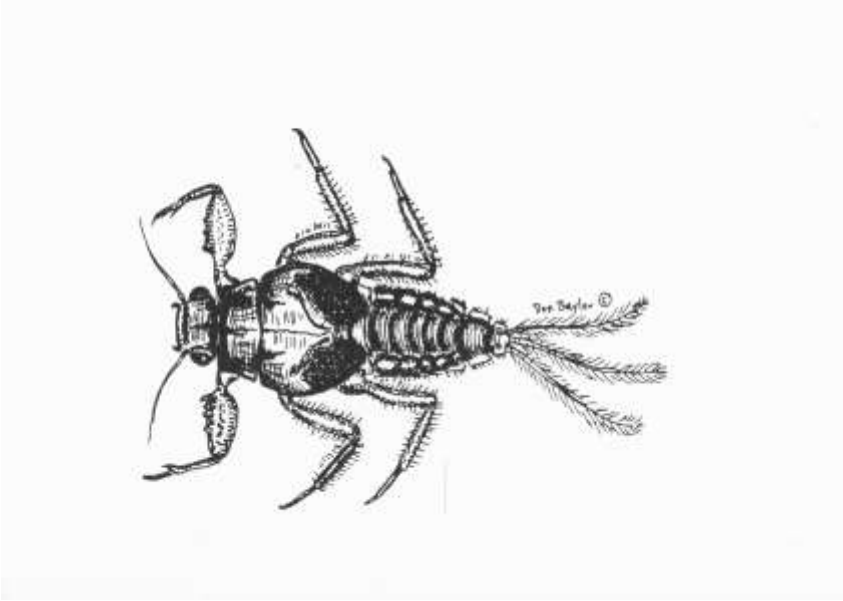
# BENTHIC MACROINVERTEBRATES OF MILL AND RATTLESNAKE CREEKS

FOR

THE BRODHEAD WATERSHED ASOCIATION

April 18, 2019

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# BENTHIC MACROINVERTEBRATES OF MILL CREEK, APRIL 18, 2019

## EXECUTIVE SUMMARY

On April 18, 2019, three stations on Mill Creek had excellent Index of Biotic Integrity scores. Scores were 89.5, 98.2, and 90.7 for the upper, middle, and lower stations, respectively. The scores average 92.8 which is within the range qualifying macroinvertebrate populations for Exceptional Value status.

## BACKGROUND

On April 18, 2019, at the request of the Brodhead Watershed Association, Aquatic Resource Consulting (ARC) biologists Don Baylor and Chris Hartzler sampled benthic macroinvertebrates at three stations on Mill Creek. The purpose of this study was to evaluate the water quality of Mill Creek to ascertain whether the benthic macroinvertebrate population would meet PA Department of Environmental Protection (DEP) qualifications for Exceptional Value classification. Aquatic macroinvertebrates are preferred indicators of stream water quality because of their limited mobility, one to three year life cycles, and specific sensitivities to pollutants. Clean streams usually support numerous species of invertebrates, theoretically evenly represented numerically. Impairment may be indicated by low taxa richness, shifts in community balance toward dominance of pollution-tolerant forms, or overall scarcity of invertebrates (Plafkin, et al. 1989). In order to assure an accurate assessment, recent work in bio-monitoring stresses the use of several parameters, or metrics, to measure different components of the community structure.

Macroinvertebrate sampling methods followed those recommended by the US Environmental Protection Agency Protocol III (Plafkin, et al., 1989) with the latest modifications adopted by the PA Department of Environmental Protection for riffle/run freestone streams (PA DEP, 2009). At each station, six samples were taken with a D-frame kick net (Wildlife Supply Company #425-D5) of 500u nitex from the best riffle/run areas in a one hundred meter stretch. Samples were taken by placing the net against the substrate and disturbing approximately one square meter above the net by foot for one minute. Organisms and debris were composited for each station in a plastic container and preserved in alcohol for transport to the laboratory. Habitat was evaluated at each station using DEP's Water Quality Network Habitat Assessment forms for streams with riffle/run prevalence. Twelve habitat parameters were ranked on a scale of 1-20 and combined for a total habitat score.

