SHIELDS RIVER

HABITAT AND AQUATIC INVERTEBRATE ASSESSMENT

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The Montana Department of Environmental Quality
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INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in September 2000 from two sites on the Shields River, Montana. A multimetric approach to bioassessment was applied to the data: this approach uses attributes of the benthic invertebrate assemblage in an integrated way to measure biotic health. A stream with good biotic health has been described as "...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999).

The additive multimetric approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana is "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site, combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1994). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied is advantageous to the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. This writer (1998) has recently studied the assemblages of the Montana Valley and Foothill Prairies ecoregion, and has recommended a battery of metrics specific to that ecoregion, which has been shown to be sensitive to impairment, related to habitat assessment parameters and consistent over replicated samples.

Habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by metals, other toxicants, high water temperatures, or high levels of organic and/or nutrient pollution might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment in an oligotrophic setting.

METHODS

Aquatic invertebrates were sampled by Pat Newby of the Montana Department of Environmental Quality (MT DEQ). Two sites on Shields River were sampled; Table 1 gives site locations. Both sites lie within the Montana Valleys and Foothill Prairies (MVFP) ecoregion.The sampling method employed is described in the MT DEQ Standard Operating Procedures for Macroinvertebrate Sampling (Bukantis 1998). In addition, habitat quality was evaluated by scoring various instream, streambank and riparian zone parameters using a DEQ-modified version of the U.S. EPA's Rapid Bioassessment Protocols. Aquatic invertebrate samples and associated habitat assessment data were delivered to Rhithron Biological Associates, Missoula, Montana, for laboratory and data analyses.

Table 1. Sampling locations on Shields River. August 2000.

Sampling station	Latitude	Longitude
McCloud	46° 09' 56"	110° 34' 05"
Johnstone	45° 57' 21"	110° 37' 57"

In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

To assess invertebrate communities in this study, a multimetric index developed in previous work for streams of western Montana (Bollman 1998) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results. The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics, which have been shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995), were used for descriptive interpretation of Shields River results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in the ecoregions of Montana is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used in this study were selected because both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998). In addition, they are relevant to the kinds of impacts that are present in the Shields River drainage, and they have been demonstrated to be more variable with anthropogenic impairment than with natural environmental gradients. Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.
2. **Plecoptera (stonefly) taxa richness.** Stoneflies are particularly susceptible to impairments that affect a stream on a larger or reach-level scale, such as loss of riparian canopy, streambank instability, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.
3. **Trichoptera (caddisfly) taxa richness.** Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.
4. **Number of sensitive taxa.** Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998).
5. **Percent filter feeders.** Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* spp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Hence, they are considered predators and in this study their abundance does not contribute to the percent filter feeders metric.
6. **Percent tolerant taxa.** Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges and in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values are transformed onto a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

Table 2. Metrics and scoring criteria for bioassessment of streams of western Montana ecoregions (Bollman 1998).

	Score			
Metric	**3**	**2**	**1**	**0**
Ephemeroptera taxa richness	> 5	5 - 4	3 - 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 – 5	5.01 - 10	10.01 - 25	> 25
Percent tolerant taxa	0 – 5	5.01 - 10	10.01 - 35	> 35

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by MT DEQ and are presented in Table 3a. For descriptive purposes, scores were also translated into impairment classifications according to criteria outlined in Table 3b.

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (from Bukantis, 1997)

% Comparability to reference	**Use support**
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 3b. Criteria for the assignment of impairment classifications (from Plafkin et al. 1989).

% Comparability to reference	**Classification**
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

In this report, certain other metrics were used, when appropriate, as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman, unpublished data). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent shredders. Shredding organisms consume large particles of detritus such as leaves, needles and wood. Foothill and prairie streams with healthy riparian vegetation and sufficient instream structure to retain detritus will have large numbers of shredders. Often, this feeding group dominates the fauna of headwater streams. The abundance of shredders generally increases in the fall, when leaf and blade input to streams maximizes. In another study, average shredder contribution in western Montana reference streams was 8% (Wisseman 1992).
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less-disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa

richness in unimpaired streams of western Montana is at least 14 (Bollman, unpublished data).

