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## The Effects of Low Dam Removal and Kayak Run Installation on the Biodiversity of Fish and Macroinvertebrates in the Great Miami River in Downtown Dayton, Ohio

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**The Effects of Low Dam Removal and  
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Honors Thesis

Sarah Anne Stalder

Department: Biology

Advisor: Jeffrey Kavanaugh, Ph.D.

April 2016

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## **Abstract**

Five Rivers Metroparks and the Miami Conservancy District have made plans to remove the upper portion of the Monument Avenue low-head dam in downtown Dayton due to the hazard it poses for recreation on the river and its negative impact on water quality and biodiversity. The plans also include modifying the dam with “kayak drops” and the construction of a second kayak drop slightly upstream of the location of the current low dam to enhance recreational opportunities on the river. Typically, low dam removal alter the flow and depth of a river, especially above the dam in the impounded area where the river should revert back to a more natural flowing-water habitat characterized by alternating pools and riffles. Greater flow velocity should improve water quality and remove fine silt from the channel bottom and improve habitat conditions for aquatic life. Engineering modifications to the dam should remove the dangerous undertow below the dam significantly reducing the danger of drowning to recreational users. The goal of this project is to help analyze the effects of low dam removal on macroinvertebrate and fish communities by measuring the communities before and after low dam removal. However, the contents of this thesis only cover pre-removal conditions since post-removal monitoring will take place after graduation. From our findings, it is evident that the regions surrounding the dam are degraded, and dam removal will be a beneficial remediation strategy in this region.

## **Acknowledgements**

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## **GENERAL BACKGROUND**

### **Introduction**

The construction of low-head dams (low dams) in the mid-western United States exploded in the early 1900's as industrial demand for hydroelectric power and water increased. Low dams provide an efficient and inexpensive power supply, they may be an effective form of flood control, and are used for navigation, water supply regulation, irrigation, and recreation (Bednarek, 2001). However, due to technological changes within the past 20 years many of these dams have become more of a nuisance and often times no longer serve their original purposes. The drowning danger they pose, cost of repairs, and environmental impacts have inspired the removal of many of these dams (IFC Consulting, 2005).

The growing literature base on the effects of these dams on wildlife and water quality shows that the formation of the dam pool, or impoundment, above the dams significantly alters the aquatic habitat and negatively impacts the biotic and abiotic conditions of the river. Many reports, especially put out by the Ohio Environmental Protection Agency (OHEPA), focus on the fish and macroinvertebrate communities in the river as a measure of the relative health of a stream (OHEPA, 2008; 2010a; 2010b; 2011; 2012). High numbers of tolerant species indicate a low quality, impacted environment, while less tolerant (i.e., more sensitive) species indicate a healthier stream. Additionally, physical features of the habitat are also used to assess environmental quality; (e.g. sediment types, channel alterations, and flow velocity). Beyond these factors, more complex measurements help to understand functioning of river ecosystems including characteristics of sediment movement in the stream channel, water chemistry analysis, and nutrient concentration levels.

## **Literature Review**

There have been multiple low dam removals within Ohio in recent years. Many of these have been monitored to record the effects of dam removal on the stream habitat and biota using standard OHEPA monitoring procedures. Some of the important OHEPA procedures include the Index of Biological Integrity (IBI) for measuring the quality of fish communities and the Invertebrate Community Index (ICI) for monitoring stream invertebrate communities. The Qualitative Habitat Evaluation Index (QHEI) assesses physical aspects of stream habitats, such as channel morphology, in-stream cover, substrate types, vegetation, flow, etc. This section discusses some relevant cases and lays a foundation for understanding the dynamics between low dam removal and the effects on physical and biological components of a river ecosystem.

### **German Farm Dam – Auglaize River**

The German Farm Dam off of the Auglaize River near Delphos, Ohio was built in the 1930's and used primarily for recreational reasons (i.e. to create an impoundment for fishing and boating) (ODNR, 2010a). Though no rigorous "before and after" dam removal studies were performed, the Ohio Department of Natural Resources (ODNR) collected some data to better understand the dam removal process. The original dam, made of timber, was eventually modified to a concrete dam which stood about 6 feet tall (ODNR, 2010a). This publicly-owned dam was eventually removed by the ODNR Division of Wildlife in 2002 to improve the health of fish, wildlife, and water quality in the region (ODNR, 2010a). Additionally it was noted that the removal was necessary because the dam posed a public safety hazard. Before the dam was removed, the ODNR

reported the composition of the river bed to be sand, gravel, cobble, and bedrock, while the fish caught in the river consisted of typical stream sport fish such as smallmouth and largemouth bass, catfish, and sunfish (ODNR, 2010a). The ODNR also reported the water quality above the dam to be between “fair” to “poor” and the water quality below the dam to be considered “good” (ODNR, 2010a). Though there are no post-dam removal studies, the pictures below (See Figure 1 and Figure 2; ODNR, 2010a) show the difference of the area before and after dam removal. The extent of the dam pool is reduced and the site has returned to a more natural free-flowing, pool-riffle habitat.



Figure 1 from ODNR Website: <http://water.ohiodnr.gov/safety/dam-safety/german-farm-dam>





Figure 2 from ODNR Website: <http://water.ohiodnr.gov/safety/dam-safety/german-farm-dam>

### **St. John's Dam - Sandusky River**

A more thorough study of dam removal in Ohio is the St. John's Dam project on the Sandusky River. The 7-foot concrete arch dam was built in 1935 by the Ohio-American Water Company for use as a backup water supply for the city of Tiffin (ODNR, 2010b). In 1999, it was decided the dam needed removal after the ODNR Division of Water determined the dam was unsafe during a routine inspection. By 2003 a detailed mapping of the river was completed and the ODNR reported that the water quality above the dam was "poor", while the water quality downstream of the dam was "good" to "fair"; they also found that only a small number of species of fish were caught within the dam pool (Granata et al., 2008).