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In the laboratory, samples were rinsed in a USGS No. 35 sieve and placed in a white pan marked with a grid to delineate 28 squares measuring two inches on a side. Organisms were then picked from randomly selected grids until 200 organisms +/- 20% were obtained. Organisms were identified to the lowest taxonomic level practicable, enumerated, and assigned a pollution tolerance value (PA DEP, 2009). Metrics for riffle/run freestone streams were calculated for each subsample, including Total Taxa Richness, Ephemeroptera + Plecoptera + Trichoptera Taxa Richness (EPT), Modified Beck's Index, , Hilsenhoff Biotic Index, Shannon Diversity Index, , and Percent Sensitive Individuals. A description and brief rationale for each of the metrics follow:

1. **Total Taxa Richness** – is an index of diversity. The number of taxa (kinds) of invertebrates indicates the health of the benthic community through measurement of the variety of species present. Generally, number of species increases with increased water quality. However, variability in natural habitat (stream order and size, substrate composition, current velocity) also affects this number.

2. **Ephemeroptera, Plecoptera, and Trichoptera Taxa Richness (PTV 1-4)** Mayflies, stoneflies, and caddisflies, collectively referred to as EPT, are generally considered pollution sensitive (Plafkin et al. 1989). Thus, the total number of taxa within the EPT insect groups is used to evaluate community balance. This metric has been modified to include only the EPT taxa with pollution tolerance values of 1-4. Healthy biotic conditions are reflected when these taxa are well represented in the benthic community.

3. **Modified Beck's Index** is a weighted count of taxa with pollution tolerance values of 0, 1, or 2. This metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of pollution sensitive taxa. It is calculated by multiplying by 3 the number of taxa with a pollution tolerance value of 0, multiplying by 2 the number of taxa with a pollution tolerance value of 1, and multiplying by 1 the number of taxa with a pollution tolerance value of 2. The three values are added to yield the Modified Beck's Index score.

4. **Hilsenhoff Biotic Index** – is a direct measure of organic pollution in streams. The biotic index value is the mean tolerance value of all organisms in a sample. Tolerance values range from 0.00 to 10.00; the higher the value, the greater the level of pollution indicated.

**Table 1.**
**Evaluation of water quality using biotic index values (Hilsenhoff, 1987)**

| BIOTIC INDEX | WATER QUALITY | DEGREE OF ORGANIC POLLUTION |
|---|---|---|
| 0.00-3.50 | Excellent | None Apparent |
| 3.51-4.50 | Very Good | Possible Slight |
| 4.51-5.50 | Good | Some |
| 5.51-6.50 | Fair | Fairly Significant |
| 6.51-7.50 | Fairly Poor | Significant |
| 7.51-8.50 | Poor | Very Significant |
| 8.51-10.00 | Very Poor | Severe |

5. **Shannon Diversity Index** measures taxonomic richness and evenness of numbers of individuals across the taxa of a subsample. This metric is expected to decrease in values with increased anthropogenic stress to a stream ecosystem, reflecting loss of pollution-sensitive taxa and predominance of a few pollution-tolerant taxa.

6. **Percent Sensitive Individuals** is the percentage of individuals in the subsample with pollution tolerance values of 0-3. It is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem.

## INDEX CALCULATION

An overall index is used to integrate information from these various metrics and standardize them into one score for a subsample. The values for any standardized core metric are set to a maximum value of 1.00, with values closer to zero corresponding to increasing deviation from the expected reference condition and progressively higher values corresponding more closely to the biological reference condition. The adjusted standardized metric values for the six core metrics are averaged and multiplied by 100 to produce an index score ranging from 0-100. This number represents the index of biotic integrity (IBI) score for a sample. The following table shows metric standardization equations and index calculations for the sub-sample from Station 1 on Mill Creek.

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**Table 2.**
**Metric standardization and Index of Biotic Integrity calculations for the benthic macroinvertebrate sample from Station 1 on Mill Creek, April 18, 2019.**

| Metric | Standardization Equation | Observed Metric Value | Standardized Metric Score | Adjusted Standardized Metric Score Maximum =1.00 |
|---|---|---|---|---|
| Total Taxa Richness | Observed value / 33 | 24 | 0.727 | 0.727 |
| EPT Taxa Richness | Observed Value/ 19 | 16 | 0.842 | 0.842 |
| Modified Beck's Index | Observed value/38 | 36 | 0.947 | 0.947 |
| Hilsenhoff Biotic Index | 10-observed value/ (10-1.89) | 1.53 | 1.044 | 1.000 |
| Shannon Diversity Index | Observed value / 2.86 | 2.44 | 0.853 | 0.853 |
| Percent Sensitive Individuals | Observed value / 84.5 | 87.9 | 1.032 | 1.000 |
| Average of adjusted standardized core metric scores x 100 = IBI score | | | | **89.5** |

**Sampling Stations**

Three stations were sampled for benthic macroinvertebrates on Mill Creek on April 18, 2019 (Figure 1). Locations were as follows:

Station 1. – Approximately 150 meters below the confluence of Mill Creek and Rattlesnake Creek and 2.3 miles upstream from the mouth of Mill Creek - near Krummel Lane at coordinates 41.171102/-75.273766 with a drainage area of 5.28 square miles.