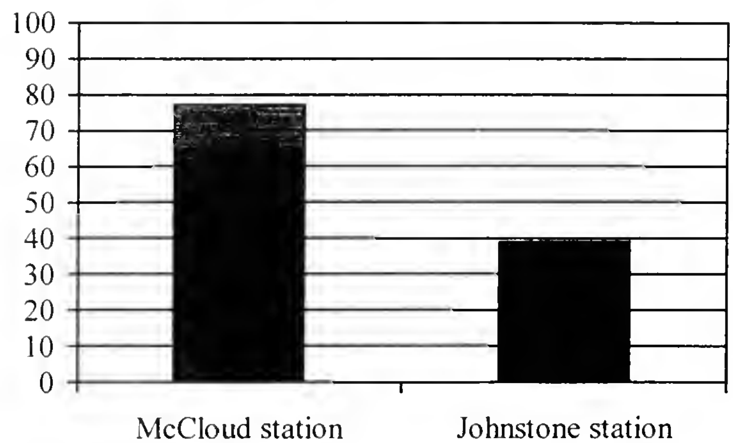
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman, unpublished data).

RESULTS

Habitat assessment

Figure 1 compares habitat assessment results for the two sites studied. Breakdown of total scores into the nine evaluated components is presented in Table 1.

Figure 1. Total habitat assessment scores, expressed as percent of maximum, for two sites on Shields River, August, 2000.



Habitat assessments indicate that conditions contrasted sharply between McCloud station and Johnstone station. Overall assessment at McCloud station suggested sub-optimal conditions, whereas Johnstone station was judged to have marginal habitat. At McCloud station, all but one of the instream indicators were scored optimally; the exception was sediment deposition, since some point bar formation was noted. In addition, flow status was judged sub-optimal, as were all of the streambank and riparian indicators.

In contrast, degradation of instream habitats was indicated by the assessment conducted at Johnstone station. Substrate embeddedness was noted, and sediment deposition was judged to be heavy. The investigator detected marginal flow status at this location. Streambank stability and vegetation were given poor scores, and the riparian zone was noted to be minimally intact.

Table 4. Stream and riparian habitat assessment: Shields River, August 2000.

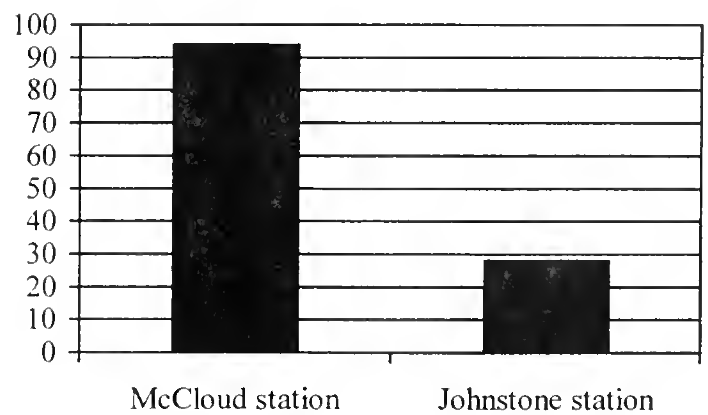
Maximum possible score	Location:	McCloud station	Johnstone station
	Parameter		
10	Riffle development	9	9
10	Benthic substrate	9	6
20	Embeddedness	16	6
20	Channel alteration	20	18
20	Sediment deposition	15	4
20	Channel flow status	14	7
10 / 10	Bank stability (left/right)	12	4
10 / 10	Bank vegetation protection (left/right)	7 / 7	2 / 2
10 / 10	Riparian vegetation zone width (left/right)	7 / 7	2 / 2
160	**TOTAL SCORE**	123	62
PERCENT OF MAXIMUM:		77	39
	CONDITION[1]	**SUB-OPTIMAL**	**MARGINAL**

[1]Optimal >81%, Sub-Optimal 75-56%, Marginal 49-29%, Poor <23%. (Plafkin et al. 1989.)