The dam was removed in November of 2003 and through a collaboration between the Ohio State University, the OHEPA, and the Ohio Department of Transportation, a



collective post-dam removal study was conducted to address changes in the fish, macroinvertebrates, and habitat using a Habitat Sustainability Index (HSI) based on occurrence of the golden redhorse (fish) and stoneflies (insect). The OHEPA's ICI and QHEI were also used. The reports showed that the HSI for the golden redhorse steadily increased each year after dam removal, from 2003-2006 (Granata et al., 2008). Similar results were also found for the stonefly HSI. In addition, ICI and QHEI scores improved in upstream regions post-dam removal. Prior to dam removal, QHEI scores were only showing partial attainment or non-attainment of Ohio's Water Quality Standards (WQS), while post-removal all scores in each of the ten study sites showed full attainment of WQS. The authors summarized their results as a positive trend in habitat recovery as a result of dam removal. However, they did note that one portion of the river did not recover as well, noting it consisted of sand substrates and low in-stream cover, but they predicted with the help of sediment transports and continued flushing of the area that all habitats should recover over time (Granata et al., 2008).

### **Kent Dam - Cuyahoga River**

The original Kent Dam located on the Cuyahoga River in Kent, Ohio was built in 1834 to supply water power for a grist mill. The dam was created using sandstone blocks stacked 14 feet high and stretching over 125 feet in length. A flood in 1913 destroyed much of the dam, but for aesthetic reasons it was reconstructed in 1925 (ODNR, 2010c). The dam served as an iconic feature in the college town for almost 170 years. However, in 1988 the OHEPA recommended that the city of Kent remove the dam to improve water quality in the middle Cuyahoga River. The dam was responsible for nutrient

enrichment and hydromodifications that led to non-attainment of Ohio's WQS (OHEPA, 2008). However, because the dam is considered a historic structure, through the National Historic Preservation Act, its basic structure was retained and converted into a waterfall in 2004 (ODNR, 2010c).

Pre and post-modification studies of the Kent dam were performed by the OHEPA in 2004 and 2007, respectively. After dam modification, the ICI improved at two sample sites by an average of 28 points (from ICI = 14 "low-fair" to ICI = 44 "very good" at River Mile 50) (OHEPA, 2008). The IBI also increased at many sample sites and reached full-attainment of WQS. However, QHEI scores did not show significant improvement due to higher stream velocities which precluded high sedimentation rates (OHEPA, 2008). Altogether, six of the seven sample sites improved from non-attainment to partial or full-attainment of WQS after the modification of the dam's structure (OHEPA, 2008).

### **Munroe Falls Dam - Cuyahoga River**

Approximately 5 miles downstream of the Kent dam on the Cuyahoga River was the Monroe Falls dam, whose presence gave the town its namesake. The original log dam was built in 1817 to power a grist mill. The dam became a part of the Pennsylvania and Ohio Canal in 1841, and the grist mill was used to supply water for the Munroe Falls Paper Company (OHEPA, 2008). In 2006 the OEPA decided to remove the dam to remedy the non-attainment of Ohio's WQS in the river, which was consistently reported in studies from 1984, 1991, 1996, 2000, and 2005. Additionally, the dam was in need of expensive repairs; therefore, it was thought to be more practical for both ecological and

economic reasons to remove the dam altogether. Studies included a biological study by the OHEPA and a sediment assessment conducted by the University of Akron. Along with the dam removal, the area was further renovated to include an observation deck and a small amphitheater built with salvaged pieces of the dam.

According to the OHEPA study, before dam removal the dam pool was in non-attainment of WQS (IBI=30, ICI=18 and QHEI=48.5), while below the impoundment the WQS only reached partial-attainment (IBI=34, ICI=42, QHEI=83) (OHEPA, 2008; Figure 3). However, after dam removal only the area of the former dam pool improved to partial-attainment (IBI=32, ICI=50, QHEI=71), while the free flowing region did not show improvement in WQS attainment (IBI=31, ICI=44, QHEI=66.5) (OHEPA, 2008; See Figure 4). It is important to note that the post-dam removal data was collected in 2007, during the restoration construction period. Sampling so soon after removal and during construction activity probably interfered with the ability to fully understand long term changes to the river ecosystem. The authors noted phosphorus levels, even after removal, exceeded the statewide Total Daily Maximum Load (TDML) of 0.17 mg/L (OHEPA, 2008). However, the OHEPA concluded that, besides the nutrient loading, the restoration of the Monroe Falls dam pool was improved through more in-stream cover, enhanced riparian vegetation, and higher quality aquatic macrophyte beds (See Figure 3 and Figure 4). They concluded that the region should continue to improve overtime eventually resulting in full-attainment of Ohio WQS.

In the University of Akron sediment study, the geomorphic and sedimentological conditions were characterized in 2003 before removal, in 2006 just after removal, and finally in 2009 three years following removal. Pre-removal characterization showed the

water depth was higher in the region immediately surrounding the dam compared to reaches farther upstream and downstream (Peck and Kasper, 2013). In addition, the impounded region was dominated by substrates such as sand and mud, while the free-flowing regions were dominated by gravel (Peck and Kasper, 2013). However, following dam removal, shifts in substrates followed models proposed by Doyle et al. (2003). The removal of the Munroe Falls dam lowered base-level water flow, increased the flow velocity upstream, and allowed for the formation of sandy bars upstream of the former dam replacing the finer muds (Peck and Kasper, 2013). Moreover, the regions previously dominated by sand and mud became embedded with gravel and filled with sand forming meander chutes in the region downstream (Peck and Kasper, 2013). Overall, these changes follow expected patterns of sediment alterations following dam removal and they illustrate how dam removals produce changes in hydrology, which alters sediment and channel characteristics that ultimately affect the biota in the aquatic ecosystem. The study shows that faster flow, shallower depth, and differentiation among substrates all contribute to support a healthier, more diverse habitat for a larger range of aquatic species.