Station 2. - On the property of Kendrick and Donna Bisset near Preacher Hill Road 1.92 miles upstream from the mouth at coordinates 41.164102/-75.269828 with a drainage area of 5.85 square miles.

Station 3 - On the property of Dave Price near Sand Spring Road 1 mile upstream from the mouth at coordinates 41.161836/-75.259101 with a drainage area of 6.70 square miles.


**Figure 1. Map of stations sampled for benthic macroinvertebrates on Mill Creek on April 18, 2019.**

## RESULTS AND DISCUSSION

### Benthic Macroinvertebrate Communities

Table 3 shows the taxa, numbers, and biotic index pollution tolerance value (PT) for benthic macroinvertebrate samples from Mill Creek on April 18, 2019. Table 4 shows metric values and IBI scores for those samples according to DEP's 2012 protocols. Extensive analysis by DEP of samples from unimpaired Special Protection Pennsylvania streams found a natural variability of up to 11 points among samples from similar habitat and that a difference of greater than 11 points in IBI scores is indicative of anthropogenic impairment between similar stations (DEP 2012). For samples collected from smaller streams between October and May, an IBI score $\geq$ 63 results in Aquatic Life Use (ALU)attainment, and an IBI score < 63 results in ALU impairment (PA DEP 2012). For these samples, October-May small stream benchmarks were applicable.

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**Table 3**
**Taxa, numbers, and biotic index pollution tolerance value (PT) for benthic macroinvertebrate samples from Mill Creek April 18, 2019.**

| TAXA | STATION 1 Upper- Krummel Lane | STATION 2 Middle - Bisset, Preacher Hill | STATION 3 Lower - David Price, Sand spring | PT |
|---|---|---|---|---|
| **Ephemeroptera (mayflies)** | | | | |
| *Epeorus spp.* | 24 | 21 | 23 | 0 |
| *Cinygmula spp.* | 22 | 9 | 1 | 1 |
| *Maccaffertium spp.* | - | 1 | 2 | 3 |
| *Ephemerella spp.* | 66 | 65 | 36 | 1 |
| *Eurylophella spp.* | 2 | 4 | - | 4 |
| *Paraleptophlebia spp.* | 12 | 6 | 2 | 1 |
| *Ameletus spp.* | - | - | 1 | 0 |
| *Baetis spp.* | 3 | 6 | 14 | 6 |
| *Diphetor spp.* | 2 | 5 | 4 | 6 |
| **Trichoptera (caddisflies)** | | | | |
| *Rhyacophila spp.* | 5 | 7 | 10 | 1 |
| *Dolophilodes spp.* | 4 | 2 | - | 0 |
| *Brachycentrus spp.* | - | 1 | - | 1 |
| *Micrasema spp.* | - | 1 | - | 2 |
| *Lepidostoma spp.* | - | 1 | - | 1 |
| *Psilotreta spp.* | - | - | 1 | 0 |
| *Neophylax. spp.* | 1 | 2 | 4 | 3 |
| *Apatania spp.* | - | 1 | - | 3 |
| *Pycnopsyche spp.* | - | - | 1 | 4 |
| *Diplectrona spp.* | 6 | 2 | 6 | 0 |
| *Ceratopsyche spp.* | - | 5 | 3 | 5 |
| *Cheumatopsyche spp.* | - | - | 6 | 6 |