Bioassessment

Aquatic invertebrate taxa lists, metric results and other information for each sample are given in the Appendix. Figure 2 compares the total bioassessment scores calculated for invertebrate communities collected at each of the two sites. Breakdown of scores for each metric calculated from Shields River invertebrate samples is presented in Table 5.

Figure 2. Total bioassessment scores, expressed as percent of maximum, for two sites on Shields River, August 2000.



The benthic assemblage sampled at McCloud station scored maximal values for all but one of the bioassessment metrics, resulting in a total score indicating excellent biotic health. Full support of designated uses was indicated. The percentage of filter-feeding organisms was higher than expected for an unimpaired site. At Johnstone station, on the other hand, mayfly richness, stonefly richness and caddisfly richness were all lower than expected in undisturbed conditions, and no sensitive taxa were collected. In addition, a large proportion of sampled organisms were tolerant, and a large proportion were filter-feeders. The total bioassessment score calculated for the assemblage sampled at this site indicated moderate impairment of biotic health and partial support of designated uses.

Table 5. Metric values and bioassessments for Shields River, August 2000.

	Sites	
	McCloud station	**Johnstone station**
Metric		
Ephemeroptera richness	8	3
Plecoptera richness	8	1
Trichoptera richness	9	4
Sensitive taxa richness	5	0
Percent tolerant taxa	3	26
Percent filter-feeders	9	29
	Metric scores	
Ephemeroptera richness	3	1
Plecoptera richness	3	1
Trichoptera richness	3	2
Sensitive taxa richness	3	0
Percent tolerant taxa	3	1
Percent filter-feeders	2	0
Total score (maximum = 18)	17	5
Percent of maximum	94	28
Use support*	**FULL**	**PARTIAL**
Impairment classification[1]	**NON**	**MOD**

1. Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.
*Use support designations: See Table 3a.

Aquatic invertebrate communities

Shields River at McCloud station supported a benthic assemblage typical of a weatern Montana stream with little disturbance. The community was diverse (37 taxa were present in the sample) and most functional components were adequately represented. Nine percent of the sampled assemblage were filter-feeders, a proportion elevated slightly above that expected. Most of the filter-feeding organisms were the caddisfly *Hydropsyche* sp. This finding suggests that suspended fine organic particulates were plentiful in this reach, perhaps compromising water quality to a slight degree. It also correlates with the finding of slight streambank instability, sub-optimal riparian zone integrity, and light deposition of fine sediments noted in the habitat assessment. The overall affect of these conditions on biotic health, however, appears to be very slight. Eight mayfly taxa and a low biotic index value (2.36) suggest that water quality perturbations do not substantially impair biotic health in this reach. Excellent large-scale habitat is indicated by the high number of stonefly taxa; among them were the sensitive shredder *Zapada columbiana* and the perlid *Doroneuria* sp., which is also sensitive to many types of habitat disturbance. Long-lived taxa, including three different species of perlid stoneflies and the caddisfly *Arctopsyche grandis* were abundant, indicating adequate year-round streamflow and no periodic disruptive events. The presence of 9 caddisfly taxa and 18 "clinger" taxa suggests that the slight sediment deposition noted by the field investigator does not compromise biotic health to any great extent. Predator taxa were abundant and diverse; ten taxa comprised 16% of the sampled assemblage. This suggests good instream habitat. Sixteen percent of the organisms sampled were shredders, indicating good riparian inputs of large organic material, and stream morphology and flow conditions adequate for retention of such material.