Figure 3 from ODNR Website: <http://water.ohiodnr.gov/safety/dam-safety/munroe-falls-dam>



Figure 4 from ODNR Website: <http://water.ohiodnr.gov/safety/dam-safety/munroe-falls-dam>

### **Delaware Run Dams - Olentangy River**

In this case study performed by the Ohio EPA, two dams, the River Street and the Central Avenue dams were removed from the Olentangy River in Delaware, Ohio, located in the Eastern Corn Belt Plains ecoregion (OHEPA, 2010a). The Central Avenue dam, constructed in 1955, stood 4 feet tall and was built with masonry and used for recreational purposes for the city of Delaware (ODNR, 2010d). While just downstream was the River Street dam, originally built in the 1950's as a concrete dam standing approximately 3.5 feet in height and used for recreational and flood control purposes. The River Street dam was located north of the sewage treatment plant. Remediation of the Olentangy River by removal of the dams was based on results of a TMDL study by the OHEPA that found the river was either not attaining or only partially attaining its designation as warmwater habitat for aquatic life use (OHEPA, 2010a). The study found the main causes of impairment included hydromodification; excess nutrients from failing home sewage treatment systems and sedimentation from stormwater and agricultural runoff (OHEPA, 2010a). In addition, the Panhandle Road dam (scheduled for 2010), was also planned for removal.

Prior to dam removal, impounded regions upstream of the River Street dam were sampled for fish, macroinvertebrates, and habitat quality by the OHEPA in 2005. The River Street dam was removed by the city of Delaware in the winter of 2005 to improve aquatic life habitat, recreation, and safety on the river. This region partially met WQS pre-dam removal (IBI=32, ICI=34, QHEI=49) (OHEPA, 2010a). In 2008, the post-removal study concluded the stream had reached full-attainment of all WQS (IBI=46, ICI=52, QHEI=54.5) (OHEPA, 2010a). While the Central Avenue dam was sampled in



2005, it was not removed until June of 2008 through a pooling of city, state, and federal funds. The pre-removal study had reported the stream section only partially met WQS (IBI=38, ICI=26, QHEI=45.5) (OHEPA, 2010a). And with similar results to the River Street dam, the Central Avenue dam pool responded to dam removal by reaching full-attainment of WQS (IBI=48, ICI=44, QHEI=62.5) (OHEPA, 2010a). In both reaches the impounded regions improved significantly with respect to species richness. In this case, it is evident that the dam removal increased the overall health of the river, completing the goals set by the OHEPA for water quality improvement.

### **5<sup>th</sup> Avenue Dam – Olentangy River**

Standing 8 feet tall and spanning over 460 feet, the 5<sup>th</sup> Avenue dam was constructed in 1935 and was the largest of 10 dams built in the Olentangy River in Columbus, Ohio (ODNR, 2015). The dam was originally built to provide a source of cooling water for the Ohio State University (OSU) power plant, but has become obsolete. The dam created a safety hazard for canoeists and kayakers on the river and caused a drowning in 2008 (Stantec, 2013). The City of Columbus, the OHEPA, and OSU have worked together on a plan for dam removal that would alleviate the recreational safety hazard, improve wildlife habitat and water quality, while promoting community revitalization by attracting people to the restored riverfront. The dam was removed in 2012 and river restoration continued until late 2014.

No completed studies have been published to this date; however, pre-dam removal data is available through impact and feasibility studies performed by the OHEPA and ODNR, and long-term studies are being conducted through OSU. In a pre-dam

removal assessment made by the ODNR the water quality both above and below the dam was labeled as “poor” (ODNR, 2015). They found the stream channel consisted mostly of sand, cobble, and gravel (Stantec, 2013). In addition, a pre-removal study conducted by the OHEPA showed the free –flowing regions in the Olentangy River below the dam had a QHEI value of 68.1, or “good”, while the impounded region scored a 30.8, or “poor” (OHEPA, 2011; See Figure 5). The OHEPA study reported three “species of concern” of mussels which were rescued and transplanted before the removal (OHEPA, 2011). These findings are consistent with previous pre-dam removal studies, and with the extensive restoration the habitat is expected to make a full recovery and attain all of Ohio’s WQS. A photo immediately after the removal of the dam shows a significant change in habitat in the reach (See Figure 6). The dam restoration monitoring required QHEI, IBI, and ICI measures to be taken three and five years after the completion of the restoration, leaving post removal data to be collected in 2017 and 2019, so final results will be available in the coming years.



Figure 5 from ODNR Website: <http://water.ohiodnr.gov/safety/dam-safety/fifth-ave->



Figure 6 from ODNR Website: <http://water.ohiodnr.gov/safety/dam-safety/fifth-ave-dam>

### **Englewood Dam - Stillwater River**

The Englewood dam was the largest of five dams that were built in the 1920's and 30's in the Stillwater River as a result of the 1913 flood in the Dayton, OH region (Five Rivers Metropark., 2011). The dam was built to be incorporated into the Miami Conservancy District's plan for flood control, but also to provide an impoundment for boaters and waders. This purpose, ironically, was a main reason that the dam, built in 1935, was removed by Five River's Metroparks in September of 2009 (Five Rivers Metropark, 2011). Not only was the dam a hindrance to the ecological health of the Stillwater River, but it was also a danger to boaters, waders, and other recreational users. The undertow caused by water flowing over the dam had taken three lives by drowning when people were unable to escape the violent undertow (Five Rivers Metropark, 2011).

A pre-removal study was conducted by the OHEPA in 2008, and post-removal studies in 2010 and 2011. The river was sampled for fish, macroinvertebrates, and the physical habitat assessed with the QHEI according to standard OHEPA protocols. Pre-dam removal results showed that the free flowing region downstream was in full-attainment of WQS (IBI=57, ICI=50, QHEI=87) (OHEPA, 2012). Conversely, the impounded region had non-attainment of WQS within the reach (IBI=40, ICI=34, QHEI=53) (OHEPA, 2012). Within one year of the dam removal the downstream region of the dam was still in full-attainment of WQS (IBI=57, ICI=Exceptional, QHEI=91), while the previously impounded region had recovered to partial-attainment, with the macroinvertebrates making a full recovery, but the slower recovery of fish and the physical habitat preventing the site from reaching full-attainment (IBI=41, ICI=52, QHEI=66) (OHEPA, 2012). However, by 2011, two years after dam removal, both fish

and the physical habitat had reached full-attainment (IBI=45, QHEI=72.5) (OHEPA, 2012). The Englewood Dam study illustrates the complexity of the biotic communities' response and the importance of long term monitoring. It can take several years for a river reach to fully respond to a significant change in physical habitat, following dam removal. Understanding this complex response helps human communities to make better-informed decisions on the best ways to improve their water resources.