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| Table 3. continued | | | | |
|---|---|---|---|---|
| **TAXA** | **STATION 1** | **STATION 2** | **STATION 3** | **PT** |
| **Plecoptera (stoneflies)** | | | | |
| *Pteronarcys spp.* | **3** | **6** | **7** | **0** |
| *Tallaperla spp.* | **1** | **8** | **-** | **0** |
| Leuctridae | **-** | **1** | **1** | **0** |
| *Paraleuctra spp.* | **2** | **-** | **-** | **0** |
| *Acroneuria spp.* | **-** | **-** | **3** | **0** |
| *Agnetina spp.* | **-** | **2** | **-** | **2** |
| *Paragnetina spp.* | **2** | **-** | **3** | **1** |
| *Isoperla spp.* | **5** | **4** | **3** | **2** |
| *Sweltsa spp.* | **4** | **6** | **-** | **0** |
| *Diura spp.* | **9** | **2** | **-** | **2** |
| *Beloneuria spp.* | **-** | **-** | **1** | **2** |
| Chloroperlidae | **-** | **-** | **5** | **0** |
| Alloperla spp. | **-** | **1** | **-** | **0** |
| **Diptera (true flies)** | | | | |
| Chironomidae | **6** | **15** | **45** | **6** |
| *Hexatoma spp.* | **2** | **1** | **13** | **2** |
| *Antocha spp.* | **3** | **3** | **2** | **3** |
| *Tipula spp.* | **-** | **4** | **-** | **4** |
| *Pseudolimnophila spp.* | **2** | **-** | **-** | **2** |
| *Blepharicera spp.* | **-** | **-** | **1** | **0** |
| *Simulium spp.* | **-** | **1** | **-** | **6** |
| *Prosimulium spp.* | **-** | **2** | **3** | **2** |
| **Odonata (Dragonflies)** | | | | |
| *Gomphus spp.* | **5** | **2** | **1** | **5** |
| **Oligochaeta (worms)** | **-** | **3** | **-** | **10** |
| **Megaloptera (helgrammites)** | | | | |
| *Nigronis app.* | **2** | **-** | **2** | **2** |
| **Coleoptera ( beetles)** | | | | |
| *Promoresia spp.* | **-** | **3** | **1** | **2** |
| Elmidae | **-** | **2** | **-** | **5** |
| *Ectopria spp.* | **-** | **1** | **-** | **5** |

## BENTHIC MACROINVERTEBRATES OF MILL CREEK, APRIL 18, 2019

### Benthic Macroinvertebrate Communities

All three stations on Mill Creek had excellent IBI scores (Table 4). Relative abundance of organisms was also excellent with subsampling requiring 6-8 grids to obtain approximately 200 organisms (Table 3). Station 2 scored a near-optimal 98.2. Metric values for Station 2 were optimal for Total Taxa Richness, EPT Taxa Richness, and Beck's Index and were near optimal for Diversity, Hilsenhoff Biotic Index, and Percent Sensitive Individuals. The benthic community at Station 2 was dominated by intolerant mayfly taxa, including *Epeorus* (PT=0) and *Ephemerella* (PT=1) but also had excellent balance reflected in the excellent score for Shannon diversity.

Stations 1 and 3 scored slightly lower than Station 2 but had scores approximating 90 indicating exceptional water quality (Table 4). Station 1 was dominated by intolerant taxa and organisms resulting in optimal metric scores for Hilsenhoff Biotic Index and Percent Sensitive Individuals and near-optimal for Beck's Index. These measures of pollution sensitivity reflect a community free of organic enrichment. The slightly lower overall IBI score at Station 1 was a result of lower Total Taxa Richness. Since the other metrics are superior, the lower number of taxa may be a result of field sampling and laboratory subsampling variability or the greater riparian disruption at the upstream site.

Station 3 had species composition similar to the other stations with abundant intolerant taxa but also had considerably more moderately tolerant Chironomidae midge larvae (Table 3). As a result, the one metric that was less than optimal at Station 3 was Percent Sensitive Individuals (Table 4). Beck's Index, Shannon Diversity, and EPT Taxa Richness were at or near optimum for Station 3.

All stations sampled for benthic macroinvertebrates on Mill Creek had a predominance of intolerant taxa and organisms resulting in excellent IBI scores reflective of exceptional water quality. Mayflies predominated in numbers of taxa and individuals and most were in the intolerant range (PT 0-3) (Table 3).