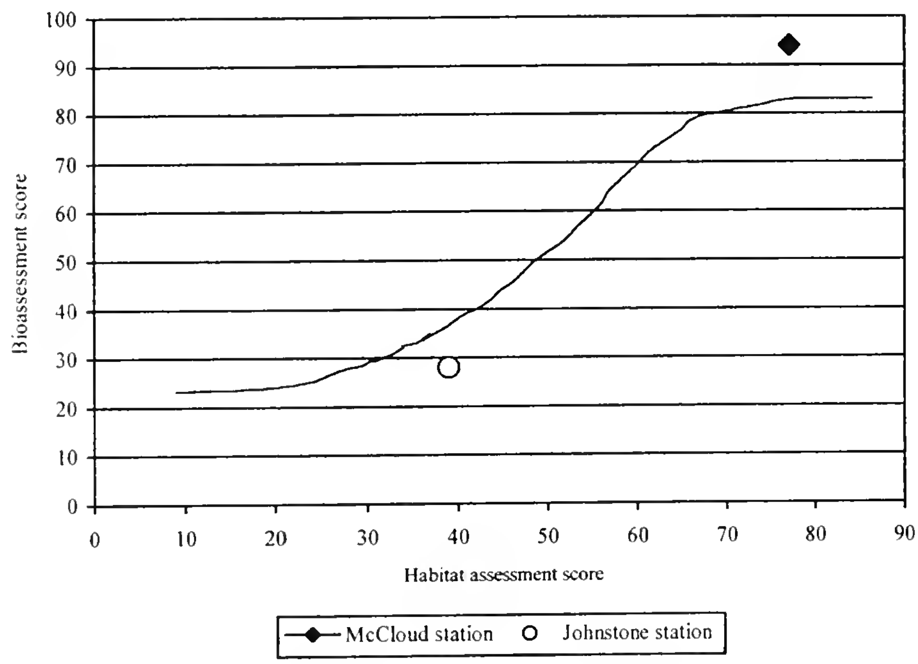
At Johnstone station, on the other hand, only 3 mayfly taxa were represented in the sample, and the biotic index value (4.89) was considerably higher than expected. In addition, 33% of the assemblage were midges. These findings suggest that water quality impairs biotic health in this reach of Shields River. Abundant filter-feeders (29% of the assemblage) suggest that fine suspended organic material was abundant here, and may be an indication of poor streambank stability and associated erosion, heavy sediment deposition, and embeddedness of benthic substrates noted in the habitat assessment. No sensitive taxa were present in the sample. Only two predator taxa (1% of the assemblage), most of them the tolerant snipefly *Atherix* sp., were collected, suggesting monotonous substrates and poor instream habitat quality. Further, 4 caddisfly taxa, dominated by the sediment-tolerant *Hydropsyche* sp., and 10 "clinger" taxa were present in the sample, indicating that sediment deposition limited the diversity of benthic invertebrates here. Only 20 unique taxa were collected. A single shredder taxa was present, indicating very limited riparian contributions of large organic material.

CONCLUSIONS

- With the exception of a slightly elevated filter-feeder component to the assemblage, the benthic invertebrates at the McCloud station indicate essentially unimpaired biotic health. Increased filter-feeders may indicate excessive suspended fine organic particulates, which in this reach of Shields River may be a consequence of some degree of streambank instability and associated erosion.
- Both water quality perturbations and habitat degradation appear to impair biotic health at the Johnstone station. Impairment was classified as "moderate", but the score was very low. Metric performance and taxonomic composition of the assemblage suggested that water quality was impaired by nutrient and/or organic enrichment. Habitat degradation appears to have resulted in heavy fine sediment deposition with the resultant loss of instream habitat.

- The relationship between habitat assessment scores and bioassessment scores suggests that neither water quality nor habitat degradation limited biotic health at McCloud station. However, both habitat degradation, and, to a lesser extent, diminished water quality combined to impair integrity at Johnstone station. Figure 3 illustrates these relationships. The point representing McCloud station lies high in the upper right quadrant of the graph, where its high habitat assessment score is coupled with a high bioassessment score. In contrast, the point representing Johnstone station lies slightly below a line describing the expected relationship between habitat and biotic health when water quality is unimpaired.

Figure 3. Total bioassessment scores plotted against habitat assessment scores for two sites on Shields River, August 2000. The red line describes the hypothetical relationship expected when water quality is good and biotic health is determined predominantly by habitat quality (Barbour and Stribling 1991).



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APPENDIX

Aquatic invertebrate taxonomic and metric data,
Shields River, August 2000.