### **West Milton Dam – Stillwater River**

Built in 1918 as a source of hydropower for a local trolley, the West Milton Dam on the Stillwater River in eastern Ohio also served several other functions in its 96-year life span (Ohio River Foundation, 2015). The dam was used as water source for Dayton Power & Light in the 1960s after it was deeded to the company by West Milton (Ohio River Foundation, 2015). Later, the water supply was found to be of unacceptable quality and West Milton connected to Troy public water instead. Since then the dam impoundment has been used for recreation. Due to its age, the dam was deteriorating and in need of costly repairs (OHEPA, 2010b). The city of West Milton decided the most cost-effective and beneficial solution would be removal. In December of 2014 dam removal was complete and in 2015 the restoration project concluded. The goals set for the project were: to reconnect the upper 200 miles of the Stillwater River watershed to the downstream region, to remove the safety hazard and potential source of liability posed by the dam, to avoid current and future repair costs, and to add future recreational and economic opportunities (Ohio River Foundation, 2015).

Though there are no completed studies assessing the effectiveness of the restoration, the OHEPA did complete a pre-dam removal study to evaluate the biological community and the habitat in 2010. In this study they compared the free-flowing regions and the impounded regions by measuring fish and macroinvertebrate communities as well as an assessment of the physical habitat. The report found that the free flowing regions, one upstream of the impoundment and one downstream of the impoundment both reached full-attainment of Ohio's WQS (upstream: IBI=58, QHEI=83.5, downstream: IBI=54, ICI=42, QHEI=79.5) (OHEPA, 2010b). However, due to the decreased quality of macroinvertebrates in the impounded region, the dam pool only reached partial-attainment of Ohio's WQS (IBI=53, ICI=18, QHEI=55) (OHEPA, 2010b). The OHEPA plans to study the post-removal/restoration as well to compare to the pre-removal data in 2016. The complexity of the removal and restoration most likely will lengthen the response time for the river to recover, however the city of West Milton hopes that the region will reach full-attainment following the completion of the project and will also improve recreation and reduce costs and safety liabilities.

### **Conceptual Framework**

There are typical patterns in how Ohio streams respond to changes in habitat following low dam removal. First, the physical habitat undergoes significant changes. Measures of the physical habitat, including changes to sediments and geomorphic characteristics of the stream channel often show significant improvement compared to the dammed, impounded stream (OHEPA, 2008; 2010a; 2010b; 2011; 2012; Peck and Kasper, 2013, Santucci et al., 2005, Stantec, 2013). Faster flow rates, decreased depth,



and improved substrate composition are typical improvements seen to the physical habitat following dam removal (Peck and Kasper, 2013). These changes are the catalysts which result in changes within biotic communities.

The literature shows that biotic communities in impounded reaches of rivers, given enough time, will recover and increase in biodiversity following dam removal (OHEPA, 2008; 2010a; 2010b; 2011; 2012). Macroinvertebrates tend to recover more quickly, with some populations improving within a year of dam removal (OHEPA, 2010b, Ohio River Foundation, 2015). Fish communities tend to recover more slowly, and may require between a year, or more, to show significant improvement (OHEPA, 2010b, Ohio River Foundation, 2015). The varying response times among components of the aquatic community is often overlooked on the political side of dam removal as stakeholders often do not consider long term results in their removal plans (Wildman, 2013). Wildman (2013) points out that the longer term effects of dam removal are often unaddressed because funding is often limited to covering the design and costs of the removal itself – not in long-term monitoring of the effects. These, and other details, pose problems for understanding the full ramifications of dam removal and whether we are considering all of the consequences of these decisions.

## **THESIS**

### **Title**

The effects of low dam removal and kayak run installation on the biodiversity of fish and macroinvertebrates in the Great Miami River in downtown Dayton, Ohio

## **Abstract**

Five Rivers Metroparks and the Miami Conservancy District have made plans to remove the upper portion of the Monument Avenue low-head dam in downtown Dayton due to the hazard it poses for recreation on the river and its negative impact on water quality and biodiversity. The plans also include modifying the dam with “kayak drops” and the construction of a second kayak drop slightly upstream of the location of the current low dam to enhance recreational opportunities on the river. Typically, low dam removal alter the flow and depth of a river, especially above the dam in the impounded area where the river should revert back to a more natural flowing-water habitat characterized by alternating pools and riffles. Greater flow velocity should improve water quality and remove fine silt from the channel bottom and improve habitat conditions for aquatic life. Engineering modifications to the dam should remove the dangerous undertow below the dam significantly reducing the danger of drowning to recreational users. The goal of this project is to help analyze the effects of low dam removal on macroinvertebrate and fish communities by measuring the communities before and after low dam removal. However, the contents of this thesis only cover pre-removal conditions since post-removal monitoring will take place after graduation. From our findings, it is evident that the regions surrounding the dam are degraded, and dam removal will be a beneficial remediation strategy in this region.

## **Introduction**

A low-head dam, as defined by the ODNR, is a constructed barrier; usually less than 15 ft. in height, made of timber, stone, concrete, etc. that extends from bank to bank

across a stream channel (IFC Consulting, 2005). They may be built for water storage to compensate for fluctuations in river and stream flow, flood control, to provide water for energy production or for industrial uses in factories and manufacturing, as well as for navigation and recreation. (McCully, 2001; Bednarek, 2001). Within the past few decades many regions around the USA have found dams that once proved useful are no longer serving their original purpose. Their removal has become increasingly frequent as a practice for restoring the ecological health of rivers and streams as well as enhancing safety for recreational activities. A number of different justifications are given for dam removals, but the enhancement of ecology, economics, and safety are the main reasons.