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**Table 4.**
**Metric scores, adjusted standardized metric scores, and Index of Biotic Integrity (IBI) scores for benthic macroinvertebrate samples from Mill Creek, April 18, 2019.**

| | Station 1 | | | Station 2 | | | Station 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| **METRIC** | **Metric Value** | **Standardized Metric value** | **Adjusted Standardized Metric Score** Maximum =1.00 | **Metric Value** | **Standardized Metric value** | **Adjusted Standardized Metric Score** Maximum =1.00 | **Metric Value** | **Standardized Metric value** | **Adjusted Standardized Metric Score** Maximum =1.00 |
| **Number of Organisms** | 203 | | | 200 | | | 205 | | |
| **Number of Grids Picked /Subsample** | 6 | | | 8 | | | 7 | | |
| **Total Taxa Richness** | 24 | 0.727 | 0.727 | 36 | 1.091 | 1.00 | 30 | 0.909 | 0.909 |
| **EPT Taxa Richness (PT 0-4)** | 16 | 0.842 | 0.842 | 22 | 1.158 | 1.00 | 18 | 0.947 | 0.947 |
| **Beck's Index** | 36 | 0.947 | 0.947 | 43 | 1.132 | 1.00 | 42 | 1.105 | 1.00 |
| **Shannon Diversity** | 2.44 | 0.853 | 0.853 | 2.75 | 0.962 | 0.962 | 2.68 | 0.937 | 0.937 |
| **Hilsenhoff Biotic Index** | 1.53 | 1.044 | 1.00 | 1.94 | 0.994 | 0.994 | 2.74 | 0.895 | 0.895 |
| **Percent Sensitive Individuals** | 87.19 | 1.032 | 1.00 | 79.00 | 0.935 | 0.935 | 63.90 | 0.756 | 0.756 |
| **Index of Biotic Integrity (IBI) Score** | | | **89.5** | | | **98.2** | | | **90.7** |

**Field Water Chemistry**

Field water chemistry measurements were taken with a YSI Professional 2030 meter and Hach kit for pH and alkalinity. Results were as expected in a relatively infertile small freestone stream. Values for specific conductance and total dissolved solids were low and increased in a downstream direction (Table 5).

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**Table 5.**
**Field water chemistry of stations sampled for benthic macroinvertebrates on Mill Creek on April 18, 2019**

| METRIC | STATION 1 | STATION 2 | STATION 3 |
|---|---|---|---|
| **Temperature** | **8.1 c** | **8.1 c** | **8.3 c** |
| **pH** | **6.5** | **6.5** | **7.0** |
| **Alkalinity** | **10** | **10** | **10** |
| **Dissolved Oxygen** | **10.59 mg/l** | **10.78 mg/l** | **10.9 mg/l** |
| **Dissolved Oxygen %** | **89.4%** | **91.2%** | **92.5%** |
| **Specific Conductance** | **27.3 mS/cm** | **36.9 mS/cm** | **51.7 mS/cm** |
| **Total dissolved Solids** | **26.2 mg/l** | **35.4 mg/l** | **48.9 mg/l** |

**Habitat**

On April 18, 2019, habitat was in the optimal range at all three Mill Creek stations (Table 6). The upper Station 1 had more impact to bank vegetative protection and more disruptive pressure because homes sites encroached close to the stream banks. Stations 2 and 3 had more natural undisturbed riparian areas. However Station 2 had considerable riparian growth of invasive Japanese knotweed. Because of the small stream size and steep gradient, all stations scored less than optimal for velocity/depth regimes. Riffle habitat was abundant, but slow deep habitat was missing.

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**Table 6**
**Habitat Assessment of Sampling Stations on Mill Creek**
**April 18, 2019**

| **Parameter** | **Station 1** | **Station 2** | **Station 3** |
|---|---|---|---|
| 1. Instream Cover | 15 | 15 | 18 |
| 2. Epifaunal Substrate | 20 | 20 | 20 |
| 3. Embeddedness | 17 | 19 | 20 |
| 4. Velocity/Depth Regimes | 14 | 14 | 15 |
| 5. Channel Alteration | 20 | 20 | 20 |
| 6. Sediment Deposition | 19 | 19 | 20 |
| 7. Frequency of Riffles | 20 | 20 | 20 |
| 8. Channel Flow Status | 20 | 20 | 20 |
| 9. Condition of Banks | 17 | 18 | 18 |
| 10. Bank Vegetative Protection | 15 | 17 | 18 |
| 11. Grazing or Other Disruptive Pressure | 16 | 20 | 20 |
| 12. Riparian Vegetative Zone Width | 8 | 20 | 19 |
| **TOTAL SCORE** | **201** | **222** | **228** |

Score ranges: Optimal 340-192, Suboptimal 180-132, Marginal 120-72, Poor <60

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