# Muncie
SANITARY DISTRICT

**Indiana Scientific Purpose License Number: 18-161**

# Bureau of Water Quality
# Annual Macroinvertebrate Community Report
# 2018

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***Photo description (previous page): Lampsilis fasciola showing one of its four known lure displays. All four displays were seen at a single site in 2018.***

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***Acknowledgements**: Thank you to Emily Musenbrock and Kevin Meyer for their assistance in obtaining these samples, and for their countless hours of data entry, proofing, slide preparation, and general assistance in preparing this report. Extra thanks and acknowledgement to Kevin Meyer for creating Figure 1.*

## PREFACE

This paper contains results of the Bureau of Water Quality's (BWQ's) macroinvertebrate and mussel biomonitoring for the year 2018. For the purpose of displaying trends, some graphs and tables will present data from past years. However, the analysis given here is only for 2018. If further investigation of past years is needed, please refer to prior reports from this organization.

From 2013-2018 an additional Buck Creek site was sampled. This site (BUC 0.0) was sampled to observe changes in the site before and after best management practices (implemented in late 2013) were put into place.

In 2014, one zebra mussel *Dreissena polymorpha* was found on a sampler in Prairie Creek Reservoir, upstream of Muncie. The reservoir is very near White River, connected via Prairie Creek. In 2015 zebra mussels were found on a sampler in Prairie Creek. In 2018 zebra mussels are well established throughout the West Fork White River downstream of Prairie Creek.

Unique to this year, no "sites" were sampled for mussels. Instead, a project was undertaken to complete timed surveys on surface mussels in the West Fork White River throughout Delaware County. In 2018, this was completed within Muncie city limits. This will likely be a three to four year project.

## INTRODUCTION

**West Fork White River and the Bureau of Water Quality.—**The headwaters of the West Fork White River (WFWR) can be found near Winchester, Indiana, moving westward through Muncie, draining approximately 384 square miles at the Madison County/Delaware County line (Hoggat 1975). The land along the river in Delaware County is primarily used for agriculture (corn, soybeans, and livestock), but also includes the urban area of Muncie. Muncie is a heavily industrialized community that has included electroplating firms, transmission assembly plants, a secondary lead smelter, foundries, heat treatment operations, galvanizing operations, and tool and die shops (ICLEI Case Study #19 1994).

In 1972, the Division of Water Quality (DWQ), now named the Bureau of Water Quality (BWQ), was established out of a need to regulate and control the sources responsible for polluting White River and its tributaries in and around Muncie, Indiana. The BWQ also wanted to attain those goals set forth by legislation of the 1970's and 1980's (The Water Pollution Act of 1972, the Clean Water Act of 1977 and the Water Quality Act of 1987). One of the ultimate goals is biological integrity, defined by Karr & Dudley (1981) as "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region."

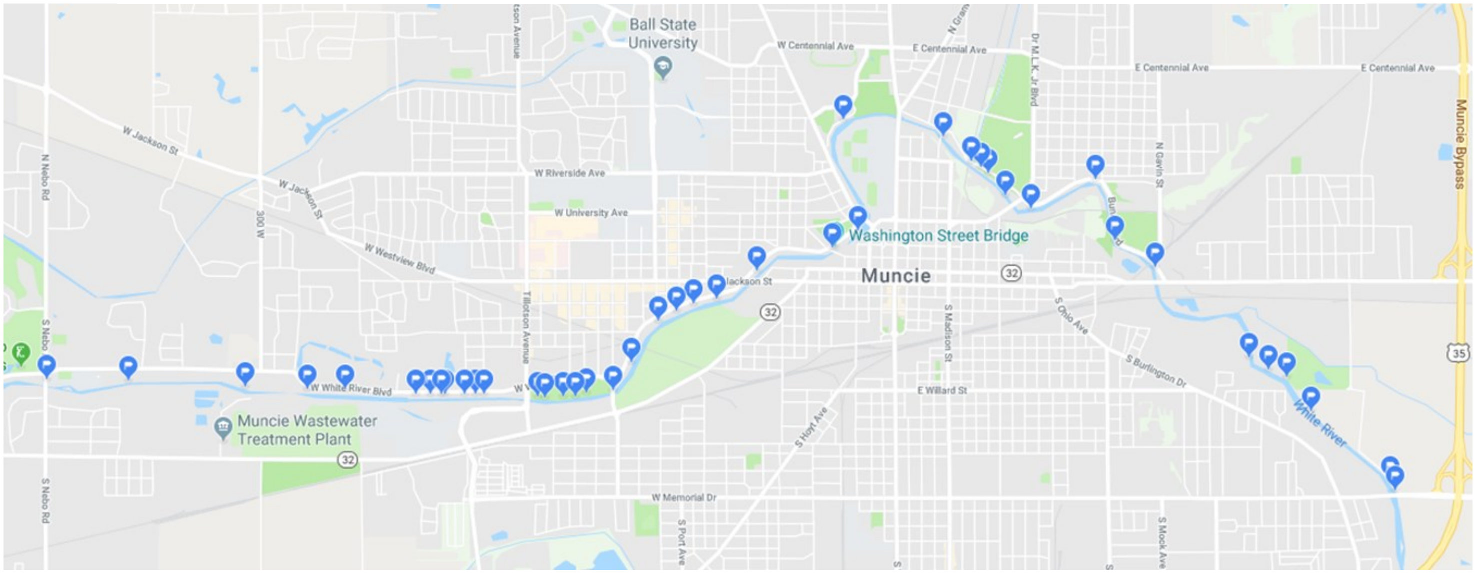
Since the establishment of the BWQ, industries have installed millions of dollars in industrial pretreatment equipment, and corrective action is constantly being taken to prevent spills from entering the sewers and waterways. In addition, an ongoing program has reduced, and in some cases eliminated, pollution entering White River from combined sewer overflows (CSOs). Improvements have been made to the Muncie Water Pollution Control Facility (MWPCF), local sewers have been built to correct septic tank problems, and wildlife habitat has been developed along the river (Craddock 1990).

To get the best representation of the quality of a water system, both chemical and biological monitoring should be implemented. The benefits of chemical testing are vast; however, chemical monitoring can miss or underestimate combined chemical effects, sporadic events, and other factors such as habitat degradation (Karr 1981).

A benefit to using biological communities as indicators of water quality is their longevity and sensitivity to disturbances in the habitat in which they live. The observed condition of the aquatic biota, at any given time, is the result of the chemical and physical dynamics that occur in a water body over time (OEPA DWQMA 1987). Alone, neither gives a complete picture of water quality, however, the combination of biological and chemical monitoring increases the chances that degradation to the water body will be detected (Karr 1991).

**Mussels as biomonitors**.—Freshwater mussels are considered the most imperiled group of organisms in North America (Lydeard et al. 2004; Strayer et al. 2004), if not the world (Strayer 2008), and are declining at alarming and unprecedented rates (Neves et al 1997; Ricciardi & Rasmussen 1999; Vaughn & Taylor 1999; Strayer & Smith 2003; Poole & Downing 2004; Regnier et al. 2009). In North America alone, 72% of the native mussel fauna is either federally listed as endangered or threatened or considered to be in need of some protection (Haag 2009). At one time, 90 species of Unionid (of the family Unionidae) mussels were known to have existed in the eight Great Lake and Upper Mississippi states. Now, 33% are listed as extinct, endangered, or are candidates for that listing (Ball & Schoenung 1995). In the United States, 71 taxa are currently listed as endangered or threatened by the Endangered Species Act (USFWS 2005) and are suffering an extinction rate higher than any other North American fauna (Ricciardi & Rasmussen 1999). Contributors to this decline include commercial harvest, degradation of habitat (including channelization and dredging), toxic chemicals, and siltation. Other significant contributors include: impoundments (Vaughn & Taylor 1999; Watters 2000; Dean et al. 2002), water pollution (organic, inorganic, and thermal) (Mummert et al. 2003; Keller & Augspurger 2005; Valenti et al. 2005; 2006; Gooding et al. 2006; Bringolf et al. 2007; March et al. 2007; Wang et al. 2007; Cope et al. 2008; Besser et al. 2009), habitat alterations, and land use practices (Clarke 1981; Ball & Schoenung 1995; Biggins et al. 1995; Couch 1997; Gatenby et al. 1998; Payne et al. 1999; Watters 1999; Poole & Downing 2004). In 1990, the US EPA listed sedimentation as the top pollutant of rivers in the United States (Box & Mossa 1999). Studies have shown that silt accumulation of 0.25 to 1 inch resulted in nearly 90% mortality of mussels tested (Ellis 1936). This affects mussels by reducing interstitial flow rates, clogging mussel gills, and reducing light for photosynthesis of algae (primary forage of the

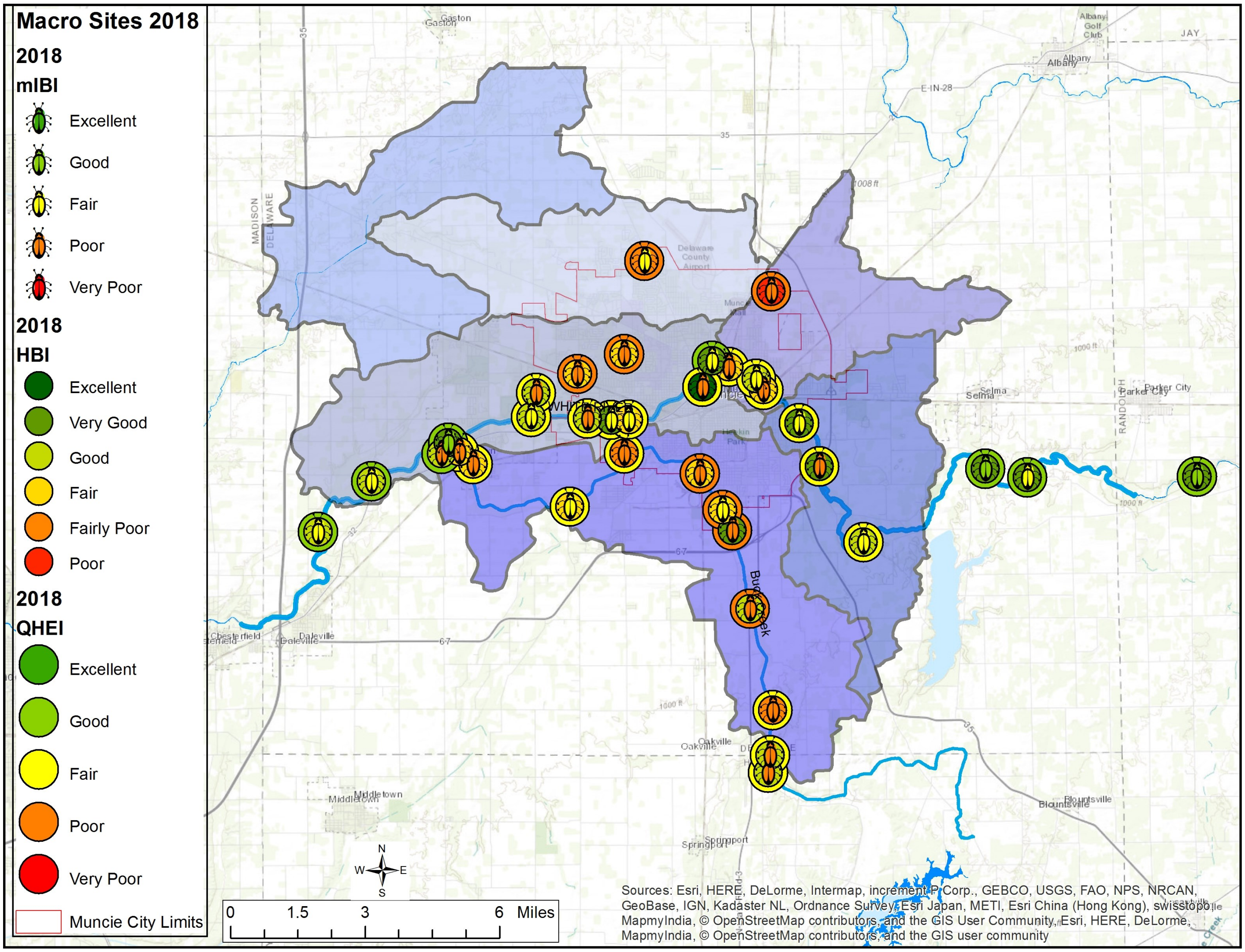
Figure 1.—Mussel sampling sections, 2018.



mussel). Suspended particles also cause difficulty with the necessary fish and mussel interactions needed for reproduction and survival (Box & Mossa 1999). These indicate the importance of water quality as a factor in mussel survival. It is for these reasons, as well as their long life span, feeding habits, persistent shells (Strayer 1999a) and sensitive growth and reproductive rates (Burky 1983) that mussels serve well as biological indicators.

**Macroinvertebrates as Biomonitors**.—There are numerous reasons for using macroinvertebrates as indicators of water quality. Their ubiquitous nature, large numbers (individuals and species), and relative ease of sampling with inexpensive equipment make them ideal for bioassessments (Lenat et al. 1980; Hellawell 1986; Lenat & Barbour 1993). Macroinvertebrates are relatively sessile, allowing spatial analysis of disturbances (Tesmer & Wefring 1979; Hellawell 1986; Abel 1989). The extended life cycles of most aquatic insects allows for temporal analysis as well (Lenat et al. 1980; Hellawell 1986). Finally, macroinvertebrate species are well documented; many identification keys and forms of analysis are available, and specific responses to pollutants and stressors are well known (Hellawell 1986; Abel 1989; Rosenberg & Resh 1993). They are especially useful in situations where intermittent or mild

Figure 2.—Macroinvertebrate sites, 2018.



Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community organic enrichment is present (Chutter 1972).

## MUSSEL METHODS

**Mussel Field Sampling.**— In 2018, a project was begun to determine the distribution of mussels on White River from the Delaware/Randolph County line to the Delaware/Madison county line. Sampling methods followed the Timed Search Survey. This is one of the more popular sampling methods, due to its efficient coverage of large areas (Metcalf-Smith et al 2000), and its effectiveness at obtaining high species richness and finding rare species (Vaughn et al 1997).

Sampling began at the downstream city limits of Muncie, and proceeded upstream. Densities were determined using catch per unit effort.

## MACROINVERTEBRATE METHODS

**Macroinvertebrate Field Sampling.—** Macroinvertebrate samples were taken at 14 sites on White River, and five sites along Buck Creek (Figure 1 and Appendix B, Table 9). Sampling followed the current IDEM Multi-habitat Macroinvertebrate Collection Procedure (MHAB) (IDEM 2010). This methodology includes a composite of a one minute riffle or mid-stream kick (if there is no riffle present) and an approximately 12-minute, 50-m riparian bank sample. The contents were elutriated six times and poured through a #30 USGS sieve. The remaining content in the sieve was then subsampled for 15 minutes. Organisms were placed in a vial with 99.5% isopropyl alcohol and returned to the lab for later identification.

Field sheets (Appendix B, Table 14) were

Table 1.—mIBI submetrics and stand alone indices and their response to disturbance

| mIBI Sub-Metrics and Stand-Alone Indices | Response to Disturbance |
|---|---|
| Total Number of Taxa | Decrease |
| Total Abundance of Individuals | Decrease |
| Number of EPT taxa | Decrease |
| % Orthocladiinae & Tanytarsini | Increase |
| % Non-Insects (-Crayfish) | Increase |
| Number of Dipteran Taxa | Increase |
| % Intolerant Taxa (Score 0-3) | Decrease |
| % Tolerant Taxa | Decrease |
| % Predators | Decrease |
| % Shredders & Scrapers | Decrease |
| % Collectors/Filterers | Increase |
| % Sprawlers | Decrease |
| Hilsenhoff Biotic Index | Increase |
| Shannon-Wiener Diversity Index (H’) | Decrease |
| Shannon Evenness Index (J’) | Decrease |
| % Dominance of Top Three Taxa | Increase |
| % Chironomidae | Increase |

completed, including the “Qualitative Habitat Evaluation Index” sheet (Appendix B, Table 18). Taxa sheets for each macroinvertebrate site can be found in Appendix B, Table 15. QHEI sheets and tabulations can be found in Appendix B, Table 18.