Low-head dams cause ecological harm to rivers and streams through the formation of pool areas (impoundments) as well as blocking the ability of fish and macroinvertebrates to move upstream past the dam. The dam pool resembles a lake ecosystem in many cases due to the depth and slow flow velocity (ICF Consulting, 2005). Sediments are usually fine silts and the area is relatively homogenous, filled with more tolerant fish and macroinvertebrate species (OHEPA, 2008; OHEPA, 2010a; OHEPA, 2010b; OHEPA, 2012; Santucci et al., 2005). However, below the dam is a free-flowing area which is more heterogeneous with a variety of depths, substrates, and greater species diversity of fish and macroinvertebrates (OHEPA, 2008; OHEPA, 2010a; OHEPA, 2010; OHEPA, 2012; Santucci et al., 2005). This divide between the upstream and downstream regions around dams causes significant differences in the ecosystems. The dam inhibits movement of fish and macroinvertebrates from downstream areas to upstream areas

while also lessening water quality (ICF Consulting, 2005). It is for these ecological reasons that many low-head dams are being removed.

In addition, as dams age, the cost for repair and maintenance become greater than the cost to simply remove the structure completely and dam removal, rather than repair, is favored (ICF Consulting, 2005). Removal is an attractive option, especially when the dams are no longer useful, or have failed and are simply a burden to maintain. Moreover, the recreational and safety concerns for many fishers, boaters, and waders are also a cause for removal. These dams produce a seemingly harmless undertow current which can be deadly by sucking victims in and not allowing them to break free from the current.

Dam removal had become more popular within the past 20 years. Between 2000 and 2005 nearly 160 dams were removed in the United States and that number continues to grow (ICF Consulting, 2005). Additionally, dam removal is an important remediation strategy in the Midwest, and especially Ohio. In the year 2014 alone, 72 dams were removed in the United States and that quantity will only increase in the coming years (Kober and McClain, 2015). These trends show the growing consciousness of the importance for healthy and safe rivers and streams in our local areas.

### **Study Area**

The study areas lie immediately upstream (above) and downstream (below) the Monument Ave dam in Downtown Dayton, OH. This dam is located on the Great Miami River (GMR), just downstream of the confluence of the Mad River with the GMR. The region is characterized by a temperate climate and the dam results in the formation of two

different ecological habitats; stream-like below the dam, and a lake-like impoundment, or dam pool upstream of the dam.

## **Methods**

### ***Fish***

The collection of fish data was done according to OHEPA protocols (OHEPA, 2003b) for electrofishing. Electrofishing uses two submerged electrodes in the water to create an electrical field. The alternating current (AC) momentarily stuns the fish when they come into contact with the electric field where they can then be netted, identified, weighed, and released again. This methodology allows for many fish to return back to their natural habitat after capture and also is the least selective method of fish collection when compared to seining (EPA, 2003b). Two methods of electrofishing were used: boat and wading methods.

Below the dam, where the depth of the river ranges from ankle to hip deep, wading electrofishing was performed using a generator located on the bank of the river, handheld nets, and a live well to store and sort the fish until they were later released. The surveyed area began approximately 200ft below the dam, just under the Monument Ave Bridge to approximately 550ft below the dam focusing on the eastern half of the river bank due to cord length restrictions. The survey took approximately three hours to complete and all fish were identified, counted, and weighed on site and then were released. The wadeable sampling took place in the morning and afternoon on September 26, 2014 by team of UD students, Dr. Kavanaugh, and myself.

For sampling fish from the deeper, dam pool area we partnered with Five Rivers Metroparks and followed OHEPA's boat electrofishing protocol (OHEPA, 2003b). Sampling began at Riverscape and continued downstream for approximately one-quarter of a mile. Sampling took approximately three hours and afterwards all fish were identified, counted, weighed and returned to the river unharmed. Boat electrofishing took place on September 17, 2014. For boat shocking, I joined a team from Five Rivers Metroparks to collect the data.

Data sheets were sent to Dr. Kavanaugh's lab where it was analyzed with an Index of Biological Integrity (IBI). The IBI is an index used by the Ohio EPA that measures the quality of the fish community in a stream or river based on multiple "metrics" of fish composition, (e.g., total number of species, number of tolerant species, number of darters, and other metrics). The score ranges from 12-60 taking into account 12 different metrics giving scores of 1, 3, or 5 for each. A program developed by the Northeast Ohio Regional Sewer District was used to calculate the scores for the Monument Avenue sites.

### ***Macroinvertebrates***

Three different methods were used to sample macroinvertebrates. These were: sweep net, kick net, and Hester Dendy artificial substrate samplers used to sample below the dam, and only Hester Dendy artificial substrate samplers were used above the dam due to the depth of the pool where sweep net and kick net sampling was not possible. Jars containing the collected macroinvertebrates were preserved in 70% ethanol, brought



back to the lab and processed, separating the macroinvertebrates from the debris for each individual sampling method.

Below the dam the sweep net and kick net samples were collected following protocols described in Johnson (2007). Sweep net samples consist of a total of 20 jabs of the net at all the different microhabitats at the site. Kick net samples were collected by hand-cleaning and kicking the substrate in a 1 square meter area and collecting all the dislodged macroinvertebrates in the net. Three separate kick net samples were collected and combined into one sample. All of the macroinvertebrates and any debris (sand, gravel, leaves, etc.) were placed into jars with 70% ethanol to be sorted and identified later in the laboratory. Sampling took approximately two hours on September 10, 2014.

The Kick Net sample occupied 2 large glass jars. Due to the size of the sample it was decided that a sub-sample would be taken. From each jar a 20% sub-sample was taken, resulting in a 20% sub-sample of the whole sample. Additionally, a qualitative scan of the remainder of the sample was taken to ensure that any rare species were not overlooked. From this stage, the macroinvertebrates from the sub-sample were then picked from the debris in the sample, identified to order, and then to family. At the family level they were counted and the counts of families were recorded in an Excel spreadsheet for MAIS analysis. Additionally, 100% of the sweep net sample was processed. The macroinvertebrates were then identified to family level, counted, and the numbers recorded in the Excel spreadsheet.

