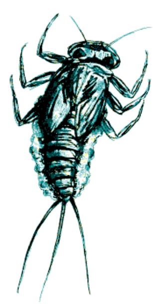
# BIOLOGICAL ASSESSMENT OF SITES ON THE GALLATIN RIVER, GALLATIN COUNTY, MONTANA:

# MACROINVERTEBRATE ASSEMBLAGES

**A REPORT TO**
**THE BLUE WATER TASK FORCE**

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## INTRODUCTION

With increased development in the watershed, the integrity of the Gallatin River and its tributaries may be threatened by impacts to channel structure and riparian zones as well as by degradation of water quality. Monitoring and assessment of biological assemblages can help to detect whether impacts and degradation are in fact occurring. For the past several years, the Blue Water Task Force (BWTF) has sampled benthic macroinvertebrates for monitoring and assessment of the waters of the Gallatin River drainage. The taxonomic and functional composition of benthic macroinvertebrate assemblages are known to respond to the effects of stressors that may be associated with accelerating human influences. Such stressors may include pollutants, sediment, thermal impacts and hydrologic alterations, and changes to the natural morphology of river channels and riparian zones.

In late July 2014, 4 sites on the Gallatin River were sampled for benthic macroinvertebrates: 2 replicates were collected at each site.

This report begins by describing the methods for processing and identifying these 4 samples. Data resulting from that work were translated into a multimetric index, and scores were calculated. Scores were used to assign impairment classes to the sites. Narrative interpretations of the ecological condition of the macroinvertebrate assemblages are also reported. These narratives use the taxonomic and functional composition, tolerance and sensitivity characteristics, and habits of the benthic invertebrates to describe probable water quality and habitat influences on the assemblages. Narrative interpretations follow; these maximize the information available in the data: they do not rely solely on a single cumulative index score which may mask the effects of stressors on the biota. For the narrative interpretations, data from replicate samples is combined into a composite result.

## METHODS

### *Sample processing*

Eight macroinvertebrate samples, collected at 4 sites on the Gallatin River in July 2014, were delivered to Rhithron's laboratory facility in Missoula, Montana. Each site was represented by 2 replicate samples. All samples arrived in good condition. Table 1 gives site names, identifiers, and other metadata for the samples.

Subsamples of a minimum of 300 organisms were obtained using methods consistent with Montana Department of Environmental Quality (MDEQ) standard procedures (MDEQ 2006): Caton sub-sampling devices (Caton 1991), divided into 30 grids, each approximately 6 cm by 6 cm were used. Each individual sample was thoroughly mixed in its jar(s), poured out and evenly spread into the Caton tray, and individual grids were randomly selected. Grid contents were examined under stereoscopic microscopes using 10x – 30x magnification. All aquatic invertebrates from each selected grid were sorted from the substrate, and placed in 70% ethanol for subsequent identification. Grid selection, examination, and sorting continued until at

**Table 1.** Sites on the Gallatin River, and sample information.

| Site identifier | Site name | Date sampled | Latitude (°North) | Longitude |
|---|---|---|---|---|
| **Moose Creek** | **Moose Creek** | 7/29/2014 | 45.3566 | -111.172 |
| **Deer Creek Access** | **Deer Creek** | 7/29/2014 | 45.2987 | -111.203 |
| **Doe Creek** | **Buck** | 7/29/2014 | 45.2131 | -111.2469 |
| **Taylor Creek** | **Taylor** | 7/29/2014 | 45.0906 | -111.2126 |

least 300 organisms were sorted. The final grid was completely sorted of all organisms. If a sample contained fewer than 300 organisms, it was entirely sorted.

Organisms were individually examined using 10x – 80x dissecting scopes (Leica S8E) and identified to the lowest practical level consistent with MDEQ (MDEQ 2006) data requirements, using appropriate taxonomic references and keys.

Identification, counts, life stages, and information about the condition of specimens were recorded electronically. To obtain accuracy in richness measures, organisms that could not be identified to the target level specified in MDEQ protocols were designated as "not unique" if other specimens from the same group could be taken to target levels. Organisms designated as "unique" were those that could be definitively distinguished from other organisms in the sample. Identified organisms were preserved in 70% ethanol in labeled vials, and archived at the Rhithron laboratory. Midges were morphotyped using 10x – 80x dissecting microscopes (Leica S8E) and representative specimens were slide mounted and examined at 200x – 1000x magnification using an Olympus BX 51 compound microscope. Slide mounted organisms were archived at the Rhithron laboratory along with the other identified invertebrates.