**Macroinvertebrate Laboratory Methods.—** All organisms were identified to the lowest practical level, usually genus. Non- Chironomid macroinvertebrates were identified using numerous dichotomous keys recommended in IDEM’s protocol, as well as Peckarsky et al. (1990). Chironomids (with heads removed) were mounted on slides in a high viscosity mountant. Chironomids were then identified using Peckarsky et al. (1990), Mason (1998), and Epler (2001).

**Macroinvertebrate Data Tabulation**.— Macroinvertebrate calculations were based on IDEM’s Macroinvertebrate Index of Biotic Integrity (mIBI), the Hilsenhoff Biotic Index (HBI), Shannon-Wiener Diversity Index (H’), Shannon Evenness Index (J’), Percent Dominance of Top Three Taxa, and Percent Chironomidae.

*IDEM’s Macroinvertebrate Index of Biotic Integrity (mIBI):* The mIBI is a multimetric index (Table 1) that has been calibrated using statewide data . After calculating each metric, the resulting score is assigned a specific “rank” (1, 3, or 5) based on the drainage area of the site. The sum of all metrics is then used to determine the final score. This final score is assigned a narrative rating (Table 2). IDEM ratings also include a designation of “Fully Supporting” of aquatic life (mIBI score $\geq$ 36), or “Not Supporting” of aquatic life (mIBI score <36).

Table 2.—mIBI scores and corresponding ratings.

| **Total Score** | **Narrative Rating** |
|---|---|
| 54-60 | Excellent |
| 44-53 | Good |
| 35-43 | Fair |
| 23-34 | Poor |
| 0-22 | Very Poor |

*Hilsenhoff Biotic Index (HBI):* The HBI (Hilsenhoff 1987) is a biotic index that incorporates a weighted relative abundance of each taxon in order to determine a score for the community (Rosenberg & Resh 1993). Organisms are assigned a value between 0 and 10, according to their tolerance of organic and nutrient pollution (Appendix B, Table 10). The number of each organism is multiplied by the tolerance value. The sum of these results is then averaged to get the resulting HBI value for the site. Modified descriptive ratings can be found below in Table 3.

The Hilsenhoff Biotic Index is calculated as follows:

$$HBI = \sum \frac{x_i t_i}{N}$$

Where:

$X_i$ = number of each species

$T_i$ = tolerance value for each species (Appendix. B, Table 10)

$N$ = total number of arthropods in the sample with tolerance ratings

Table 3.—HBI values and corresponding ratings.

| HBI Score | Water Quality | Degree of Organic Pollution |
|---|---|---|
| 0.00-3.50 | Excellent | No apparent organic pollution. |
| 3.51-4.50 | Very Good | Possible slight organic pollution. |
| 4.51-5.50 | Good | Some organic pollution. |
| 5.51-6.50 | Fair | Fairly significant organic pollution |
| 6.51-7.50 | Fairly Poor | Significant organic pollution. |
| 7.51-8.50 | Poor | Very significant organic pollution. |
| 8.51-10.00 | Very Poor | Severe organic pollution. |

*Shannon-Wiener Diversity Index (H’):* The Shannon-Wiener Diversity Index is based on the premise that species diversity decreases with decreasing water quality (Wilhm 1967; Rosenberg & Resh 1993) in an effectively infinite community (Kaesler et al. 1978). This index incorporates both species richness as well as evenness (Ludwig &

Reynolds 1988). Higher H' scores indicate increased species diversity (Vandermeer 1981; Gerritsen et al. 1998). The Shannon Wiener Index is calculated as follows:

Where: $$H^{'} = \sum p_i \ln p_i$$

$p_i$ = relative abundance of each species calculated as a proportion of individuals of a given species to the total number of individuals in the community.

*Shannon Evenness Index (J'):* Shannon Evenness Index (Pielou 1966) is calculated from the Shannon-Wiener Diversity Index and is a ratio of observed diversity to maximum diversity in order to measure evenness of the community. Higher J' scores indicate increased community evenness.

The Shannon Evenness Index is calculated as follows:

$$J' = \frac{H^{'}}{\ln s}$$

Where:

$s$ = number of species

*Percent Dominance of Top Three Taxa:* A well balanced community is indicative of a healthy community. Predominance of only a few macroinvertebrate species can be indicative of stressors in the system (Plafkin et al. 1989; Klemm et al. 1990).

*Percent Chironomidae:* Chironomidae are generally considered to be pollution tolerant. An overabundance of these organisms can be indicative of stressors in the system (Plafkin et al. 1989; Barbour et al. 1994).

*Qualitative Habitat Evaluation Index (QHEI):* The QHEI was assessed to better determine the effect of habitat quality on the resulting scores. The QHEI (Rankin 1989) is an index that evaluates macro-habitat quality that has been found to be essential for fish communities as well as other aquatic life. QHEI metrics include substrate, instream cover, channel morphology, riparian condition, pool and riffle quality, and gradient. Each metric in the habitat assessment was scored, with the final sum of these scores reflecting available habitat (higher scores reflect better habitat). Narrative ratings for QHEI scores can be found in Table 4.

Table 4.—QHEI scores and corresponding ratings.

| **QHEI score** | **Narrative Rating** |
|---|---|
| 90-100 | Excellent |
| 71-89.9 | Good |
| 52-70.9 | Fair |
| 27-51.9 | Poor |
| 0-26 | Very Poor |

## MUSSEL RESULTS

In 2018, 120 sampler hours yielded 4,081 Unionid mussels of 17 species found within the city limits of Muncie. The most common mussels found were *Actinonaias ligamentina* (35.2%) and *Lasmigona costata* (26.2%). Most sites (30 of 37 sites) sampled in Muncie had zebra mussels present.

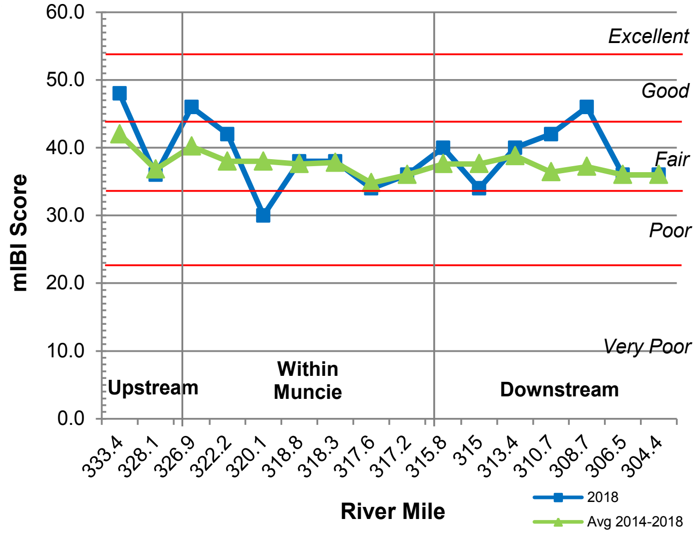
## MACROINVERTEBRATE RESULTS

**mIBI.—White River:** White River mIBI scores (Graph 2 and Appendix B, Table 10) ranged from 30.0 (WHI 320.1) to 48.0 (WHI 333.4), *Poor* to *Good*. In 2018, WHI 320.1, WHI 317.6, WHI 315.0, and WHI 311.7 would be considered "Not Supporting" of aquatic life by IDEM. Mean mIBI scores (Appendix B, Table 11) upstream, within, and downstream of Muncie were all *Fair*.

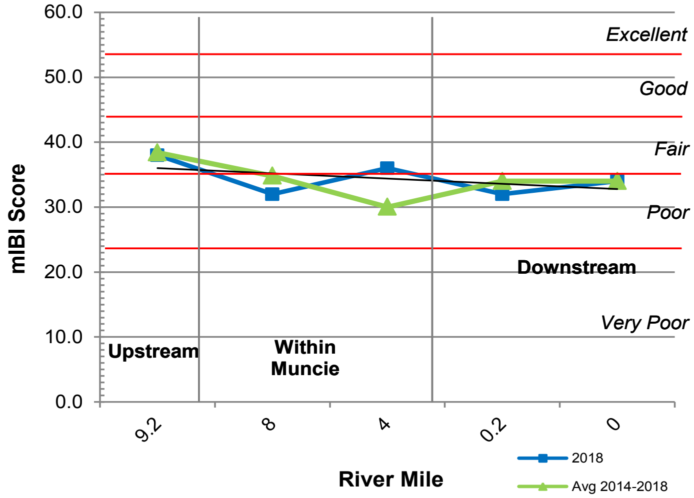
**Buck Creek:** Buck Creek mIBI scores (Graph 3 and Appendix B, Table 10) ranged from 28.0 (BUC 13.8, BUC 5.9, and BUC 0.9) to 38.0 (BUC 9.2), *Poor* to *Fair*. The mean mIBI score for Buck Creek was 32.7, *Poor* (Appendix B, Table 11). In 2018, BUC 15.2, BUC 14.9, BUC 13.8, BUC 11.3, BUC 9.5, BUC 8.0, BUC 5.9, and BUC 0.9, and BUC 0.2 would be considered "Not Supporting" of aquatic life by IDEM. No spatial or temporal trends were detected.

In addition to the temporal trends detected from 2014-2018, a few observations should be noted. On White River, there have only been three *Poor* mIBI scores upstream of Muncie since 2009. Scores appear to fluctuate on White River from

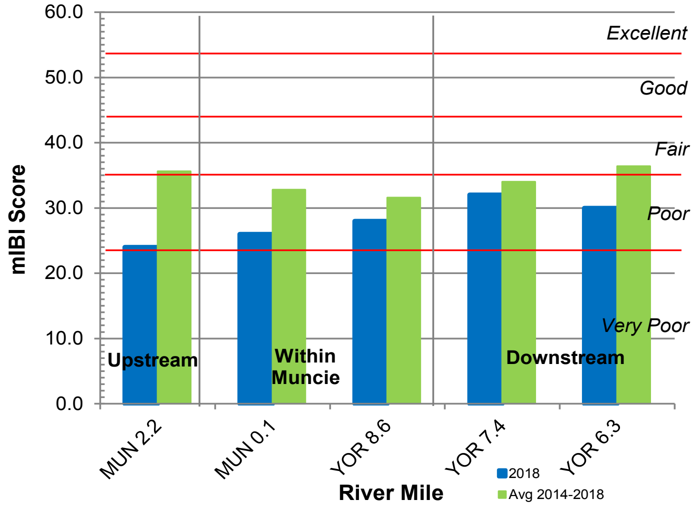
Graph 1.—WFWR mIBI scores, 2018.



Graph 2.—Buck Creek mIBI scores, 2018



Graph 3.—Tributary mIBI scores, 2018.



year to year, especially dramatic in recent years. Lower mIBI scores appear to be fairly common among tributary sites.

**Smaller Tributary Sites:** mIBI scores at the smaller tributaries (Graph 4 and Appendix B, Table 10) ranged from 24 (MUN 2.2) to 38 (GRE 0.1) *Poor* to *Fair*. MUN 2.2, MUN 0.1, YOR 8.6, YOR 7.4, and YOR 6.3 would be considered "Not Supporting" of aquatic life by IDEM. Since 2014, mIBI scores have significantly decreased ($R^2 = 0.81, p < 0.05$) at YOR 8.6.

## Stand Alone Indices.—

*HBI:* **White River:** White River HBI scores (Graph 5 and Appendix B, Table 10) ranged from 5.63 (WHI 313.4) to 3.56 (WHI 318.8), *Fair* to *Very Good*. Mean HBI scores (Appendix B, Table 11) dropped slightly from *Very Good* to *Good* within Muncie, and dropped slightly downstream of Muncie city limits. Since 2014, HBI scores have increased at WHI 317.6 ($R^2 = 0.82, p < 0.05$). No spatial or temporal trends were detected.

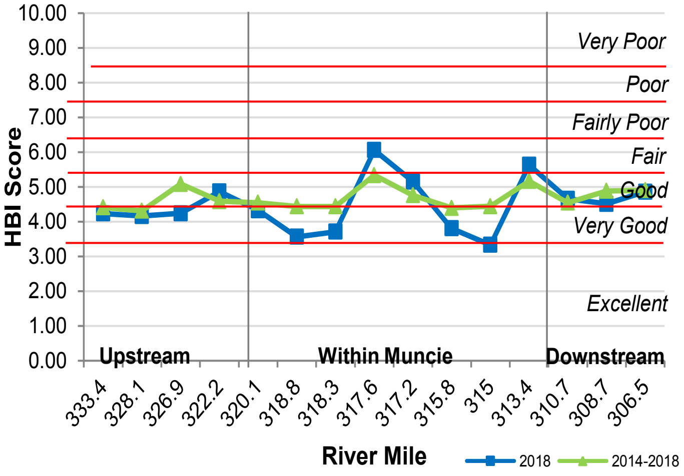
**Buck Creek:** Buck Creek HBI scores (Graph 6, Appendix B, Table 10) ranged from 6.85 (BUC 5.9) to 4.44 (BUC 9.5), *Fairly Poor* to *Very Good*. The mean HBI score (Appendix B, Table 11) was 5.6, *Fair*. ). No spatial or temporal trends were detected.

**Smaller Tributary Sites:** HBI scores at the smaller tributaries (Graph 7 and Appendix B, Table 10) ranged from 7.65 (MUN 2.2) to 5.33 (YOR 6.3), *Poor* to *Good*.

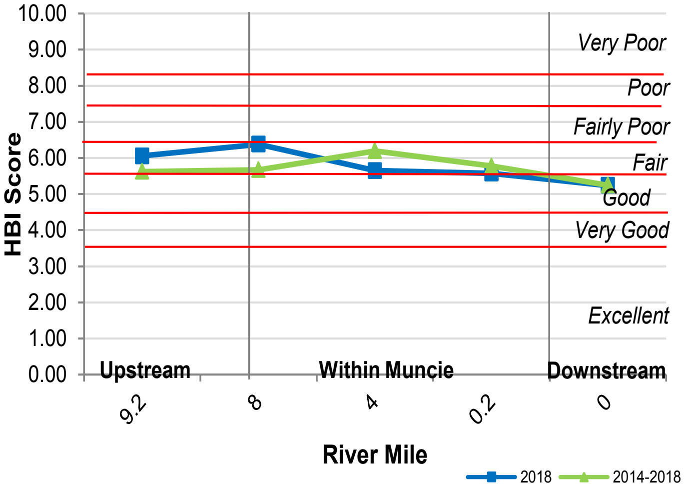
*H':* **White River:** White River H' scores (Graph 8 and Appendix B, Table 10) ranged from 1.74 (WHI 315.0) to 3.47 (WHI 328.1 and WHI 30.7). Mean H' scores (Appendix B, Table 11) dropped as White River progressed into Muncie, but improved slightly downstream of city limits. Shannon-Wiener scores siginificantly decreased since 2014 at MUN 0.1 ($R^2 = 0.91, p < 0.05$), and YOR 8.6 ($R^2 = 0.78, p < 0.05$). No spatial trends were detected.

**Buck Creek:** Buck Creek H' scores (Graph 9 and Appendix B, Table 10) ranged

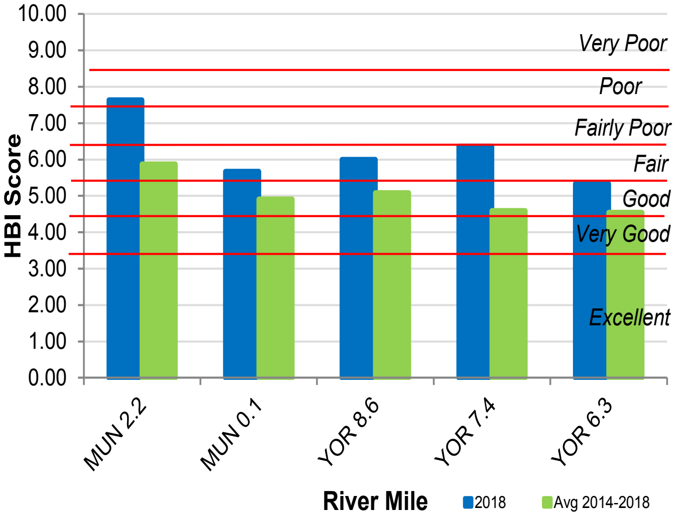
Graph 4.—WFWR HBI scores, 2018



Graph 5.—Buck Creek HBI scores, 2018.



Graph 6.—Tributary HBI scores, 2018.



from 2.39 (BUC 9.5) to 3.14 (BUC 0.0). The mean H' score at Buck Creek sites in 2018 (Appendix B, Table 11) was 2.71. No spatial or temporal trends were detected in 2018.