Hester-Dendy artificial substrate samplers were used both above and below the Monument Avenue dam. This method is a type of quantitative sampling because the plates of the Hester Dendy sampler have a known surface area. The method is routinely

used by the OHEPA to assess water quality in rivers and streams in Ohio (EPA, 2003a). Five groups of sampler plates were secured via rope to a cinderblock that was buried in the sediment to anchor the samplers. The plates themselves were submerged in the water, but not buried in the sediment. The samplers were left in the river for approximately six weeks to allow for colonization of the plates by macroinvertebrates and were recovered September 25, 2014. Once recovered, the sampler plates were placed individually into 70% ethanol to be cleaned off, sorted, and identified in the laboratory. 100% of each sample was picked through. In the lab, the macroinvertebrates from each of the 5 sets of plates were gently removed using a soft-bristle toothbrush and preserved in 70% ethanol. Macroinvertebrates were picked, identified to family-level, counted and added to the Excel spreadsheet for analysis.

Macroinvertebrate data was analyzed with the MAIS index (Johnson, 2007). This is comparable to the Invertebrate Community Index (ICI), used by the OHEPA except the ICI uses species-level identification while the MAIS uses family-level identifications. The MAIS measures the quality of the stream or river based on multiple metrics of macroinvertebrate community composition. It can be used to rank streams with scores from 0-18 using 9 different metrics.

### ***Abiotic***

#### ***Qualitative Habitat Evaluation Index:***

The Qualitative Habitat Evaluation Index (QHEI) is an index used by the Ohio EPA to assess the physical habitat of a river or stream. The index takes into account six different metrics: substrate conditions, in stream cover, channel morphology, bank

erosion and riparian zone quality, pool/glide and riffle/run quality, and gradient, to assess the general condition of a stream habitat. The QHEI was performed on October 26, 2015. The QHEI was recorded on data sheets in the field and QHEI score was calculated for both the dam pool and the below dam sites.

#### Water Chemistry:

To determine the water chemistry above and below the dam the temperature (°C), pH, conductivity (µs), total dissolved solids (ppm), and dissolved oxygen (% and mg/L) were taken for two months, 3-5 times a week starting in September of 2015. Each sample was taken in the morning (before 9 a.m.) to ensure primary production was at its lowest (so oxygen released by algae would not interfere with base-level dissolved oxygen readings). The pH, conductivity, and total dissolved solids were measured with a handheld PEN meter; dissolved oxygen and temperature were taken with a YSI handheld meter. Water chemistry data were recorded at multiple sites within the overall study area.

## **Results**

### ***Fish***

A total of 149 fish from 18 different species were collected in the dam pool. A total of 527 fish from 20 different species were collected below the Monument Ave dam. The 2014 electrofishing results are summarized in Table 1. IBI metrics and scores per location are presented in Appendix Table 1, and species lists collected per location are presented in Appendix Table 2.

| Table 1 – IBI Comparison Above and Below Monument Ave. Dam |           |                   |
|--|-----------|-------------------|
| Sample Site / Date   | IBI Score | Evaluation        |
| Monument Ave. - Above<br>9/26/2014                         | 30        | “Fair”            |
| Monument Ave. – Below<br>9/25/2014                         | 34        | “Marginally Good” |

### ***Macroinvertebrates***

A total of 28 macroinvertebrate families were collected through the use of kick and sweep nets samples for use in calculating the MAIS and are shown in Table 2. Hester-Dendy data are presented separately. MAIS metrics and scores are presented in Appendix Table 3, and species lists collected per location are presented in Appendix Table 4.1. Table 3 summarizes results from Hester Dendy samples comparing samples taken above and below the dam. Species lists for the Hester Dendy samplers are presented in Appendix Table 4.2 and 4.3.

| Table 2 – MAIS of Below the Monument Ave. Dam |            |            |
|---|------------|------------|
| Sample Site / Date                            | MAIS Score | Evaluation |
| Monument Ave. - Below<br>9/10/2014            | 11         | “Poor”     |

| Table 3 – Hester-Dendy Comparison  |                         |              |                   |                      |
|------------------------------------|-------------------------|--------------|-------------------|----------------------|
| Sample Site / Date                 | Total Number of Species | EPT Richness | % 5 Dominant Taxa | # of Intolerant Taxa |
| Monument Ave. - Above<br>9/10/2014 | 10                      | 4            | 97 %              | 5                    |
| Monument Ave. – Below<br>9/10/2014 | 10                      | 6            | 99 %              | 7                    |

### *Abiotic*

#### QHEI

The results of the habitat assessments from the 2015 observation sites are summarized in Table 4. QHEI field data sheets, metrics and scores are presented in Appendix Table 5.

| Table 4 – QHEI Comparison Above and Below Monument Ave. Dam |            |            |
|---|------------|------------|
| Sample Site / Date  | QHEI Score | Evaluation |
| Monument Ave. - Above<br>10/26/2015                         | 46.5       | “Fair”     |
| Monument Ave. – Below<br>10/25/2015                         | 70         | “Good”     |

### Water Chemistry

The results from the water chemistry sampling from 2015 are summarized in Table 5. Water quality standards are presented in Appendix Table 6.

| Table 5 – Water Sampling Comparison Above and Below Monument Ave. Dam |                          |            |                   |                |                   |                           |
|---|--------------------------|------------|-------------------|----------------|-------------------|---------------------------|
| Site  | Average Temperature (°C) | Average pH | Average TDS (ppm) | Average DO (%) | Average DO (mg/L) | Average Conductivity (µs) |
| MA – Above  | 16.24                    | 8.02       | 353.18            | 83.56          | 8.03              | 671.33                    |
| MA – Below  | 15.67                    | 8.20       | 348.5             | 89.99          | 8.66              | 686.79                    |

### **Discussion**

Overall, the fish, macroinvertebrate, and physical habitat data suggests that the Great Miami River in the sampling locations near the Monument Avenue low dam are degraded. The water chemistry results indicate water quality is good and there is not much difference chemical characteristics between the above and below dam sample sites. The dissolved oxygen is slightly higher below the dam, most likely due to aeration caused by water falling over the dam. The DO (8.06 above, and 8.66 below, Table 5) is high enough to support fish and macroinvertebrates within this region. Though our water chemistry sampling was limited, there are no data that suggests a cause for concern



within this region. Each of the values are well within the accepted range for a stream comparable to the Great Miami River (Behar, 1996).

