate communities in Irondequoit Creek indicate that water quality is better at the upper and middle locations than at the downstream location. Thus, it appears that as Irondequoit Creek passes through areas of greater suburban and urban development its water quality declines.

Figures 9-11 compare scaled metric values within locations among the three habitats. While there is some variation among metrics, the vegetation habitat exhibits the least impact, the gravel habitat shows intermediate impact, and the mud habitat has the greatest impact. At the upstream location, all habitats appear to be only slightly impacted, although the vegetation habitat borders the lower limit of no impact (Figure 9). At the midstream location, average metric values categorize the gravel habitat as slightly impacted, the vegetation as non-impacted, and the mud as moderately impacted (Figure 10). At the downstream location, average metric values categorize the gravel and vegetation habitats as moderately impacted, while the mud habitat is severely impacted (Figure 11). As seen above, relative stream health improves from downstream to upstream.

At the downstream location (Ellison Park) stream health assessment can be compared to historical data from previous macroinvertebrate studies (Coon 1997; Sutton 1998). Sutton (1998) calculated macroinvertebrate metrics for the gravel habitat at Ellison Park for samples taken in June of 1995, while the RIBS (NYSDEC Rotating Intensive Basin Survey) for Irondequoit Creek took samples from gravel habitat in August of 1995 and 1996 (Coon 1997). Both studies evaluated results using the New York State expected index values for flowing water (Bode et al. 1990). Sutton (1998) and my study categorized Ellison Park's benthic macroinvertebrate community as moderately impacted based on the EPT and PMA metrics. However, Sutton's study assessed the downstream macroinvertebrate community as moderately impacted using the TR metric, while my study characterized the community as slightly impacted. Also, Sutton's (1998) HBI metric assessed the downstream impact as slight, while my study characterized the downstream location as moderately impacted. The RIBS report identified the downstream site as slightly impacted in both years 1995 and 1996 (Coon 1997). Overall, assessments from these three studies are in substantial agreement and categorized the gravel habitat of lower Irondequoit Creek as slightly to moderately impacted. Data from Cook's (1998) chironmid analysis revealed higher taxa richness and Simpson's Diversity values in the upstream location than in the downstream. Based on these results, it seems reasonable to conclude that my data indicating healthier benthic macroinvertebrate communities at the up- and midstream locations are valid.

The degree of impact at the downstream site is not surprising given the history of the watershed. Since the early 1800s the Irondequoit Basin has been subject to polluted effluent from many anthropogenic sources. Throughout its history the basin's waters have undergone large population fluctuations and as a result, Irondequoit Basin has received nutrient-rich raw and treated sewage, excessive sediment caused by logging practices, raw effluent from tanneries, and nutrients, sediment and pesticide runoff from agricultural practices (Verna 1995; Tangorra 1996). This pattern of pollution rendered Irondequoit Bay and its tributaries culturally eutrophied (Verna 1995; Tangorra 1996).

In efforts to remediate and/or prevent further degradation of Irondequoit Bay and its tributaries, sewage diversions were established and the Frank E. Van Lare Treatment Plant was enlarged and updated to institute primary and secondary treatment, as well as phosphorus removal, for the basin (Verna 1995). The changing degree of impact from upstream to downstream in Irondequoit Creek may reflect efforts made to improve the quality of water entering Irondequoit Creek. My results can also be used as a comparison of stream health in subsequent years as cleanup efforts continue within the Irondequoit Creek Watershed.

Haphazard vs. Random 100 Counts vs. Whole Samples

The second objective of my study was to examine the reliability of the NYSDEC Stream Biomonitoring Protocol (Bode et al. 1996). In my study, haphazard subsampling of 100 organisms per sample was not performed in the field. The entire sample was taken back to the lab for sorting, then after sorting and elimination of debris, 100 organisms were sampled haphazardly and randomly, with replacement, identified and then returned to the whole sample. In my study, organisms sorted by the haphazard method were considered comparable to Bode et al.'s (1996) field sort.

Some researchers suspect that field sorting may bias a sample to over represent larger, more easily seen organisms versus smaller, less visible or rare invertebrates (Lenz and Miller 1996). Barbour and Gerritsen (1996) suggested that fixed-count methods require non-biased subsampling, or random sampling, to ensure accurate assessments of stream health. In my study, the random grid/quadrat method of sorting was used to eliminate this potential bias (Cao et al. 1998; Barbour and Gerritsen 1996). No differences were found between 100 count random and haphazard subsamples, other than for the HBI metric (Figure 12), suggesting that haphazard and random samples of 100 organisms give nearly equivalent results.

Fixed count, subsampling methods are the preferred methodology because they are a more practical and economical approach for using benthic macroinvertebrates to assess ecosystem health (Barbour and Gerritsen 1996; Plafkin et al. 1989), but do they provide statistical results equivalent to whole samples? I found significant differences (1-way ANOVA, $p<0.01$) between the TR and EPT metrics calculated from fixed count methods versus those calculated from whole samples (Tables 19 and 20). However, following Bode et al.'s protocol (1996), even though statistical differences were found for two individual metrics, the average metrics for all methods showed the midstream location to be slightly impacted (Figure 12).

The elimination of rare species often indicates differences between a relatively "pristine" stream reach and a polluted one. Cao et al. (1998) suggest that fixed count methods, random or haphazard, overlook rare species, resulting in diminished species richness values and difficulty in discerning differences in stream health among sites. Streams with less distinct variations may not be differentiated at all with fixed count methods. The haphazard and random subsamples in my study all underestimated TR and EPT richness compared to whole samples for the same location (Figure 12). These results suggest that the fixed 100 count random and haphazard samples do eliminate rare species and result in lower richness values as opposed to entire counts, but again these differences did not generally suggest differences in stream community health. Higher richness values for the whole sample also support the idea that a larger number of samples will yield a greater number of species up to a point (Figure 2).

Although most metrics calculated in my study followed expected trends across locations and habitats, the HBI metric did not. This metric relies on taxonomic resolution to the species level, although some tolerance values are established for genus- and family-level identifications (Lenz and Miller 1996; Bode et al. 1996). Taxa, in my study, were identified to the lowest practical level possible and included family, genus and species level identifications. Perhaps if the taxonomic resolution was to species level across all of my samples the HBI index values would follow predicted stream health assessments. Family-level identifications can be used with Hilsenhoff's Family Level Biotic Index, which yielded results similar to the HBI in a study by Lenz and Miller (1996). However, in my study, the Family Biotic Index rated the midstream gravel habitat non-impacted, as opposed to the HBI rating of slightly impacted.

Summary/Conclusions

Generally, as development and civilization encroach upon stream banks, stream health tends to degrade. The watershed of Irondequoit Creek is increasingly developed from upstream to downstream. Therefore, it is useful to know that the upstream and midstream locations were slightly impaired (averaged across habitats), while the downstream location was moderately impaired. My study provides a detailed list of organisms to which, in the event that better land management practices are put in place, the human impact on stream health can be compared in the future.

Low fixed count methods of sampling may indeed eliminate rare species, leading to inaccurate stream health assessments. In my study, although statistical differences were found among random and haphazard (100 counts) versus whole sample counts, no statistical differences were found among stream health assessments determined by these methods. Therefore, according to Bode et al.'s (1996) protocol, stream health assessments were as accurate for 100 counts as they were for the whole sample.

Literature Cited

Barbour, M.T., and J. Gerritson. 1996. Subsampling of benthic samples: A defense of the fixed count method. *J. N. Am. Benthol. Soc.* 15:386-391.

Barbour, M.T., J.L. Plafkin, B.P. Bradley, C.G. Graves and R.W. Wisseman. 1992. Evaluation of EPA's Rapid Bioassessment Benthic Metrics: Metric redundancy and variability among reference stream sites. *Environmental Toxicology and Chemistry* (11):437-449.

Bartenhagen, K.A. 1995. A water quality manager's guide to water resource protection. M.S. thesis. Duke University School of Environment.

Bode, R.W., M.A. Novak, and L.E. Abele. 1990. Biological impairment criteria for flowing waters in New York State. NYSDEC, Division of Water, Albany, NY.

Bode, R.W., M.A. Novak and L.E. Abele. 1991. Quality assurance work plan for biological stream monitoring in New York State. NYSDEC, Division of Water, Albany, NY.

Bode, R.W., M.A. Novak and L.E. Abele. 1996. Quality assurance work plan for biological stream monitoring in New York State. NYSDEC, Division of Water, Albany, NY.

Brower, J.E., J.H. Zar and C.N. von Ende. 1990. Field and Laboratory Methods for General Ecology, 3rd Ed. Wm. C. Brown Publishers, Dubuque, IA.

Brown, A.V., and P.P. Brussock. 1991. Comparisons of benthic invertebrates between riffles and pools. *Hydrobiologia* 220:99-108.

Cao, Y., D.D. Williams and N.E. Williams 1998. How important are rare species in aquatic community ecology and bioassessment. *Limnology and Oceanography* 43(7):1403-1409.

Chutter, F.M. 1972. An empirical biotic index of the quality of water in South African streams and rivers. *Water Resources* 6:19-30.

Cook, E. 1998. Chironomid (Diptera: Chironomidae) larvae as indicators of water quality in Irondequoit Creek, New York. M.S. thesis, Department of Biological Sciences, SUNY College at Brockport.

Coon, W. 1997. Hydrology, Sedimentology and Biology of Ellison Park Wetland at the Mouth of Irondequoit Creek near Rochester, New York. U.S. Geological Survey, Water Resources Division.

EPA, Monroe County Health Department. 1993. Rochester Embayment Area of Concern. (www.epa.gov/grtlakes/aoc/rochester.html).

Haynes, J.M., and J.N. McNamara. 1998. Indicators of change in water quality and environmental health in the Irondequoit Creek Wetland Complex. Department of Biological Sciences. SUNY College at Brockport

Hellawell, J.M. 1986. Biological Indicators of Freshwater Pollution and Environmental Management. Elsevier, London.

Hilsenhoff, W.L. 1982. Using a biotic index to evaluate water quality in streams. Technical Bulletin No. 132. Wisconsin Department of Natural Resources, Madison, WI.

Jenkins, R. A, K.R.Wade and Pugh 1984. Macroinvertebrate habitat relationships in the River Teifi catchment and the significance to conservation. *Freshwater Biology* 14:23-42.

Johnston, W.H. and D.A. Sherwood. 1988. Water Resources of Monroe County, New York, Water Years 1984-1988, with Emphasis on Water Quality in the Irondequoit Creek Basin; Part 2.

Kappel, W.M., R.M. Yager and P.J. Zarriello. 1981. Quantity and Quality of Urban Storm Runoff in the Irondequoit Creek Basin near Rochester, New York. Part 2: Quality of Storm Runoff and Atmospheric Deposition, Rainfall-Runoff-Quality Modeling, and Potential of Wetlands for Sediment and Nutrient Retention.

Lenat, D.R., and M.T. Barbour. 1994. Using benthic macroinvertebrate community structure for rapid, cost-effective, water quality monitoring: rapid bioassessment. In: S.L. Loeb and A. Spacie (Eds.), Biological Monitoring of Aquatic Ecosystems, Lewis Publishers, Boca Raton, FL

Lenz, B.N., and M.A. Miller. 1996. Comparison of aquatic macroinvertebrate samples collected using different field methods. USGS Fact Sheet FS-216-96.

Loeb, S.L. and A. Spacie (Eds.). 1994. Biological Monitoring of Aquatic Ecosystems. Lewis Publishers, Boca Raton, FL.

Mackay, R.J. 1992. Colonization by lotic macroinvertebrates: A review of processes and patterns. *Canadian Journal of Fisheries and Aquatic Science* 49:617-628.

McCulloh, D.L. 1986. Benthic macroinvertebrate distribution in the riffle-pool community of two East Texas streams. *Hydrobiologia* 135:61-70.

Merritt, R.W., and K.W. Cummins. 1996. An Introduction to the Aquatic Insects of North America: (3rd Ed.) Kendall/Hunt Publishing Company, Dubuque, IA.

Monroe County Department of Health, Rochester, NY. 1993. Rochester Embayment Remedial Action Plan, Stage I. 1993. New York State Department of Environmental Conservation, Albany, NY

Monroe County Department of Health, Rochester, NY. 1997. Rochester Embayment Remedial Action Plan, Stage II, Volume 1. New York State Department of Environmental Conservation, Albany, NY.

Parsons, M., and R.H. Norris. 1996. The effect of habitat specific sampling on biological assessment of water quality using a predictive model. *Freshwater Biology* 36:419-434.

Peckarsky, B.L., P.R. Fraissinet, M.A. Penton, and D.J. Conklin, Jr. 1990. Freshwater Macroinvertebrates of Northeastern North America. Cornell University Press, Ithaca, NY.

Pennak, R.W. 1989. Freshwater Invertebrates of the United States, 3rd Ed. John Wiley and Sons, New York.

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. EPA/444/4-89/001. Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, D.C.

Reice, S.R., and M. Wohlenberg. 1993. Monitoring freshwater benthic macroinvertebrates and benthic processes: Measures for assessment of ecosystem health. In: Freshwater Biomonitoring and Benthic Macroinvertebrates, D.M. Rosenberg and V.H. Resh (Eds.). Routledge, Chapman & Hall, Inc. New York.

Resh, V.H., and J.K. Jackson. 1993. Rapid assessment approaches to biomonitoring using benthic macroinvertebrates. In: Freshwater Biomonitoring and Benthic Macroinvertebrates, D.M. Rosenberg and V.H. Resh (Eds.). Routledge, Chapman & Hall, Inc. New York.

Resh, V.H., R.H. Norris and M.T. Barbour. 1995. Design and implementation of rapid bioassessment approaches for water resources monitoring using benthic macroinvertebrates. *Australian Journal of Ecology* 20:108-121.

Richards, C., and G. Host. 1994. Examining land use influences on stream habitats and macroinvertebrates: A GIS approach. *Water Resources Bulletin* 30(4):729-738.

Rosenberg, D.M. and V.H. Resh.(Eds.) 1993. Freshwater Biomonitoring and Benthic Macroinvertebrates. Routledge, Chapman & Hall, Inc. New York.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry: 2nd Ed. W.H. Freeman, San Francisco.

Somers, K.M., R.A. Reid and S.M. David. 1998. Rapid biological assessments: How many animals are enough? *J. N. Am. Benthol. Soc.* 17(3):348-358.

Sutton, W.L. 1998. Biological stream assessment of Irondequoit Creek and two tributaries, Thomas and Allen Creeks. In cooperation with NYSDEC, Division of Fish and Wildlife. Albany, NY.

Tangorra, P.A. 1996. Sediment chemistry of Irondequoit Bay, NY. M.S. thesis. Department of Biological Sciences, SUNY College at Brockport.

Thorne, R. S. J., and P. Williams. 1997. The response of benthic macroinvertebrates to pollution in developing countries: A multimetric system of bioassessment. *Freshwater Biology* 37:671-686.

Verna, A. 1995. The paleolimnology of Irondequoit Bay: Trophic history inferred from sediment diatom assemblages. M.S. thesis. Department of Biological Sciences, SUNY College at Brockport.

Wiggins, G.B. 1977. Larvae of the North American Caddisfly Genera. University of Toronto Press, Toronto.

Table 1. Physical (depth, width, current, canopy, % embeddedness, temperature and particle size) and chemical (conductivity, dissolved oxygen and pH) habitat parameters across habitats (gravel, vegetation, mud) and locations (upstream, midstream, downstream). Measurements were taken at the uppermost and lowermost station at each location. Gravel and vegetation habitat parameters were taken at different sites for the upstream and midstream samples. Habitat parameters were measured at three different habitat sites at the downstream location.

	Upstream		Midstream		Downstream		
	Gravel, Veg	Mud	Veg, Gravel	Mud	Upper Site Veg, Mud	Lower Site Veg, Mud	Gravel
Depth (cm)	44.5	44.5	41.8	71.8	55	94	48
Width (m)	4.9	4.9	9.8	9.3	18	18	14.4
Current (cm/s)	79.8	79.8	52	20.2	29	18	81
Canopy (%)	6	6	45	45.2	2	0	60
Embeddedness (%)	30	80	24	85	92	96	43
Temperature (C)	10.9	10.9	12.2	13	14.9	10.5	12.3
Conductivity (umhos)	353	353	972	1099	600	555	992
DO (mg/L)	10	10	11	11.2	6.9	12.6	10.3
pH	7.5	7.5	7	8.2	8.1	7.8	7.9
Particle size (phi)	-1.2	4.8	-2.9	3.4	3	5.6	-4.6

Table 2. Particle size, % embeddedness, current and canopy cover at the upstream, midstream and downstream locations in the gravel habitat. Habitat comparability criteria identified by Bode et al. (1991).

Gravel	Upstream	Midstream	Downstream
Particle size (phi)	-1.2	-2.9	-4.6
Embeddedness (%)	30	24	43
Current (cm/s)	79.8	52	81
Canopy (%)	6	45	60

Table 3. Particle size, % embeddedness, current and canopy cover at the upstream, midstream and downstream locations in the mud habitat. Habitat comparability criteria identified by Bode et al. (1991).

Mud	Upstream	Midstream	Downstream
Particle size (phi)	4.8	3.4	4.3
Embeddedness (%)	80	85	94
Current (cm/s)	79.8	20.2	23.5
Canopy (%)	6	45.2	1

Table 4. Average raw and scaled metric results including Taxa Richness (TR; modified from Bode et al. (1996) Species Richness), Ephemeroptera-Plecoptera-Trichoptera Richness (EPT), Hilsenhoff Biotic Index (HBI) and Percent Model Affinity (PMA) for gravel habitats among three locations (upstream, midstream and downstream) compared by 1-way ANOVA.

		Upstream	Midstream	Downstream	*F*	*P-value*
Taxa Richness	Raw	37.80	29.80	25.40	5.331	**0.022**
	Scaled	9.28	8.36	7.19	5.633	**0.019**
EPT Richness	Raw	8.80	9.80	3.40	12.095	**0.001**
	Scaled	6.78	7.33	3.58	11.894	**0.001**
HBI	Raw	5.88	6.06	6.87	3.220	0.076
	Scaled	5.78	5.55	4.54	3.220	0.076
PMA	Raw	58.22	47.42	36.00	6.434	**0.013**
	Scaled	6.27	4.70	2.79	6.701	**0.011**

Table 5. Average raw and scaled metric results including Taxa Richness (TR; modified from Bode et al. (1996) Species Richness), Ephemeroptera-Plecoptera-Trichoptera (EPT) Richness, Hilsenhoff Biotic Index (HBI) and Non-Chironomid/Non-Oligochate (NCO) Richness for vegetation habitats among three locations (upstream, midstream and downstream) compared by 1-way ANOVA.