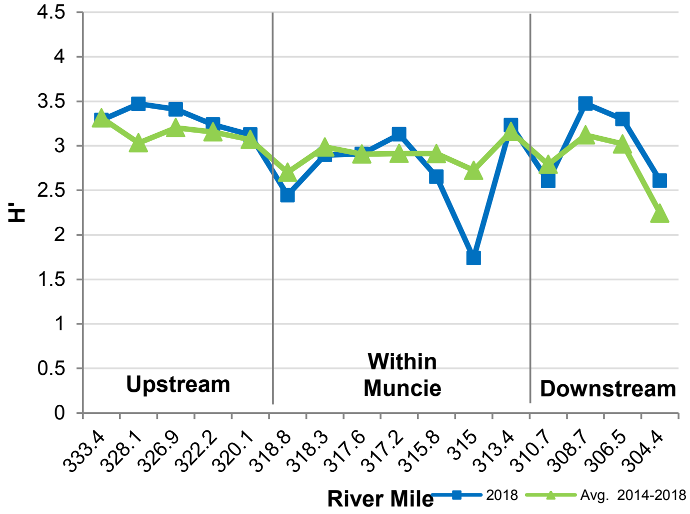
**Smaller Tributary Sites**: H' scores at the smaller tributaries ranged from (Graph 10 and Appendix B, Table 10) 1.09 (MUN 0.1) to 3.47 at GRE 0.1.

*Remaining Stand Alone Indices:* **White River:** White River J' scores (Appendix B, Table 10) ranged from 0.59 (WHI 315.0) to 0.91 (WHI 320.1 and WHI 318.3). Mean J' scores (Appendix B, Table 11) worsened as White River progressed downstream. White River "Percent Dominance of Top Three Taxa" (Appendix B, Table 10) ranged from 0.22 (WHI 328.1) to 0.59 (WHI 315.0). Mean scores (Appendix B, Table 11) worsened as White River progressed downstream. White River "Percent Chironomidae" (Appendix B, Table 10) ranged from 0.00 (WHI 333.4, WHI 318.8, WHI 317.2, and WHI 315.8) to 0.23 (WHI 313.4). Mean scores (Appendix B, Table 11) worsened within city limits, then improved slightly as White River progressed downstream.

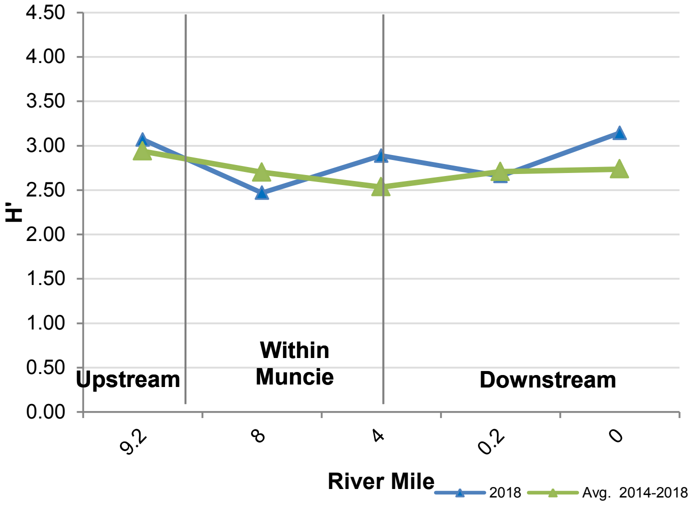
**Buck Creek:** Buck Creek J' scores (Appendix B, Table 10) ranged from 0.73 (BUC 9.5) to 0.93 (BUC 11.3 and BUC 0.0). The mean Buck Creek J' score (Appendix B, Table 11) was 0.80. Buck Creek "Percent Dominance of Top Three Taxa" (Appendix B, Table 10) ranged from 0.57 (BUC 5.9) to 0.30 (BUC 0.0), with a mean of 0.50 (Appendix B, Table 11). Buck Creek "Percent Chironomidae" scores (Appendix B, Table 10) ranged from 0.49 (BUC 4.0) to 0.00 (BUC 15.2 and BUC 0.2), with a mean of 0.10 (Appendix B, Table 11).

**Smaller Tributary Sites:** J' scores at the smaller tributaries (Appendix B, Table 10) ranged from 0.51 (YOR 8.6) to 0.91 (MUN 0.1 and YOR 6.3). "Percent Dominance of Top Three Taxa" ranged from (Appendix B, Table 10) 0.58 (MUN 2.2) to 0.35 (YOR 6.3). "Percent Chironomidae" (Appendix B, Table 10) ranged from 0.06 (YOR 7.4) to 0.00 (YOR 8.6 and YOR 6.3).

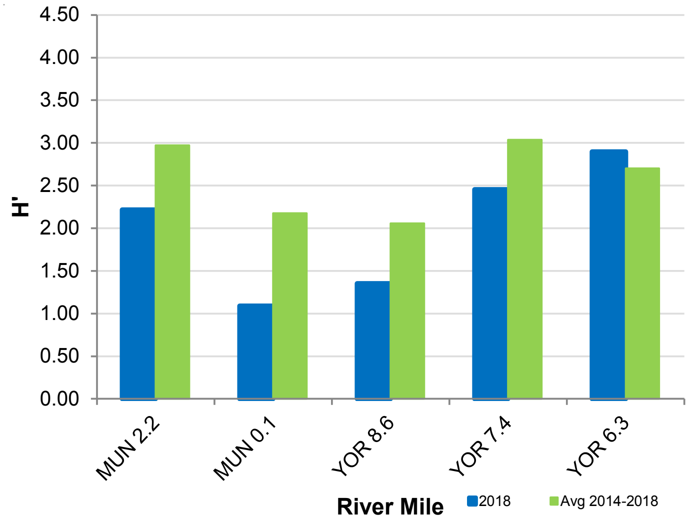
Graph 7.—WFWR H’ scores, 2018.



Graph 8.—Buck Creek H’ scores, 2018.



Graph 9.—Tributary H’ scores, 2018.



*QHEI:* **White River:** White River QHEI scores ranged from 58.8 (WHI 311.7) to 82.0 (WHI 306.5), *Fair* to *Good* (Graph 11 and Appendix B, Table 10). Mean scores worsened within Muncie city limits, but recovered downstream (Appendix B, Table 11). Since 2014, QHEI scores have significantly increased at WHI 333.4 ($R^2 = 0.85$, $p < 0.05$). No spatial trends were detected in 2018.

**Buck Creek:** Buck Creek QHEI scores (Graph 12 and Appendix B, Table 10) ranged from 39.5 (BUC 11.3) to 73.0 (BUC 0.0), *Poor* to *Good*, with a mean score of 58.1, *Fair* (Appendix B, Table 11). Since 2014, QHEI scores significantly increased at BUC 0.0 ($R^2 = 0.82$, $p < 0.05$). No spatial trends were detected in 2018.

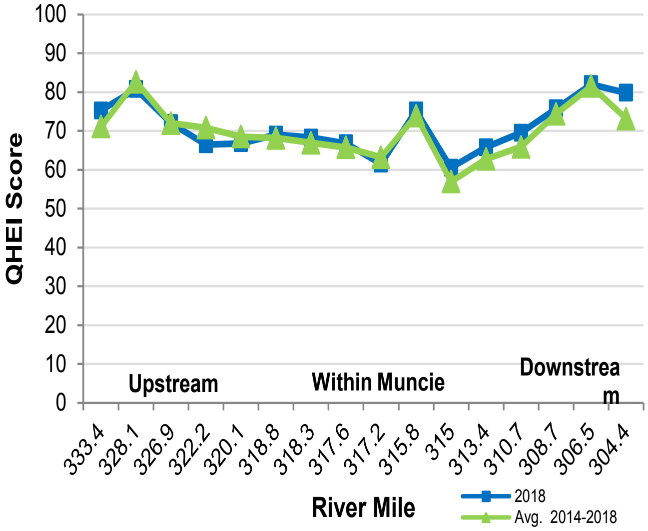
**Smaller Tributary Sites:** QHEI scores at the smaller tributaries ranged from (Graph 13 and Appendix B, Table 10) 43.8 (YOR 8.6) to 66.5 (YOR 6.3), *Poor* to *Fair*. Since 2014, QHEI scores have significantly decreased at YOR 8.6 ($R^2 = 0.92$, $p < 0.05$), and have significantly increased at YOR 6.3 ($R^2 = 0.98$, $p < 0.01$). No spatial trends were detected in 2018.

## DISCUSSION

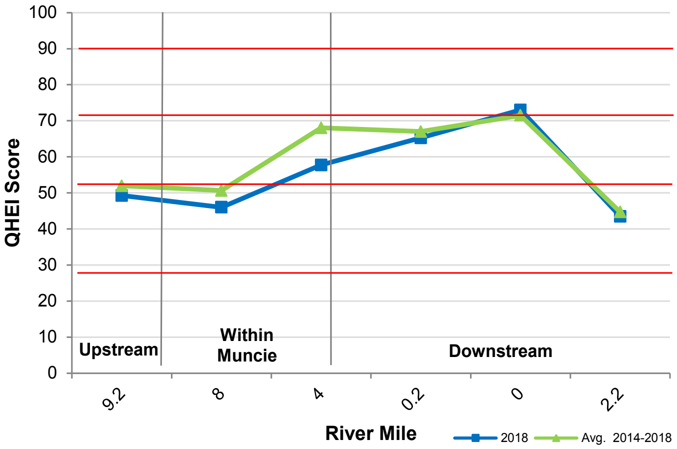
**Mussels.**—Mussel sampling results continue to indicate good water quality within Muncie city limits, considering the urban impacts on this stretch of White River.

It has been noted that one mussel species, the white heelsplitter *Lasmigona complanata*, has not been found in White River upstream of Muncie. This species’ opportunistic nature, and its ability to tolerate silt, habitat disturbance, and impoundments (Grabarkiewicz & Davis 2008), appear to make it an ideal species to inhabit White River within city limits. However, it is possible that this species is unable to expand its range upstream due to the inability of its host species to navigate the five impoundments within Muncie city limits. Dams are well documented as obstacles to mussel population abundance and expansion (Vaughn & Taylor 1999; Watters 2000; Dean

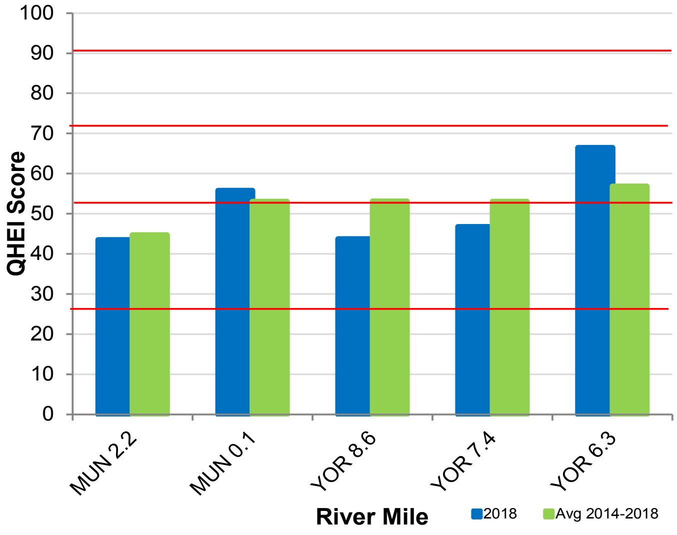
Graph 10.—WFWR QHEI scores, 2017.



Graph 11.—Buck Creek QHEI scores, 2017.



Graph 132—Tributary QHEI scores, 2017.



et al. 2002). Habitats are altered upstream and downstream of the impoundment, resulting in an increase of pollutants, siltation, stagnation, thermal changes, and anoxic conditions (Watters 1999), causing additional complications for mussel populations (Watters 1996; Dean et al. 2002; Lessard & Hayes 2003; Tienmann et al. 2004; Poff et al. 2007; Maloney et al. 2008). Dams have been implicated as one of the leading causes of current-day decline in freshwater mussel populations in North America (Parmalee & Bogan 1998; Haag 2009). They have been cited as being responsible for the "local extirpation of 30-60% of the native freshwater mussel species in many United States rivers" (NRCS 2009). Studies have shown that the impacts of impoundments have resulted in reduced abundance, diversity, and species richness of mussel fauna (Dean et al. 2002; Baldigo et al. 2004; Tiemann et al. 2004; Santucci et al. 2005; Galbraith & Vaughn 2011: Tiemann et al. 2016).

In late summer 2017, zebra mussels were found in White River downstream of Prairie Creek Reservoir (where they were first observed in 2015). Within weeks, zebra mussels were identified on dead mussel shell in the WR 313.4 site. In 2018, random quadrat sampling at each macroinvertebrate site yielded densities of 0-36/m$^2$ at sites between WHI 322.2-WHI 308.7.

Timed search surveys will continue in 2019, likely upstream of Muncie, and will continue until all of the West Fork of White River in Delaware County has been assessed.

**Macroinvertebrates**—Many sites had lower mIBI scores in 2018. Most of these sites also had unusually low abundance and/or diversity.

*Poor* mIBI scores at some sites may be attributed to a lack of suitable habitat for macroinvertebrates, quantified by *Poor* QHEI scores. Sites at BUC 11.3, BUC 9.5, BUC 8.0, GRE 0.1, MUN 2.2, YOR 8.6, and YOR 7.4 all had *Poor* QHEI scores, indicating that a lack of habitat may limit the macroinvertebrates that can inhabit these sites.

Organic impairment appears to be a likely stressor at one site. BUC 5.9 is the only site in 2018 to have a *Fairly Poor* HBI score., coinciding with a *Poor* mIBI as well.

Many remaining sites with *Poor* mIBI scores do not suggest organic impairment or habitat limitations. Most of these sites have very low abundance and/or diversity, exaggerating any effects on this sample and carrying over into multiple metrics. These include BUC 15.2, BUC 14.9, BUC 13.8, BUC 0.9, BUC 0.2, BUC 0.0, MUN 0.1, WHI 320.1, WHI 315.0, WHI 311.7, and YOR 6.3..

Only WHI 317.6 had a *Poor* mIBI, but did not have low abundance. This site was dominated (50%) by *Hyallela azteca*, *Goniobasis livascens*, and *Caenis* spp. *H. azteca* and *G. livascens* are moderately tolerant to tolerant non-insects, and their dominance affects multiple indices. This site was also dominated (49.8%) by non-insects, and had 37.0% tolerant organisms.

Significant decreases in mIBI scores from 2014-2018 indicate potential water quality issues at YOR 8.6 (*Fair* to *Poor*). Conversely, a significant increase in mIBI scores from 2014-2018 was seen at WHI 333.4 (*Fair* to *Good*), indicating potentially improved water quality.

A significant increase in HBI scores from 2014-2018 at WHI 317.6 suggests decreased water quality, specifically increased organic enrichment, at this site.

Significant decreases in H' scores from 2014-2018 show decreased diversity in macroinvertebrate populations at some sites, potentially indicating stressors at these sites. These sites include MUN 0.1 (3.35-1.09) and YOR 8.6 (2.31-1.35).

Significant increases in QHEI scores from 2014-2018 indicate increased habitat availability at some sites. These sites include WHI 333.4 (*Fair* to *Good*), BUC 0.0 (*Fair* to *Good*), and YOR 6.3 (*Poor* to *Fair*). Significant decreases in QHEI scores from 2014-2018 indicate decreased habitat availability at YOR 8.6 (*Fair* to *Poor*).

Observed trends give us some indication of negative impacts on sample sites. *Poor* mIBI scores (as seen in 2018 at WHI 320.1) generally are not seen on White River upstream of Muncie city limits, and is unusual for this site. Scores from this site will be watched closely in future years to determine if this is indicative of a trend.

Multiple negative mIBI scores at tributary sites likely reflect impacts that are more apparent due to their smaller size. Additionally, diversity and/or abundance may be limited by the colder temperatures found in spring-fed Buck Creek (Vannote & Sweeney 1980; Ward 1976).

Climatological fluctuations and extremes have been considered as factors in years with unusually low mIBI scores (Bowley 2012; Bowley 2015; Bowley 2016). Other stressors may need to be considered including the effects of multiple stressors. These may include ecological, morphological, hydrological, biological, chemical or climatological effects. To complicate an already challenging situation, most aquatic macroinvertebrates have complex life cycles that include multiple stages, some being terrestrial.