The physical habitats in the two sampling locations were very different from each other. The dam pool was a wide, deep, very slow-moving impoundment with no riffles; while the area below the dam was mostly shallow, but with a variety of depths (ranging from just a few centimeters to over a meter) and a variety of different flow velocities (from slow to fast). The QHEI scores confirm these basic observations; that is, the dam pool scored low (QHEI= 46.5) and represents a “fair” habitat (Table 4). However, this ranking is on the low end of “fair”, and is close to “poor”. The region is dominated by nearly stagnant, deep, slow-moving water, little to no vegetation, and no riffles (See Figure 7). The substrates consisted mainly of sand and fine silts, and the region is levied on both sides which tends to constrain the channel which keeps it from meandering and forming distinct series of pools and riffles (true of both sites) (Figure 7). In contrast, the below-dam site is free-flowing and characterized as “good” (QHEI = 70), but this score is on the higher end of the “good” range and is close to the “excellent” range. The higher QHEI score indicates the site more closely resembles an undisturbed habitat. There is a range of riffles, runs, small pools, and glides all ranging in depth. The substrate consists of silt, cobble, and gravel (more suitable habitat for a variety of fish and their prey), (See Figure 7 and Figure 8). The physical habitat provides the foundation for which species can potentially live in the region and thus controls the overall diversity of the river reach.

The fish data shows an interesting pattern that is reflected in the literature. The dam pool scored only slightly lower than the below-dam site; it was evaluated as “poor” for the region (IBI = 30; Table 1). The free-flowing area, was evaluated as “marginally

good” (IBI =34; Table 1). This is interesting because the dam pool has a more degraded physical habitat, and is home to a higher number of tolerant species than the free flowing region (Appendix Table 2). A possible explanation for why both sites have similar IBI scores is because of the large numbers of highly-tolerant bluntnose minnows which dominate the below dam region. But even with the large number of bluntnose minnow, the below-dam score is higher due to the many other moderately-intolerant and intolerant species such as darters.

In general, the species found in the dam pool represent fish that favor impoundments or deep pool habitats – not shallow faster-flowing habitats. The low IBI score is due mainly to the large number of carp, a highly-tolerant, non-native species, and overall fewer total species of fish. The IBI for the dam pool would have been even lower if it had not been for the several species of redhorse suckers that were collected; these are intolerant species that, while desirable, still were not able to raise the dam pool score above the “poor” rating. Another factor possibly raising the quality of some fish in the dam pool is that some of the intolerant species are coming from the high-quality Mad River that joins the dam pool immediately upstream of the sampling area. Once the kayak runs are completed, it is expected that the physical habitat of the dam pool area will be improved by more diverse physical habitats which will lead to a more diverse, less-tolerant fish community.

The macroinvertebrate data reveal a similar characterization to the fish data for the two sample sites. This sample site scored within the “good” range (MAIS= 11, Table 2). However, because of the ecoregion which the sample sites are located, this score is on the low end of the “good” range, very close to the “fair” evaluation. Comparisons of

macroinvertebrate data collected with Hester-Dendy samplers showed the number of species at both sites was the same, but the community composition was different. Above dam samples were dominated by midges (Chironomidae) with small numbers of mayflies and caddisflies (Appendix Table 4.1). The below dam is populated more evenly by caddisflies, midges, and mayflies, reflecting the fast-flowing habitat preferences of caddisflies and mayflies (Appendix Table 4.1). There were also more families of EPT (Ephemeroptera, Plecoptera, and Tricoptera) than in the dam pool, again reflecting the fast-flowing habitat preferences of EPT taxa (Table 3). In addition, the free-flowing region consisted of a higher number of intolerant taxa than in the dam-pool region (Table 3). So, just as in the fish samples, the macroinvertebrate data showed a higher quality community below the dam – seen in both the MAIS index using kick net and sweep net methods as well as the Hester-Dendy samples which could be directly compared between the two sampling locations. Once modifications to the low dam are complete, other sampling methods should be employed in the above dam area to evaluate the changing macroinvertebrate community located there.



Figure 7 Pre-Dam removal, Monument Ave. Courtesy of J. Kavanaugh



Figure 8: Monument Ave Dam/Kayak Run Construction Courtesy of J. Kavanaugh

## **Future Directions**

This study represents an assessment of the physical, chemical, and biological conditions above and below the Monument Avenue low dam, prior to its modification into a kayak run, as well as the conditions prior to the second upstream kayak run for which construction has not started as of April 2016. The project will not be complete until follow-up sampling to evaluate the conditions after dam modification/kayak run installation is completed; this sampling is expected to occur in 2017 or 2018. These findings provide invaluable background conditions in order to evaluate the effects of the low dam modifications on the biodiversity of fish and macroinvertebrates in the Great Miami River.

A supplementary study related to the dam removal/kayak run installation could investigate bacteria levels within the river, to ensure it is safe for humans to be boating and swimming in the water around the kayak runs.