		Upstream	Midstream	Downstream	*F*	*P-value*
Taxa Richness	Raw	24.60	25.60	16.60	3.672	0.057
	Scaled	7.74	9.40	5.20	5.249	**0.023**
EPT Richness	Raw	4.40	9.80	0.00	103.257	**0.000**
	Scaled	6.08	9.84	0.00	129.536	**0.000**
HBI	Raw	4.08	5.83	4.74	5.663	**0.019**
	Scaled	9.04	6.92	8.80	5.948	**0.016**
NCO	Raw	12.80	15.60	14.80	0.817	0.465
	Scaled	8.32	10.00	9.28	2.702	0.107

Table 6. Average raw and scaled metric results including Taxa Richness (TR; modified from Bode et al. 1996 Species Richness), Hilsenhoff Biotic Index (HBI), Percent Model Affinity (PMA), Non-Chironomid/Non-Oligochate (NCO) Richness, Shannon Weiner Diversity (DIV) and DOM-3 (% of three most dominant species) for mud habitats among three locations (upstream, midstream and downstream) compared by 1-way ANOVA.

		Upstream	Midstream	Downstream	*F*	*P-value*
Taxa Richness	Raw	19.20	19.40	14.80	2.587	0.116
	Scaled	7.38	7.37	5.13	2.903	0.094
HBI	Raw	6.78	7.34	7.83	1.581	0.246
	Scaled	7.97	6.66	5.39	1.627	0.237
PMA	Raw	49.84	38.64	48.45	2.314	0.141
	Scaled	3.97	2.11	3.69	2.174	0.156
NCO	Raw	7.40	6.40	6.80	0.167	0.848
	Scaled	ND	ND	ND	ND	ND
DIV	Raw	2.03	1.85	1.14	8.234	**0.006**
	Scaled	2.85	1.88	0.15	5.692	**0.018**
DOM3	Raw	66.75	70.99	88.50	5.044	**0.026**
	Scaled	6.38	5.67	2.56	5.396	**0.021**

Table 7. Raw and scaled taxa richness (TR) values among locations (upstream-U, midstream-M, downstream-D) within habitats (gravel, vegetation, mud) compared by 1-way ANOVA and Student Newman Keuls (if significance was found with ANOVA). (*, P<0.05; **, P< 0.01; ***, P<0.005).

	TR	U-M	U-D	M-D
Gravel	Raw	**	***	ns
Gravel	Scaled	ns	***	*
Veg	Raw	ns	ns	ns
Veg	Scaled	ns	*	***
Mud	Raw	ns	ns	ns
Mud	Scaled	ns	ns	ns

Table 8. Raw and scaled Ephemeroptera-Plecoptera-Trichoptera (EPT) Richness values among locations (upstream-U, midstream-M, downstream-D) within habitats (gravel, vegetation, mud) compared by 1-way ANOVA and Student Newman-Keuls (if significance was found with ANOVA). (*, P<0.05; **, P< 0.01; ***, P<0.005).

		U-M	U-D	M-D
Gravel	Raw	ns	***	***
Gravel	Scaled	ns	***	***
Veg	Raw	***	***	***
Veg	Scaled	***	***	***

Table 9. Raw and scaled Hilsenhoff Biotic Index values among locations (upstream, midstream, downstream) within habitats (gravel, vegetation, mud) compared by 1-way ANOVA and Student Newman-Keuls (if significance was found with ANOVA). (*, P<0.05; **, P< 0.01; ***, P<0.005).

		U-M	U-D	M-D
Gravel	Raw	ns	ns	ns
Gravel	Scaled	ns	ns	ns
Veg	Raw	***	ns	**
Veg	Scaled	***	ns	***
Mud	Raw	ns	ns	ns
Mud	Scaled	ns	ns	ns

Table 10. Raw and scaled Percent Model Affinity (PMA) values among locations (upstream-U, midstream-M, downstream-D) within habitats (gravel, mud) compared by 1-way ANOVA and Student Newman-Keuls (if significance was found with ANOVA). (*, P<0.05; **, P< 0.01; ***, P<0.005)

		U-M	U-D	M-D
Gravel	Raw	*	***	*
Gravel	Scaled	*	***	*
Mud	Raw	ns	ns	ns
Mud	Scaled	ns	ns	ns

Table 11. Raw and scaled Non-Choronomid/Non-Oligochaete (NCO) values among locations (upstream-U, midstream-M, downstream-D) within habitats (vegetation, mud) compared by 1-way ANOVA and Student Newman-Keuls (if signifcance was found with ANOVA). (*, P<0.05; **, P< 0.01; ***, P<0.005)

		U-M	U-D	M-D
Veg	Raw	ns	ns	ns
Veg	Scaled	ns	ns	ns
Mud	Raw	ns	ns	ns

Table 12. Raw and scaled Shannon-Weiner Diversity (DIV) values among locations (upstream-U, midstream-M, downstream-D) within the mud habitat compared by 1-way ANOVA and Student Newman-Keuls (if signficance was found with ANOVA). (*, P<0.05; **, P< 0.01; ***, P<0.005)

		U-M	U-D	M-D
Mud	Raw	ns	***	***
Mud	Scaled	ns	***	**

Table 13. Raw and scaled DOM-3 (% of three most dominant species) values among locations (upstream-U, midstream-M, downstream-D) within the mud habitat compared by 1-way ANOVA and Student Newman-Keuls (if significance was found with ANOVA). (*, P<0.05; **, P< 0.01; ***, P<0.005)

		U-M	U-D	M-D
Mud	Raw	ns	***	***
Mud	Scaled	ns	***	***

Table 14. Raw and scaled metric results for Taxa Richness (TR; modified from Bode et al. 1996), Ephemeroptera-Plecoptera-Trichoptera (EPT) Richness, Hilsenhoff Biotic Index (HBI), Percent Model Affinity (PMA), Non-Chironomid/Non-Oligochaete (NCO) Richness, Shannon-Weiner Diversity (DIV) and percentage of the three most dominant species (DOM-3) at the upstream location among three habitats (gravel, vegetation and mud) compared by 1-way ANOVA.

		Gravel	Veg	Mud	*F*	*P-value*
Taxa Richness	Raw	37.800	24.600	19.200	8.069	**0.006**
	Scaled	9.278	7.740	7.385	1.237	0.325
EPT Richness	Raw	8.800	4.400	NA	16.133	**0.004**
	Scaled	6.782	6.100	NA	0.622	0.453
HBI	Raw	5.877	4.081	6.782	10.265	**0.003**
	Scaled	5.779	9.040	7.973	5.886	**0.017**
PMA	Raw	58.220	NA	49.842	1.200	0.305
	Scaled	6.270	NA	3.968	3.599	0.094
NCO	Raw	NA	12.800	7.400	5.207	0.052
	Scaled	ND	ND	ND	ND	ND
DIV	Raw	NA	NA	2.034	*	*
	Scaled	NA	NA	2.850	*	*
DOM-3	Raw	NA	NA	66.746	*	*
	Scaled	NA	NA	6.376	*	*

Table 15. Raw and scaled metric results for Taxa Richness (TR; modified from Bode et al. 1996), Ephemeroptera-Plecoptera-Trichoptera (EPT) Richness, Hilsenhoff Biotic Index (HBI), Percent Model Affinity (PMA), Non-Chironomid/Non-Oligochaete (NCO) Richness, Shannon-Weiner Diversity (DIV) and percentage of the three most dominant species (DOM-3) at the midstream location among three habitats (gravel, vegetation and mud) compared by 1-way ANOVA.

		Gravel	Veg	Mud	*F*	*P-value*
Taxa Richness	Raw	29.800	25.600	19.400	7.851	**0.007**
	Scaled	8.356	9.400	7.367	2.668	0.110
EPT Richness	Raw	9.800	9.800	NA	0.000	1.000
	Scaled	7.327	9.840	NA	12.433	**0.008**
HBI	Raw	6.063	5.830	7.337	11.138	**0.002**
	Scaled	5.546	6.920	6.657	2.120	0.163
PMA	Raw	47.416	NA	38.638	2.438	0.157
	Scaled	4.696	NA	2.105	9.883	**0.014**
NCO	Raw	NA	15.600	6.400	26.286	**0.014**
	Scaled	ND	ND	ND	ND	ND
DIV	Raw	NA	NA	1.854	*	*
	Scaled	NA	NA	1.880	*	*
DOM-3	Raw	NA	NA	70.990	*	*
	Scaled	NA	NA	5.668	*	*

Table 16. Raw and scaled metric results for Taxa Richness (TR; modified from Bode et al. 1996), Ephemeroptera-Plecoptera-Trichoptera (EPT) Richness, Hilsenhoff Biotic Index (HBI), Percent Model Affinity (PMA), Non-Chironomid/Non-Oligochaete (NCO) Richness, Shannon-Weiner Diversity (DIV) and percentage of the three most dominant species (DOM-3) at the downstream location among three habitats (gravel, vegetation and mud) compared by 1-way ANOVA.

		Gravel	Veg	Mud	*F*	*P-value*
Taxa Richness	Raw	25.400	16.600	14.800	17.678	**0.000**
	Scaled	7.193	5.200	5.172	3.351	0.070
EPT Richness	Raw	3.400	0.000	NA	25.130	**0.001**
	Scaled	3.583	0.000	NA	34.597	**0.000**
HBI	Raw	6.868	4.736	7.830	16.190	**0.000**
	Scaled	4.540	8.804	5.385	7.601	**0.007**
PMA	Raw	35.996	NA	48.454	9.795	**0.014**
	Scaled	2.792	NA	3.691	1.345	0.280
NCO	Raw	NA	14.800	6.800	18.935	**0.002**
	Scaled	ND	ND	ND	ND	ND
DIV	Raw	NA	NA	1.136	*	*
	Scaled	NA	NA	0.150	*	*
DOM-3	Raw	NA	NA	88.500	*	*
	Scaled	NA	NA	2.562	*	*

Tables 14, 15, 16: NA-not applicable, ND-No data conversion formula available, *No ANOVA perfomed,

Table 17. When 1-way ANOVA comparisons resulted in significant difference, Student Newman-Keuls' tests were run on raw and scaled Taxa Richness values among habitats (gravel-G, vegetation-V, mud-M) within each location (upstream, midstream, downstream) using Student Newman-Keuls'. (*, P<0.05; **, P< 0.01; ***, P<0.005).

		Gravel-Vegetation	Vegetation-Mud	Gravel-Mud
Upstream	Raw	***	ns	***
	Scaled	ns	ns	ns
Midstream	Raw	*	***	***
	Scaled	ns	ns	ns
Downstream	Raw	***	ns	***
	Scaled	ns	ns	ns

Table 18. When 1-way ANOVA comparisons resulted in significant difference, Student Newman-Keuls' tests were run on raw and scaled Hilsenhoff Biotic Index comparisons among habitats (gravel-G, vegetation-V, mud-M) within each location (upstream, midstream, and downstream). (*, P<0.05; **, P< 0.01; ***, P<0.005).

		Gravel-Vegetation	Vegetation-Mud	Gravel-Mud
Upstream	Raw	***	***	ns
	Scaled	***	ns	**
Midstream	Raw	ns	***	***
	Scaled	ns	ns	ns
Downstream	Raw	***	***	*
	Scaled	***	***	ns

Table 19. Raw and scaled metric averages and 1-way ANOVA results comparing random (RCC, RNB) and haphazard 100 count subsamples (HCC) and whole samples (WNB) taken from gravel community samples at the midstream location, Powder Mill Park, Rochester, NY.

		HCC[1]	RCC[1]	RNB[1]	WNB[1]	*F*	*P-Value*
TR	Raw	14.20	13.60	15.00	20.40	8.18	**0.002**
	Scale	3.74	3.51	3.97	5.65	8.21	**0.002**
EPT	Raw	5.00	6.20	7.00	9.80	4.92	**0.013**
	Scaled	4.76	5.47	5.80	7.33	5.02	**0.012**
HBI	Raw	2.61	1.81	5.10	5.52	31.34	**0.000**
	Scaled	9.39	9.87	6.73	6.21	26.47	**0.000**
PMA	Raw	41.00	43.80	51.27	52.58	2.00	0.155
	Scaled	3.62	4.09	5.32	5.55	1.93	0.165

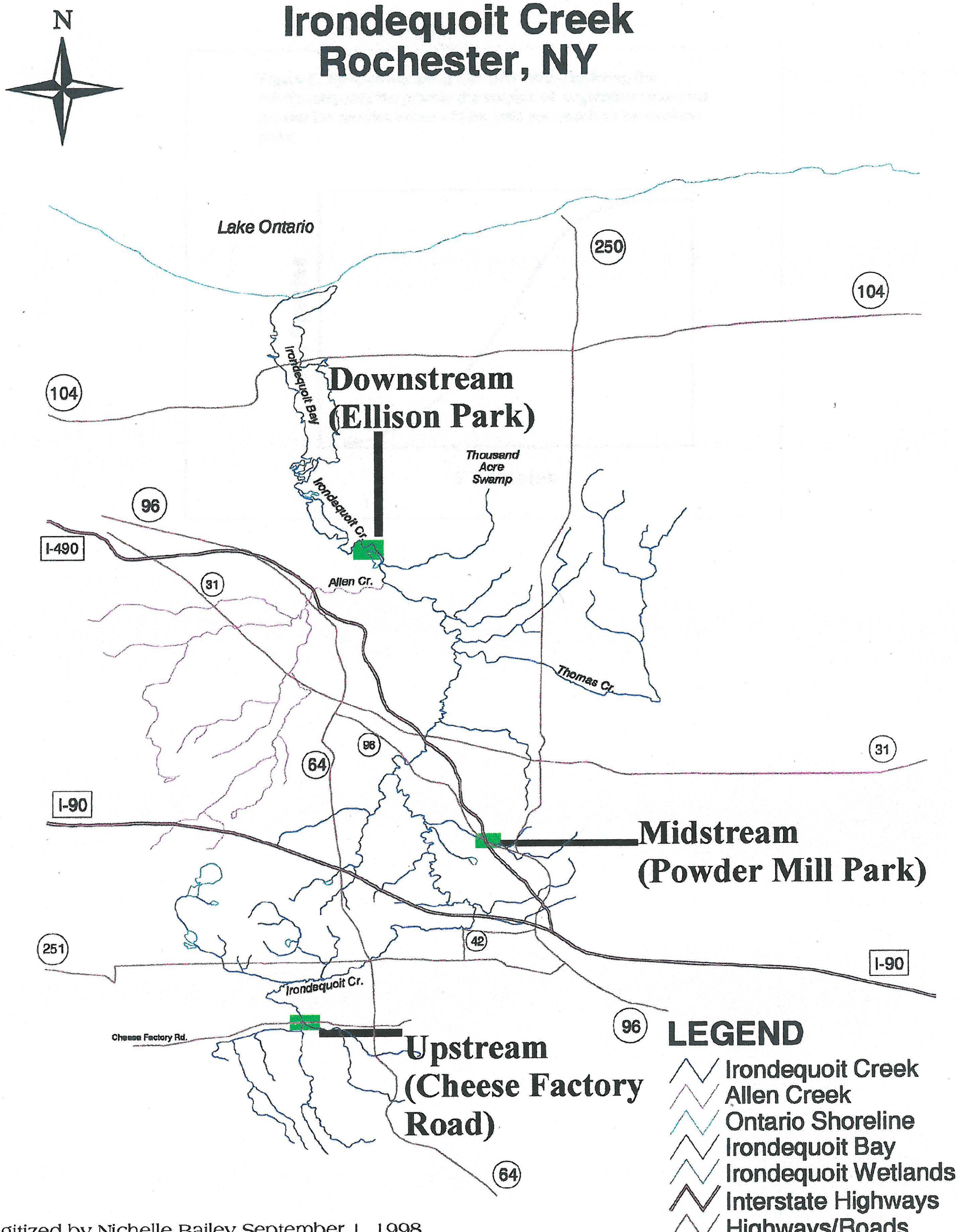
1 HCC Cody's haphazard 100 count subsample
RCC Cody's random 100 count subsample
RNB Bailey's random 100 count subsample
WNB Bailey's whole sample

Table 20. Raw and scaled Student Newman-Keuls comparisons among random (RCC, RNB) and haphazard 100 count subsamples (HCC) and whole samples (WNB) taken from gravel community samples at the midstream location, Powder Mill Park, Rochester, NY.

		HCC-RCC[1]	HCC-RNB[1]	HCC-WNB[1]	RCC-RNB[1]	RNB-WNB[1]	RCC-WNB[1]
TR	Raw	ns	ns	***	ns	***	***
	Scaled	ns	ns	***	ns	***	***
EPT	Raw	ns	ns	***	ns	**	***
	Scaled	ns	ns	***	ns	**	***
HBI	Raw	*	***	***	***	ns	***
	Scaled	ns	***	***	***	ns	***
PMA	Raw	ns	ns	ns	ns	ns	ns
	Scaled	ns	ns	ns	ns	ns	ns

1 HCC Cody's haphazard 100 count subsample; * P<.05
RCC Cody's random 100 count subsample; ** P<.01
RNB Bailey's random 100 count subsample; *** P<.005
WNB Bailey's whole sample

Figure 1. Sample Locations
Irondequoit Creek
Rochester, NY



Digitized by Nichelle Bailey September 1, 1998

Figure 2. Species-sampling intensity curve depicting the relationship that the greater the number of organsims taken, the greater the species count will be, until you reach an aysmptotic point.