An emerging global concern has also been considered for the recent drop in scores, particularly in abundance and diversity. A growing body of evidence has supported what is being called an “Insect Apocalypse”, indicating an alarming drop in insect abundance and diversity worldwide. A study in Germany’s protected areas found a 76% seasonal decline in insect biomass of over 27 years (Hallmann et al. 2017), finding no significant correlation with landuse, habitat or climate change. A study in Puerto Rico showed a 2.2-2.7% annual loss in ground-dwelling and canopy-dwelling arthropods (Lister & Garcia 2018), indicating “climate warming” as the likely cause. Similar declines in flying insects have been seen in areas all around the globe (Thomas et al. 2004; Shortall et al. 2009; Sanchez-Bayo & Wyckhuys 2019).

Since most flying insects spend part of their life cycle as aquatic insects, it stands to reason that a similar trend would be seen at an aquatic level. Declines in abundance and diversity, and increases in homogeneity and/or replacement from tolerant and generalist species has been seen in the Odonata (Hickling et al. 2005; McKinney 2006; Kadoya et al. 2009; Kalkman et al. 2010), Ephemeroptera (Zahradkova et al. 2009; Zedkova et al. 2015), and Trichoptera orders (Karatayev et al. 2009; Houghton & Holzenthal 2010; Jenderedjian et al. 2012). Future work at the BWQ will be looking at long-term trends in our macroinvertebrate data to determine if sites in this area are experiencing similar trends. Research and analysis, as well as continued monitoring, will be conducted in an attempt to determine all stressors affecting macroinvertebrate communities.

Dramatic improvements have been seen since the inception of our macroinvertebrate and mussel sampling programs. Point source pollutants have been controlled through the utilization of local permits regulated by the Bureau of Water Quality. Improvements have been and continue to be made to our Water Pollution Control Facility. Whereas most analyses historically have focused on White River, studying the tributaries and nonpoint source pollution impacting them has become critical. These impacts on water quality include hydromodifications (channelization, impoundments, dredging, and removal of riparian zones), urban storm water (sources include CSOs, SSOs, and impervious surfaces), and sedimentation. In 1990, the US EPA listed sedimentation as the top pollutant of rivers in the United States (Box & Mossa 1999), and it has been determined that reductions in water quality are detectable at > 15% impervious surface (Roy et al. 2003).

This shift in focus would benefit from public outreach, education, and cooperation to instill better management practices throughout Delaware County. These include buffer strips, rain barrels, rain gardens, better construction site practices, and the further separation of CSOs. As improved management practices are implemented, it is expected that water quality will continue to improve.

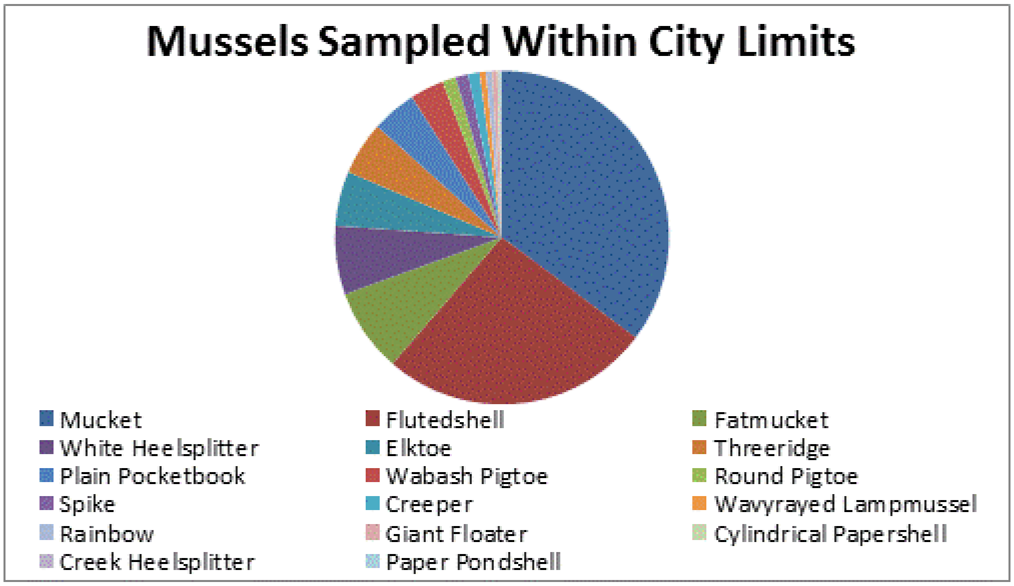
Overall, the water systems in this area appear to be in good condition, especially considering the industrial, urban, and agricultural areas through which they flow. Efforts by the citizens of Delaware County, the City of Muncie, the Muncie Sanitary District, the Bureau of Water Quality, and the industrial community are responsible for the improvements in water quality since the BWQ was established in 1972.

**Appendix A.—**Mussel assemblages and relative abundance found within city limits, 2018.

Table 4.—Mussel assemblage within Muncie city limits, 2018.

| Scientific Name | Common Name | # Found |
|---|---|---|
| *Lasmigona costata* | flutedshell | 1068 |
| *Actinonaias ligamentina* | mucket | 1437 |
| *Lampsilis siliquoidea* | fatmucket | 330 |
| *Lasmigona complanata* | white heelsplitter | 271 |
| *Alasmidonta marginata* | elktoe | 217 |
| *Amblema plicata* | threeridge | 211 |
| *Lampsilis cardium* | plain pocketbook | 178 |
| *Fusconcaia flava* | Wabash pigtoe | 133 |
| *Pleurobema sintoxia* | round pigtoe | 54 |
| *Eurynia dilatata* | spike | 50 |
| *Strophitus undulatus* | creeper | 45 |
| *Lampsilis fasciola* | wavy-rayed lampmussel | 25 |
| *Villosa iris* | rainbow | 24 |
| *Pyganodon grandis* | giant floater | 20 |
| *Anodontoides ferussacianus* | cylindrical papershell | 7 |
| *Lasmigona compressa* | creek heelsplitter | 6 |
| *Utterbackia imbecillis* | paper pondshell | 5 |
|  | **TOTAL** | 4081 |

Graph 13.—Relative abundance for Unionid mussels sampled within Muncie city limits,, 2018.



**Appendix B.—**Macroinvertebrate sites, field sheets, tolerance and attributes used for calculations, taxa identified, taxa sheets, QHEI sheets, and resulting scores.

Table 5.—Macroinvertebrate site field sheets, 2018.

## BUREAU OF WATER QUALITY
## MUSSEL BED SURVEY

**Stream** ____________ **Station** ____________ **County** ____________ **Date** ____________

**Collected by:**

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**Collection Notes:**

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**Width:**

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Table 5.—Macroinvertebrate site field sheets, 2018 (con't).

**Bureau of Water Quality Mussel Data**

**Stream** **Station** **Date**

| Transect | Collector | Species | Width | Height | Age | Count |
|---|---|---|---|---|---|---|
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Table 6.—Macroinvertebrate site descriptions and locations, 2018.

| | | | | |
|---|---|---|---|---|
| **Buck Creek** | **CR 950N (BUC 15.2)** | **Lat./Long.** | 40.070817 | -85.363497 |
| **Drainage= 13 sq. miles** | **HUC14:** 05120201020020 | | | |
| Water is much colder (4.2°C to 6.5°C lower than White River) due to the system being spring fed (Conrad and Warrner 2005). | | | | |
| **Buck Creek** | **CR 800S (BUC 14.9)** | **Lat./Long.** | 40.076306 | -85.362624 |
| **Drainage= 27 sq. miles** | **HUC14:** 05120201020020 | | | |
| Water is much colder (4.2°C to 6.5°C lower than White River) due to the system being spring fed (Conrad and Warrner 2005). | | | | |
| **Buck Creek** | **CR 700S (BUC 13.8)** | **Lat./Long.** | 40.090910 | -85.361338 |
| **Drainage= 27 sq. miles** | **HUC14:** 05120201020020 | | | |
| Water is much colder (4.2°C to 6.5°C lower than White River) due to the system being spring fed (Conrad and Warrner 2005). | | | | |
| **Buck Creek** | **SR 3 (BUC 11.3)** | **Lat./Long.** | 40.123676 | -85.370897 |
| **Drainage= 36 sq. miles** | **HUC14:** 05120201020020 | | | |
| Water is much colder (4.2°C to 6.5°C lower than White River) due to the system being spring fed (Conrad and Warrner 2005). | | | | |
| **Buck Creek** | **CR 300S/Fuson Rd. (BUC 9.5)** | **Lat./Long.** | 40.149185 | -85.378202 |
| **Drainage= 49 sq. miles** | **HUC14:** 05120201020020 | | | |
| Water is much colder (4.2°C to 6.5°C lower than White River) due to the system being spring fed (Conrad and Warrner 2005). | | | | |
| **Buck Creek** | **Madison St. (BUC 9.2)** | **Lat./Long.** | 40.155806, | -85.382286 |
| **Drainage= 49 sq. miles** | **HUC 14:** 05120201020020 | | | |
| Water is much colder (4.2°C to 6.5°C lower than White River) due to the system being spring fed (Conrad and Warrner 2005). | | | | |
| **Buck Creek** | **23rd St. (BUC 8.0)** | **Lat./Long.** | 40.16756, | -85.391803 |
| **Drainage= 49 sq. miles** | **HUC 14:** 05120201020020 | | | |
| Water is much colder (4.2°C to 6.5°C lower than White River) due to the system being spring fed (Conrad and Warrner 2005). | | | | |
| **Buck Creek** | **Tillotson Ave. (BUC 5.9)** | **Lat./Long.** | 40.174127 | -85.423697 |
| **Drainage= 49 sq. miles** | **HUC14:** 05120201020020 | | | |
| Water is much colder (4.2°C to 6.5°C lower than White River) due to the system being spring fed (Conrad and Warrner 2005). | | | | |
| **Buck Creek** | **CR 325W (BUC 4.0)** | **Lat./Long.** | 40.15686, | -85.446570 |
| **Drainage= 49 sq. miles** | **HUC 14:** 05120201020060 | | | |
| Water is much colder (4.2°C to 6.5°C lower than White River) due to the system being spring fed (Conrad and Warrner 2005). | | | | |
| **Buck Creek** | **Cornbread Rd. W. Crossing (BUC 0.9)** | **Lat./Long.** | 40.170817 | -85.487403 |
| **Drainage= 100 sq. miles** | **HUC 14:** 05120201020060 | | | |
| Water is much colder (4.2°C to 6.5°C lower than White River) due to the system being spring fed (Conrad and Warrner 2005). | | | | |
| **Buck Creek** | **SR 32 (BUC 0.2)** | **Lat./Long.** | 40.174756, | -85.493202 |
| **Drainage= 100 sq. miles** | **HUC 14:** 05120201020060 | | | |
| Water is much colder (4.2°C to 6.5°C lower than White River) due to the system being spring fed (Conrad and Warrner 2005). | | | | |
| **Buck Creek** | **Confluence (BUC 0.0)** | **Lat./Long.** | 40.174082, | -85.500697 |
| **Drainage= 100 sq. miles** | **HUC 14:** 05120201020060 | | | |
| Due to severe erosion and numerous band stabilization efforts, this site underwent reconstruction in the fall of 2013. This site was sampled pre-construction in 2013, and will be sampled annually hereafter to assess water quality and habitat. During construction, banks were naturally stabilized, and large boulders and j-hooks were installed. The riffle at the j-hooks is fast, and deep.<br>Water is much colder (4.2°C to 6.5°C lower than White River) due to the system being spring fed (Conrad and Warrner 2005). | | | | |
| **20. Greenfarm Ditch** | **Moore Rd. (GRE 0.1)** | **Lat./Long.** | 40.236342, | -85.414939 |
| **Drainage= 3 sq. miles** | | | | |
| The surroudning landuse at this site is primarily residential and commercial. Both banks are mowed to the edge.<br>This site is just within the influence of the City of Muncie. | | | | |
| **Muncie Creek** | **Indiana Ave. (MUN 2.2)** | **Lat./Long.** | 40.226458, | -85.361522 |
| **Drainage= 10.0 sq. miles** | **HUC 14:** 05120201010130 | | | |
| **Muncie Creek** | **McCulloch Park (MUN 0.1)** | **Lat./Long.** | 40.201933, | -85.379461 |
| **Drainage= 10.0 sq. miles** | **HUC 14:** 05120201010130 | | | |
| **West Fork White River** | **CR 1100W (WHI 333.4)** | **Lat./Long.** | 40.165932, | -85.182243 |
| **Drainage= 120 sq. miles** | **HUC 14:** 05120201010090 | | | |
| **West Fork White River** | **CR 700E (WHI 328.1)** | **Lat./Long.** | 40.165859, | -85.253616 |
| **Drainage= 184 sq. miles** | **HUC 14:** 05120201010100 | | | |

Table 6.—Macroinvertebrate site descriptions and locations, 2018 (con't).

| | | | | |
|---|---|---|---|---|
| **West Fork White River** | **Smithfield (WHI 326.9)** | **Lat./Long.** | 40.168793, | -85.271332 |
| **Drainage= 184 sq. miles** | **HUC 14:** 05120201010100 | | | |
| **West Fork White River** | **Camp Red Wing (CRW) (WHI 322.2)** | **Lat./Long.** | 40.145227, | -85.322876 |
| **Drainage= 213 sq. miles** | **HUC 14:** 05120201010120 | | | |
| **West Fork White River** | **Burlington (WHI 320.1)** | **Lat./Long.** | 40.169697, | -85.341393 |
| **Drainage= 220 sq. miles** | **HUC 14:** 05120201010120 | | | |
| Large man-made boulder and cobble riffle stretches the width of the stream. | | | | |
| **West Fork White River** | **Water Company (WHI 318.8)** | **Lat./Long.** | 40.183727, | -85.349831 |
| **Drainage= 220 sq. miles** | **HUC 14:** 05120201010120 | | | |
| Site downstream of Water Company low head dam. Riffle sampled in riffle and dam for consistency to past efforts. | | | | |
| **West Fork White River** | **River Rd. (WHI 318.3)** | **Lat./Long.** | 40.184911, | -85.429108 |
| **Drainage= 220 sq. miles** | **HUC 14:** 05120201010120 | | | |
| **West Fork White River** | **E. Jackson (WHI 317.6)** | **Lat./Long.** | 40.194584, | -85.364861 |
| **Drainage= 231 sq. miles** | **HUC 14:** 05120201010130 | | | |
| Site substrate almost exclusively bedrock. | | | | |
| **West Fork White River** | **Bunch Blvd. (WHI 317.2)** | **Lat./Long.** | 40.198117, | -85.367828 |
| **Drainage= 231 sq. miles** | **HUC 14:** 05120201010130 | | | |
| **West Fork White River** | **Elm St. (WHI 315.8)** | **Lat./Long.** | 40.204031, | -85.386483 |
| **Drainage= 241 sq. miles** | **HUC 14:** 05120201020060 | | | |
| Substrate is dominated by bedrock. | | | | |
| **West Fork White River** | **High St. (WHI 315.0)** | **Lat./Long.** | 40.195446, | -85.390610 |
| **Drainage= 241 sq. miles** | **HUC 14:** 05120201020060 | | | |
| Site is downstream of large low head dam in downtown Muncie. | | | | |
| **West Fork White River** | **Tillotson Ave. (WHI 313.4)** | **Lat./Long.** | 40.184975, | -85.421722 |
| **Drainage= 245 sq. miles** | **HUC 14:** 05120201020060 | | | |
| **West Fork White River** | **Above MWWPCF (WHI 311.7)** | **Lat./Long.** | 40.185396, | -85.439118 |
| **Drainage= 245 sq. miles** | **HUC 14:** 05120201020060 | | | |
| **West Fork White River** | **CR 400W/Nebo Rd. (WHI 310.7)** | **Lat./Long.** | 40.186045, | -85.462912 |
| **Drainage= 246 sq. miles** | **HUC 14:** 05120201020060 | | | |
| This is the first annual baseline site downstream of the MWPCF. | | | | |
| **West Fork White River** | **CR 575W (WHI 308.7)** | **Lat./Long.** | 40.177713, | -85.497803 |
| **Drainage= 248 sq. miles** | **HUC 14:** 05120201020060 | | | |
| **West Fork White River** | **CR 750W (WHI 306.5)** | **Lat./Long.** | 40.165253, | -85.530273 |
| **Drainage= 367 sq. miles** | **HUC 14:** 05120201030010 | | | |
| Flow is extremely fast at this site. | | | | |
| **West Fork White River** | **CR 300S (WHI 304.4)** | **Lat./Long.** | 40.148876, | -85.552838 |
| **Drainage= 370 sq. miles** | **HUC 14:** 05120201030020 | | | |
| Flow is very fast at this site. | | | | |
| **York Prairie Creek** | **Brook Rd./Storer Elem. (YOR 8.6)** | **Lat./Long.** | 40.206286, | -85.423686 |
| **Drainage= 4.00 sq. miles** | **HUC 14:** 05120201030010 | | | |
| **York Prairie Creek** | **CR 300W (YOR 7.4)** | **Lat./Long.** | 40.199781, | -85.443308 |
| **Drainage= 4.00 sq. miles** | **HUC 14:** 05120201030010 | | | |
| **York Prairie Creek** | **CR 400W (YOR 6.3)** | **Lat./Long.** | 40.193758, | -85.460747 |
| **Drainage= 4.00 sq. miles** | **HUC 14:** 05120201030010 | | | |