***Quality control procedures***

Quality control (QC) procedures for initial sample processing and subsampling involved checking sorting efficiency. These checks were conducted on 100% of the samples by independent observers who microscopically re-examined 25% of sorted substrate from each sample. All organisms that were missed were counted and this number was added to the total number obtained in the original sort. Sorting efficiency was evaluated by applying the following calculation:

$$SE = \frac{n_1}{n_{1+2}} \times 100$$

where: SE is the sorting efficiency, expressed as a percentage, $n_1$ is the total number of specimens in the first sort, $n_2$ is the total number of specimens expected in the second sort, based on the results of the re-sorted 25%.

Quality assurance procedures for taxonomic determinations of invertebrates involved checking accuracy, precision and enumeration. One sample (12.5% of samples) was randomly selected and all organisms re-identified and counted by an independent taxonomist. Taxa lists and enumerations were compared by calculating the Percent Taxonomic Disagreement (PTD), the Percent Difference in Enumeration (PDE) (Stribling et al. 2003), and a Bray-Curtis similarity statistic (Bray and Curtis 1957) for the selected sample. Rhithron's internal minimum data quality standards require less than 10% PTD, less than 5% PDE, and 95% similarity as measured by the Bray-Curtis statistic. Results for quality control parameters are reported in Table 2.

***Data analysis***

Taxa and counts for each sample were entered into Rhithron's database application (RAILIS v.2.1). Life stages, "unique" designations, and the condition of specimens were also entered. Bioassessment metrics were calculated by the database application and a multimetric index developed for montane ecoregions of Montana (MVFP: Bollman 1998) was calculated and scored.

Narrative interpretations of the taxonomic and functional composition of the aquatic invertebrate assemblages are based on demonstrated associations between assemblage components and habitat and water quality variables gleaned from the published literature, the writer's own research (especially Bollman 1998) and professional judgment, and those of other expert sources (especially Wisseman 1996). These interpretations are not intended to replace canonical procedures for stressor identification, since such procedures require substantial surveys of habitat, and historical and current data related to water quality, land use, point and non-point source influences, soils, hydrology, geology, and other resources that were not readily available for this study. Instead, attributes of invertebrate taxa that are well-substantiated in diverse literature, published and unpublished research, and that are generally accepted by regional aquatic ecologists, are combined into descriptions of probable water quality and instream and reach-scale habitat conditions.

The approach to this analysis uses some assemblage attributes that are interpreted as evidence of water quality and other attributes that are interpreted as evidence of habitat integrity. Attributes are considered individually, so information is maximized by not relying on a single cumulative score, which may mask stress on the biota.

Water quality variables are estimated by examining mayfly taxa richness and the Hilsenhoff Biotic Index (HBI) value. Other indicators of water quality include the richness and abundance of hemoglobin-bearing taxa and the richness of sensitive taxa. Mayfly taxa richness has been demonstrated to be significantly correlated with chemical measures of dissolved oxygen, pH, and conductivity (e.g. Bollman 1998, Fore et al. 1996, Wisseman 1996). The Hilsenhoff Biotic Index (HBI) (Hilsenhoff 1987) has a long history of use and validation (Cairns and Pratt 1993). In Montana foothills, the HBI was demonstrated to be significantly associated with conductivity, pH, water temperature, sediment deposition, and the presence of filamentous algae (Bollman 1998). The presence of filamentous algae is also suspected when macroinvertebrates associated or dependent on it (e.g. LeSage and Harrison 1980, Anderson 1976) are abundant. Nutrient enrichment in Montana streams often results in large crops of filamentous algae (Watson 1988). Sensitive taxa exhibit intolerance to a wide range of stressors (e.g. Wisseman 1996, Hellawell 1986, Friedrich 1990, Barbour et al. 1999), including nutrient enrichment, acidification, thermal stress, sediment deposition, habitat disruption, and others. These taxa are expected to be present in predictable numbers in functioning montane and foothills streams (e.g. Bollman 1998).

Thermal characteristics of the sampled site are predicted by the richness and abundance of cold stenotherm taxa (Clark 1997), and by calculation of the temperature preference of the macroinvertebrate assemblage (Brandt 2001). Hemoglobin-bearing taxa are also indicators of warm water temperatures (Walshe 1947), since dissolved oxygen is directly associated with water temperature; oxygen concentrations can also vary with the degree of nutrient enrichment. Increased temperatures and high nutrient concentrations can, alone or in concert, create conditions favorable to hypoxic sediments, habitats preferred by hemoglobin-bearers.