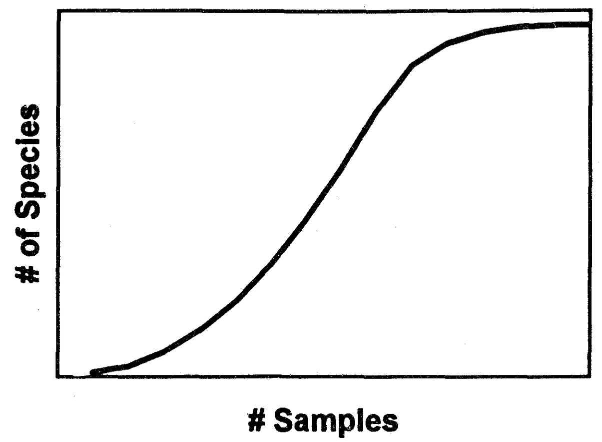
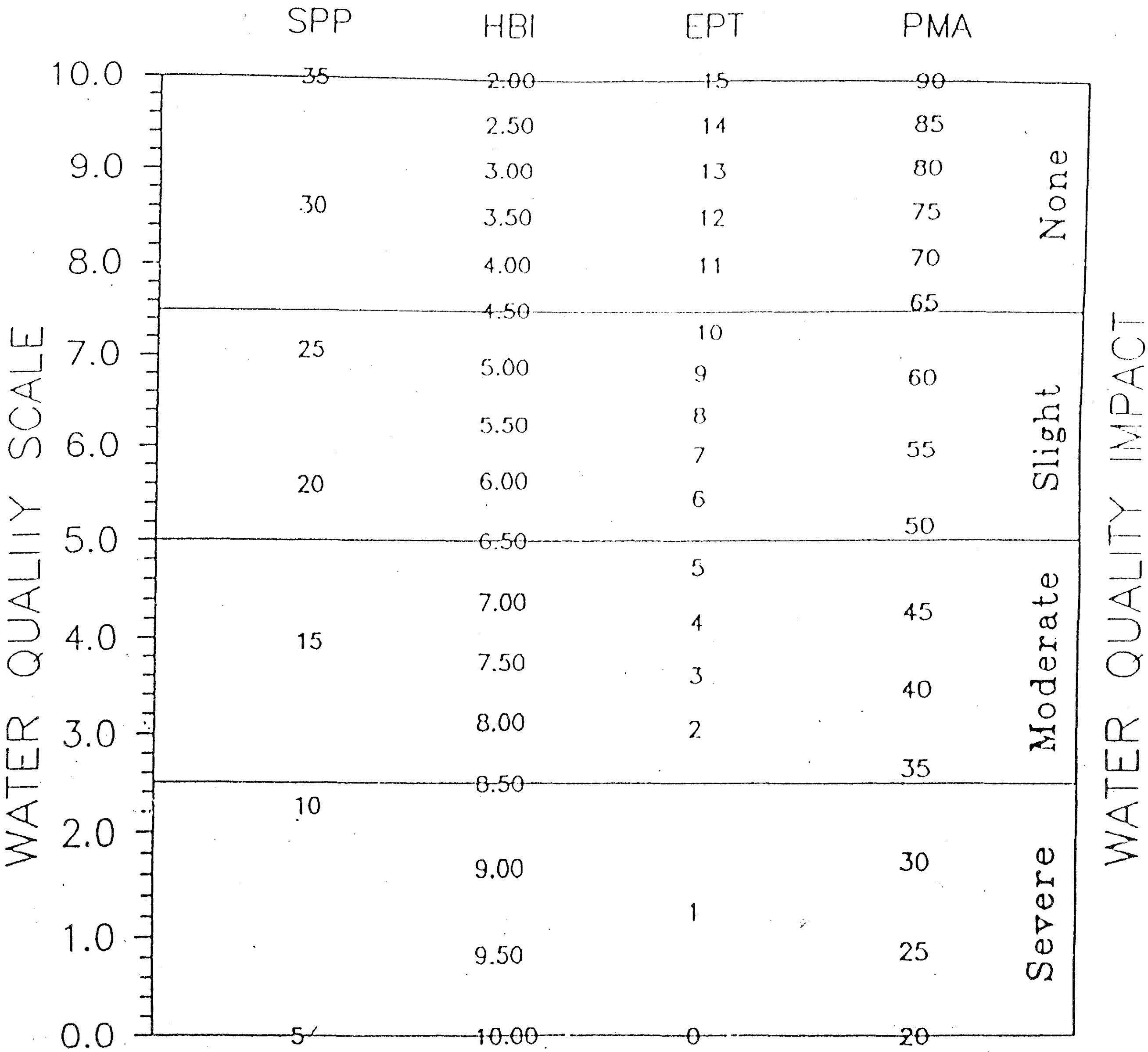
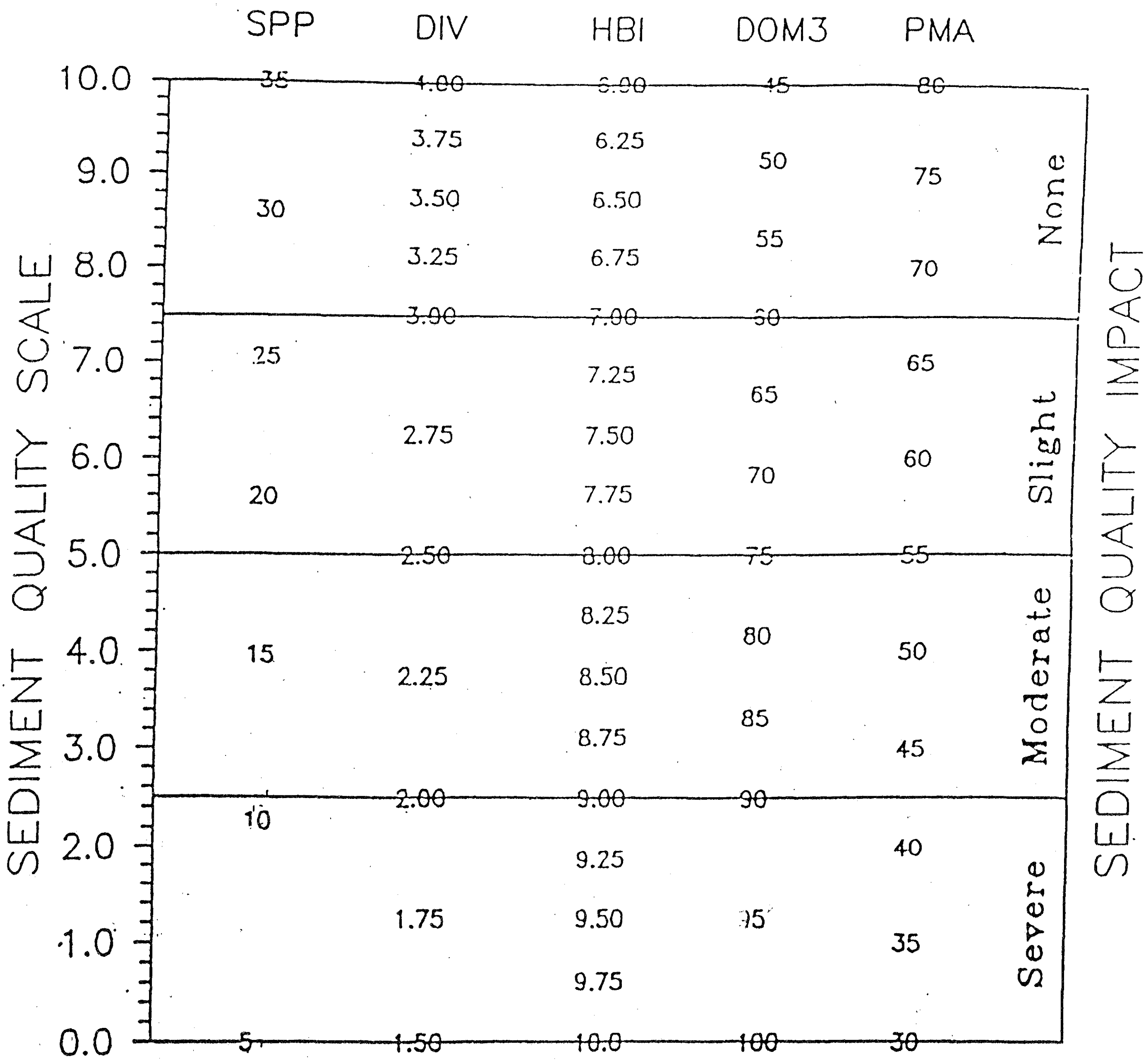


Figure 3. BIOLOGICAL ASSESSMENT PROFILE OF INDEX VALUES FOR RIFFLE HABITATS



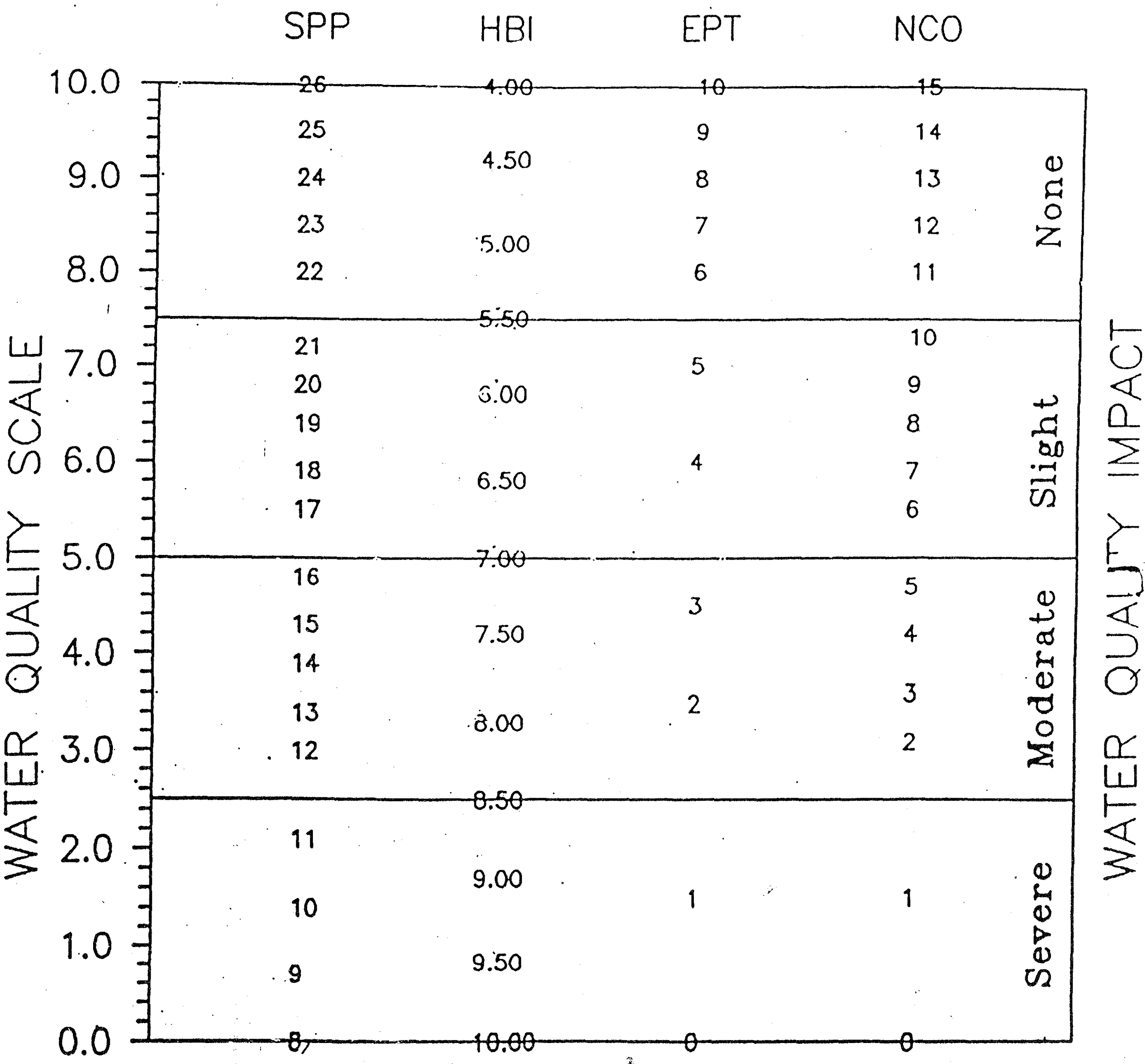
The Biological Assessment Profile of index values is a method of plotting biological index values on a common scale of water quality impact. For riffle habitats, these indices are used: SPP (species richness), HBI (Hilsenhoff Biotic Index), EPT (EPT richness), and PMA (Percent Model Affinity). Values from the four indices are converted to a common 0-10 scale as shown in this figure. The mean scale value of the four indices represents the assessed impact for each site.

Figure 4 BIOLOGICAL ASSESSMENT PROFILE OF INDEX VALUES FOR PONAR SAMPLES FROM SOFT SEDIMENTS



The Biological Assessment Profile of index values is a method of plotting biological index values on a common scale of water quality impact. For Ponar samples from soft sediments, these indices are used: SPP (species richness), HBI (Hilsenhoff Biotic Index), DOM3 (Dominance-3), PMA (Percent Model Affinity), and DIV (species diversity). Values from the five indices are converted to a common 0-10 scale as shown in this figure. The mean scale value of the five indices represents the assessed impact for each site.

Figure 5 BIOLOGICAL ASSESSMENT PROFILE OF INDEX VALUES FOR NET SAMPLES FROM SLOW, SANDY STREAMS



The Biological Assessment Profile of index values is a method of plotting biological index values on a common scale of water quality impact. For net samples from slow, sandy streams, these indices are used: SPP (species richness), HBI (Hilsenhoff Biotic Index), EPT (EPT richness), and NCO (NCO richness). Values from the four indices are converted to a common 0-10 scale as shown in this figure. The mean scale value of the four indices represents the assessed impact for each site.

Figure 6. Stream health assessment among locations for gravel habitat

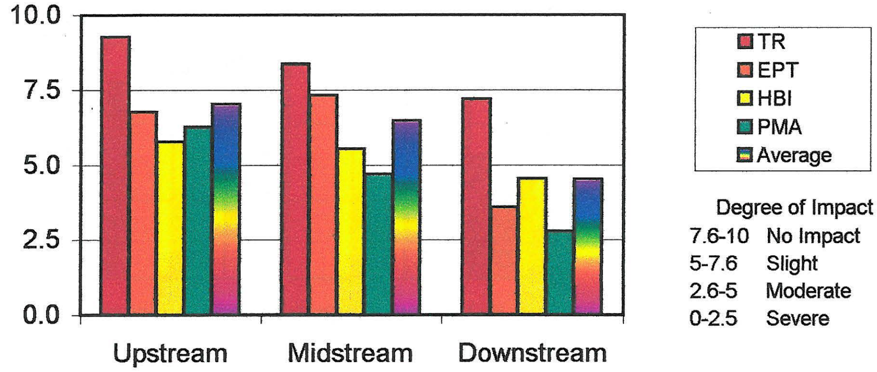


Figure 7. Stream health assessment among locations for vegetation habitat

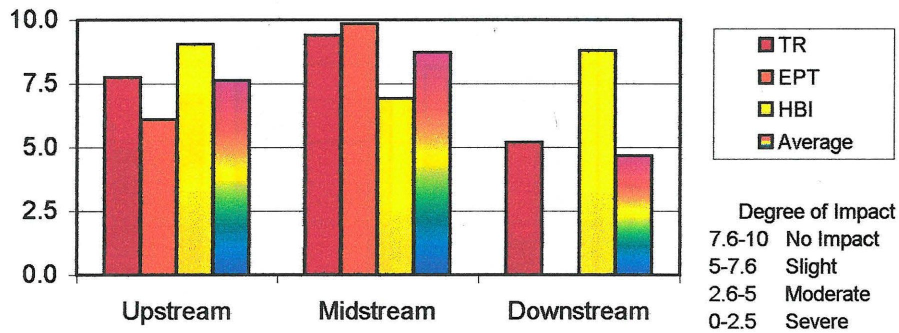


Figure 8. Stream health assessment among locations for mud habitat

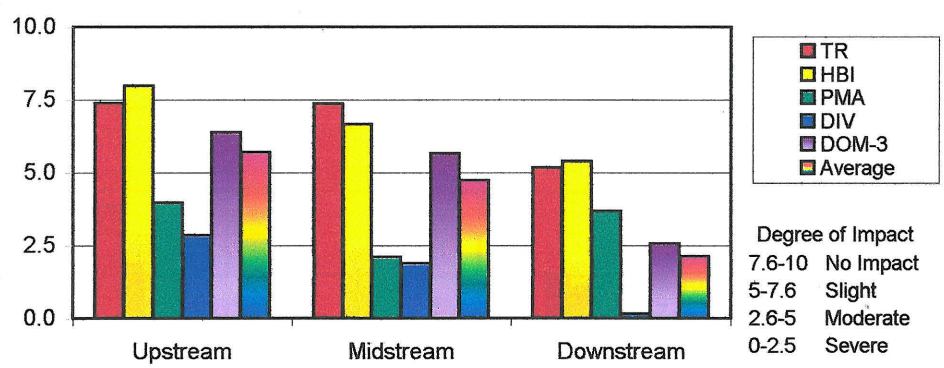


Figure 9. Stream health assessment among habitats for upstream location

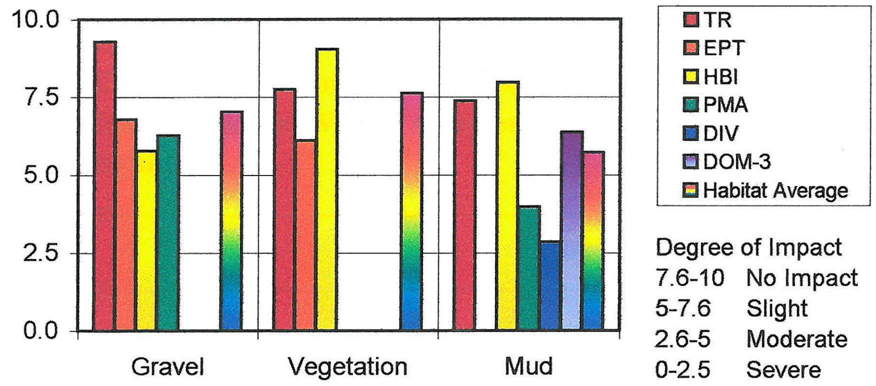


Figure 10. Stream health assessment among habitats for midstream location

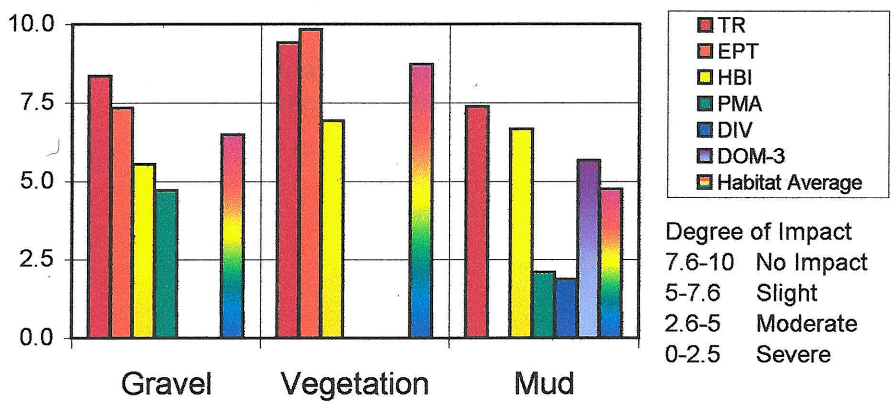


Figure 11. Stream health assessment among habitats for downstream location

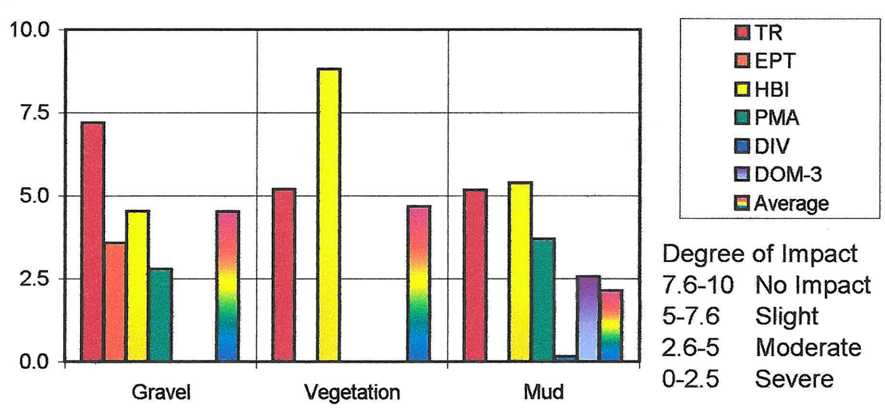
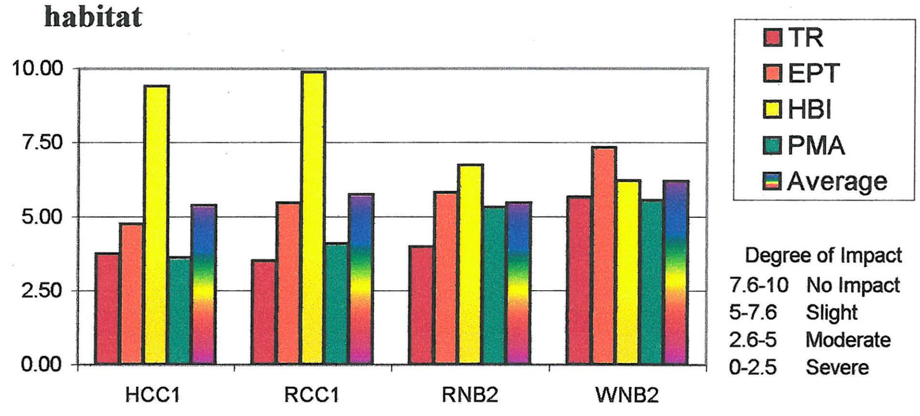


Figure 12. Stream health assessment for Random, Haphazard and Whole samples from the midstream gravel habitat



1. Sampling by C. Cody, May 1998
2. Sampling by N. Bailey-Billhardt, April 1997

APPENDIX A.