Table 7.—Tolerance values used in mIBI/HBI calculations.

| Species | Tolerance Value |
|---|---|
| Ablabesmyia | 5 |
| Ablabesmyia annulata | 4 |
| Ablabesmyia janta | 5 |
| Ablabesmyia mallochi | 5 |
| Acariformes | 4 |
| Acentrella | 4 |
| Acentrella ampla | 6 |
| Acentria | 5 |
| Acerpenna | 4 |
| Acerpenna macdunnoughi | 1 |
| Acerpenna pygmaea | 2 |
| Acroneuria | 1 |
| Acroneuria abnormis | 0 |
| Acroneuria evoluta | 3 |
| Acroneuria internata | 2 |
| Acroneuria lycorias | 2 |
| AESHNIDAE | 3 |
| Agabetes | 5 |
| Agabus | 5 |
| Agapetus | 0 |
| Agnetina | 2 |
| Agnetina annulipes | 2 |
| Agnetina capitata | 2 |
| Agnetina flavescens | 2 |
| Agraylea | 6 |
| Allocapnia | 3 |
| Allocapnia vivipara | 3 |
| Alloperla | 0 |
| Ameletus | 0 |
| Ameletus lineatus | 0 |
| Ameletus ludens | 0 |
| AMNICOLA | 5 |
| Amnicola limosus | 5 |
| Amphinemura | 3 |
| Amphinemura delosa | 3 |
| Amphinemura nigritta | 3 |
| AMPHIPODA | 4 |
| ANCYLIDAE | 6 |
| Ancyronyx variegatus | 4 |
| Anthopotamus | 4 |
| Anthopotamus verticis | 4 |
| Antocha | 2 |
| Arcteonais lomondi | 6 |
| Argia | 5 |
| ASELLIDAE | 8 |
| ASTACIDAE | 6 |
| ATHERICIDAE | 2 |
| Atractides | 6 |
| Atrichopogon | 5 |
| Atrichopogon websteri | 4 |

| Species | Tolerance Value |
|---|---|
| Attenella attenuata | 3 |
| Aulodrilus | 7 |
| Aulodrilus americanus | 7 |
| Aulodrilus limnobius | 7 |
| Aulodrilus pigueti | 7 |
| Aulodrilus pluriseta | 7 |
| BAETIDAE | 4 |
| Baetis | 3 |
| Baetis brunneicolor | 4 |
| Baetis flavistriga | 3 |
| Baetis intercalaris | 3 |
| Baetis tricaudatus | 4 |
| Baetisca | 4 |
| BAETISCIDAE | 3 |
| Basiaeschna | 6 |
| Basiaeschna janata | 6 |
| Belostoma flumineum | 4 |
| Berosus | 7 |
| Berosus peregrinus | 6 |
| Berosus striatus | 5 |
| BITHYNIA | 8 |
| Bithynia tentaculata | 8 |
| BLEPHARICERIDAE | 0 |
| vejdovskyanum | 7 |
| Boyeria | 2 |
| Boyeria vinosa | 4 |
| BRACHYCENTRIDAE | 1 |
| Brachycentrus lateralis | 1 |
| Brachycentrus numerosus | 1 |
| Brachycercus | 3 |
| BRANCHIOBDELLIDAE | 6 |
| Branchiura | 6 |
| Branchiura sowerbyi | 6 |
| Brillia | 5 |
| Caecidotea | 8 |
| Caecidotea communis | 8 |
| CAENIDAE | 7 |
| Caenis | 3 |
| Callibaetis | 6 |
| Calopteryx | 4 |
| Cambarus | 2 |
| Cambarus diogenes | 6 |
| CAPNIIDAE | 1 |
| Cardiocladius | 5 |
| Cardiocladius obscurus | 2 |
| Centroptilum | 3 |
| Ceraclea | 3 |
| Ceraclea ancylus | 3 |
| Ceraclea maculata | 4 |
| CERATOPOGONIDAE | 6 |

Table 7.—Tolerance values used in mIBI/HBI calculations (con't).

| Species | Tolerance Value |
|---|---|
| Ceratopsyche alhedra | 3 |
| Ceratopsyche bronta | 5 |
| Ceratopsyche morosa | 2 |
| Ceratopsyche slossonae | 2 |
| Ceratopsyche sparna | 3 |
| Chaetogaster | 7 |
| Chaetogaster diaphanus | 6 |
| Chaetogaster diastrophus | 6 |
| Chaetogaster limnaei | 6 |
| Chaoborus | 8 |
| Chauliodes | 4 |
| Cheumatopsyche | 3 |
| Chimarra | 4 |
| Chimarra aterrima | 2 |
| Chimarra obscura | 4 |
| Chimarra socia | 2 |
| CHIRONOMIDAE(all other) | 6 |
| CHIRONOMIDAE(blood red) | 8 |
| Chironomus | 8 |
| CHLOROPERLIDAE | 1 |
| Choroterpes | 4 |
| Chrysops | 5 |
| Cincinnatia cincinnatiensis | 5 |
| Cladopelma | 9 |
| Cladotanytarsus | 4 |
| Climacia | 5 |
| Clinotanypus pinguis | 8 |
| Clioperla clio | 1 |
| Cloeon | 4 |
| Cnephia mutata | 5 |
| COENAGRIONIDAE | 9 |
| Conchapelopia | 4 |
| Corbicula fluminea | 6 |
| Cordulegaster | 3 |
| CORDULEGASTRIDAE | 3 |
| CORDULIIDAE | 3 |
| CORIXIDAE | 5 |
| CORYDALIDAE | 1 |
| Corydalus cornutus | 2 |
| Corynoneura | 4 |
| Corynoneura celeripes | 2 |
| Crangonyx | 6 |
| Crenitis | 5 |
| Cricotopus | 4 |
| Cricotopus bicinctus | 7 |
| Cryptochironomus | 5 |
| Cryptochironomus blarina | 8 |
| Cryptochironomus fulvus | 8 |
| Cryptotendipes | 4 |
| CULICIDAE | 8 |

| Species | Tolerance Value |
|---|---|
| Culicoides | 10 |
| CURCULIONIDAE | 5 |
| Cyrnellus fraternus | 4 |
| Dannella | 2 |
| Dannella lita | 4 |
| Dero | 10 |
| Dero digitata | 10 |
| Dero furcata | 10 |
| Dero nivea | 10 |
| Dero obtusa | 10 |
| Dero vaga | 10 |
| Diamesa | 8 |
| Dibusa angata | 3 |
| Dicranota | 3 |
| Dicrotendipes | 6 |
| Dicrotendipes fumidus | 6 |
| Dicrotendipes modestus | 6 |
| Dicrotendipes neomodestus | 5 |
| Dineutus | 4 |
| Dineutus assimilis | 4 |
| Dineutus horni | 4 |
| Dineutus nigrior | 4 |
| Diplocladius cultriger | 8 |
| Dixa | 1 |
| DOLICHOPODIDAE | 4 |
| Dolophilodes | 0 |
| Doncricotopus bicaudatus | 5 |
| Dreissena polymorpha | 8 |
| Dromogomphus | 6 |
| Drunella walkeri | 0 |
| DRYOPIDAE | 5 |
| Dubiraphia | 5 |
| Dubiraphia bivittata | 3 |
| Dubiraphia quadrinotata | 3 |
| Eccoptura | 3 |
| Eclipidrilus | 5 |
| Ectopria | 5 |
| Ectopria nervosa | 4 |
| Elliptio complanata | 8 |
| ELMIDAE | 4 |
| EMPIDIDAE | 6 |
| Enallagma | 9 |
| ENCHYTRAEIDAE | 10 |
| Endochironomus | 6 |
| Endochironomus nigricans | 5 |
| Epeorus | 0 |
| Ephemera | 3 |
| Ephemerella | 3 |
| Ephemerella dorothea | 1 |
| Ephemerella excrucians | 1 |

Table 7.—Tolerance values used in mIBI/HBI calculations (con't).

| Species | Tolerance Value |
|---|---|
| Ephemerella invaria | 1 |
| Ephemerella needhami | 2 |
| Ephemerella subvaria | 1 |
| EPHEMERELLIDAE | 1 |
| EPHEMERIDAE | 4 |
| Ephoron | 2 |
| Ephoron leukon | 2 |
| EPHYDRIDAE | 6 |
| Erythemis | 2 |
| Eukiefferiella claripennis | 8 |
| Eurylophella | 2 |
| Eurylophella bicolor | 1 |
| Eurylophella funeralis | 2 |
| Eurylophella temporalis | 5 |
| Ferrissia | 6 |
| Ferrissia parallelus | 6 |
| Ferrissia rivularis | 6 |
| Ferrissia walkeri | 6 |
| Fossaria | 6 |
| GAMMARIDAE | 4 |
| Gammarus | 6 |
| Gammarus fasciatus | 6 |
| Gammarus pseudolimnaeus | 4 |
| GASTROPODA | 7 |
| Glossosoma | 0 |
| GLOSSOSOMATIDAE | 0 |
| Glyptotendipes | 6 |
| Goera | 3 |
| GOMPHIDAE | 1 |
| Gomphus | 5 |
| Goniobasis | 6 |
| Goniobasis livescens | 6 |
| Gyraulus | 8 |
| Gyraulus circumstriatus | 8 |
| Gyraulus deflectus | 8 |
| Gyraulus parvus | 8 |
| Gyrinus | 4 |
| Haemonais waldvogeli | 8 |
| Hagenius brevistylus | 1 |
| Haliplus | 6 |
| Haliplus borealis | 5 |
| Haliplus connexus | 6 |
| Haliplus cribrarius | 6 |
| Haliplus immaculicollis | 6 |
| Haliplus longulus | 6 |
| Haliplus pantherinus | 6 |
| Haploperla brevis | 1 |
| HAPLOTAXIDAE | 5 |
| Harnischia | 8 |
| Harnischia curtilamellata | 4 |

| Species | Tolerance Value |
|---|---|
| Helichus | 5 |
| Helichus striatus | 2 |
| Helicopsyche borealis | 3 |
| HELICOPSYCHIDAE | 3 |
| Helisoma | 6 |
| Helisoma anceps | 6 |
| Helius | 4 |
| Helobdella | 10 |
| Helobdella stagnalis | 8 |
| Helobdella triserialis | 8 |
| Helochares | 5 |
| Helophorus | 5 |
| Heptagenia | 3 |
| Heptagenia diabasia | 2 |
| Heptagenia flavescens | 4 |
| Heptagenia pulla | 4 |
| HEPTAGENIIDAE | 4 |
| Hesperocorixa | 5 |
| Hesperocorixa interrupta | 5 |
| Hesperocorixa lucida | 5 |
| Hesperocorixa vulgaris | 5 |
| Hetaerina | 3 |
| Heterocloeon | 3 |
| Heterocloeon curiosum | 2 |
| Heterotrissocladius | 0 |
| Hexagenia | 4 |
| Hexagenia limbata | 3 |
| Hexatoma | 2 |
| HIRUDINEA | 8 |
| Hyalella azteca | 8 |
| Hydatophylax | 2 |
| Hydrobaenus | 8 |
| HYDROBIIDAE | 7 |
| Hydrobius | 5 |
| Hydrobius fuscipes | 4 |
| Hydrochara | 5 |
| Hydrochus | 5 |
| Hydroporus | 4 |
| Hydropsyche | 4 |
| Hydropsyche betteni | 6 |
| Hydropsyche bidens | 3 |
| Hydropsyche depravata | 6 |
| Hydropsyche dicantha | 4 |
| Hydropsyche frisoni | 2 |
| Hydropsyche orris | 3 |
| Hydropsyche phalerata | 1 |
| Hydropsyche scalaris | 2 |
| Hydropsyche simulans | 2 |
| Hydropsyche valanis | 3 |
| Hydropsyche venularis | 3 |

Table 7.—Tolerance values used in mIBI/HBI calculations (con't).

| Species | Tolerance Value |
|---|---|
| HYDROPSYCHIDAE | 4 |
| Hydroptila | 3 |
| Hydroptila albicornis | 6 |
| Hydroptila armata | 6 |
| Hydroptila consimilis | 6 |
| Hydroptila hamata | 6 |
| Hydroptila spatulata | 6 |
| Hydroptila waubesiana | 6 |
| HYDROPTILIDAE | 4 |
| Ilybius biguttulus | 8 |
| Ilyodrilus templetoni | 10 |
| Ischnura | 9 |
| Isochaetides freyi | 8 |
| Isonychia | 2 |
| Isonychia bicolor | 2 |
| ISONYCHIIDAE | 2 |
| Isoperla | 2 |
| Isoperla dicala | 2 |
| Isoperla frisoni | 2 |
| Isoperla namata | 2 |
| ISOPODA | 8 |
| Isotomurus | 5 |
| Labrundinia | 4 |
| Labrundinia pilosella | 3 |
| Laccobius | 2 |
| Laccobius spangleri | 4 |
| Laccophilus | 8 |
| Laccophilus maculosus | 8 |
| maculosus | 8 |
| Lampsilis radiata radiata | 6 |
| Larsia | 4 |
| Lebertia | 4 |
| Lepidostoma | 1 |
| LEPIDOSTOMATIDAE | 1 |
| LEPTOCERIDAE | 4 |
| Leptocerus americanus | 4 |
| Leptophlebia | 4 |
| LEPTOPHLEBIIDAE | 2 |
| Leucrocuta | 2 |
| Leucrocuta aphrodite | 1 |
| Leucrocuta hebe | 3 |
| Leucrocuta maculipennis | 2 |
| Leuctra | 0 |
| Leuctra ferruginea | 0 |
| Leuctra tenuis | 0 |
| LEUCTRIDAE | 0 |
| Libellula | 9 |
| LIBELLULIDAE | 9 |
| LIMNEPHILIDAE | 4 |
| Limnephilus | 3 |

| Species | Tolerance Value |
|---|---|
| Limnodrilus cervix | 10 |
| Limnodrilus claparedianus | 10 |
| Limnodrilus hoffmeisteri | 10 |
| Limnodrilus profundicola | 10 |
| Limnodrilus udekemianus | 10 |
| Limnophila | 3 |
| Limonia | 6 |
| Liodessus affinis | 6 |
| Liodessus flavicollis | 6 |
| Lirceus | 8 |
| LUMBRICULIDAE | 5 |
| Lutrochus laticeps | 3 |
| Lymnaea | 6 |
| adpressa | 6 |
| LYMNAEIDAE | 6 |
| Lype diversa | 3 |
| Maccaffertium exiguum | 2 |
| Maccaffertium luteum | 4 |
| mediopunctatum | 2 |
| integrum | 3 |
| Maccaffertium modestum | 1 |
| Maccaffertium pudicum | 2 |
| Maccaffertium pulchellum | 2 |
| Maccaffertium terminatum | 2 |
| Maccaffertium vicarium | 2 |
| Macromia | 2 |
| MACROMIIDAE | 3 |
| Macronychus glabratus | 3 |
| Macrostemum | 3 |
| Macrostemum carolina | 3 |
| Macrostemum zebratum | 2 |
| METRETOPODIDAE | 2 |
| Micrasema rusticum | 2 |
| Microcylloepus pusillus | 3 |
| Micropsectra | 4 |
| Microtendipes | 7 |
| Microtendipes caelum | 3 |
| Molanna | 6 |
| Molanna blenda | 4 |
| MOLANNIDAE | 6 |
| MUSCIDAE | 6 |
| Musculium | 6 |
| Musculium partumeium | 6 |
| Musculium transversum | 6 |
| Mystacides | 4 |
| Mystacides sepulchralis | 4 |
| NAIDIDAE | 8 |
| Nais | 8 |
| Nais barbata | 8 |
| Nais behningi | 6 |