The condition of instream and streamside habitats is estimated by 3 characteristics of the macroinvertebrate assemblages. Stress from sediment is evaluated by caddisfly richness and by "clinger" richness (Kleindl 1996, Bollman 1998, Karr and Chu 1999).

The functional characteristics of macroinvertebrate assemblages are based on the morphology and behaviors associated with feeding, and are interpreted in terms of the River Continuum Concept (Vannote et al. 1980) in the narratives. Alterations from predicted patterns in montane and foothills streams may be interpreted as evidence of water quality or habitat disruption. For example, shredders and the microbes they depend on are sensitive to modifications of the riparian zone (Plafkin et al. 1989).

## RESULTS

### *Quality Control Procedures*

Results of quality control procedures for subsampling and taxonomy are given in Table 2. Sorting efficiency averaged 95.24% for all samples, and all 3 quality control parameters for taxonomy and enumeration fell well within internal and industry quality standards.

### *Bioassessment*

Table 3 summarizes values and scores for metrics in the MVFP bioassessment index (Bollman 1998), which was used to evaluate the aquatic invertebrate assemblages. Results for each sample replicate are reported, and impairment classifications are assigned. Bioassessment scores for each replicate sample are graphed in Figure 1 as percent of maximum possible score.

**Table 2.** Results of quality control procedures for subsampling and taxonomy. Gallatin River, July 2014.

| RAI sample identifier (replicates) | Site name | Sorting efficiency | PDE | PTD | Bray-Curtis similarity for taxonomy and enumeration |
|---|---|---|---|---|---|
| BWTF13GR2005 | Moose Creek | 99.39% | | | |
| BWTF13GR2006 | Moose Creek | 100.00% | | | |
| BWTF13GR2007 | Deer Creek | 97.52% | | | |
| BWTF13GR2008 | Deer Creek | 81.75% | | | |
| BWTF13GR2003 | Buck | 95.11% | 0.00% | 4.84% | 95.16% |
| BWTF13GR2004 | Buck | 96.36% | | | |
| BWTF13GR2001 | Taylor | 95.71% | | | |
| BWTF13GR2002 | Taylor | 96.08% | | | |