Complete taxonomic listing of macroinvertebrates found at the upstream, midstream and downstream locations in the gravel, vegetation and mud habitats.

Appendix A. Benthic macroinvertebrates collected at the upstream location (Cheese Factory Road), Irondequoit Creek, in Spring of 1997.

Habitat Sampled	Upstream Gravel					Upstream Vegetation					Upstream Mud				
Station (up- to downstream)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Taxon															
P. Platyhelminthes															
C. Turbellaria															
O. Tricladida															
P. Nematomorpha															
P. Annelida	1														
C. Oligochaeta	15	116	166	305	18	39	22		3		15	40	143	15	33
O. Tubificida															
O. Haplotaxidae															
F. Tubificidae															
Limnodrilus hoffmeisteri															
C. Hirudinea	1			7											
O. Rhynchobdellida															
F. Glossiphoniidae	2														
Helobdella stagnalis		7	19		8										
Placobdella sp.															
F. Piscicolidae															
Myzobdella lugubris															
P. Arthropoda															
C. Crustacea															
O. Isopoda															
F. Asellidae															
Caecidotea sp.	10	20	29	56	27		2					1		1	2
O. Amphipoda						1		3	15						
F. Gammaridae	1	1			3										
Gammarus fasciatus				1							2				
G. psuedolimnaeus															
O. Decapoda															
F. Cambaridae		1		2											
C. Insecta															
O. Diptera															
F. Chironomidae												3	2		
pupae	17	53	22	98	6	7	5	2	14	2	1			2	3
Chironomus **sp.**		6												1	
Cladopelma **sp.**															
Cryptochironomus **sp.**	13	12		49	2		1		1		5			11	1
Cryptotendipes **sp.**															
Dicrotendipes **sp.**		31	1	88	1	2	2		1			20	1		1
Einfeldia **sp.**															
Endochironomus **sp.**															
Glyptotendipes **sp.**															
Microtendipes **sp.**	158		1	157	29	3	10				1				
Parachironomus **sp.**															
Paracladopelma **sp.**															
Paratendipes **sp.**		125	20	49		30	11		15		10	31	79	74	27
Phaenopsectra **sp.**				10								1			
Polypedilum **sp.**	112	44		98	18	3	4		1	5	2		1	14	2
Saetheria **sp.**															
Stenochironomus **sp.**															
Stictochironomus **sp.**				10											
Tribelos **sp.**		6													
Cladotanytarsus **sp.**			1	39	1	2			1		1		2		
Micropsectra **sp.**		62	50	29	1	4	2		2		1		1	1	10
Paratanytarsus **sp.**	7	6			1										
Rheotanytarsus **sp.**	13	6				2	13	2		1		2		20	
Stempellinella **sp.**		19							10				1	1	

Appendix A. Benthic macroinvertebrates collected at the upstream location (Cheese Factory Road), Irondequoit Creek, in Spring of 1997.

Habitat Sampled	Upstream Gravel					Upstream Vegetation					Upstream Mud				
Station (up- to downstream)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Taxon															
Sublettea sp.															
Tanytarsus sp.	99	50		127	22	2	13	1	2		1	13	1	1	4
Brillia sp.							1								
Cricotopus/Orthocladius	389	143	50	284	102	25	48	1	13	4	3		5	33	4
Eukiefferiella sp.	6				12	10	1								
Heterotrissocladius sp.		56		10		45	10	10	12				1		
Nanocladius sp.		19		10		2	13			1	10			10	1
Parametriocnemus sp.		13													
Paraphaenocladius sp.															
Parorthocladius sp.										1					
Rheocricotopus sp.				10				1							
Smittia sp.		6													
Thienemanniella sp.							2								
Ablabesmyia sp.							1								
Clinotanypus sp.							1								
Coelotanypus sp.															
Natarsia sp.							2						1	1	
Nilotanypus sp.	7														
Procladius sp.							1				1		5		
Tanypus sp.															
Thienemannimya sp.	13	13		10						1					
Diamesa sp.	7	6									1				1
Pagastia sp.	13														10
Unidentified Chironomidae														10	
F. Athericidae															
Atherix sp.															
F. Simulidae									1						
Simulium sp.		1		7		3				1					
F. Tabanidae															
Chrysops sp.		3							1			2	1		2
F. Empididae										1					
Hemerodromia sp.	1		8	5	2		1	1	1	1					
Chelifera sp.															
F. Ceratopogonidae		2													
Culicoides sp.														4	2
Mallochohelea sp.											5				
Probezzia sp.	1	11					1	1	1					9	5
Pupae									2						
Sphaeromias sp.												5	6		
F. Ephydridae													1		
F. Stratiomyidae															
Odontomyia sp.						1					2				
Myxosargus sp.															
Nemotelus sp.															
Stratiomys sp.		1												2	
F. Sciomyzidae (pupae)															1
F. Tipulidae															
Dicranota sp.															
Antocha sp.	15	6	1	7	2				1						
Leptotarsus sp.	1			1											
Ormosia sp.		3				4									
Prioncera sp.	1														
Molophilus sp.											1				
Pilaria sp.												1			
Paradelphomyia sp.									1						

Appendix A. Benthic macroinvertebrates collected at the upstream location (Cheese Factory Road), Irondequoit Creek, in Spring of 1997.

Habitat Sampled	Upstream Gravel					Upstream Vegetation					Upstream Mud				
Station (up- to downstream)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Taxon															
Rhabdomastix sp.									19					3	
O. Trichoptera		5			1										
F. Beraeidae															
Beraea sp.															
F. Helicopsychidae															
Helecopsyche sp.				4											
F. Philopotamidae															
Wormalida sp.															
Chimarra sp.	2				1										
F. Limnephilidae															
Hydatophylax argus				9											
F. Polycentropodidae					7	1	1		1	2					
Polycentropus sp.															
Neurecleosis sp.															
F. Hydropsychidae															
Ceratopsyche sp.															
Cheumatopsyche sp.	3		1	3	24										
Hydropsyche sp.	12														
Potamyia sp.	2			1	17	1									
pupae															
F. Glossomatidae															
Glossosoma sp.															
F. Hydroptiladae															
Hydroptila sp.	1	17	34	131	2	2					1				1
F. Brachycentridae															
Micrasema sp.															
F. Helicopsychidae															
Helicopsyche sp.															
F. Leptoceridae				4											
Leptosarsus sp.															
Setodes sp.															
F. Limnephilidae sp.		1					1								
Chyranda sp.															
F. Odontoceridae	4		5												
Namamyia sp.															
F. Psychomiidae															
Lype sp.			16	22											
O. Coleoptera												1			
F. Chrysomelidae		5							5						
F. Elmidae	2	17	7	17			1						2	1	1
Dubiraphia sp.															
Macronychus sp.						2									
Ancyronyx sp.	5	4	5	12	4										
Optioservus sp.															
Ordobrevia sp.	6	10	7	17	26		1					1			
Stenelmis sp.	8	6	5		5		1			1					
F. Psephenidae	1	4	3	7		1	3		14				1		
Ectopria sp.	2		1	8	1		2								
Psephenus sp.															
F. Hysteridae															
F. Haliplidae									1						
Peltodytes sp.															
F. Gyrinidae															
Dineutus sp.															
F. Dytiscidae				1											

Appendix A. Benthic macroinvertebrates collected at the upstream location (Cheese Factory Road), Irondequoit Creek, in Spring of 1997.

Habitat Sampled	Upstream Gravel					Upstream Vegetation					Upstream Mud				
Station (up- to downstream)	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Taxon															
Hydaticus sp.															
Laccophilus sp.															
Neosantopterus sp.		2	1												
Uvaris sp.															
F. Hydrophilidae								1							
Enochrus sp.															
F. Dryopidae															
Helichus sp.															
O. Hemiptera															
F. Corixidae															
F. Notonectidae															
Notonecta sp.															
F. Belostomidae															
Belostoma sp.															
F. Gerridae															
Gerris sp.															
Rheumatobates sp.															
F. Pleidae															
Neoplea sp.															
Paraples sp.															
F. Mesoveliidae															
Mesovelia sp.															
F. Nepidae															
Nepa sp.												1			
Ranatra sp.															
F. Hebridae															
Hebrus sp.															
O. Odonata		1													
F. Aeshnidae															
Boyeria sp.															
Anax sp.															
F. Coenogrionidae															
Enallagma sp.															
Ishnura sp.															
F. Calopterygidae															
Calopteryx sp.									1					12	
Hetaerina sp.			1												
F. Lestidae															
Lestes sp.															
F. Gomphidae															
Arigomphus sp.															
F. Corduliidae															
Somatochlora sp.															
O. Ephemeroptera									1						
F. Isonychiadae															
Isonychia sp.															
F. Baetidae															
Acerpenna sp.	1														
Baeits sp.															
F. Caenidae															
Amercaenis sp.	11	45	89	444	60	3	1		1		1		1	3	
F. Ephemeridae															
Hexagenia sp.															
F. Heptageniidae															
Stenacron sp.															

Appendix A. Benthic macroinvertebrates collected at the upstream location (Cheese Factory Road), Irondequoit Creek, in Spring of 1997.

Habitat Sampled	Upstream Gravel					Upstream Vegetation					Upstream Mud				
Station (up- to downstream)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Taxon															
Heptagenia sp.															
Stenonema sp.	16	1	6	22	27	1				1					
F. Ephemerellidae															
Ephemerella sp.															
F. Leptophlebiidae															
Paraleptophlebia sp.				1											
O. Plecoptera															
F. Perlodidae								1							
Isoperla sp.	47	75	16	33	28	22	25	54	20	26			1		
F. Nemouridae															
Amphinemura wui		1				1		1	1						
F. Taeniopterygidae															
Strophopteryx fasciata															
O. Lepidoptera															
instar															
F. Pyralidae															
Acentria sp.															
F. Tortricidae															
Archips sp.															
O. Megalopterta															
F. Sialidae															
Sialis sp.															
O. Collembola															
F. Poduridae															
Podura aquatica															
C. Arachnida															
O. Aranae															
F. Pisauridae															
Dolomedes sp.															
F. Tetragnathridae															
Tetragnathra sp.															
P. Mollusca				2											
C. Pelecypoda															
O. Veneroida															
F. Sphaeridae															
Pisidium sp.															
Sphaerium sp.	5														
F. Dreissenidae															
Dreissena polymorpha															
C. Gastropoda															
O. Basommatophora															
F. Physidae															
Physella sp.												1			
Aplexa elongata													1		
F. Lymnaeidae															
Fossaria sp.															
Pseudosuccinea columella		2						6	8						
F. Ancylidae															
Laevapex fuscus															
F. Planorbidae															
Gyraulus sp.									2						
Planorbella sp.		1													
Menetus dilatatus								1							
O. Mesogastropoda															
F. Hydrobiidae															

Appendix A. Benthic macroinvertebrates collected at the upstream location (Cheese Factory Road), Irondequoit Creek, in Spring of 1997.

Habitat Sampled	Upstream Gravel					Upstream Vegetation					Upstream Mud				
Station (up- to downstream)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Taxon															
Amnicola limosa															
F. Bithyniidae															
Bithynia tentaculata															

Creek, in Spring of 1997.

Habitat Sampled	Midstream Gravel					Midstream Vegetation					Midstream Mud				
Station (up- to downstream)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Taxon															
P. Platyhelminthes															
C. Turbellaria															
O. Tricladida															
P. Nematomorpha															
P. Annelida															
C. Oligochaeta	302	182	132	151	117	457	494	62	71	400	321	238	669	136	
O. Tubificida															
O. Haplotaxidae															
F. Tubificidae															
Limnodrilus hoffmeisteri															
C. Hirudinea															
O. Rhynchobdellida															
F. Glossiphoniidae															
Helobdella stagnalis															
Placobdella sp.															
F. Piscicolidae															
Myzobdella lugubris															
P. Arthropoda															
C. Crustacea															
O. Isopoda															
F. Asellidae															
Caecidotea sp.	8			4	6	30	9	1		4		1	14		
O. Amphipoda															
F. Gammaridae	44	6	9		8		28	25	8	28	2	3	102	11	9
Gammarus fasciatus						47									
G. psuedolimnaeus				19											
O. Decapoda															
F. Cambaridae															
C. Insecta															
O. Diptera															
F. Chironomidae															
pupae	33	23	44	83	21	15	72	73	33	20		7	17	8	476
***Chironomus* sp.**											1			8	
***Cladopelma* sp.**															
***Cryptochironomus* sp.**	11		58	27	17		22				1	15	17	38	173
***Cryptotendipes* sp.**															
***Dicrotendipes* sp.**													6		
***Einfeldia* sp.**															
***Endochironomus* sp.**											12		6		
***Glyptotendipes* sp.**															31
***Microtendipes* sp.**	5	1	23		4										
***Parachironomus* sp.**															
***Paracladopelma* sp.**														8	
***Paratendipes* sp.**	5		23		4	6					247	126	193	183	204
***Phaenopsectra* sp.**					4						2	75	134	23	502
***Polypedilum* sp.**	44	21	127	107	105	95	155	237	75	90	53	96	47	289	235
***Saetheria* sp.**														8	16
***Stenochironomus* sp.**															
***Stictochironomus* sp.**															
***Tribelos* sp.**											1	5	6	7	330
***Cladotanytarsus* sp.**	83	41	255	509	121	19			6	329	12	146	70	152	47
***Micropsectra* sp.**											10	5		7	
***Paratanytarsus* sp.**	6														
***Rheotanytarsus* sp.**	44	3	185	161	21	19	88	53	6	959			6	7	
***Stempellinella* sp.**															
***Sublettea* sp.**						45			6						
***Tanytarsus* sp.**	5	2	70	107		6				120	10	20	47	8	
***Brillia* sp.**					4					30					
Cricotopus/Orthocladius	259	12	347	1287	80	325	1677	1898	423	959	13	10	46	23	31

Creek, in Spring of 1997.

Habitat Sampled	Midstream Gravel					Midstream Vegetation					Midstream Mud				
Station (up- to downstream)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Taxon															
Eukiefferiella sp.	33					19	132	158	56	120					
Heterotrissocladius sp.									6						
Nanocladius sp.					4						10	5	6		
Parametriocnemus sp.															
Paraphaenocladius sp.															
Parorthocladius sp.															
Rheocricotopus sp.															
Smittia sp.															
Thienemanniella sp.									6						
Ablabesmyia sp.															
Clinotanypus sp.															
Coelotanypus sp.															
Natarsia sp.															
Nilotanypus sp.															
Procladius sp.															
Tanypus sp.															
Thienemannimya sp.															
Diamesa sp.	33		46	456	54	102	132	132	31	299					
Pagastia sp.	22	10	23	27				158	6	90					
Unidentified Chironomidae											1				
F. Athericidae															
Atherix sp.															
F. Simulidae															
Simulium sp.	16		1	1	23	24	74	49	14	9		1	1		1
F. Tabanidae															
Chrysops sp.															
F. Empididae															
Hemerodromia sp.		3	9	2	5				4	10			6	1	
Chelifera sp.	7			5											
F. Ceratopogonidae															
Culicoides sp.						1									
Mallochohelea sp.															
Probezzia sp.															
Pupae		1													
Sphaeromias sp.				1									4		
F. Ephydridae															
F. Stratiomyidae															
Odontomyia sp.															
Myxosargus sp.															
Nemotelus sp.															
Stratiomys sp.															
F. Sciomyzidae (pupae)															
F. Tipulidae															
Dicranota sp.	2														
Antocha sp.	90	46	147	128	15	7	5	2	12	30		1	3		1
Leptotarsus sp.					2										
Ormosia sp.															
Prioncera sp.															
Molophilus sp.															
Pilaria sp.															
Paradelphomyia sp.															
Rhabdomastix sp.															
O. Trichoptera															
F. Beraeidae															
Beraea sp.															
F. Helicopsychidae															
Helecopsyche sp.															
F. Philopotamidae													0		
Wormalida sp.	1														

Creek, in Spring of 1997.