Table 7.—Tolerance values used in mIBI/HBI calculations (con't).

| Species | Tolerance Value |
|---|---|
| Nais bretscheri | 6 |
| Nais communis | 8 |
| Nais elinguis | 10 |
| Nais pardalis | 8 |
| Nais simplex | 6 |
| Nais variabilis | 10 |
| Nanocladius | 5 |
| Nanocladius distinctus | 6 |
| Nanocladius spiniplenus | 4 |
| Natarsia | 6 |
| Natarsia baltimoreus | 6 |
| Nectopsyche | 2 |
| Nectopsyche diarina | 3 |
| Nectopsyche exquisita | 3 |
| Nectopsyche pavida | 2 |
| NEMATODA | 6 |
| Nemoura | 1 |
| NEMOURIDAE | 2 |
| Neoperla | 3 |
| Neophylax | 3 |
| Neophylax concinnus | 3 |
| Neophylax fuscus | 3 |
| Neotrichia | 4 |
| Neureclipsis | 3 |
| Neurocordulia obsoleta | 0 |
| Nigronia fasciatus | 2 |
| Nigronia serricornis | 4 |
| Nilotanypus | 6 |
| Nilotanypus fimbriatus | 3 |
| Nilothauma | 3 |
| Nixe | 3 |
| Nixe perfida | 5 |
| Nyctiophylax | 3 |
| Nyctiophylax moestus | 5 |
| Nymphula | 7 |
| Ochrotrichia | 2 |
| ODONTOCERIDAE | 0 |
| Oecetis | 3 |
| OLIGOCHAETA | 8 |
| OLIGONEURIIDAE | 2 |
| Oligostomis | 2 |
| Ophidonais serpentina | 6 |
| Ophiogomphus | 1 |
| Optioservus | 4 |
| Optioservus fastiditus | 2 |
| Optioservus trivittatus | 4 |
| Orconectes | 4 |
| Orconectes propinquus | 4 |
| Orconectes rusticus | 6 |
| Orconectes virilis | 6 |

| Species | Tolerance Value |
|---|---|
| Orthocladius | 4 |
| Orthocladius carlatus | 2 |
| Orthotrichia | 6 |
| Oulimnius | 4 |
| Oulimnius latiusculus | 4 |
| Oxyethira | 5 |
| Pagastia | 1 |
| Palmacorixa | 5 |
| Palmacorixa buenoi | 4 |
| Palmacorixa gillettei | 4 |
| Palmacorixa nana | 4 |
| Paracapnia | 1 |
| Paracapnia angulata | 1 |
| Parachironomus | 4 |
| Parachironomus carinatus | 5 |
| Parachironomus frequens | 4 |
| Paracladopelma | 7 |
| Paragnetina | 2 |
| Paragnetina media | 2 |
| Parakiefferiella | 5 |
| Paraleptophlebia | 3 |
| Paraleptophlebia guttata | 1 |
| Paraleptophlebia moerens | 1 |
| Paraleptophlebia mollis | 1 |
| Paraleuctra | 0 |
| Parametriocnemus | 3 |
| lundbeckii | 5 |
| Paranais frici | 10 |
| Paraponyx | 5 |
| Paratanytarsus | 4 |
| Paratendipes | 6 |
| Paratendipes albimanus | 4 |
| Pedicia | 4 |
| Pelocoris femoratus | 4 |
| Peltodytes | 7 |
| Peltodytes edentulus | 6 |
| Peltodytes tortulosus | 6 |
| Pentaneura | 6 |
| Pentaneura inconspicua | 5 |
| Pericoma | 6 |
| Perlesta | 4 |
| Perlesta placida | 5 |
| PERLIDAE | 1 |
| Perlinella drymo | 1 |
| PERLODIDAE | 2 |
| Petrophila | 5 |
| Phaenopsectra | 7 |
| Phaenopsectra flavipes | 6 |
| Phaenopsectra punctipes | 4 |
| PHILOPOTAMIDAE | 3 |

Table 7.—Tolerance values used in mIBI/HBI calculations (con't).

| Species | Tolerance Value |
|---|---|
| PHRYGANEIDAE | 4 |
| Phylocentropus | 4 |
| Physa | 8 |
| Physella | 8 |
| Physella gyrina | 8 |
| Physella heterostropha | 8 |
| Physella integra | 8 |
| PHYSIDAE | 8 |
| Pilaria | 7 |
| PISIDIIDAE | 8 |
| Pisidium | 6 |
| Pisidium casertanum | 6 |
| Pisidium compressum | 6 |
| Pisidium variabile | 6 |
| Placobdella montifera | 8 |
| PLANORBIDAE | 6 |
| Plathemis lydia | 8 |
| Platycentropus | 4 |
| Plauditus | 4 |
| Plauditus punctiventris | 2 |
| Pleurocera acuta | 6 |
| PLEUROCERIDAE | 6 |
| POLYCENTROPODIDAE | 6 |
| Polycentropus | 3 |
| POLYMITARCYIDAE | 2 |
| Polypedilum aviceps | 2 |
| Polypedilum convictum | 4 |
| Polypedilum illinoense | 7 |
| Polypedilum ontario | 3 |
| POTAMANTHIDAE | 4 |
| Potamothrix moldaviensis | 8 |
| Potamothrix vejdovskyi | 8 |
| Potamyia | 5 |
| Potamyia flava | 3 |
| Pristina | 8 |
| Pristina aequiseta | 8 |
| Pristina breviseta | 8 |
| Pristina leidyi | 8 |
| Pristina synclites | 8 |
| Pristinella | 8 |
| Pristinella jenkinae | 8 |
| Pristinella osborni | 8 |
| Probythinella lacustris | 8 |
| Procladius | 7 |
| Prodiamesa olivacea | 3 |
| Prostoia | 2 |
| Protoplasa | 3 |
| Protoptila | 1 |
| Psectrocladius | 6 |
| Psectrotanypus | 8 |

| Species | Tolerance Value |
|---|---|
| Psectrotanypus dyari | 9 |
| PSEPHENIDAE | 4 |
| Psephenus | 4 |
| Psephenus herricki | 4 |
| Pseudochironomus | 5 |
| Pseudocloeon | 2 |
| Pseudocloeon dardanus | 2 |
| Pseudocloeon propinquus | 1 |
| Pseudolimnophila | 2 |
| Pseudostenophylax | 0 |
| Pseudosuccinea columella | 6 |
| Psychoda | 4 |
| PSYCHODIDAE | 10 |
| Psychomyia flavida | 2 |
| PSYCHOMYIIDAE | 2 |
| PTERONARCYIDAE | 0 |
| Pteronarcys | 0 |
| Pteronarcys dorsata | 0 |
| Ptilostomis | 5 |
| Pycnopsyche | 3 |
| Pyganodon cataracta | 6 |
| PYRALIDAE | 5 |
| Quistradrilus multisetosus | 10 |
| Radix auricularia | 6 |
| Ranatra fusca | 4 |
| Ranatra nigra | 4 |
| Rheocricotopus | 5 |
| Rheocricotopus robacki | 4 |
| Rheotanytarsus | 3 |
| Rhithrogena | 0 |
| Rhyacodrilus | 10 |
| Rhyacophila | 1 |
| Rhyacophila glaberrima | 1 |
| RHYACOPHILIDAE | 0 |
| Ripistes parasita | 8 |
| Saetheria tylus | 4 |
| SCIRTIDAE | 5 |
| SERICOSTOMATIDAE | 3 |
| Serratella | 1 |
| Serratella deficiens | 2 |
| Setodes | 2 |
| Shipsa rotunda | 2 |
| SIALIDAE | 4 |
| Sialis | 5 |
| Sigara alternata | 4 |
| Sigara grossolineata | 4 |
| Sigara mathesoni | 4 |
| Sigara modesta | 4 |
| Sigara signata | 4 |
| Sigara variabilis | 4 |

Table 7.—Tolerance values used in mIBI/HBI calculations (con't).

| Species | Tolerance Value |
|---|---|
| SIMULIIDAE | 6 |
| Simulium | 5 |
| Simulium venustum | 5 |
| Simulium vittatum | 7 |
| SIPHLONURIDAE | 7 |
| Siphlonurus | 4 |
| Siphloplecton | 2 |
| Slavina appendiculata | 6 |
| Somatochlora | 1 |
| Sperchon | 4 |
| Sphaerium | 6 |
| Sphaerium striatinum | 6 |
| Spirosperma ferox | 6 |
| catascopium | 6 |
| Stagnicola elodes | 6 |
| Stempellinella | 3 |
| Stenacron | 3 |
| Stenacron carolina | 2 |
| Stenacron interpunctatum | 7 |
| Stenelmis | 5 |
| Stenelmis bicarinata | 5 |
| Stenelmis crenata | 5 |
| Stenelmis musgravei | 5 |
| Stenelmis sandersoni | 5 |
| Stenelmis vittipennis | 5 |
| Stenochironomus | 4 |
| Stenonema | 3 |
| Stenonema femoratum | 3 |
| Stictochironomus | 4 |
| Strophopteryx | 3 |
| Strophopteryx fasciata | 3 |
| Stylaria lacustris | 8 |
| Stylodrilus heringianus | 5 |
| Stylogomphus | 1 |
| Stylurus | 4 |
| Sublettea coffmani | 2 |
| Sweltsa | 0 |
| Sympetrum | 10 |
| SYRPHIDAE | 10 |
| TABANIDAE | 6 |
| Tabanus | 5 |
| TAENIOPTERYGIDAE | 2 |
| Taeniopteryx | 2 |
| Taeniopteryx burksi | 2 |
| Taeniopteryx nivalis | 2 |
| Taeniopteryx parvula | 2 |
| TALITRIDAE | 8 |
| Tanypus | 9 |
| Tanypus neopunctipennis | 8 |
| Tanytarsus | 4 |

| Species | Tolerance Value |
|---|---|
| Telopelopia okoboji | 4 |
| Thienemanniella | 4 |
| Thienemanniella similis | 2 |
| Thienemanniella xena | 4 |
| Tipula | 7 |
| Tipula abdominalis | 4 |
| TIPULIDAE | 3 |
| Tribelos | 5 |
| Trichocorixa | 5 |
| Trichocorixa calva | 4 |
| Trichocorixa kanza | 4 |
| Trichocorixa sexcincta | 4 |
| TRICORYTHIDAE | 4 |
| Tricorythodes | 3 |
| Tubifex | 10 |
| Tubifex tubifex | 10 |
| TUBIFICIDAE | 10 |
| TURBELLARIA | 4 |
| Tvetenia | 5 |
| Ulomorpha | 4 |
| UNIONIDAE | 6 |
| Valvata | 8 |
| Valvata lewisi | 8 |
| Valvata piscinalis | 8 |
| Valvata sincera | 8 |
| Valvata tricarinata | 8 |
| VALVATIDAE | 8 |
| Vejdovskyella | 6 |
| Vejdovskyella intermedia | 6 |
| VIVIPARIDAE | 6 |
| Viviparus georgianus | 6 |
| Wormaldia | 2 |
| Xenochironomus xenolabis | 0 |
| Xylotopus | 2 |
| Zavrelimyia | 4 |

Table 8.—Scores for macroinvertebrate sites, 2018.

| | BUC 15.2 | BUC 14.9 | BUC 13.8 | BUC 11.3 | BUC 9.5 | BUC 9.2 | BUC 8.0 |
|---|---|---|---|---|---|---|---|
| **mIBI Submetrics** | | | | | | | |
| Total # of Taxa | 3 | 3 | 3 | 3 | 3 | 5 | 3 |
| Total Abundance | 1 | 1 | 1 | 1 | 1 | 3 | 3 |
| Number EPT Taxa | 1 | 3 | 1 | 1 | 1 | 3 | 1 |
| % Orthocladiinae & Tanytarsini | 5 | 5 | 3 | 5 | 3 | 3 | 5 |
| % Non-Insects (minus Crayfish | 5 | 5 | 3 | 5 | 5 | 3 | 1 |
| # Diptera Taxa | 1 | 3 | 1 | 3 | 3 | 5 | 3 |
| % Intolerant Taxa (Score 0-3) | 3 | 1 | 1 | 1 | 1 | 1 | 1 |
| % Tolerant Taxa (Score 8-10) | 5 | 5 | 1 | 5 | 5 | 1 | 1 |
| % Predators | 3 | 3 | 3 | 3 | 5 | 3 | 3 |
| % Shredders & Scrapers | 1 | 1 | 5 | 1 | 1 | 5 | 5 |
| % Collector/Filterers | 5 | 3 | 5 | 5 | 5 | 5 | 5 |
| % Sprawlers | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 34 | 34 | 28 | 34 | 34 | 38 | 32 |
| | *Poor* | *Poor* | *Poor* | *Poor* | *Poor* | *Fair* | *Poor* |
| **Stand Alone Indices** | | | | | | | |
| Hilsenhoff Index | 4.93 | 4.77 | 6.60 | 5.00 | 4.44 | 6.05 | 6.38 |
| | *Good* | *Good* | *Fairly Poor* | *Good* | *Very Good* | *Fair* | *Fair* |
| Shannon Index of Diversity (H') | 2.55 | 2.77 | 2.59 | 3.00 | 2.39 | 3.07 | 2.47 |
| Shannon Evenness Index (J') | 0.84 | 0.87 | 0.80 | 0.93 | 0.73 | 0.80 | 0.76 |
| % Dominance of Top 3 Taxa | 0.49 | 0.36 | 0.53 | 0.31 | 0.60 | 0.47 | 0.56 |
| % Chironomidae | 0.00 | 0.12 | 0.03 | 0.20 | 0.08 | 0.12 | 0.13 |
| **QHEI Scores** | 66.0 | 64.75 | 59.25 | 39.5 | 51 | 49.3 | 46 |
| | *Fair* | *Fair* | *Fair* | *Poor* | *Poor* | *Poor* | *Poor* |

Table 8.—Scores for macroinvertebrate sites, 2018 (con't).

| | BUC 5.9 | BUC 4.0 | BUC 0.9 | BUC 0.2 | BUC 0.0 | GRE 0.1 | MUN 2.2 |
|---|---|---|---|---|---|---|---|
| **mIBI Submetrics** | | | | | | | |
| Total # of Taxa | 3 | 3 | 1 | 3 | 3 | 5 | 1 |
| Total Abundance | 1 | 1 | 1 | 1 | 1 | 5 | 1 |
| Number EPT Taxa | 1 | 1 | 1 | 3 | 1 | 1 | 1 |
| % Orthocladiinae & Tanytarsini | 5 | 5 | 5 | 5 | 5 | 3 | 5 |
| % Non-Insects (minus Crayfish | 1 | 5 | 3 | 3 | 5 | 5 | 1 |
| # Diptera Taxa | 3 | 3 | 1 | 1 | 3 | 5 | 1 |
| % Intolerant Taxa (Score 0-3) | 1 | 1 | 1 | 3 | 1 | 1 | 1 |
| % Tolerant Taxa (Score 8-10) | 1 | 5 | 5 | 1 | 3 | 3 | 1 |
| % Predators | 1 | 3 | 3 | 1 | 1 | 3 | 1 |
| % Shredders & Scrapers | 5 | 3 | 1 | 5 | 5 | 1 | 5 |
| % Collector/Filterers | 5 | 5 | 5 | 5 | 3 | 5 | 5 |
| % Sprawlers | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| | 28 | 36 | 28 | 32 | 34 | 38 | 24 |
| | *Poor* | *Fair* | *Poor* | *Poor* | *Poor* | *Fair* | *Poor* |
| **Stand Alone Indices** | | | | | | | |
| Hilsenhoff Index | 6.85 | 5.65 | 5.63 | 5.57 | 5.24 | 6.96 | 7.64 |
| | *Fairly Poor* | *Fair* | *Fair* | *Fair* | *Good* | *Fairly Poor* | *Poor* |
| Shannon Index of Diversity (H') | 2.48 | 2.89 | 2.52 | 2.66 | 3.14 | 3.47 | 2.22 |
| Shannon Evenness Index (J') | 0.74 | 0.87 | 0.89 | 0.83 | 0.93 | 0.85 | 0.89 |
| % Dominance of Top 3 Taxa | 0.57 | 0.40 | 0.48 | 0.50 | 0.30 | 0.27 | 0.58 |
| % Chironomidae | 0.24 | 0.49 | 0.09 | 0.00 | 0.28 | 0.17 | 0.04 |
| **QHEI Scores** | 55.3 | 57.75 | 70.5 | 65.25 | 73 | 46.25 | 43.5 |
| | *Fair* | *Fair* | *Fair* | *Fair* | *Good* | *Poor* | *Poor* |