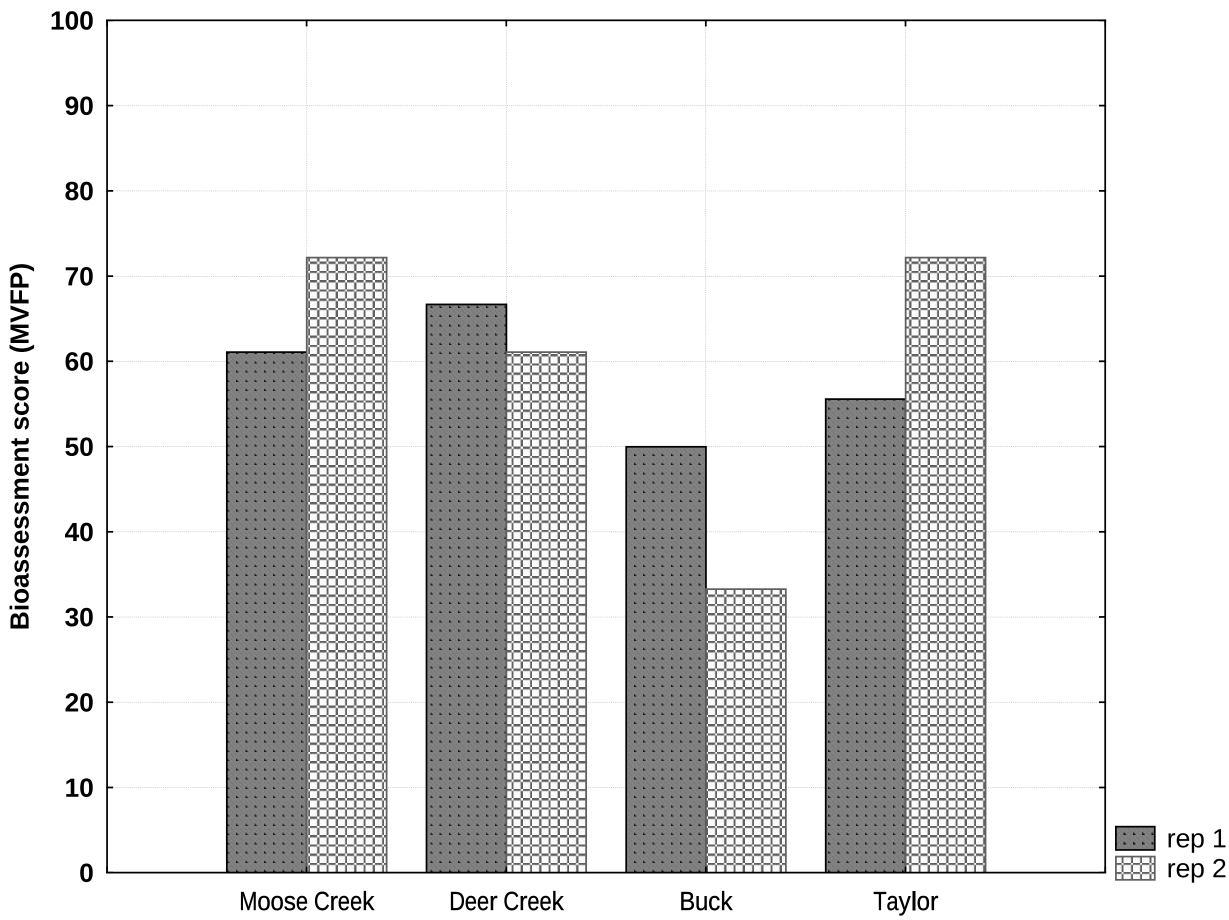


**Figure 1.** Bioassessment scores (MVFP: Bollman 1998) for replicate samples collected at sites on the Gallatin River, July 2014. Scores are given as percent of maximum score.

**Table 3.** Bioassessment index (MVFP: Bollman 1998) and individual metrics and scores for samples collected at sites on the Gallatin River, July 2014.

| | **Moose Creek** | | **Deer Creek** | | **Buck** | | **Taylor** | |
|---|---|---|---|---|---|---|---|---|
| **METRICS** | Rep. 1 | Rep. 2 | Rep. 1 | Rep. 2 | Rep. 1 | Rep. 2 | Rep. 1 | Rep. 2 |
| **Ephemeroptera richness** | 6 | 9 | 10 | 9 | 4 | 3 | 11 | 9 |
| **Plecoptera richness** | 1 | 2 | 3 | 3 | 1 | 1 | 3 | 5 |
| **Trichoptera richness** | 8 | 8 | 6 | 7 | 5 | 2 | 2 | 2 |
| **Number of sensitive taxa** | 3 | 3 | 3 | 1 | 1 | 0 | 3 | 5 |
| **Percent filterers** | 19.5 | 18.2 | 26.8 | 30.3 | 36.0 | 71.0 | 18.2 | 8.4 |
| **Percent tolerant taxa** | 11.9 | 7.3 | 5.4 | 6.5 | 7.1 | 2.7 | 22.3 | 33.6 |
| | | | | | | | | |
| **Ephemeroptera richness** | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 3 |
| **Plecoptera richness** | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 3 |
| **Trichoptera richness** | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 |
| **Number of sensitive taxa** | 2 | 2 | 2 | 1 | 1 | 0 | 2 | 3 |
| **Percent filterers** | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 2 |
| **Percent tolerant taxa** | 1 | 2 | 2 | 2 | 2 | 3 | 1 | 1 |
| **TOTAL SCORE (max.=18)** | 11 | 13 | 12 | 11 | 9 | 6 | 10 | 13 |
| **PERCENT OF MAX.** | 61.11 | 72.22 | 66.67 | 61.11 | 50.00 | 33.33 | 55.56 | 72.22 |
| **Impairment classification*** | **SLI** | **SLI** | **SLI** | **SLI** | **MOD** | **MOD** | **SLI** | **SLI** |

* Impairment classifications: (NON) non-impaired (score ≥75% of maximum), (SLI) slightly impaired (score 50-75% of maximum), (MOD) moderately impaired (score 25-50% of maximum), (SEV) severely impaired (score <25% of maximum).

***Aquatic invertebrate assemblages***

***Moose Creek***

Ten mayfly taxa were collected in replicate samples taken at this site. Although the biotic index value (4.19) was somewhat elevated compared to expectations for a montane stream, it seems likely that water quality was unimpaired here. The midge *Cricotopus (Nostococladius)* sp. was abundant, accounting for 13% of sampled organisms, and the tolerance value assigned to it (6) probably underestimates its sensitivity to pollution. Larvae of this midge live within colonies of the blue-green alga *Nostoc* sp., in a mutualistic relationship. *Nostoc* sp. prefers cool, clean water, thus, it is reasonable to conclude that *C. (Nostococladius)* sp. is a relatively sensitive organism. The site supported at least 5 sensitive taxa, including the mayflies *Caudatella heterocaudata* and *Epeorus deceptivus*. The calculated thermal preference of the assemblage was 14.9°C.