Habitat Sampled	Midstream Gravel					Midstream Vegetation					Midstream Mud				
Station (up- to downstream)	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Taxon															
Chimarra sp.															
F. Limnephilidae															
Hydatophylax argus								2	3	13					
F. Polycentropodidae															
Polycentropus sp.	1														
Neurecleosis sp.			1												
F. Hydropsychidae															
Ceratopsyche sp.	196	26	139	136	7	50	100	137	75	37					
Cheumatopsyche sp.	32	3	31	7		4	6	7		6		2	10		1
Hydropsyche sp.	22	12	32		24	27	4	2	2						
Potamyia sp.	6												1	6	
pupae		6	7	2	5				2						
F. Glossomatidae															
Glossosoma sp.	7														
F. Hydroptiladae															
Hydroptila sp.	276	228	156	138	18	66	189	841	154	91		8	44		
F. Brachycentridae															
Micrasema sp.	4			2					1						
F. Helicopsychidae															
Helicopsyche sp.			2												
F. Leptoceridae															
Leptosarsus sp.	3														
Setodes sp.															
F. Limnephilidae sp.															
Chyranda sp.															
F. Odontoceridae															
Namamyia sp.															
F. Psychomiidae															
Lype sp.										11					
O. Coleoptera															
F. Chrysomelidae															
F. Elmidae															
Dubiraphia sp.		2		4											
Macronychus sp.															
Ancyronyx sp.	12													1	
Optioservus sp.	20	10	34	58	36	1			1	15					
Ordobrevia sp.		1		1									2		
Stenelmis sp.	2	3			2.17		1			1					
F. Psephenidae															
Ectopria sp.															
Psephenus sp.															
F. Hysteridae			2												
F. Haliplidae															
Peltodytes sp.															
F. Gyrinidae															
Dineutus sp.															
F. Dytiscidae															
Hydaticus sp.															
Laccophilus sp.															
Neosantopterus sp.															
Uvaris sp.															
F. Hydrophilidae															
Enochrus sp.															
F. Dryopidae															
Helichus sp.						3									
O. Hemiptera															
F. Corixidae															
F. Notonectidae															
Notonecta sp.															

Creek, in Spring of 1997.

Habitat Sampled	Midstream Gravel					Midstream Vegetation					Midstream Mud				
Station (up- to downstream)	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Taxon															
F. Belostomidae															
Belostoma sp.															
F. Gerridae															
Gerris sp.															
Rheumatobates sp.															
F. Pleidae															
Neoplea sp.															
Paraples sp.															
F. Mesoveliidae															
Mesovelia sp.															
F. Nepidae															
Nepa sp.															
Ranatra sp.															
F. Hebridae															
Hebrus sp.															
O. Odonata															
F. Aeshnidae															
Boyeria sp.															
Anax sp.															
F. Coenogrionidae															
Enallagma sp.															
Ishnura sp.															
F. Calopterygidae															
Calopteryx sp.															
Hetaerina sp.															
F. Lestidae															
Lestes sp.															
F. Gomphidae															
Arigomphus sp.															
F. Corduliidae															
Somatochlora sp.															
O. Ephemeroptera															
F. Isonychiadae															
Isonychia sp.	1														
F. Baetidae															
Acerpenna sp.			38	28	21	88	117	173	143	45					
Baeits sp.		2													
F. Caenidae															
Amercaenis sp.							1								
F. Ephemeridae															
Hexagenia sp.															
F. Heptageniidae															
Stenacron sp.															
Heptagenia sp.															
Stenonema sp.	8	3	4		1	3	1	1	2	1			1		
F. Ephemerellidae															
Ephemerella sp.	19	7	78	37	22	24	35	30	24	13			2	1	
F. Leptophlebiidae															
Paraleptophlebia sp.															
O. Plecoptera															
F. Perlodidae															
Isoperla sp.	2		6	3		33	2	3	3						
F. Nemouridae															
Amphinemura wui			2				30	18	16	19					
F. Taeniopterygidae															
Strophopteryx fasciata						18									
O. Lepidoptera															
instar															
F. Pyralidae															

Appendix A. Benthic macroinvertebrates collected at the midstream location (Powder Mill Park), Irondequoit Creek, in Spring of 1997.

Habitat Sampled	Midstream Gravel					Midstream Vegetation					Midstream Mud				
Station (up- to downstream)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Taxon															
Acentria sp.															
F. Tortricidae															
Archips sp.														1	
O. Megalopterta															
F. Sialidae															
Sialis sp.												1			
O. Collembola															
F. Poduridae															
Podura aquatica															
C. Arachnida															
O. Aranae															
F. Pisauridae															
Dolomedes sp.															
F. Tetragnathridae															
Tetragnathra sp.															
P. Mollusca															2
C. Pelecypoda															
O. Veneroida															
F. Sphaeridae															
Pisidium sp.															
Sphaerium sp.															
F. Dreissenidae															
Dreissena polymorpha															
C. Gastropoda															
O. Basommatophora															
F. Physidae															
Physella sp.															
Aplexa elongata															
F. Lymnaeidae															
Fossaria sp.														1	
Pseudosuccinea columella															
F. Ancylidae															
Laevapex fuscus															
F. Planorbidae															
Gyraulus sp.															
Planorbella sp.															
Menetus dilatatus															
O. Mesogastropoda															
F. Hydrobiidae															
Amnicola limosa															
F. Bithyniidae															
Bithynia tentaculata															

Appendix A. Benthic macroinvertebrates collected at the downstream site (Ellison Park), Irondequoit Creek, in Spring of 1997.

Habitat Sampled	Downstream Gravel					Downstream Vegetation					Downstream Mud				
Station (up- to downstream)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Taxon															
P. Platyhelminthes															
C. Turbellaria															
O. Tricladida							3								
P. Nematomorpha											1				2
P. Annelida															
C. Oligochaeta															
O. Tubificida															
F. Tubificidae															
Limnodrilus hoffmeisteri		625	1367	1616	216	3	5	1	61	433	406	496	487	180	1178
C. Hirudinea															
O. Rhynchobdellida															
F. Glossiphoniidae															
Helobdella stagnalis															
Placobdella sp.															
F. Piscicolidae															
Myzobdella lugubris		1													
P. Arthropoda															
C. Crustacea															
O. Isopoda															
F. Asellidae										22					
Caecidotea sp.	10	5	2	4	2	3	10	47	69		5	1		1	
O. Amphipoda															
F. Gammaridae	5		6	10	6					165					
Gammarus fasciatus		18				2	258	16	27	1317	7	3	2	4	3
G. psuedolimnaeus						25	1188	1361	624		127	49	63	130	112
O. Decapoda															
F. Cambaridae															
C. Insecta															
O. Diptera										11					
F. Chironomidae						14	4		1		87	45	50	178	157
pupae		175	6	128	63			2							
***Chironomus* sp.**	8		9								49	16	31	126	56
***Cladopelma* sp.**														1	
***Cryptochironomus* sp.**	26	131	53	158	20						2	1	1	3	
***Cryptotendipes* sp.**					6										
***Dicrotendipes* sp.**		12	9								1	1		3	1
***Einfeldia* sp.**															
***Endochironomus* sp.**	4			14											
***Glyptotendipes* sp.**															
***Microtendipes* sp.**	9	143	97	287	20										
***Parachironomus* sp.**															
***Paracladopelma* sp.**	2													1	
***Paratendipes* sp.**	44	24		29											
***Phaenopsectra* sp.**	6	24		43	7										
***Polypedilum* sp.**	49	60	106	244	65						4				

Appendix A. Benthic macroinvertebrates collected at the downstream site (Ellison Park), Irondequoit Creek, in Spring of 1997.

Habitat Sampled	Downstream Gravel					Downstream Vegetation					Downstream Mud				
Station (up- to downstream)	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Taxon															
Saetheria sp.		36													
Stenochironomus sp.															
Stictochironomus sp.															
Tribelos sp.															
Cladotanytarsus sp.	6	12		43											
Micropsectra sp.											1				
Paratanytarsus sp.															
Rheotanytarsus sp.															
Stempellinella sp.															
Sublettea sp.															
Tanytarsus sp.				14	6								1	1	
Brillia sp.															
Cricotopus/Orthocladius	21	538	381	431	169										
Eukiefferiella sp.		12			26										
Heterotrissocladius sp.															
Nanocladius sp.	9	48	9	57											
Parametriocnemus sp.															
Paraphaenocladius sp.															
Parorthocladius sp.															
Rheocricotopus sp.															
Smittia sp.															
Thienemanniella sp.															
Ablabesmyia sp.															
Clinotanypus sp.															
Coelotanypus sp.															
Natarsia sp.															
Nilotanypus sp.															
Procladius sp.											8	3	8	10	6
Tanypus sp.											1	2		4	
Thienemannimya sp.															
Diamesa sp.	4	155	221	115	332										
Pagastia sp.	2														
Unidentified Chironomidae													1	5	4
F. Athericidae															
Atherix sp.					1										
F. Simulidae															
Simulium sp.	1		1		1									1	2
F. Tabanidae															
Chrysops sp.															
F. Empididae															
Hemerodromia sp.			1		3										
Chelifera sp.			4												
F. Ceratopogonidae										1					
Culicoides sp.															
Mallochohelea sp.															

Appendix A. Benthic macroinvertebrates collected at the downstream site (Ellison Park), Irondequoit Creek, in Spring of 1997.

Habitat Sampled	Downstream Gravel					Downstream Vegetation					Downstream Mud				
Station (up- to downstream)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Taxon															
Probezzia sp.											2		2	3	
Pupae															
Sphaeromias sp.															
F. Ephydridae															
F. Stratiomyidae															
Odontomyia sp.															
Myxosargus sp.							1								
Nemotelus sp.															
Stratiomys sp.															
F. Sciomyzidae (pupae)															
F. Tipulidae															
Dicranota sp.		101													
Antocha sp.	5	27	145	25	31										
Leptotarsus sp.															
Ormosia sp.															
Prioncera sp.															
Molophilus sp.															
Pilaria sp.															
Paradelphomyia sp.															
Rhabdomastix sp.															
O. Trichoptera															
F. Beraeidae															
Beraea sp.															
F. Helicopsychidae															
Helecopsyche sp.															
F. Philopotamidae															
Wormalida sp.															
Chimarra sp.															
F. Limnephilidae															
Hydatophylax argus															
F. Polycentropodidae															
Polycentropus sp.															
Neurecleosis sp.															
F. Hydropsychidae															
Ceratopsyche sp.		20													
Cheumatopsyche sp.		5	45	9	18										
Hydropsyche sp.		10	1								8				3
Potamyia sp.			42	5	9										
pupae		25													
F. Glossomatidae	1	2	9	12	5										
Glossosoma sp.															
F. Hydroptiladae															
Hydroptila sp.				1											
F. Brachycentridae															
Micrasema sp.															

Appendix A. Benthic macroinvertebrates collected at the downstream site (Ellison Park), Irondequoit Creek, in Spring of 1997.

Habitat Sampled	Downstream Gravel					Downstream Vegetation					Downstream Mud				
Station (up- to downstream)	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Taxon															
F. Helicopsychidae															
Helicopsyche sp.															
F. Leptoceridae															
Leptosarsus sp.															
Setodes sp.															
F. Limnephilidae sp.															
Chyranda sp.															
F. Odontoceridae															
Namamyia sp.															
F. Psychomiidae															
Lype sp.															
O. Coleoptera					1										
F. Chrysomelidae															
F. Elmidae	1			1				3		1					
Dubiraphia sp.											1				1
Macronychus sp.		24								1					
Ancyronyx sp.	2	1	13	11	28				3						
Optioservus sp.	3	31													
Ordobrevia sp.	6	11	44	34	50										
Stenelmis sp.	3	1	4												
F. Psephenidae		2													
Ectopria sp.	1		1												
Psephenus sp.															
F. Hysteridae															
F. Haliplidae															
Peltodytes sp.							1					1			
F. Gyrinidae															
Dineutus sp.															
F. Dytiscidae															
Hydaticus sp.															
Laccophilus sp.							3	9							
Neosantopterus sp.															
Uvaris sp.															
F. Hydrophilidae															
Enochrus sp.								1							
F. Dryopidae															
Helichus sp.															
O. Hemiptera										19					
F. Corixidae						2	41	20	26			2			4
F. Notonectidae										1					
Notonecta sp.						5	3	3							
F. Belostomidae										1					
Belostoma sp.							3								
F. Gerridae															
Gerris sp.															

Appendix A. Benthic macroinvertebrates collected at the downstream site (Ellison Park), Irondequoit Creek, in Spring of 1997.

Habitat Sampled	**Downstream Gravel**					**Downstream Vegetation**					**Downstream Mud**				
Station (up- to downstream)	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Taxon															
Rheumatobates sp.															
F. Pleidae															
Neoplea sp.															
Paraples sp.															
F. Mesoveliidae															
Mesovelia sp.							1								
F. Nepidae															
Nepa sp.															
Ranatra sp.						1	2								
F. Hebridae															
Hebrus sp.								1							
O. Odonata															
F. Aeshnidae															
Boyeria sp.															
Anax sp.						1									
F. Coenogrionidae										1					
Enallagma sp.						2	7	8	5						
Ishnura sp.						4									
F. Calopterygidae															
Calopteryx sp.															
Hetaerina sp.															
F. Lestidae															
Lestes sp.															
F. Gomphidae															
Arigomphus sp.															
F. Corduliidae															
Somatochlora sp.															
O. Ephemeroptera															
F. Isonychiadae															
Isonychia sp.															
F. Baetidae															
Acerpenna sp.															
Baeits sp.															
F. Caenidae															
Amercaenis sp.															
F. Ephemeridae															
Hexagenia sp.															
F. Heptageniidae															
Stenacron sp.															
Heptagenia sp.															
Stenonema sp.															
F. Ephemerellidae															
Ephemerella sp.															
F. Leptophlebiidae															
Paraleptophlebia sp.															

Appendix A. Benthic macroinvertebrates collected at the downstream site (Ellison Park), Irondequoit Creek, in Spring of 1997.

Habitat Sampled	Downstream Gravel					Downstream Vegetation					Downstream Mud				
Station (up- to downstream)	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Taxon															
O. Plecoptera															
F. Perlodidae															
Isoperla sp.															
F. Nemouridae															
Amphinemura wui															
F. Taeniopterygidae															
Strophopteryx fasciata															
O. Lepidoptera															
instar															
F. Pyralidae															
Acentria sp.						6	4	1	4						2
F. Tortricidae															
Archips sp.															
O. Megalopterta															
F. Sialidae										2					
Sialis sp.															
O. Collembola															
F. Poduridae															
Podura aquatica															
C. Arachnida															
O. Aranae															
F. Pisauridae										3					
Dolomedes sp.						1	1	2							
F. Tetragnathridae															
Tetragnathra sp.							2	12	2						
P. Mollusca															
C. Pelecypoda															
O. Veneroida															
F. Sphaeridae										1					
Pisidium sp.						1		2		3	5	2			13
Sphaerium sp.							1		4						
F. Dreissenidae															
Dreissena polymorpha	1		1	1											
C. Gastropoda															
O. Basommatophora															
F. Physidae															
Physella sp.										7				2	
Aplexa elongata						10	35	136	3						
F. Lymnaeidae															
Fossaria sp.															
Pseudosuccinea columella															
F. Ancylidae								2							
Laevapex fuscus											2				
F. Planorbidae															
Gyraulus sp.															

Appendix A. Benthic macroinvertebrates collected at the downstream site (Ellison Park), Irondequoit Creek, in Spring of 1997.

Habitat Sampled	Downstream Gravel					Downstream Vegetation					Downstream Mud				
Station (up- to downstream)	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Taxon															
Planorbella sp.															
Menetus dilatatus															
O. Mesogastropoda								3							
F. Hydrobiidae															
Amnicola limosa												1			
F. Bithyniidae															
Bithynia tentaculata										1					

APPENDIX B.

Location (upstream, midstream and downstream) comparison (both raw and scaled) for Taxa Richness, Ephemeroptera-Plecoptera-Trichoptera Richness, Hilsenhoff Biotic Index, Percent Model Affinity, Non-Chironomid/Non-Oligochaete Richness, Shannon-Weiner Diversity and Dominance-3 using 1-way ANOVA and Student Newman-Keuls.

Appendix B. Location (U, M, D = upstream, midstream, and downstream) comparison (both raw and scaled) among habitats (G, V, M = gravel, vegetation, and mud) for taxa richness using 1-way ANOVA.

Raw		MG	DG	UG		
Taxa Richness	1	38	25	41		
	2	25	30	48		
	3	30	25	27		
	4	28	24	43		
	5	28	23	30		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MG	5	149	29.8	24.2		
DG	5	127	25.4	7.3		
UG	5	189	37.8	79.7		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	395.2	2	197.6	5.330935	0.022045	3.88529
Within Groups	444.8	12	37.06667			
Total	840	14				

Scaled		MG	DG	UG		
Taxa Richness	1	10.00	7.06	10.00		
	2	7.06	8.61	10.00		
	3	8.61	7.06	7.78		
	4	8.06	6.76	10.00		
	5	8.06	6.47	8.61		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MG	5	41.78105	8.356209	1.157754		
DG	5	35.96	7.192	0.68837		
UG	5	46.39	9.278	1.06352		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	10.92746	2	5.463731	5.633401	0.018822	3.88529
Within Groups	11.63858	12	0.969881			
Total	22.56604	14				

Raw		MV	DV	UV		
Taxa Richness	1	27	15	27		
	2	23	20	33		
	3	23	19	16		
	4	28	12	33		
	5	27	17	14		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MV	5	128	25.6	5.8		
DV	5	83	16.6	10.3		
UV	5	123	24.6	83.3		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	243.3333	2	121.6667	3.672032	0.05699	3.88529
Within Groups	397.6	12	33.13333			
Total	640.9333	14				

Scaled		MV	DV	UV		
Taxa Richness	1	10	4.30	10		
	2	8.50	6.80	10.00		
	3	8.50	6.40	4.80		
	4	10.00	3.00	10.00		
	5	10.00	5.50	3.90		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MV	5	47	9.4	0.675		
DV	5	26	5.2	2.435		
UV	5	38.7	7.74	9.678		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	44.74533	2	22.37267	5.248514	0.023032	3.88529
Within Groups	51.152	12	4.262667			
Total	95.89733	14				

Appendix B. Location (U, M, D = upstream, midstream, and downstream) comparison (both raw and scaled) among habitats (G, V, M = gravel, vegetation, and mud) for taxa richness using 1-way ANOVA.

Raw		**MM**	**DM**	**UM**			**Scaled**		**MM**	**DM**	**UM**		
Taxa Richness	**1**	15	18	19			**Taxa Richness**	**1**	5.45	6.82	7.27		
	2	19	14	15				**2**	7.27	4.72	5.45		
	3	26	10	21				**3**	10.00	2.27	8.27		
	4	22	17	22				**4**	8.65	6.36	8.65		
	5	15	15	19				**5**	5.45	5.45	7.27		
Anova: Single Factor							Anova: Single Factor						
SUMMARY							SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*			*Groups*	*Count*	*Sum*	*Average*	*Variance*		
MM	5	97	19.4	22.3			**MM**	5	36.83566	7.367133	3.978129		
DM	5	74	14.8	9.7			**DM**	5	25.62859	5.125717	3.205734		
UM	5	96	19.2	7.2			**UM**	5	36.92308	7.384615	1.535925		
ANOVA							ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	*Source of Variation*	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	67.6	2	33.8	2.586735	0.116396	3.88529	Between Groups	16.87812	2	8.439059	2.903417	0.093663	3.88529
Within Groups	156.8	12	13.06667				Within Groups	34.87915	12	2.906596			
Total	224.4	14					Total	51.75727	14				

Appendix B. Location (U, M, D = upstream, midstream, and downstream) comparison (both raw and scaled) among habitats (G, V, M = gravel, vegetation and mud) for EPT richness using 1-way ANOVA.