Table 8.—Scores for macroinvertebrate sites, 2018 (con't).

| | MUN 0.1 | WHI 333.4 | WHI 328.1 | WHI 326.9 | WHI 322.2 | WHI 320.1 | WHI 318.8 |
|---|---|---|---|---|---|---|---|
| **mIBI Submetrics** | | | | | | | |
| Total # of Taxa | 1 | 5 | 5 | 5 | 5 | 3 | 3 |
| Total Abundance | 1 | 5 | 3 | 5 | 5 | 1 | 1 |
| Number EPT Taxa | 1 | 5 | 5 | 5 | 5 | 3 | 3 |
| % Orthocladiinae & Tanytarsini | 5 | 5 | 1 | 3 | 5 | 1 | 5 |
| % Non-Insects (-Crayfish) | 5 | 5 | 5 | 5 | 3 | 5 | 5 |
| # Diptera Taxa | 1 | 1 | 3 | 3 | 3 | 1 | 1 |
| % Intolerant Taxa (Score 0-3) | 1 | 5 | 5 | 5 | 5 | 3 | 3 |
| % Tolerant Taxa (Score 8-10) | 5 | 5 | 5 | 5 | 3 | 5 | 5 |
| % Predators | 1 | 1 | 1 | 1 | 1 | 1 | 5 |
| % Shredders & Scrapers | 1 | 5 | 1 | 5 | 3 | 1 | 1 |
| % Collector/Filterers | 3 | 5 | 1 | 3 | 3 | 5 | 5 |
| % Sprawlers | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 26 | 48 | 36 | 46 | 42 | 30 | 38 |
| | *Poor* | *Good* | *Fair* | *Good* | *Fair* | *Poor* | *Fair* |
| **Stand Alone Indices** | | | | | | | |
| Hilsenhoff Index | 5.67 | 4.23 | 4.16 | 4.24 | 4.86 | 4.33 | 3.56 |
| | *Fair* | *Very Good* | *Very Good* | *Very Good* | *Good* | *Very Good* | *Very Good* |
| Shannon Index of Diversity (H') | 1.09 | 3.29 | 3.47 | 3.41 | 3.24 | 3.12 | 2.44 |
| Shannon Evenness Index (J') | 0.79 | 0.84 | 0.88 | 0.84 | 0.79 | 0.91 | 0.77 |
| % Dominance of Top 3 Taxa | 0.90 | 0.34 | 0.22 | 0.31 | 0.34 | 0.29 | 0.54 |
| % Chironomidae | 0.00 | 0.00 | 0.10 | 0.07 | 0.04 | 0.03 | 0.00 |
| **QHEI Scores** | 55.8 | 75.25 | 80.75 | 72 | 66.5 | 66.75 | 69.00 |
| | *Fair* | *Good* | *Good* | *Good* | *Fair* | *Fair* | *Fair* |

Table 8.—Scores for macroinvertebrate sites, 2018 (con't).

| | WHI 318.3 | WHI 317.6 | WHI 317.2 | WHI 315.8 | WHI 315.0 | WHI 313.4 | WHI 311.7 |
|---|---|---|---|---|---|---|---|
| **mIBI Submetrics** | | | | | | | |
| Total # of Taxa | 3 | 5 | 3 | 3 | 1 | 5 | 3 |
| Total Abundance | 1 | 5 | 1 | 1 | 1 | 3 | 1 |
| Number EPT Taxa | 3 | 3 | 3 | 3 | 3 | 5 | 3 |
| % Orthocladiinae & Tanytarsini | 5 | 3 | 5 | 5 | 5 | 5 | 5 |
| % Non-Insects (-Crayfish) | 5 | 1 | 5 | 5 | 5 | 1 | 3 |
| # Diptera Taxa | 1 | 3 | 1 | 1 | 1 | 5 | 3 |
| % Intolerant Taxa (Score 0-3) | 5 | 3 | 1 | 5 | 5 | 3 | 3 |
| % Tolerant Taxa (Score 8-10) | 5 | 1 | 5 | 5 | 5 | 3 | 3 |
| % Predators | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| % Shredders & Scrapers | 3 | 3 | 3 | 5 | 1 | 5 | 3 |
| % Collector/Filterers | 5 | 5 | 5 | 5 | 5 | 3 | 5 |
| % Sprawlers | 1 | 1 | 3 | 1 | 1 | 1 | 1 |
| | 38 | 34 | 36 | 40 | 34 | 40 | 34 |
| | *Fair* | *Poor* | *Fair* | *Fair* | *Poor* | *Fair* | *Poor* |
| **Stand Alone Indices** | | | | | | | |
| Hilsenhoff Index | 3.71 | 6.06 | 5.15 | 3.81 | 3.33 | 5.63 | 5.22 |
| | *Very Good* | *Fair* | *Good* | *Very Good* | *Excellent* | *Fair* | *Good* |
| Shannon Index of Diversity (H') | 2.90 | 2.91 | 3.13 | 2.65 | 1.74 | 3.23 | 3.22 |
| Shannon Evenness Index (J') | 0.91 | 0.73 | 0.86 | 0.82 | 0.59 | 0.82 | 0.89 |
| % Dominance of Top 3 Taxa | 0.36 | 0.50 | 0.39 | 0.46 | 0.59 | 0.40 | 0.31 |
| % Chironomidae | 0.04 | 0.06 | 0.00 | 0.00 | 0.01 | 0.23 | 0.10 |
| **QHEI Scores** | 68.25 | 66.75 | 61.5 | 75.3 | 60.5 | 65.8 | 58.8 |
| | *Fair* | *Fair* | *Fair* | *Good* | *Fair* | *Fair* | *Fair* |

Table 8.—Scores for macroinvertebrate sites, 2018 (con't).

| | **WHI 310.7** | **WHI 308.7** | **WHI 306.5** | **WHI 304.4** | **YOR 8.6** | **YOR 7.4** | **YOR 6.3** |
|---|---|---|---|---|---|---|---|
| **mIBI Submetrics** | | | | | | | |
| Total # of Taxa | 3 | 5 | 5 | 3 | 1 | 3 | 3 |
| Total Abundance | 3 | 5 | 3 | 3 | 1 | 1 | 1 |
| Number EPT Taxa | 1 | 5 | 5 | 3 | 1 | 3 | 3 |
| % Orthocladiinae & Tanytarsini | 5 | 3 | 3 | 5 | 5 | 5 | 5 |
| % Non-Insects (-Crayfish) | 3 | 3 | 1 | 1 | 5 | 5 | 3 |
| # Diptera Taxa | 3 | 3 | 1 | 1 | 1 | 1 | 1 |
| % Intolerant Taxa (Score 0-3) | 3 | 5 | 5 | 3 | 1 | 1 | 1 |
| % Tolerant Taxa (Score 8-10) | 5 | 5 | 3 | 5 | 5 | 3 | 5 |
| % Predators | 5 | 1 | 1 | 1 | 1 | 1 | 3 |
| % Shredders & Scrapers | 5 | 5 | 5 | 5 | 1 | 3 | 1 |
| % Collector/Filterers | 5 | 5 | 3 | 5 | 5 | 5 | 3 |
| % Sprawlers | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 42 | 46 | 36 | 36 | 28 | 32 | 30 |
| | *Fair* | *Good* | *Fair* | *Fair* | *Poor* | *Poor* | *Poor* |
| **Stand Alone Indices** | | | | | | | |
| Hilsenhoff Index | 4.66 | 4.51 | 4.86 | 5.22 | 6.00 | 6.36 | 5.33 |
| | *Good* | *Very Good* | *Good* | *Good* | *Fair* | *Fair* | *Good* |
| Shannon Index of Diversity (H') | 2.60 | 3.47 | 3.30 | 2.61 | 1.35 | 2.45 | 2.90 |
| Shannon Evenness Index (J') | 0.74 | 0.83 | 0.87 | 0.71 | 0.51 | 0.81 | 0.91 |
| % Dominance of Top 3 Taxa | 0.56 | 0.34 | 0.32 | 0.58 | 0.55 | 0.55 | 0.35 |
| % Chironomidae | 0.06 | 0.06 | 0.03 | 0.04 | 0.00 | 0.06 | 0.00 |
| **QHEI Scores** | 69.5 | 75.8 | 82.0 | 79.8 | 43.75 | 46.8 | 66.5 |
| | *Fair* | *Good* | *Good* | *Good* | *Poor* | *Poor* | *Fair* |

Table 9.—Mean scores for macroinvertebrate metrics, 2018.

| **Mean Scores** | **mIBI** | **Rating** |
|---|---|---|
| WFWR Upstream of Muncie | 40.4 | *Fair* |
| WFWR Within Muncie | 36.3 | *Fair* |
| WFWR Downstream of Muncie | 40.0 | *Fair* |
| Buck Creek | 32.7 | *Poor* |

| **Mean Scores** | **% Dom** |
|---|---|
| WFWR Upstream of Muncie | 0.30 |
| WFWR Within Muncie | 0.43 |
| WFWR Downstream of Muncie | 0.45 |
| Buck Creek | 0.5 |

| **Mean Scores** | **HBI** | **Rating** |
|---|---|---|
| WFWR Upstream of Muncie | 4.36 | *Very Good* |
| WFWR Within Muncie | 4.63 | *Good* |
| WFWR Downstream of Muncie | 4.81 | *Good* |
| Buck Creek | 5.6 | *Fair* |

| **Mean Scores** | **% Chiron.** |
|---|---|
| WFWR Upstream of Muncie | 0.05 |
| WFWR Within Muncie | 0.06 |
| WFWR Downstream of Muncie | 0.04 |
| Buck Creek | 0.1 |

| **Mean Scores** | **H'** |
|---|---|
| WFWR Upstream of Muncie | 3.31 |
| WFWR Within Muncie | 2.82 |
| WFWR Downstream of Muncie | 3.00 |
| Buck Creek | 2.71 |

| **Mean Scores** | **QHEI** | **Rating** |
|---|---|---|
| WFWR Upstream of Muncie | 72.3 | *Good* |
| WFWR Within Muncie | 65.3 | *Fair* |
| WFWR Downstream of Muncie | 76.8 | *Good* |
| Buck Creek | 58.1 | *Fair* |

| **Mean Scores** | **J'** |
|---|---|
| WFWR Upstream of Muncie | 0.85 |
| WFWR Within Muncie | 0.80 |
| WFWR Downstream of Muncie | 0.79 |
| Buck Creek | 0.8 |

Table 10.—Field sheet for all macroinvertebrate sampling.

## Bureau of Water Quality
## Macroinvertebrate Sampling Field Sheet

Name of Stream ________________________ Station ________________________
Collection Date ________________________ County ________________________
Sample ID ________________________ Method ________________________
Number of Samples ________________________
Collection Notes ________________________________________________
________________________________________________
________________________________________________

If riffle present score it 1 then rank all other habitat present

________ Natural Riffle
________ Artificial Riffle (Rip/Rap)
________ Slab/Bedrock ☐ w/ silt cover ☐ w/out silt cover
________ Cobble ☐ w/ silt cover ☐ w/out silt cover
________ Gravel ☐ w/ silt cover ☐ w/out silt cover
________ Sand ☐ w/ silt cover ☐ w/out silt cover
________ Mud/Silt
________ Undercut Banks (Trees, roots, root wads)
________ Riparian Vegetation (e.g. Grass)
________ Water Willow, Root Mats
________ Leaf Mats
________ Logs/Woody Debris
________ Submerged Macrophytes
________ Filatementous Algae/Duckweed
________ Other

Undercut?
No ☐ Mean depth ☐
Slight ☐ Mean width ☐
Very ☐ Max depth ☐
Water Clarity ☐ High water mark ☐
Clear ☐
Slight Turbid ☐
Turbid ☐

Incident Radiation ☐ %

**Aesthetics**
Foam ☐
Discoloration ☐
Foam/Scum ☐
Oil Sheen ☐
Trash/Litter ☐
Nuisance Odor ☐
Sludge deposits ☐
CSOs/SSOs/Outfalls ☐
Impoundment ☐
Bridge ☐

Inc. Rad.= how much shade there would be if the sun was directly overhead
summer foliage, verticle incidence, canopy cover

Date/Initials
Sample in lab ____________
Macro I.D. ____________
Chironomid I.D. ____________
Macro taxa entered ____________
Chiron taxa entered ____________
Taxa proofed ____________

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**Bureau of Water Quality - Habitat Summary** **QHEI Score: 46.8**

STREAM: YPC
DATE: 7/11/18
STATION: 300 W.
SCORERS NAME: LAB
SAMPLE#:
SITE ID: YOR - 8.6

**1)SUBSTRATE** (check only two substrate TYPE boxes)

| TYPE | Pool % | Riffle % | TYPE | Pool % | Riffle % |
|---|---|---|---|---|---|
| ☐ ☐ Boulder/Slab [10] | | | ☐ ☐ Gravel [7] | | |
| ☐ ☐ Boulder [9] | 10 | | ☐ ☐ Sand [6] | 20 | |
| ☐ ☐ Cobble [8] | | | ☐ ☐ Bedrock [5] | | |
| ☐ ☐ Hardpan [4] | 10 | | ☐ ☐ Detritus [3] | | |
| ☐ ☐ Muck [2] | | | ☑ ☑ Artificial [0] | 50 | ## |
| ☐ ☐ Silt [2] | 10 | | | | |

NUMBER OF SUBSTRATE TYPES ☑ 4 or more [2]
**(high quality only, score > 5)** ☐ 3 or less [0]
COMMENTS:

Check one, or avg. two
SUBSTRATE ORIGIN
☐ Limestone [1]
☑ Tills [1]
☐ Wetlands [0]
☐ Hardpan [0]
☐ Sandstone [0]
☐ Rip/Rap [0]
☐ Lacustrine [0]
☐ Shale [-1]
☐ Coal Fines [-2]

Check one, or avg. two
SUBSTRATE QUALITY
☐ Silt Heavy [-2]
☑ Silt Moderate [-1]
☑ Silt Normal [0]
☐ Silt Free [1]
EMBEDDEDNESS
☐ Extensive [-2]
☑ Moderate [-1]
☑ Normal [0]
☐ None [1]

Substrate **2.0** **Max 20**

**2)INSTREAM COVER** (check all that are present)
TYPE (score all that occur)
☑ Undercut Banks [1]
☐ Overhanging Vegetation [1]
☑ Shallows in Slow Water [1]
☑ Rootmats [1]
☑ Pools > 70 cm [2]
☑ Rootwads [1]
☑ Boulders [1]
☐ Oxbows, Backwaters [1]
☑ Aquatic Macrophytes [1]
☐ Logs or Woody Debris [1]
COMMENTS:

Amount (check one, or average two)
☐ Extensive > 75% [11]
☑ Moderate 25-75% [7]
☐ Sparse 5-25% [3]
☐ Nearly Absent < 5% [1]

Cover **15.0** **Max 20**

**3) CHANNEL MORPHOLOGY** (check one per category, or average two)
SINUOSITY
☐ High [4]
☐ Moderate [3]
☐ Low [2]
☑ None [1]
DEVELOPMENT
☐ Excellent [7]
☐ Good [5]
☑ Fair [3]
☐ Poor [1]
CHANNELIZATION
☐ None [6]
☐ Recovered [4]
☐ Recovering [3]
☑ Little Recovery [1]
STABILITY
☐ High [3]
☑ Moderate [2]
☐ Low [1]