Eight caddisfly taxa and 19 “clinger” taxa were counted, suggesting that colonization of rocky substrate habitats was not inhibited by sediment deposition. Overall taxa richness (47) was typical of a minimally-impaired stream in the Middle Rockies ecoregion. Instream habitats were probably diverse and intact. The collection included only 2 stonefly taxa: low richness in this group may be related to altered channel morphology, disrupted riparian function, or unstable streambanks. Less motile semivoltine taxa were well-represented, indicating year-round surface flow and the absence of catastrophes such as thermal stress or scouring sediment pulses. All expected functional groups were represented in proportions that seem appropriate for a montane stream.

***Deer Creek***

High mayfly taxa richness (12) and low biotic index value (2.90) suggest that water quality was excellent in this reach. The sampled site supported at least 4 sensitive taxa, including the mayflies *Drunella doddsii* and *Epeorus deceptivus*. The thermal preference of the assemblage was 14.4°C.

Both caddisflies (8 taxa) and “clingers” (26 taxa) were well-represented, strongly suggesting that sediment deposition did not interfere with colonization of stony substrate habitats. Overall taxa richness (55) was high. It seems likely that instream habitats were diverse and intact. At least 10 less motile semivoltine taxa were supported at this site, indicating that dewatering, toxic pollutants, and scouring sediment pulses were not influential. The functional composition of the assemblage included all expected groups, in appropriate proportions.

***Buck***

Samples collected at this site were overwhelmed by the midge *Tanytarsus* sp., which accounted for 45% of collected specimens. Mayfly taxa richness (5) was somewhat lower than expected, and abundance of the group was also limited. The biotic index value (5.47) was high. These findings suggest impaired water quality. No sensitive or cold stenotherm taxa were counted. The thermal preference of the assemblage was estimated at 14.8°C.

There were fewer caddisfly taxa (5) than expected in replicate samples, and "clinger" richness (14) was also somewhat blunted. Sediment deposition may have had some influence on the composition of this assemblage. Overall taxa richness (39) was relatively low, suggesting moderately limited instream habitat diversity, or some habitat disruption. A single stonefly taxon (*Pteronarcys* sp.) was collected: low richness in this group may be related to disrupted riparian vegetation, altered channel morphology, or unstable streambanks. There were 3 less-motile semivoltine taxa in the samples: it seems unlikely that catastrophic dewatering, thermal stress, or scouring sediment pulses were influential. Filterers, especially *Tanytarsus* sp. dominated the functional composition of the assemblage, and gatherers were also abundant. This pattern is sometimes interpreted as evidence of water quality impairment. All other expected feeding groups were present.

***<u>Taylor</u>***

This site supported at least 12 mayfly taxa, and the biotic index value (3.30) was within expectations for a montane stream. These findings suggest that water quality was excellent here. Five sensitive taxa, including the mayflies *Drunella doddsii* and *Caudatella heterocaudata* were counted in replicate samples. The presence of the mountain midge *Deuterophlebia* sp. suggests cold, clean, swiftly flowing water. Four cold stenotherm taxa accounted for 6.4% of the sampled assemblage. The flatworm *Polycelis coronata* was common, suggesting that groundwater inputs augmented surface flow in the reach. The temperature preference of the invertebrate assemblage was calculated at 13.8°C.

Twenty-four "clinger" taxa were collected, but caddisfly richness (4) was lower than expected, and the group was relatively uncommon in the samples. Nonetheless, it seems unlikely that sediment deposition limited colonization of stony substrates. Overall taxa richness (48) was high: instream habitats were probably diverse and intact. Five stonefly taxa, including the salmonflies *Pteronarcys californica* and *Pteronarcella* sp., were counted. High diversity in this group may be related to intact riparian function, natural channel morphology, and stable streambanks. Semivoltine taxa were well-represented (9 taxa), indicating year-round surface flow and stable instream conditions. All expected functional groups were present, but shredders were somewhat less abundant than expected for a montane stream. Rapid flow conditions may have limited retention of leafy and woody debris.

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**APPENDIX**

**Taxa lists and metric summaries: sample composites**

**Blue Water Task Force**
**Gallatin River**

**July 2014**