Raw		MG	DG	UG			Scaled		MG	DG	UG		
EPT Richness	1	14	1	10			EPT Richness	1	9.50	1.25	7.27		
	2	8	5	7				2	6.36	4.72	5.91		
	3	12	4	7				3	8.50	4.17	5.91		
	4	8	4	11				4	6.36	4.17	8.00		
	5	7	3	9				5	5.91	3.61	6.82		
Anova: Single Factor							Anova: Single Factor						
SUMMARY							SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*			*Groups*	*Count*	*Sum*	*Average*	*Variance*		
MG	5	49	9.8	9.2			MG	5	36.6364	7.327273	2.4911157		
DG	5	17	3.4	2.3			DG	5	17.9167	3.583333	1.8557099		
UG	5	44	8.8	3.2			UG	5	33.9091	6.781818	0.8123967		
ANOVA							ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	*Source of Variation*	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	118.533	2	59.26667	12.09524	0.00133	3.88529	Between Groups	40.9082	2	20.45409	11.893706	0.00142	3.88529
Within Groups	58.8	12	4.9				Within Groups	20.6369	12	1.719741			
Total	177.333	14					Total	61.5451	14				
Raw		MV	DV	UV			Scaled		MV	DV	UV		
EPT Richness	1	9	0	7			EPT Richness	1	9.60	0.00	8.40		
	2	10	0	4				2	10.00	0.00	6.00		
	3	10	0	3				3	10.00	0.00	4.50		
	4	11	0	5				4	10.00	0.00	7.00		
	5	9	0	3				5	9.60	0.00	4.50		
Anova: Single Factor							Anova: Single Factor						
SUMMARY							SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*			*Groups*	*Count*	*Sum*	*Average*	*Variance*		
MV	5	49	9.8	0.7			MV	5	49.2	9.84	0.048		
DV	5	0	0	0			DV	5	0	0	0		
UV	5	22	4.4	2.8			UV	5	30.4	6.08	2.807		
ANOVA							ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	*Source of Variation*	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	240.933	2	120.4667	103.2571	2.7E-08	3.88529	Between Groups	246.549	2	123.2747	129.53555	7.5E-09	3.88529
Within Groups	14	12	1.166667				Within Groups	11.42	12	0.951667			
Total	254.933	14					Total	257.969	14				

Appendix B. Location (U, M, D = upstream, midstream and downstream) comparison (both raw and scaled) among habitats (G,V,M = gravel, vegetation, mud) for Hilsenhoff Biotic Index using 1-way ANOVA.

Raw		**MG**	**DG**	**UG**		
HBI	**1**	5.99	6.11	5.26		
	2	6.67	6.62	5.69		
	3	5.89	7.68	6.77		
	4	5.54	7.82	6.32		
	5	6.22	6.10	5.35		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MG	5	30.31459	6.062918	0.173217		
DG	5	34.34086	6.868172	0.699346		
UG	5	29.38258	5.876515	0.421246		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.777603	2	1.388801	3.220261	0.075936	3.88529
Within Groups	5.175238	12	0.43127			
Total	7.952841	14				

Scaled		**MG**	**DG**	**UG**		
HBI	**1**	5.64	5.48	6.55		
	2	4.79	4.85	6.01		
	3	5.76	3.52	4.66		
	4	6.19	3.35	5.23		
	5	5.34	5.50	6.44		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MG	5	27.73176	5.546353	0.270651		
DG	5	22.69893	4.539786	1.092729		
UG	5	28.89678	5.779356	0.658198		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4.340004	2	2.170002	3.220261	0.075936	3.88529
Within Groups	8.086309	12	0.673859			
Total	12.42631	14				

Raw		**MV**	**DV**	**UV**		
HBI	**1**	6.64	4.30	5.57		
	2	5.89	4.48	5.23		
	3	5.22	4.46	2.83		
	4	5.50	4.92	3.59		
	5	5.92	5.52	3.19		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MV	5	29.15065	5.83013	0.287617		
DV	5	23.68	4.736	0.24508		
UV	5	20.40361	4.080723	1.536566		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7.81156	2	3.90578	5.662565	0.018541	3.88529
Within Groups	8.277054	12	0.689755			
Total	16.08861	14				

Scaled		**MV**	**DV**	**UV**		
HBI	**1**	5.50	9.60	7.40		
	2	6.90	9.22	7.80		
	3	7.90	9.40	10.00		
	4	7.50	8.40	10.00		
	5	6.80	7.40	10.00		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MV	5	34.6	6.92	0.832		
DV	5	44.02	8.804	0.82408		
UV	5	45.2	9.04	1.748		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	13.49925	2	6.749627	5.948415	0.016034	3.88529
Within Groups	13.61632	12	1.134693			
Total	27.11557	14				

Appendix B. Location (U, M, D = upstream, midstream and downstream) comparison (both raw and scaled) among habitats (G,V,M = gravel, vegetation, mud) for Hilsenhoff Biotic Index using 1-way ANOVA.

Raw		**MM**	**DM**	**UM**		
HBI	**1**	7.88	7.48	6.16		
	2	7.53	8.72	7.37		
	3	7.95	8.59	8.03		
	4	6.85	5.92	5.86		
	5	6.47	8.44	6.50		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MM	5	36.68562	7.337123	0.425491		
DM	5	39.15	7.83	1.3781		
UM	5	33.90974	6.781948	0.804435		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.749266	2	1.374633	1.581234	0.245736	3.88529
Within Groups	10.4321	12	0.869342			
Total	13.18137	14				

Scaled		**MM**	**DM**	**UM**		
HBI	**1**	5.30	6.30	9.61		
	2	6.17	3.20	6.59		
	3	5.11	3.53	4.93		
	4	7.88	10.00	10.00		
	5	8.82	3.90	8.74		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MM	5	33.28596	6.657192	2.659321		
DM	5	26.925	5.385	8.143625		
UM	5	39.86539	7.973077	4.636646		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	16.74695	2	8.373475	1.627013	0.237018	3.88529
Within Groups	61.75837	12	5.146531			
Total	78.50532	14				

Appendix B. Location (U, M, D = upstream, midstream, and downstream) comparison (both raw and scaled) among habitats (G, V, M = gravel, vegetation, mud) for Percent Model Affinity using 1-way ANOVA.

Raw		**MG**	**DG**	**UG**		
Pecent Model Affinity	**1**	48.83	37.42	37.17		
	2	45.12	37.46	46.94		
	3	51.27	37.38	69.69		
	4	40.83	28.43	62.34		
	5	51.03	39.29	74.96		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MG	5	237.08	47.416	19.64018		
DG	5	179.98	35.996	18.54533		
UG	5	291.1	58.22	249.776		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1235.082	2	617.5408	6.433578	0.0126	3.88529
Within Groups	1151.846	12	95.98715			
Total	2386.927	14				

Scaled		**MG**	**DG**	**UG**		
Pecent Model Affinity	**1**	4.89	3.05	3.01		
	2	4.29	3.06	4.59		
	3	5.37	3.05	8.05		
	4	3.60	1.45	7.15		
	5	5.33	3.35	8.55		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MG	5	23.48065	4.696129	0.561451		
DG	5	13.95806	2.791613	0.579554		
UG	5	31.35096	6.270192	5.650671		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	30.34229	2	15.17114	6.701354	0.011112	3.88529
Within Groups	27.16671	12	2.263892			
Total	57.50899	14				

Raw		**MM**	**DM**	**UM**		
Pecent Model Affinity	**1**	40.29	57.65	58.75		
	2	42.22	40.39	50.57		
	3	53.08	44.61	45.45		
	4	37.04	55.92	41.83		
	5	20.56	43.70	52.61		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MM	5	193.19	38.638	138.3747		
DM	5	242.27	48.454	60.67813		
UM	5	249.21	49.842	42.75652		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	373.0167	2	186.5083	2.31391	0.1413	3.88529
Within Groups	967.2375	12	80.60312			
Total	1340.254	14				

Scaled		**MM**	**DM**	**UM**		
Pecent Model Affinity	**1**	2.06	5.53	5.75		
	2	2.44	2.08	4.11		
	3	4.62	2.92	3.09		
	4	1.41	5.18	2.37		
	5	0.00	2.74	4.52		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MM	5	10.526	2.1052	2.834771		
DM	5	18.454	3.6908	2.427125		
UM	5	19.842	3.9684	1.710261		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	10.10451	2	5.052253	2.173898	0.156434	3.88529
Within Groups	27.88863	12	2.324052			
Total	37.99313	14				

Appendix B. Location (U, M, D = upstream, midstream, and downstream) comparison (both raw and scaled) among habitats (G, V, M = gravel, vegetation, mud) for NCO richness using 1-way ANOVA.

NCO Raw		MV	DV	UV
	1	16	13	13
	2	15	18	13
	3	15	17	10
	4	16	10	21
	5	16	16	7

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
MV	5	78	15.6	0.3
DV	5	74	14.8	10.7
UV	5	64	12.8	27.2

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	20.8	2	10.4	0.816754	0.464988	3.88529
Within Groups	152.8	12	12.73333			
Total	173.6	14				

NCO Scaled		MV	DV	UV
	1	10.00	9.10	9.10
	2	10.00	10.00	9.10
	3	10.00	10.00	7.40
	4	10.00	7.30	10.00
	5	10.00	10.00	6.00

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
MV	5	50	10	0
DV	5	46.4	9.28	1.377
UV	5	41.6	8.32	2.567

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	7.104	2	3.552	2.70182556	0.1074596	3.88529031
Within Groups	15.776	12	1.31466667			
Total	22.88	14				

NCO Raw		MM	DM	UM
	1	1	9	6
	2	7	7	8
	3	12	3	8
	4	7	6	8
	5	5	9	7

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
MM	5	32	6.4	15.8
DM	5	34	6.8	6.2
UM	5	37	7.4	0.8

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.53333	2	1.266667	0.166667	0.848408	3.88529
Within Groups	91.2	12	7.6			
Total	93.7333	14				

Appendix B. Location (U, M, D = upstream, midstream, downstream) comparison (both raw and scaled) among habitats (G, V, M = gravel, vegetation, mud) for Shannon-Weiner Diversity and Dom-3 metrics using 1-way ANOVA.

Raw		**MM**	**UM**	**DM**		
DIV	**1**	1.39	2.44	1.41		
	2	1.95	1.87	0.82		
	3	1.97	1.32	0.9		
	4	2.01	2.34	1.65		
	5	1.95	2.2	0.9		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MM	5	9.27	1.854	0.06788		
UM	5	10.17	2.034	0.20568		
DM	5	5.68	1.136	0.13763		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.257213	2	1.128607	8.234198	0.005609	3.88529
Within Groups	1.64476	12	0.137063			
Total	3.901973	14				

Scaled		**MM**	**UM**	**DM**		
DIV	**1**	0.00	4.70	0.00		
	2	2.25	1.85	0.00		
	3	2.35	0.00	0.00		
	4	2.55	4.20	0.75		
	5	2.25	3.50	0.00		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MM	5	9.4	1.88	1.1195		
UM	5	14.25	2.85	3.6975		
DM	5	0.75	0.15	0.1125		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	18.70633	2	9.353167	5.692159	0.018262	3.88529
Within Groups	19.718	12	1.643167			
Total	38.42433	14				

Raw		**MM**	**UM**	**DM**		
DOM3	**1**	89.22	54.69	86.47		
	2	66.67	73.98	94.7		
	3	68.22	88.72	92.88		
	4	67.31	53.28	74.73		
	5	63.53	63.06	93.72		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MM	5	354.95	70.99	106.9656		
UM	5	333.73	66.746	218.8636		
DM	5	442.5	88.5	69.65165		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1329.747	2	664.8735	5.043533	0.025719	3.88529
Within Groups	1581.923	12	131.8269			
Total	2911.67	14				

Scaled		**MM**	**UM**	**DM**		
DOM3	**1**	2.63	8.39	3.09		
	2	6.39	5.17	1.33		
	3	6.13	2.71	1.78		
	4	6.28	8.62	5.05		
	5	6.91	6.99	1.57		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
MM	5	28.34167	5.668333	2.971265		
UM	5	31.87833	6.375667	6.079544		
DM	5	12.80833	2.561667	2.392018		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	41.16382	2	20.58191	5.396021	0.0213	3.88529
Within Groups	45.77131	12	3.814276			
Total	86.93513	14				

Appendix B. Student Neuman-Keuls (raw vs scaled) comparing locations (U, M, D = upstream, midstream and downstream) within the same habitat (gravel, vegetation and mud) for taxa richness.

	Raw	0.05	0.01	0.01	Midstream	Downstream	Upstream	M-D	D-U	M-U
Gravel	37.07	5.93	7.94	8.80	29.80	25.40	37.80	4.40	12.40	8.00
Veg	33.13	5.60	7.51	8.32	25.60	16.60	24.60	9.00	8.00	1.00
Mud	13.07	3.52	4.71	5.23	19.40	14.80	19.20	4.60	4.40	0.20
	Scaled									
Gravel	0.97	0.96	1.28	1.42	8.35	7.192	9.28	1.16	2.09	0.93
Veg	4.26	2.01	2.69	2.99	9.40	5.20	7.74	4.20	2.54	1.66
Mud	2.91	1.66	2.22	2.47	7.37	5.17	7.38	2.20	2.21	0.02
		Midstream	**Downstream**	**Upstream**	**M-D**	**D-U**	**M-U**			
Gravel	**Raw**	29.80	25.40	37.80	4.40	12.40	8.00		*	**<.05**
0.05	5.93				ns	*	*		**	**<.01**
0.01	7.94				ns	**	**		***	**<.005**
0.01	8.80				ns	***	ns	ns	***	ns
Gravel	**Scaled**	8.35	7.19	9.28	1.16	2.09	0.93			
0.05	0.96				*	*	ns			
0.01	1.28				ns	**	ns			
0.01	1.42				ns	***	ns	*	***	ns
Veg	**Scaled**	9.40	5.20	7.74	4.20	2.54	1.66			
0.05	2.01				*	*	ns			
0.01	2.69				**	ns	ns			
0.01	2.99				***	ns	ns	***	*	ns

Appendix B. Student Neuman-Keuls (raw vs scaled) comparing locations (U, M, D = upstream, midstream, and downstream) within the gravel and vegetation habitats for EPT richness.

	Raw	**0.05**	**0.01**	**0.01**	**Midstream**	**Downstream**	**Upstream**	**M-D**	**D-U**	**M-U**
Gravel	4.90	2.15	2.89	3.20	9.80	3.40	8.80	6.40	5.40	1.00
Veg	1.17	1.05	1.41	1.56	9.80	0.00	4.40	9.80	4.40	5.40
Mud										
	Scaled									
Gravel	1.72	1.28	1.71	1.90	7.33	3.58	6.78	3.74	3.20	0.55
Veg	0.95	0.95	1.27	1.41	9.84	0.00	6.08	9.84	6.08	3.76
Mud										
		Midstream	**Downstream**	**Upstream**	**M-D**	**D-U**	**M-U**			
Gravel	**Raw**	9.80	3.40	8.80	6.40	5.40	1.00		*	**<.05**
0.05	2.15				*	*	ns		**	**<.01**
0.01	2.89				**	**	ns		***	**<.005**
0.01	3.20				***	***	ns	***	***	ns
Gravel	**Scaled**	7.33	3.58	6.78	3.74	3.20	0.55			
0.05	1.28				*	*	ns			
0.01	1.71				**	**	ns			
0.01	1.90				***	***	ns	***	***	ns
Veg	**Raw**	9.80	0.00	4.40	9.80	4.40	5.40			
0.05	1.05				*	*	*			
0.01	1.41				**	**	**			
0.01	1.56				***	***	***	***	***	***
Veg	**Scaled**	9.84	0.00	6.08	9.84	6.08	3.76			
0.05	0.95				*	*	*			
0.01	1.27				**	**	**			
0.01	1.41				***	***	***	***	***	***

Appendix B. Student Nueman-Keuls (raw vs. scaled) comparing locations (U, M, D = upstream, midstream and downstream) within the same habitats (gravel, vegetation and mud) for the Hilsenhoff Biotic Index.

	Raw	0.05	0.01	0.01	Midstream	Downstream	Upstream	M-D	D-U	M-U
Gravel	0.43	0.64	0.86	0.95	6.06	6.87	5.88	0.81	0.99	0.19
Veg	0.69	0.81	1.08	1.20	5.83	4.74	4.08	1.09	0.66	1.75
Mud	0.87	0.91	1.22	1.35	7.34	7.83	6.78	0.49	1.05	0.56
	Scaled									
Gravel	0.67	0.80	1.07	1.19	6.06	6.87	5.88	0.81	0.99	0.19
Veg	1.13	1.04	1.39	1.54	6.92	8.80	9.04	1.88	0.24	2.12
Mud	5.15	2.21	2.96	3.28	6.66	5.39	7.97	1.27	2.59	1.32
		Midstream	**Downstream**	**Upstream**	**M-D**	**D-U**	**M-U**		*	**<.05**
Veg	**Raw**	5.83	4.74	4.08	1.09	0.66	1.75		**	**<.01**
0.05	0.81				*	ns	*		***	**<.005**
0.01	1.08				**	ns	**			
0.01	1.20				ns	ns	***	**	ns	***
Veg	**Scaled**	6.92	8.80	9.04	1.88	0.24	2.12			
0.05	1.04				*	ns	*			
0.01	1.39				**	ns	**			
0.01	1.54				***	ns	***	***	ns	***

Appendix B. Student Neuman-Keuls (raw vs. scaled) comparing locations (U, M, D = upstream, midstream, and downstream) within the same habitat (gravel and vegetation) for Percent Model Affinity.