Check all that occur.
STREAM MODIFICATIONS/OTHER
☐ Snagging
☐ Relocation
☑ Canopy Removal
☐ Dredging
☑ One Side Channel Modifications
☐ Impounded
☐ Islands
☐ Leveed
☑ Bank Shaping
COMMENTS:

Channel **7.0** **Max 20**

**4) RIPARIAN ZONE AND BANK EROSION** (check one per category, or two and average) Right and Left are facing downstream

RIPARIAN WIDTH (L R)
☐ ☐ Wide > 50 m [4]
☐ ☐ Moderate 10-50 m [3]
☑ ☑ Narrow 5-10 m [2]
☐ ☑ Very Narrow < 5 m [1]
☐ ☐ None [0]

FLOOD PLAIN QUALITY (Past 100 meter riparian) (L R)
☐ ☐ Forest, Swamp [3]
☐ ☐ Shrub or Old Field [2]
☐ ☐ Fenced Pasture [1]
☐ ☐ Conservation Tillage [1]
☑ ☑ Residential, Park, New Field [1]
☐ ☐ Urban, Industrial [0]
☐ ☐ Open Pasture, Row Crop [0]
☐ ☐ Mining, Construction [0]

BANK EROSION (L R)
☐ ☐ None/Little [3]
☑ ☑ Moderate [2]
☐ ☐ Severe [1]
COMMENTS:

Riparian **4.8** **Max 10**

**5) POOL/GLIDE AND RIFFLE/RUN QUALITY**
MAX. DEPTH (check one)
☐ > 1 m [6]
☑ 0.7-1 m [4]
☐ 0.4-0.7 m [2]
☐ 0.2-0.4 m [1]
☐ < 0.2 m [POOL=0]
MORPHOLOGY (check one, or average two)
☑ Pool width > Riffle Width [2]
☐ Pool width = Riffle Width [1]
☐ Pool width < Riffle Width [0]
Check all that occur.
CURRENT VELOCITY (Pools and Riffles)
☐ Eddies [1]
☐ Fast [1]
☑ Moderate [1]
☑ Slow [1]
☐ Torrential [-1]
☐ Interstitial [-1]
☐ Intermittent [-2]
☐ Very Fast [1]
COMMENTS:

Pool/Current **8.0** **Max 12**

Check one.
RIFFLE DEPTH
☐ Best > 10 cm [2]
☑ Best 5-10 cm [1]
☐ Best < 5 cm [RIFFLE=0]
Check one.
RUN DEPTH
☐ Max. > 50 cm [2]
☑ Max. < 50 cm [1]
Check one, or avg. two
RIFFLE/RUN SUBSTRATE
☑ Stable (cobble/boulder) [2]
☐ Mod. Stable (large gravel, sand) [1]
☐ Unstable (fine gravel, sand) [0]
Check one, or avg. two
RIFFLE/RUN EMBEDDED.
☐ None [2]
☐ Low [1]
☑ Moderate [0]
☐ Extensive [-1]
COMMENTS: ☐ No Riffle [Metric = 0]

Riffle/Run **4.0** **Max 8**

**6) GRADIENT** (feet/mile) 6.3 DRAINAGE AREA (sq. mile) 3.5
% Pool 20 % Glide
% Riffle 10 % Run 70

Gradient **6.0** **Max 10**

(2):193-201.

Gatenby, C.M., P.A. Morrison, R.J. Neves & B.C. Parker. 1998. A protocol for the salvage and

STREAM: YPC
STATION: Storer
SAMPLE#:
DATE: 8/3/18
SCORERS NAME: LAB
SITE ID: YOR - 8.6

**1)SUBSTRATE** (check only two substrate TYPE boxes)

TYPE

| | Pool % | Riffle % | | Pool % | Riffle % |
|---|---|---|---|---|---|
| ☐ ☐ Boulder/Slab [10] | ____ | ____ | ☐ ☐ Gravel [7] | ____ | 30 |
| ☐ ☐ Boulder [9] | ____ | ____ | ☑ ☑ Sand [6] | ____ | 70 |
| ☐ ☐ Cobble [8] | ____ | ____ | ☐ ☐ Bedrock [5] | ____ | ____ |
| ☐ ☐ Hardpan [4] | ____ | ____ | ☐ ☐ Detritus [3] | ____ | ____ |
| ☐ ☐ Muck [2] | ____ | ____ | ☐ ☐ Artificial [0] | ____ | ____ |
| ☐ ☐ Silt [2] | ____ | ____ | | | |

NUMBER OF SUBSTRATE TYPES
**(high quality only, score > 5)**
☐ 4 or more [2]
☑ 3 or less [0]

Check one, or avg. two
SUBSTRATE ORIGIN
☐ Limestone [1]
☑ Tills [1]
☐ Wetlands [0]
☐ Hardpan [0]
☐ Sandstone [0]
☐ Rip/Rap [0]
☐ Lacustrine [0]
☐ Shale [-1]
☐ Coal Fines [-2]

Check one, or avg. two
SUBSTRATE QUALITY
☐ Silt Heavy [-2]
☑ Silt Moderate [-1]
☐ Silt Normal [0]
☐ Silt Free [1]

EMBEDDEDNESS
☐ Extensive [-2]
☐ Moderate [-1]
☑ Normal [0]
☐ None [1]

Substrate
**12.0**
**Max 20**

COMMENTS:

---

**2)INSTREAM COVER** (check all that are present)

TYPE (score all that occur)
☐ Undercut Banks [1]
☑ Overhanging Vegetation [1]
☑ Shallows in Slow Water [1]
☑ Rootmats [1]
☐ Pools > 70 cm [2]
☐ Rootwads [1]
☐ Boulders [1]
☑ Oxbows, Backwaters [1]
☑ Aquatic Macrophytes [1]
☐ Logs or Woody Debris [1]

Amount (check one, or average two)
☐ Extensive > 75% [11]
☑ Moderate 25-75% [7]
☐ Sparse 5-25% [3]
☐ Nearly Absent < 5% [1]

Cover
**12.0**
**Max 20**

COMMENTS:

---

**3) CHANNEL MORPHOLOGY** (check one per category, or average two)

SINUOSITY
☐ High [4]
☐ Moderate [3]
☐ Low [2]
☑ None [1]

DEVELOPMENT
☐ Excellent [7]
☐ Good [5]
☑ Fair [3]
☑ Poor [1]

CHANNELIZATION
☐ None [6]
☐ Recovered [4]
☑ Recovering [3]
☐ Little Recovery [1]

STABILITY
☐ High [3]
☑ Moderate [2]
☐ Low [1]

Check all that occur.
STREAM MODIFICATIONS/OTHER
☐ Snagging
☐ Relocation
☑ Canopy Removal
☐ Dredging
☑ One Side Channel Modifications
☐ Impounded
☐ Islands
☑ Leveed
☐ Bank Shaping

Channel
**8.0**
**Max 20**

COMMENTS:

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**4) RIPARIAN ZONE AND BANK EROSION** (check one per category, or two and average)
Right and Left are facing downstream

RIPARIAN WIDTH
L R
☐ ☐ Wide > 50 m [4]
☐ ☐ Moderate 10-50 m [3]
☑ ☐ Narrow 5-10 m [2]
☐ ☑ Very Narrow < 5 m [1]
☐ ☑ None [0]

FLOOD PLAIN QUALITY (Past 100 meter riparian)
L R
☐ ☐ Forest, Swamp [3]
☐ ☐ Shrub or Old Field [2]
☐ ☐ Fenced Pasture [1]
☐ ☐ Conservation Tillage [1]

L R
☑ ☑ Residential, Park, New Field [1]
☐ ☐ Urban, Industrial [0]
☐ ☐ Open Pasture, Row Crop [0]
☐ ☐ Mining, Construction [0]

BANK EROSION
L R
☑ ☑ None/Little [3]
☑ ☑ Moderate [2]
☐ ☐ Severe [1]

Riparian
**4.8**
**Max 10**

COMMENTS:

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**5) POOL/GLIDE AND RIFFLE/RUN QUALITY**

MAX. DEPTH (check one)
☐ > 1 m [6]
☐ 0.7-1 m [4]
☐ 0.4-0.7 m [2]
☐ 0.2-0.4 m [1]
☑ < 0.2 m [POOL=0]

MORPHOLOGY (check one, or average two)
☐ Pool width > Riffle Width [2]
☐ Pool width = Riffle Width [1]
☐ Pool width < Riffle Width [0]

Check all that occur
CURRENT VELOCITY (Pools and Riffles)
☐ Eddies [1]
☐ Fast [1]
☐ Moderate [1]
☐ Slow [1]
☐ Torrential [-1]
☐ Interstitial [-1]
☐ Intermittent [-2]
☐ Very Fast [1]

Pool/Current
**0.0**
**Max 12**

COMMENTS:

Check one.
RIFFLE DEPTH
☐ Best > 10 cm [2]
☑ Best 5-10 cm [1]
☐ Best < 5 cm [RIFFLE=0]

Check one.
RUN DEPTH
☐ Max. > 50 cm [2]
☑ Max. < 50 cm [1]

Check one, or avg. two
RIFFLE/RUN SUBSTRATE
☐ Stable (cobble/boulder) [2]
☐ Mod. Stable (large gravel, sand) [1]
☑ Unstable (fine gravel, sand) [0]

Check one, or avg. two
RIFFLE/RUN EMBEDDED.
☐ None [2]
☑ Low [1]
☐ Moderate [0]
☐ Extensive [-1]

Riffle/Run
**3.0**
**Max 8**

COMMENTS: ☐ No Riffle [Metric = 0]

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**6) GRADIENT** (feet/mile) 4.9
DRAINAGE AREA (sq. mile) 5.0
% Pool ☐
% Glide ☐
Gradient

quarantine of Unionid mussels from zebra mussel-infested waters. Proceedings of the Conservation,

**Bureau of Water Quality - Habitat Summary** **QHEI Score:** 66.5

STREAM: YPC
DATE: 7/11/18
STATION: 400 W.
SCORERS NAME: LAB
SAMPLE#:
SITE ID: YOR - 6.9

**1)SUBSTRATE** (check only two substrate TYPE boxes)

| TYPE | | | Pool % | Riffle % | | | | Pool % | Riffle % |
|---|---|---|---|---|---|---|---|---|---|
| ☐ | ☐ | Boulder/Slab [10] | | | ☑ | ☐ | Gravel [7] | 10 | 60 |
| ☐ | ☐ | Boulder [9] | | | ☐ | ☐ | Sand [6] | 50 | 30 |
| ☐ | ☑ | Cobble [8] | | 10 | ☐ | ☐ | Bedrock [5] | | |
| ☐ | ☐ | Hardpan [4] | | | ☐ | ☐ | Detritus [3] | 10 | |
| ☐ | ☐ | Muck [2] | | | ☐ | ☐ | Artificial [0] | | |
| ☐ | ☐ | Silt [2] | 30 | | | | | | |

NUMBER OF SUBSTRATE TYPES
**(high quality only, score > 5)**
☑ 4 or more [2]
☐ 3 or less [0]
COMMENTS:

Check one, or avg. two
SUBSTRATE ORIGIN
☐ Limestone [1]
☑ Tills [1]
☐ Wetlands [0]
☐ Hardpan [0]
☐ Sandstone [0]
☐ Rip/Rap [0]
☐ Lacustrine [0]
☐ Shale [-1]
☐ Coal Fines [-2]

Check one, or avg. two
SUBSTRATE QUALITY
☐ Silt Heavy [-2]
☑ Silt Moderate [-1]
☐ Silt Normal [0]
☐ Silt Free [1]
EMBEDDEDNESS
☐ Extensive [-2]
☑ Moderate [-1]
☑ Normal [0]
☐ None [1]

Substrate
**16.5**
**Max 20**

**2)INSTREAM COVER** (check all that are present)
TYPE (score all that occur)
☑ Undercut Banks [1]
☐ Overhanging Vegetation [1]
☑ Shallows in Slow Water [1]
☑ Rootmats [1]
☑ Pools > 70 cm [2]
☐ Rootwads [1]
☑ Boulders [1]
☐ Oxbows, Backwaters [1]
☑ Aquatic Macrophytes [1]
☑ Logs or Woody Debris [1]
COMMENTS:

Amount (check one, or average two)
☐ Extensive > 75% [11]
☑ Moderate 25-75% [7]
☐ Sparse 5-25% [3]
☐ Nearly Absent < 5% [1]

Cover
**15.0**
**Max 20**

**3) CHANNEL MORPHOLOGY** (check one per category, or average two)
SINUOSITY
☐ High [4]
☐ Moderate [3]
☑ Low [2]
☐ None [1]

DEVELOPMENT
☐ Excellent [7]
☐ Good [5]
☑ Fair [3]
☐ Poor [1]

CHANNELIZATION
☑ None [6]
☐ Recovered [4]
☐ Recovering [3]
☐ Little Recovery [1]

STABILITY
☐ High [3]
☑ Moderate [2]
☐ Low [1]

Check all that occur.
STREAM MODIFICATIONS/OTHER
☐ Snagging
☐ Relocation
☑ Canopy Removal
☐ Dredging
☐ One Side Channel Modifications
☐ Impounded
☐ Islands
☐ Leveed
☐ Bank Shaping
COMMENTS:

Channel
**13.0**
**Max 20**

**4) RIPARIAN ZONE AND BANK EROSION** (check one per category, or two and average) Right and Left are facing downstream

RIPARIAN WIDTH

| L | R | |
|---|---|---|
| ☐ | ☐ | Wide > 50 m [4] |
| ☐ | ☑ | Moderate 10-50 m [3] |
| ☑ | ☐ | Narrow 5-10 m [2] |
| ☐ | ☐ | Very Narrow < 5 m [1] |
| ☐ | ☐ | None [0] |

FLOOD PLAIN QUALITY (Past 100 meter riparian)

| L | R | | L | R | |
|---|---|---|---|---|---|
| ☐ | ☐ | Forest, Swamp [3] | ☑ | ☑ | Residential, Park, New Field [1] |
| ☐ | ☐ | Shrub or Old Field [2] | ☐ | ☐ | Urban, Industrial [0] |
| ☐ | ☐ | Fenced Pasture [1] | ☑ | ☑ | Open Pasture, Row Crop [0] |
| ☐ | ☐ | Conservation Tillage [1] | ☐ | ☐ | Mining, Construction [0] |

BANK EROSION

| L | R | |
|---|---|---|
| ☐ | ☐ | None/Little [3] |
| ☑ | ☑ | Moderate [2] |
| ☐ | ☐ | Severe [1] |

COMMENTS:

Riparian
**5.0**
**Max 10**

**5) POOL/GLIDE AND RIFFLE/RUN QUALITY**
MAX. DEPTH (check one)
☐ > 1 m [6]
☑ 0.7-1 m [4]
☐ 0.4-0.7 m [2]
☐ 0.2-0.4 m [1]
☐ < 0.2 m [POOL=0]
COMMENTS:

MORPHOLOGY (check one, or average two)
☑ Pool width > Riffle Width [2]
☐ Pool width = Riffle Width [1]
☐ Pool width < Riffle Width [0]

Check all that occur
CURRENT VELOCITY (Pools and Riffles)
☐ Eddies [1]
☐ Fast [1]
☑ Moderate [1]
☑ Slow [1]
☐ Torrential [-1]
☐ Interstitial [-1]
☐ Intermittent [-2]
☐ Very Fast [1]

Pool/Current
**8.0**
**Max 12**

Check one.
RIFFLE DEPTH
☐ Best > 10 cm [2]
☑ Best 5-10 cm [1]
☐ Best < 5 cm [RIFFLE=0]

Check one.
RUN DEPTH
☐ Max. > 50 cm [2]
☑ Max. < 50 cm [1]

Check one, or avg. two
RIFFLE/RUN SUBSTRATE
☐ Stable (cobble/boulder) [2]
☑ Mod. Stable (large gravel, sand) [1]
☐ Unstable (fine gravel, sand) [0]

Check one, or avg. two
RIFFLE/RUN EMBEDDED.
☐ None [2]
☐ Low [1]
☑ Moderate [0]
☐ Extensive [-1]

COMMENTS: ☐ No Riffle [Metric = 0]

Riffle/Run
**3.0**
**Max 8**

**6) GRADIENT** (feet/mile) 6.9
DRAINAGE AREA (sq. mile) 9.0
% Pool 30
% Riffle 5
% Glide
% Run 65

Gradient
**6.0**
**Max 10**

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