Aquatic Macroinvertebrate Taxonomic Data

9/19/00

Site Name: Shields River

Site ID: Johnstone station

Approx. percent of sample used 6

Taxon	**Quantity**	**Percent**	**HBI**	**FFG**
Physidae	32	9.76	8	CG
Acari	3	0.91	5	PA
Total Misc. Taxa	**35**	**10.67**		
Ephemerellidae - early instar	1	0.30	1	CG
Rhithrogena sp.	1	0.30	0	SC
Tricorythodes minutus	1	0.30	4	CG
Total Ephemeroptera	**3**	**0.91**		
Skwala sp.	1	0.30	2	PR
Total Plecoptera	**1**	**0.30**		
Amiocentrus aspilus	14	4.27	3	CG
Brachycentrus occidentalis	1	0.30	1	OM
Hydropsyche sp.	95	28.96	4	CF
Lepidostoma sp.-sand case larvae	18	5.49	1	SH
Total Trichoptera	**128**	**39.02**		
Microcylloepus sp.	1	0.30	7	SC
Optioservus sp.	37	11.28	4	SC
Zaitzevia sp.	9	2.74	4	CG
Total Coleoptera	**47**	**14.33**		
Atherix sp.	3	0.91	4	PR
Antocha sp.	1	0.30	3	CG
Total Diptera	**4**	**1.22**		
Cricotopus sp.	11	3.35	7	CG
Eukiefferiella Pseudomontana Gr	5	1.52	8	OM
Microtendipes sp.	2	0.61	6	CG
Orthocladius sp.	91	27.74	6	CG
Tvetenia sp.	1	0.30	5	CG
Total Chironomidae	**110**	**33.54**		
Grand Total	**328**	**100.00**		

Aquatic Macroinvertebrate Summary Data
9/19/00

Site Name: Shields River **Site ID: McCloud station**

TOTAL ABUNDANCE	322
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	264
TOTAL NUMBER OF TAXA	37
Number EPT taxa	24

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	2	2	0.62
Odonata	0	0	0.00
Ephemeroptera	8	80	24.84
Plecoptera	8	49	15.22
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	8	135	41.93
Lepidoptera	0	0	0.00
Coleoptera	3	10	3.11
Diptera	3	6	1 86
Chrionomidae	5	40	12.42

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	6.60

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	10	52	16.15
Parasite	0	0	0.00
Collector-gatherer	15	63	19.57
Collector-filterer	2	29	9.01
Macrophyte-herbivore	1	5	1.55
Piercer-herbivore	1	9	2.80
Scraper	4	103	31.99
Shredder	3	51	15.84
Xylophage	0	0	0.00
Omnivore	1	10	3.11
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	3.55
Scraper/(Scraper + C.filterer)	0.78
Shredder/Total organisms	0.05

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Glossosoma sp.	41	12.73
Cinygmula sp.	38	11.80
Lepidostoma sp.-sand case larv.	28	8 70
Hydropsyche sp.	27	8.39
Orthocladius sp.	23	7.14
SUBTOTAL 5 DOMINANTS	157	48.76
Zapada cinctipes	22	6.83
Rhithrogena sp.	16	4.97
Hesperoperla pacifica	14	4.35
Arctopsyche grandis	12	3.73
Brachycentrus americanus	10	3.11
TOTAL DOMINANTS	231	71.74

SAPROBIC INDICES

Hilsenhoff Biotic Index	2.36

DIVERSITY MEASURES

Shannon H (loge)	2.68
Shannon H (log2)	3.87
Evenness	0.74
Simpson D	0.06

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	40	12.42
Univoltine	224	69.57
Semivoltine	58	18.01

	#TAXA	ABUNDANCE	PERCENT
Tolerant	2	10	3.11
Intolerant	6	24	7.45
Clinger	18	198	61.49