	Raw	**0.05**	**0.01**	**0.005**	**Midstream**	**Downstream**	**Upstream**	**M-D**	**D-U**	**M-U**
Gravel	95.99	9.54	12.77	14.17	47.42	36.00	58.22	11.42	22.22	10.80
Veg										
Mud	80.60	8.74	11.71	12.98	38.64	48.45	49.84	9.82	1.39	11.20
	Scaled									
Gravel	2.26	1.46	1.96	2.18	4.70	2.79	6.27	1.90	3.48	1.57
Veg										
Mud	2.32	1.48	1.99	2.20	2.11	3.69	3.97	1.59	0.28	1.86
		Midstream	**Downstream**	**Upstream**	**M-D**	**D-U**	**M-U**		*	**<.05**
Gravel	**Raw**	47.42	36.00	58.22	11.42	22.22	10.80		**	**<.01**
0.05	9.54				*	*	*		***	**<.005**
0.01	12.77				ns	**	ns			
0.01	14.17				ns	***	ns	*	***	*
Gravel	**Scaled**	4.70	2.79	6.27	1.90	3.48	1.57			
0.05	1.46				*	*	*			
0.01	1.96				ns	**	ns			
0.01	2.18				ns	***	ns	*	***	*
Mud	**Raw**	38.64	48.45	49.84	9.82	1.39	11.20			
0.05	8.74				*	ns	*			
0.01	11.71				ns	ns	ns			
0.01	12.98				ns	ns	ns	ns	ns	ns
Mud	**Scaled**	2.11	3.69	3.97	1.59	0.28	1.86			
0.05	1.48				*	ns	*			
0.01	1.99				ns	ns	ns			
0.01	2.20				ns	ns	ns	ns	ns	ns

Appendix B. Student Neuman-Keuls (raw vs. scaled) comparing (U, M, D = upstream, midstream, and downstream) within the same habitat (vegetation and mud) for the metric NCO richness.

	Raw	0.05	0.01	0.01	Midstream	Downstream	Upstream	M-D	D-U	M-U
Gravel										
Veg	12.73	3.47	4.65	5.16	15.60	14.80	12.80	0.80	2.00	2.80
Mud	7.60	2.68	3.59	3.99	6.40	6.80	7.40	0.40	0.60	1.00
	Scaled									
Gravel										
Veg	1.13	1.04	1.39	1.54	10.00	9.28	8.32	0.72	0.96	1.68
Mud					nd	nd	nd			
		Midstream	**Downstream**	**Upstream**	**M-D**	**D-U**	**M-U**		*	**<.05**
Veg	**Raw**	15.60	14.80	12.80	0.80	2.00	2.80		**	**<.01**
0.05	3.47				ns	ns	ns		***	**<.005**
0.01	4.65				ns	ns	ns			
0.01	5.16				ns	ns	ns	ns	ns	ns
Veg	**Scaled**	10.00	9.28	8.32	0.72	0.96	1.68			
0.05	1.04				ns	ns	*			
0.01	1.39				ns	ns	**			
0.01	1.54				ns	ns	***	ns	ns	ns
Mud	**Raw**	6.40	6.80	7.40	0.40	0.60	1.00			
0.05	2.68				ns	ns	ns			
0.01	3.59				ns	ns	ns			
0.01	3.99				ns	ns	ns	ns	ns	ns

Appendix B. Student Neuman-Keuls (raw vs. scaled) comparing locations (U, M, D = upstream, midstream, and downstream) within the mud habitat for the Shannon-Weiner Diversity metric.

	Raw	**0.05**	**0.01**	**0.01**	**Midstream**	**Downstream**	**Upstream**	**M-D**	**D-U**	**M-U**
Mud	0.14	0.36	0.48	0.54	1.85	1.14	2.03	0.72	0.90	0.18
	Scaled									
Mud	1.64	1.25	1.67	1.85	1.88	0.15	2.85	1.73	2.70	0.97
		Midstream	**Downstream**	**Upstream**	**M-D**	**D-U**	**M-U**		*	**<.05**
Mud	**Raw**	1.85	1.14	2.03	0.72	0.90	0.18		**	**<.01**
0.05	0.36				*	*	ns		***	**<.005**
0.01	0.48				**	**	ns			
0.01	0.54				***	***	ns	***	***	ns
Mud	**Scaled**	1.88	0.15	2.85	1.73	2.70	0.97			
0.05	1.25				*	*	ns			
0.01	1.67				**	**	ns			
0.01	1.85				ns	***	ns	**	***	ns

Appendix B. Student Neuman-Keuls (raw vs. scaled) comparing locations (U, M, D = upstream, midstream, and downstream) within the mud habitat for DOM-3.

	Raw	0.05	0.01	0.01	Midstream	Downstream	Upstream	M-D	D-U	M-U
Gravel		0.00	0.00	0.00				0.00	0.00	0.00
Veg		0.00	0.00	0.00				0.00	0.00	0.00
Mud	131.83	11.18	14.97	16.60	70.99	88.50	66.75	17.51	21.75	4.24
	Scaled									
Gravel		0.00	0.00	0.00				0.00	0.00	0.00
Veg		0.00	0.00	0.00				0.00	0.00	0.00
Mud	3.81	1.90	2.55	2.82	5.67	2.56	6.38	3.11	3.81	0.71
		Midstream	**Downstream**	**Upstream**	**M-D**	**D-U**	**M-U**		*	**<.05**
Mud	**Raw**	70.99	88.50	66.75	17.51	21.75	4.24		**	**<.01**
0.05	11.18				*	*	ns		***	**<.005**
0.01	14.97				**	**	ns			
0.01	16.60				***	***	ns	***	***	ns
Mud	**Scaled**	5.67	2.56	6.38	3.11	3.81	0.71			
0.05	1.90				*	*	ns			
0.01	2.55				**	**	ns			
0.01	2.82				***	***	ns	***	***	ns

APPENDIX C.

Habitat (gravel, vegetation and mud) comparisons (both raw and scaled) among locations (upstream, midstream and downstream) for the metrics Taxa Richness, Ephemeroptera-Plecoptera-Trichoptera Richness, Hilsenhoff Biotic Index and Percent Model Affinity using 1-way ANOVA and Student Newman-Keuls.

Appendix C. Habitat (gravel, vegetation and mud) metric comparisons (both raw and scale) for the upstream sample location, Cheese Factory Road, using 1-way ANOVA.

			Upstream			
Raw			**Gravel**	**Veg**	**Mud**	
Taxa Richness		**1**	41	27	19	
		2	48	33	15	
		3	27	16	21	
		4	43	33	22	
		5	30	14	19	
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	189	37.8	79.7		
Veg	5	123	24.6	83.3		
Mud	5	96	19.2	7.2		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	915.6	2	457.8	8.06933	0.006015	3.88529
Within Groups	680.8	12	56.73333			
Total	1596.4	14				

			Upstream			
Scale-Converted			**Gravel**	**Veg**	**Mud**	
Taxa Richness		**1**	10.00	10.00	7.27	
		2	10.00	10.00	5.45	
		3	7.78	4.80	8.27	
		4	10.00	10.00	8.65	
		5	8.61	3.90	7.27	
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	46.39	9.278	1.06352		
Veg	5	38.7	7.74	9.678		
Mud	5	36.923	7.384569	1.535823		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	10.1281	2	5.064046	1.237413	0.324644	3.88529
Within Groups	49.1094	12	4.092448			
Total	59.2375	14				

			Upstream			
Raw			**Gravel**	**Veg**		
EPT Richness		**1**	10	7		
		2	7	4		
		3	7	3		
		4	11	5		
		5	9	3		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	44	8.8	3.2		
Veg	5	22	4.4	2.8		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	48.4	1	48.4	16.13333	0.003859	5.31764
Within Groups	24	8	3			
Total	72.4	9				

			Upstream			
Scale-Converted			**Gravel**	**Veg**		
EPT Richness		**1**	7.27	8.50		
		2	5.91	6.00		
		3	5.91	4.50		
		4	8.00	7.00		
		5	6.82	4.50		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	33.909	6.781818	0.812397		
Veg	5	30.5	6.1	2.925		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.16219	1	1.16219	0.621925	0.453067	5.31764
Within Groups	14.9496	8	1.868698			
Total	16.1118	9				

Appendix C. Habitat (gravel, vegetation and mud) metric comparisons (both raw and scale) for the upstream sample location, Cheese Factory Road, using 1-way ANOVA.

			Upstream							Upstream			
Raw		**Gravel**	**Veg**	**Mud**			**Scale-Converted**		**Gravel**	***Veg**	**Mud**		
HBI	**1**	5.26	5.57	6.16			**HBI**	**1**	6.55	7.4	9.61		
	2	5.69	5.23	7.37				**2**	6.01	7.8	6.59		
	3	6.77	2.83	8.03				**3**	4.66	10	4.93		
	4	6.32	3.59	5.86				**4**	5.23	10	10.00		
	5	5.35	3.19	6.50				**5**	6.44	10	8.74		
Anova: Single Factor							Anova: Single Factor						
SUMMARY							SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*			*Groups*	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	29.383	5.876515	0.421246			Gravel	5	28.897	5.779356	0.658198		
Veg	5	20.404	4.080723	1.536566			*Veg	5	45.2	9.04	1.748		
Mud	5	33.91	6.781948	0.804435			Mud	5	39.865	7.973077	4.636646		
ANOVA							ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	*Source of Variation*	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	18.9022	2	9.451083	10.26456	0.00252	3.88529	Between Groups	27.6376	2	13.81878	5.886307	0.016543	3.88529
Within Groups	11.049	12	0.920749				Within Groups	28.1714	12	2.347615			
Total	29.9512	14					Total	55.8089	14				
			Upstream							Upstream			
			Gravel	**Mud**						**Gravel**	**Mud**		
Raw		**1**	37.17	58.75			**Scale-Converted**		**1**	3.01	5.75		
PMA		**2**	46.94	50.57			**PMA**		**2**	4.59	4.11		
		3	69.69	45.45					**3**	8.05	3.09		
		4	62.34	41.83					**4**	7.15	2.37		
		5	74.96	52.61					**5**	8.55	4.52		
Anova: Single Factor							Anova: Single Factor						
SUMMARY							SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*			*Groups*	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	291.1	58.22	249.776			Gravel	5	31.351	6.270192	5.650671		
Mud	5	249.21	49.842	42.75652			Mud	5	19.842	3.9684	1.710261		
ANOVA							ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	*Source of Variation*	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	175.477	1	175.4772	1.199711	0.305256	5.31764	Between Groups	13.2456	1	13.24562	3.598897	0.094392	5.31764
Within Groups	1170.13	8	146.2662				Within Groups	29.4437	8	3.680466			
Total	1345.61	9					Total	42.6893	9				

Appendix C. Habitat (gravel, vegetation and mud) metric comparisons (both raw and scale) for the upstream sample location, Cheese Factory Road, using 1-way ANOVA.

			Upstream			
			Veg	**Mud**		
Raw		**1**	13	6		
NCO		**2**	13	8		
		3	10	8		
		4	21	8		
		5	7	7		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Veg	5	64	12.8	27.2		
Mud	5	37	7.4	0.8		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	72.9	1	72.9	5.207143	0.051916	5.31764
Within Groups	112	8	14			
Total	184.9	9				

Appendix C. Habitat (gravel, vegetation and mud) metric comparisons (both raw and scaled) for the midstream sample location, Powder Mill Park, using 1-way ANOVA.

			Midstream			
Raw			**Gravel**	**Veg**	**Mud**	
Taxa Richness		**1**	38	27	15	
		2	25	23	19	
		3	30	23	26	
		4	28	28	22	
		5	28	27	15	
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	149	29.8	24.2		
Veg	5	128	25.6	5.8		
Mud	5	97	19.4	22.3		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	273.7333	2	136.8667	7.85086	0.006608	3.88529
Within Groups	209.2	12	17.43333			
Total	482.9333	14				

			Midstream			
Scale-Converted			**Gravel**	**Veg**	**Mud**	
Taxa Richness		**1**	10	10.00	5.45	
		2	7.06	8.50	7.27	
		3	8.611	8.50	10.00	
		4	8.055	10.00	8.65	
		5	8.055	10.00	5.45	
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	41.781	8.3562	1.157145		
Veg	5	47	9.4	0.675		
Mud	5	36.83566	7.367133	3.978129		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	10.33387	2	5.166934	2.667827	0.110014	3.88529
Within Groups	23.24109	12	1.936758			
Total	33.57496	14				

			Midstream			
Raw			**Gravel**	**Veg**		
EPT Richness		**1**	14	9		
		2	8	10		
		3	12	10		
		4	8	11		
		5	7	9		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	49	9.8	9.2		
Veg	5	49	9.8	0.7		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0	1	0	0	1	5.317645
Within Groups	39.6	8	4.95			
Total	39.6	9				

			Midstream			
Scale-Converted			**Gravel**	**Veg**		
EPT Richness		**1**	9.50	9.60		
		2	6.36	10.00		
		3	8.50	10.00		
		4	6.36	10.00		
		5	5.91	9.60		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	36.63636	7.327273	2.491116		
Veg	5	49.2	9.84	0.048		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	15.7845	1	15.7845	12.43307	0.007777	5.317645
Within Groups	10.15646	8	1.269558			
Total	25.94096	9				

Appendix C. Habitat (gravel, vegetation and mud) metric comparisons (both raw and scaled) for the midstream sample location, Powder Mill Park, using 1-way ANOVA.

		Midstream				
Raw		Gravel	Veg	Mud		
HBI	1	5.99	6.64	7.88		
	2	6.67	5.89	7.53		
	3	5.89	5.22	7.95		
	4	5.54	5.50	6.85		
	5	6.22	5.92	6.47		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	30.31459	6.062918	0.173217		
Veg	5	29.15065	5.83013	0.287617		
Mud	5	36.68562	7.337123	0.425491		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6.581362	2	3.290681	11.13817	0.001841	3.88529
Within Groups	3.545302	12	0.295442			
Total	10.12666	14				

		Midstream				
Scale-Converted		Gravel	*Veg	Mud		
HBI	1	5.64	5.5	5.30		
	2	4.79	6.9	6.17		
	3	5.76	7.9	5.11		
	4	6.19	7.5	7.88		
	5	5.34	6.8	8.82		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	27.73176	5.546353	0.270651		
*Veg	5	34.6	6.92	0.832		
Mud	5	33.28596	6.657192	2.659321		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.316564	2	2.658282	2.119858	0.162786	3.88529
Within Groups	15.04789	12	1.253991			
Total	20.36445	14				

			Midstream			
			Gravel	Mud		
Raw		1	48.83	40.29		
PMA		2	45.12	42.22		
		3	51.27	53.08		
		4	40.83	37.04		
		5	51.03	20.56		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	237.08	47.416	19.64018		
Mud	5	193.19	38.638	138.3747		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	192.6332	1	192.6332	2.438165	0.157038	5.317645
Within Groups	632.0596	8	79.00745			
Total	824.6928	9				

			Midstream			
			Gravel	Mud		
Scale-Converted		1	4.89	2.06		
PMA		2	4.29	2.44		
		3	5.37	4.62		
		4	3.60	1.41		
		5	5.33	0.00		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	23.48065	4.696129	0.561451		
Mud	5	10.526	2.1052	2.834771		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	16.78228	1	16.78228	9.882912	0.013728	5.317645
Within Groups	13.58489	8	1.698111			
Total	30.36717	9				

Appendix C. Habitat (gravel, vegetation and mud) metric comparisons (both raw and scaled) for the midstream sample location, Powder Mill Park, using 1-way ANOVA.

			Midstream			
			Veg	**Mud**		
Raw		**1**	16	1		
NCO		**2**	15	7		
		3	15	12		
		4	16	7		
		5	16	5		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Veg	5	78	15.6	0.3		
Mud	5	32	6.4	15.8		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	211.6	1	211.6	26.28571	0.000899	5.317645
Within Groups	64.4	8	8.05			
Total	276	9				

Appendix C. Habitat (gravel, vegetation and mud) metric comparisons (both raw and scaled) for the downstream sample location, Ellison Park, using 1-way ANOVA.

			Downstream			
Raw		**Gravel**	**Veg**	**Mud**		
Taxa Richness	**1**	25.00	15.00	18.00		
	2	30.00	20.00	14.00		
	3	25.00	19.00	10.00		
	4	24.00	12.00	17.00		
	5	23.00	17.00	15.00		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5.00	127	25.40	7.30		
Veg	5.00	83	16.60	10.30		
Mud	5.00	74	14.80	9.70		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	321.73	2	160.87	17.68	0.000	3.89
Within Groups	109.20	12	9.10			
Total	430.93	14				
			Downstream			
Raw			**Gravel**	**Veg**		
EPT Richness		**1**	1.00	0.00		
		2	5.00	0.00		
		3	4.00	0.00		
		4	4.00	0.00		
		5	3.00	0.00		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5.00	17	3.40	2.30		
Veg	5.00	0	0.00	0.00		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	28.90	1	28.90	25.13	0.001	5.32
Within Groups	9.20	8	1.15			
Total	38.10	9				

			Downstream			
Scale-Converted		**Gravel**	**Veg**	**Mud**		
Taxa Richness	**1**	7.06	4.30	6.82		
	2	8.61	6.80	4.72		
	3	7.06	6.40	2.50		
	4	6.76	3.00	6.36		
	5	6.47	5.50	5.45		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	35.96405	7.19281046	0.68809005		
Veg	5	26	5.2	2.435		
Mud	5	25.85859	5.17171717	2.88790685		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	13.4282	2	6.71409292	3.35090487	0.069789	3.88529
Within Groups	24.044	12	2.00366563			
Total	37.4722	14				
			Downstream			
Scale-Converted			**Gravel**	**Veg**		
EPT Richness		**1**	1.25	0.00		
		2	4.72	0.00		
		3	4.17	0.00		
		4	4.17	0.00		
		5	3.61	0.00		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	17.91667	3.58333333	1.85570988		
Veg	5	0	0	0		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	32.1007	1	32.1006944	34.5966736	0.000369	5.31764
Within Groups	7.42284	8	0.92785494			
Total	39.5235	9				

Appendix C. Habitat (gravel, vegetation and mud) metric comparisons (both raw and scaled) for the downstream sample location, Ellison Park, using 1-way ANOVA.

			Downstream			
Raw		Gravel	Veg	Mud		
HBI	1	6.11	4.30	7.48		
	2	6.62	4.48	8.72		
	3	7.68	4.46	8.59		
	4	7.82	4.92	5.92		
	5	6.10	5.52	8.44		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5.00	34.34086	6.87	0.70		
Veg	5.00	23.68	4.74	0.25		
Mud	5.00	39.15	7.83	1.38		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	25.07	2	12.54	16.19	0.000	3.89
Within Groups	9.29	12	0.77			
Total	34.36	14				

			Downstream			
Scale-Converted		Gravel	*Veg	Mud		
HBI	1	5.48	9.60	6.30		
	2	4.85	9.22	3.20		
	3	3.52	9.40	3.53		
	4	3.35	8.40	10.00		
	5	5.50	7.40	3.90		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	22.69893	4.53978558	1.09272859		
*Veg	5	44.02	8.804	0.82408		
Mud	5	26.925	5.385	8.143625		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	50.9791	2	25.4895609	7.6009331	0.00737	3.88529
Within Groups	40.2417	12	3.35347786			
Total	91.2209	14				

			Downstream			
			Gravel	Mud		
Raw		1	37.42	57.65		
PMA		2	37.46	40.39		
		3	37.38	44.61		
		4	28.43	55.92		
		5	39.29	43.7		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5.00	179.98	36.00	18.55		
Mud	5.00	242.27	48.45	60.68		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	388.00	1	388.00	9.80	0.014	5.32
Within Groups	316.89	8	39.61			
Total	704.90	9				

			Downstream			
			Gravel	Mud		
Scale-Converted		1	3.05	5.53		
PMA		2	3.06	2.08		
		3	3.05	2.92		
		4	1.45	5.18		
		5	3.35	2.74		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Gravel	5	13.95806	2.7916129	0.57955437		
Mud	5	18.454	3.6908	2.4271252		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.02134	1	2.02134359	1.34456868	0.279666	5.31764
Within Groups	12.0267	8	1.50333979			
Total	14.0481	9				

Appendix C. Habitat (gravel, vegetation and mud) metric comparisons (both raw and scaled) for the downstream sample location, Ellison Park, using 1-way ANOVA.

			Downstream			
			Veg	**Mud**		
Raw		**1**	13	9		
NCO		**2**	18	7		
		3	17	3		
		4	10	6		
		5	16	9		
Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Veg	5.00	74	14.80	10.70		
Mud	5.00	34	6.80	6.20		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	160.00	1	160.00	18.93	0.002	5.32
Within Groups	67.60	8	8.45			
Total	227.60	9				

Appendix C. Student Newman-Keuls test comparing raw and scaled taxa richness values among habitats (gravel, vegetation and mud) within the same location.

	Raw	0.05	0.01	0.01	Gravel	Veg	Mud	G-V	V-M	G-M
Downstream	9.10	2.94	3.93	4.36	25.40	16.60	14.80	8.80	1.80	10.60
Upstream	56.73	7.33	9.82	10.89	37.80	24.60	19.20	13.20	5.40	18.60
Midstream	17.43	4.06	5.44	6.04	29.80	25.60	19.40	4.20	6.20	10.40
	Scaled									
Downstream	2.11	1.41	1.89	2.10	7.19	5.20	5.12	1.99	0.08	2.07
Upstream	4.09	1.97	2.64	2.93	9.28	7.74	7.38	1.54	0.36	1.89
Midstream	1.94	1.35	1.81	2.01	8.36	9.40	7.37	1.04	2.03	0.99
		Gravel	**Veg**	**Mud**	**G-V**	**V-M**	**G-M**			
Downstream	**Raw**	25.40	16.60	14.80	8.80	1.80	10.60		*	**<.05**
0.05	2.94				*	ns	*		**	**<.01**
0.01	3.93				**	ns	**		***	**<.005**
0.01	4.36				***	ns	***	***	ns	***
Downstream	**Scaled**	7.19	5.20	5.12	1.99	0.08	2.07			
0.05	1.41				*	ns	*			
0.01	1.89				**	ns	**			
0.01	2.10				ns	ns	ns	**	ns	**
Upstream	**Raw**	37.80	24.60	19.20	13.20	5.40	18.60			
0.05	7.33				*	ns	*			
0.01	9.82				**	ns	**			
0.01	10.89				***	ns	***	***	ns	***
Upstream	**Scaled**	9.28	7.74	7.38	1.54	0.36	1.89			
0.05	2.64				ns	ns	ns			
0.01	2.93				ns	ns	ns			
0.01	9.28				ns	ns	ns	ns	ns	ns
Midstream	**Raw**	29.80	25.60	19.40	4.20	6.20	10.40			
0.05	4.06				*	*	*			
0.01	5.44				ns	**	**			
0.01	6.04				ns	***	***	*	***	***
Midstream	**Scaled**	8.36	9.40	7.37	1.04	2.03	0.99			
0.05	1.35				ns	*	ns			
0.01	1.81				ns	**	ns			
0.01	2.01				ns	***	ns	ns	ns	ns

Appendix C. Student Newman-Keuls test comparing raw and scaled HBI values among habitats (gravel, vegetation and mud) within the same location (upstream, midstream and downstream).

	Raw	0.05	0.01	0.01	Gravel	Veg	Mud	G-V	V-M	G-M
Downstream	0.77	0.86	1.15	1.27	6.87	4.74	7.83	2.13	3.09	0.96
Upstream	0.92	0.93	1.25	1.39	5.88	4.08	6.78	1.80	2.70	0.91
Midstream	0.30	0.53	0.71	0.79	6.06	5.83	7.34	0.23	1.51	1.27
	Scaled									
Downstream	3.35	1.78	2.39	2.65	4.54	8.80	5.39	4.26	3.42	0.85
Upstream	2.35	1.49	2.00	2.22	5.78	9.04	7.97	3.26	1.07	2.19
Midstream	1.25	1.09	1.46	1.62	5.55	6.92	6.66	1.37	0.26	1.11
		Gravel	**Veg**	**Mud**	G-V	V-M	G-M		*	**<.05**
Downstream	**Raw**	6.87	4.74	7.83	2.13	3.09	0.96		**	**<.01**
0.05	0.86				*	*	*		***	**<.005**
0.01	1.15				**	**	ns			
0.01	1.27				***	***	ns	***	***	*
Downstream	**Scaled**	4.54	8.80	5.39	4.26	3.42	0.85			
0.05	1.78				*	*	ns			
0.01	2.39				**	**	ns			
0.01	2.65				***	***	ns	***	***	ns
Upstream	**Raw**	5.88	4.08	6.78	1.80	2.70	0.91			
0.05	0.93				*	*	ns			
0.01	1.25				**	**	ns			
0.01	1.39				***	***	ns	***	***	ns
Upstream	**Scaled**	5.78	9.04	7.97	3.26	1.07	2.19			
0.05	1.49				ns	*	*			
0.01	2.00				ns	**	**			
0.01	2.22				ns	ns	ns	ns	**	**
Midstream	**Raw**	6.06	5.83	7.34	0.23	1.51	1.27			
0.05	0.53				ns	*	*			
0.01	0.71				ns	**	**			
0.01	0.79				ns	***	***	ns	***	***
Midstream	**Scaled**	5.55	6.94	6.66	1.39	0.28	1.11			
0.05	1.09				*	ns	*			
0.01	1.46				ns	ns	ns			
0.01	1.62				ns	ns	ns	ns	ns	ns

APPENDIX D.

Comparison among random, haphazard and whole sample metrics including Taxa Richness, Ephemeroptera-Plecoptera-Trichoptera Richness, Hilsenhoff Biotic Index and Percent Model Affinity using 1-way ANOVA and Student Newman-Keuls.

Appendix D. 1-way ANOVA metric comparison (TR, EPT, HBI and PMA) among haphazard and random 100 counts and whole counts.

TAXA RICHNESS				
Sample	*Hap CC*	*Rand CC*	*Rand NB*	*Whole NB*
1	14	17	16	26
2	12	10	12	18
3	16	15	17	20
4	15	13	16	20
5	14	13	14	18

Anova: Single Factor SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Hap CC	5	71	14.2	2.2
Rand CC	5	68	13.6	6.8
Rand NB	5	75	15	4
Whole NB	5	102	20.4	10.8

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	146	3	48.66667	8.179272	0.0016	3.2389
Within Groups	95.2	16	5.95			
Total	241.2	19				

HBI				
Sample	*Hap CC*	*Rand CC*	*Rand NB*	*Whole NB*
1	2.22	1.36	4.97	5.83
2	2.08	1.04	6.53	6.47
3	2.93	2.07	4.1	5.49
4	2.5	2.09	4.4	5.47
5	3.32	2.5	5.5	4.36

Anova: Single Factor SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Hap CC	5	13.05	2.61	0.2629
Rand CC	5	9.06	1.812	0.35437
Rand NB	5	25.5	5.1	0.92795
Whole NB	5	27.62	5.524	0.58688

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	50.1225	3	16.70749	31.344656	6E-07	3.2389
Within Groups	8.5284	16	0.533025			
Total	58.6509	19				

EPT				
Sample	*Hap CC*	*Rand CC*	*Rand NB*	*Whole NB*
1	5	6	9	14
2	5	4	5	8
3	5	7	10	12
4	6	7	6	8
5	4	7	5	7

Anova: Single Factor SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Hap CC	5	25	5	0.5
Rand CC	5	31	6.2	1.7
Rand NB	5	35	7	5.5
Whole NB	5	49	9.8	9.2

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	62.4	3	20.8	4.923077	0.0131	3.2389
Within Groups	67.6	16	4.225			
Total	130	19				

PMA				
Sample	*Hap CC*	*Rand CC*	*Rand NB*	*Whole NB*
1	41	50	61	51.17
2	37	50	63	54.88
3	41	33	44.98	48.73
4	31	31	40.83	59.17
5	55	55	46.56	48.97

Anova: Single Factor SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Hap CC	5	205	41	78
Rand CC	5	219	43.8	120.7
Rand NB	5	256.37	51.274	100.75188
Whole NB	5	262.92	52.584	19.64018

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	477.899	3	159.2998	1.9969136	0.1551	3.2389
Within Groups	1276.37	16	79.77302			
Total	1754.27	19				

Appendix D. Student Newman-Keuls metric comparison (TR, EPT and HBI) among haphazard and random 100 counts and whole sample analyses for raw and scaled values.

Taxa Richness	Raw	0.05	0.01	0.005	HCC	RCC	RNB	WNB	HCC-RCC	HCC-RNB	HCC-WNB	RCC-RNB	RCC-WNB	RNB-WNB
TR	5.95	2.55	3.28	3.58	14.20	13.60	15.00	20.40	0.60	0.80	6.20	1.40	6.80	5.40
EPT	4.23	2.15	2.76	3.02	5.00	6.20	7.00	9.80	1.20	2.00	4.80	0.80	3.60	2.80
HBI	0.53	0.76	0.98	1.07	2.61	1.81	5.10	5.52	0.80	2.49	2.91	3.29	3.71	0.42
PMA	79.77	9.35	12.00	13.12	41.00	43.80	51.27	52.58	2.80	10.27	11.58	7.47	8.78	1.31
	Scale													
TR	0.57	0.79	1.02	1.11	3.74	3.51	3.97	5.65	0.23	0.23	1.91	0.46	2.14	1.68
EPT	1.17	1.13	1.45	1.59	4.76	5.47	5.80	7.33	0.71	1.04	2.57	0.33	1.86	1.53
HBI	0.64	0.84	1.08	1.18	9.39	9.87	6.73	6.21	0.48	2.67	3.18	3.14	3.66	0.51
PMA	2.26	1.58	2.02	2.21	3.62	4.09	5.32	5.55	0.46	1.70	1.92	1.23	1.46	0.23
		HCC	**RCC**	**RNB**	**WNB**	**HCC-RCC**	**HCC-RNB**	**HCC-WNB**	**RCC-RNB**	**RNB-WNB**	**RCC-WNB**		*	**<.05**
TR	**Raw**	14.20	13.60	15.00	20.40	0.60	0.80	6.20	1.40	5.40	6.80		**	**<.01**
0.05	2.55					ns	ns	*	ns	*	*		***	**<.005**
0.01	3.28					ns	ns	**	ns	**	**			
0.005	3.58					ns	ns	***	ns	***	***			
TR	**Scale**	3.74	3.51	3.97	5.65	0.23	0.23	1.91	0.46	1.68	2.14			
0.05	0.79					ns	ns	*	ns	*	*			
0.01	1.02					ns	ns	**	ns	**	**			
0.005	1.11					ns	ns	***	ns	***	***			
EPT	**Raw**	5.00	6.20	7.00	9.80	1.20	2.00	4.80	0.80	2.80	3.60			
0.05	2.15					ns	ns	*	ns	*	*			
0.01	2.76					ns	ns	**	ns	**	**			
0.005	3.02					ns	ns	***	ns	ns	***			
EPT	**Scale**	4.76	5.47	5.80	7.33	0.71	1.04	2.57	0.33	1.53	1.86			
0.05	1.13					ns	ns	*	ns	*	*			
0.01	1.45					ns	ns	**	ns	**	**			
0.005	1.59					ns	ns	***	ns	ns	***			
HBI	**Raw**	2.61	1.81	5.10	5.52	0.80	2.49	2.91	3.29	0.42	3.71			
0.05	0.76					*	*	*	*	ns	*			
0.01	0.98					ns	**	**	**	ns	**			
0.005	1.07					ns	***	***	***	ns	***			
HBI	**Scale**	9.39	9.87	6.73	6.21	0.48	2.67	3.18	3.14	0.51	3.66			
0.05	0.84					ns	*	*	*	ns	*			
0.01	1.08					ns	**	**	**	ns	**			
0.005	1.18					ns	***	***	***	ns	***			

APPENDIX E.

Raw and scaled metric values for Taxa Richness, Ephemeroptera-Plecoptera-Trichoptera Richness, Hilsenhoff Biotic Index, Percent Model Affinity, Non-Chironomid/Oligochaete Richness, Shannon-Weiner Diversity and Dominance-3 for upstream, midstream and downstream locations in the gravel, vegetation and mud habitats.

Appendix E. Metric Summary for Taxa Richness, EPT and NCO Richness, Hilsenhoff Biotic Index, Percent Model Affinity, Shannon-Weiner Diversity and DOM-3.

		TR		*EPT*		*HBI*		*PMA*		*NCO*		*DIV*		*DOM-3*	
	Trial	**Raw**	**Scale**	**Raw**	**Scale**	**Raw**	**Scale**	**Raw**	**Scale**	**Raw**	**Scale**	**Raw**	**Scale**	**Raw**	**Scale**
Upstream Gravel	**1**	41	10	10	7.27	5.26	6.55	37.17	3.01	NA	NA	NA	NA	NA	NA
	2	48	10	7	5.91	5.69	6.01	46.94	4.59	" "	" "	" "	" "	" "	" "
	3	27	8	7	5.91	6.77	4.66	69.69	8.05	" "	" "	" "	" "	" "	" "
	4	43	10	11	8.00	6.32	5.23	62.34	7.15	" "	" "	" "	" "	" "	" "
	5	30	9	9	6.82	5.35	6.44	74.96	8.55	" "	" "	" "	" "	" "	" "
Upstream Vegetation	**1**	27	10	7	8.50	5.57	7.40	NA	NA	13	9.00	NA	NA	NA	NA
	2	33	10	4	6.00	5.23	7.80	" "	" "	13	9.00	" "	" "	" "	" "
	3	16	5	3	4.50	2.83	10.00	" "	" "	10	7.30	" "	" "	" "	" "
	4	33	10	5	7.00	3.59	10.00	" "	" "	21	10.00	" "	" "	" "	" "
	5	14	4	3	4.50	3.19	10.00	" "	" "	7	5.90	" "	" "	" "	" "
Upstream Mud	**1**	19	7	NA	NA	6.16	9.61	58.75	5.75	6	NA	2.44	4.70	54.69	8.39
	2	15	5	" "	" "	7.37	6.59	50.57	4.11	8	" "	1.87	1.85	73.98	5.17
	3	21	8	" "	" "	8.03	4.93	45.45	3.09	8	" "	1.32	0.00	88.72	2.71
	4	22	9	" "	" "	5.86	10.00	41.83	2.37	8	" "	2.34	4.20	53.28	8.62
	5	19	7	" "	" "	6.50	8.74	52.61	4.52	7	" "	2.20	3.50	63.06	6.99
Midstream Gravel	**1**	38	10	14	9.50	5.99	5.64	48.83	4.89	NA	NA	NA	NA	NA	NA
	2	25	7	8	6.36	6.67	4.79	45.12	4.29	" "	" "	" "	" "	" "	" "
	3	30	9	12	8.50	5.89	5.76	51.27	5.37	" "	" "	" "	" "	" "	" "
	4	28	8	8	6.36	5.54	6.19	40.83	3.60	" "	" "	" "	" "	" "	" "
	5	28	8	7	5.91	6.22	5.34	51.03	5.33	" "	" "	" "	" "	" "	" "
Midstream Vegetation	**1**	27	10	9	9.60	6.64	5.50	NA	NA	16	10.00	NA	NA	NA	NA
	2	23	9	10	10.00	5.89	6.90	" "	" "	15	10.00	" "	" "	" "	" "
	3	23	9	10	10.00	5.22	7.90	" "	" "	15	10.00	" "	" "	" "	" "
	4	28	10	11	10.00	5.50	7.50	" "	" "	16	10.00	" "	" "	" "	" "
	5	27	10	9	9.60	5.92	6.80	" "	" "	16	10.00	" "	" "	" "	" "
Midstream Mud	**1**	15	5	NA	NA	7.88	5.30	40.29	2.06	1	NA	1.39	0.00	89.22	2.63
	2	19	7	" "	" "	7.53	6.17	42.22	2.44	7	" "	1.95	2.25	66.67	6.39
	3	26	10	" "	" "	7.95	5.11	53.08	4.62	12	" "	1.97	2.35	68.22	6.13
	4	22	9	" "	" "	6.85	7.88	37.04	1.41	7	" "	2.01	2.55	67.31	6.28
	5	15	5	" "	" "	6.47	8.82	20.56	0.00	5	" "	1.95	2.25	63.53	6.91
Downstream Gravel	**1**	25	7	1	1.25	6.11	5.48	37.42	3.05	NA	NA	NA	NA	NA	NA
	2	30	9	5	4.72	6.62	4.85	37.46	3.06	" "	" "	" "	" "	" "	" "
	3	25	7	4	4.17	7.68	3.52	37.38	3.05	" "	" "	" "	" "	" "	" "
	4	24	7	4	4.17	7.82	3.35	28.43	1.45	" "	" "	" "	" "	" "	" "
	5	23	6	3	3.61	6.10	5.50	39.29	3.35	" "	" "	" "	" "	" "	" "
Downstream Vegetation	**1**	15	4	0	0.00	4.30	9.60	NA	NA	13	9.00	NA	NA	NA	NA
	2	20	7	0	0.00	4.48	9.22	" "	" "	18	10.00	" "	" "	" "	" "
	3	19	6	0	0.00	4.46	9.40	" "	" "	17	10.00	" "	" "	" "	" "
	4	12	3	0	0.00	4.92	8.40	" "	" "	10	7.30	" "	" "	" "	" "
	5	17	6	0	0.00	5.52	7.40	" "	" "	16	10.00	" "	" "	" "	" "
Downstream Mud	**1**	18	7	NA	NA	7.48	6.30	57.65	5.53	9	NA	1.41	0.00	86.47	3.09
	2	14	5	" "	" "	8.72	3.20	40.39	2.08	7	" "	0.82	0.00	94.70	1.33
	3	10	2	" "	" "	8.59	3.53	44.61	2.92	3	" "	0.90	0.00	92.88	1.78
	4	17	6	" "	" "	5.92	10.00	55.92	5.18	6	" "	1.65	0.75	74.73	5.05
	5	15	5	" "	" "	8.44	3.90	43.70	2.74	9	" "	0.90	0.00	93.72	1.57