Aquatic Macroinvertebrate Taxonomic Data

9/19/00

Site Name: Shields River

Site ID: McCloud station

Approx. percent of sample used: 17

Taxon	Quantity	Percent	HBI	FFG
Polycelis coronata	1	0.31	4	CG
Nais variabilis	1	0.31	8	CG
Total Misc. Taxa	**2**	**0.62**		
Baetis tricaudatus	2	0.62	6	CG
Diphetor hageni	1	0.31	5	CG
Caudatella heterocaudata	4	1.24	1	CG
Drunella doddsi	6	1.86	0	CG
Drunella grandis	4	1.24	2	CG
Ephemerella sp.	9	2.80	1	CG
Cinygmula sp.	38	11.80	4	SC
Rhithrogena sp.	16	4.97	0	SC
Total Ephemeroptera	**80**	**24.84**		
Sweltsa sp.	2	0.62	1	PR
Zapada cinctipes	22	6.83	2	SH
Zapada columbiana	1	0.31	2	SH
Claassenia sabulosa	2	0.62	3	PR
Doroneuria sp.	4	1.24	1	PR
Hesperoperla pacifica	14	4.35	2	PR
Perlodidae-early instar	2	0.62	2	PR
Skwala sp.	2	0.62	2	PR
Total Plecoptera	**49**	**15.22**		
Arctopsyche grandis	12	3.73	1	PR
Brachycentrus americanus	10	3.11	1	OM
Micrasema sp.	5	1.55	1	MH
Glossosoma sp.	41	12.73	1	SC
Hydropsyche sp.	27	8.39	4	CF
Lepidostoma sp.-sand case larvae	28	8.70	1	SH
Rhyacophila-early instar	1	0.31	0	PR
Rhyacophila Brunnea Gr	6	1.86	1	PR
Rhyacophila Coloradensis Gr.	5	1.55	2	PR
Total Trichoptera	**135**	**41.93**		
Heterlimnius sp.	1	0.31	4	CG
Narpus sp.	1	0.31	4	CG
Optioservus sp.	8	2.48	4	SC
Total Coleoptera	**10**	**3.11**		
Simulium sp.	2	0.62	6	CF
Antocha sp.	2	0.62	3	CG
Hexatoma sp	2	0.62	2	PR
Total Diptera	**6**	**1.86**		
Cricotopus nostococladius	9	2.80	3	PH
Micropsectra sp	1	0.31	7	CG
Orthocladius sp.	23	7.14	6	CG
Pagastia sp.	6	1.86	1	CG
Tvetenia sp.	1	0.31	5	CG
Total Chironomidae	**40**	**12.42**		
Grand Total	**322**	**100.00**		

Aquatic Macroinvertebrate Summary Data
9/19/00

Site Name: Shields River **Site ID: Johnstone station**

TOTAL ABUNDANCE	328
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	132
TOTAL NUMBER OF TAXA	20
Number EPT taxa	8

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	2	35	10.67
Odonata	0	0	0.00
Ephemeroptera	3	3	0.91
Plecoptera	1	1	0.30
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	4	128	39.02
Lepidoptera	0	0	0.00
Coleoptera	3	47	14.33
Diptera	2	4	1.22
Chrionomidae	5	110	33.54

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	1.20

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	2	4	1.22
Parasite	1	3	0.91
Collector-gatherer	10	163	49.70
Collector-filterer	1	95	28.96
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	3	39	11.89
Shredder	1	18	5.49
Xylophage	0	0	0.00
Omnivore	2	6	1.83
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	0.41
Scraper/(Scraper + C.filterer)	0.29
Shredder/Total organisms	0.02

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Hydropsyche sp.	95	28.96
Orthocladius sp.	91	27.74
Optioservus sp.	37	11.28
Physidae	32	9.76
Lepidostoma sp.-sand case larv.	18	5.49
SUBTOTAL 5 DOMINANTS	273	83.23
Amiocentrus aspilus	14	4.27
Cricotopus sp.	11	3.35
Zaitzevia sp.	9	2.74
Eukiefferiella Pseudomontana (	5	1.52
Acari	3	0.91
TOTAL DOMINANTS	315	96.03

SAPROBIC INDICES

Hilsenhoff Biotic Index	4.89

DIVERSITY MEASURES

Shannon H (loge)	1.66
Shannon H (log2)	2.39
Evenness	0.55
Simpson D	0.16

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	109	33.31
Univoltine	171	52.06
Semivoltine	48	14.63

	#TAXA	ABUNDANCE	PERCENT
Tolerant	6	85	25.91
Intolerant	0	0	0.00
Clinger	10	171	52.13