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**Appendix Table 1**

IBI Metrics and Scores from Great Miami River Sites

2014



**Appendix Table 2**

Fish Species and Relative Numbers Collected from

Great Miami River Sites 2014



**Table 2.1**  
**GMR – Above Monument Ave. Dam**  
**September 17, 2014**  
**River Mile: 81.10**  
**Collection Method: Boat Electrofishing**  
**Drainage Area: 2511 miles<sup>2</sup>**  
**0.5 km**

| <b>Code</b> | <b>Species</b>   | <b>Number</b> | <b>Weight (kg)</b> | <b>Pollution Tolerance</b> | <b>DELT Anomalies #</b> |
|-------------|--|---------------|--------------------|----------------------------|-------------------------|
| 20-003      | <i>Dorosoma cepedianum</i><br>Eastern gizzard shad       | 83            | 1.215              | --                         | 0                       |
| 25-002      | <i>Oncorhynchus mykiss</i><br>Rainbow trout              | 1             | 0.500              | --                         | 0                       |
| 40-005      | <i>Carpodes cyprinus</i><br>Central quillback carpsucker | 9             | 6.500              | --                         | 2                       |
| 40-008      | <i>Moxostoma anisurum</i><br>Silver Redhorse             | 7             | 5.650              | Moderately Intolerant      | 5                       |
| 40-009      | <i>Moxostoma duquesnei</i><br>Black redhorse             | 5             | 2.940              | Common Intolerant          | 6                       |
| 40-011      | <i>Moxostoma macrolepidotum</i><br>Shorthead redhorse    | 1             | 0.200              | Moderately Intolerant      | 0                       |
| 40-016      | <i>Catostomus commersonii</i><br>Common white sucker     | 1             | 3.500              | Highly Tolerant            | 2                       |
| 43-001      | <i>Cyprinus carpio</i><br>Common carp                    | 21            | 48.900             | Highly Tolerant            | 13                      |
| 43-020      | <i>Notropis atherinoides</i><br>Common Emerald shiner    | 2             | 0.025              | --                         | 1                       |
| 47-002      | <i>Ictalurus punctatus</i><br>Channel catfish            | 1             | 1.700              | --                         | 0                       |

|  |   |       |                             |                          |    |
|--|---|-------|-----------------------------|--------------------------|----|
| 77-001                                   | <i>Pomoxis annularis</i><br>White crappie           | 1     | 0.005                       | --                       | 0  |
| 77-003                                   | <i>Ambloplites rupestris</i><br>Northern rockbass   | 4     | 0.925                       | --                       | 1  |
| 77-004                                   | <i>Micropterus dolomieu</i><br>Smallmouth bass      | 4     | 2.800                       | Moderately<br>Intolerant | 14 |
| 77-006                                   | <i>Micropterus salmoides</i><br>Largemouth bass     | 3     | 0.540                       | --                       | 2  |
| 80-002                                   | <i>Sander vitreus</i><br>Walleye                    | 1     | 1.900                       | --                       | 0  |
| 80-011                                   | <i>Percina caprodes</i><br>Northern logperch darter | 1     | 0.025                       | Moderately<br>Intolerant | 0  |
| 40-013                                   | <i>Moxostoma carinatum</i><br>River Redhorse        | 2     | 1.000                       | Intolerant               | 0  |
| 77-005                                   | <i>Micropterus punctulatus</i><br>Spotted Bass      | 2     | 0.060                       | --                       | 2  |
| Totals                                   |   | 149   | 78.385                      |                          | 48 |
| *DELT anomalies were<br>observed on      |   | 32.21 | % of the fish<br>collected. |                          |    |
| Index of Biotic Integrity (IBI) =        |   | 30    | (Fair)                      |                          |    |
| Modified Index of Well-Being<br>(MIwb) = |   | 7.8   | (Exceptional)               |                          |    |
| Shannon Diversity Index, no.             |   | 1.71  |                             |                          |    |
| Shannon Diversity Index, wt.             |   | 1.51  |                             |                          |    |
| N  |   | 210   |                             |                          |    |
| B  |   | 42.5  |                             |                          |    |

**Table 2.2**  
**GMR - MA Below**  
**September 26, 2014**  
**River Mile: 79.70**  
**Collection Method: Longline Electrofishing**  
**Drainage Area: 2511 miles<sup>2</sup>**  
**0.052 km**

| <b>Code</b> | <b>Species</b>   | <b>Number</b> | <b>Weight (kg)</b> | <b>Pollution Tolerance</b> |
|-------------|--|---------------|--------------------|----------------------------|
| 20-003      | <i>Dorosoma cepedianum</i><br>Eastern gizzard shad       | 41            | 0.410              | --                         |
| 40-010      | <i>Moxostoma erythrurum</i><br>Golden redhorse           | 2             | 1.140              | Moderately Intolerant      |
| 40-015      | <i>Hypentelium nigricans</i><br>Northern hog sucker      | 1             | 0.150              | Moderately Intolerant      |
| 40-016      | <i>Catostomus commersonii</i><br>Common white sucker     | 0             | 0.004              | Highly Tolerant            |
| 43-013      | <i>Semotilus atromaculatus</i><br>Creek chub             | 4             | 0.140              | Highly Tolerant            |
| 43-021      | <i>Notropis photogenis</i><br>Silver shiner              | 22            | 0.070              | Common Intolerant          |
| 43-039      | <i>Ericymba photogenis</i><br>Silverjaw minnow           | 1             | 0.003              |                            |
| 43-043      | <i>Pimephales notatus</i><br>Bluntnose minnow            | 25            | 0.055              | Highly Tolerant            |
| 43-044      | <i>Campostoma anomalum</i><br>Central stoneroller minnow | 9             | 0.130              | --                         |
| 77-003      | <i>Ambloplites rupestris</i><br>Northern rockbass        | 5             | 0.255              | --                         |
| 77-004      | <i>Micropterus dolomieu</i><br>Smallmouth bass           | 1             | 0.030              | Moderately Intolerant      |

|        |   |     |       |                       |
|--------|---|-----|-------|-----------------------|
| 77-006 | <i>Micropterus salmoides</i><br>Largemouth bass         | 1   | 0.050 | --                    |
| 77-009 | <i>Lepomis macrochirus</i><br>Northern bluegill sunfish | 3   | 0.020 | Moderately Tolerant   |
| 77-013 | <i>Lepomis gibbosus</i><br>Pumpkinseed sunfish          | 1   | 0.010 | Moderately Tolerant   |
| 80-005 | <i>Etheostoma maculata</i><br>Blackside darter          | 2   | 0.006 | --                    |
| 80-011 | <i>Percina caprodes</i><br>Northern logperch darter     | 1   | 0.005 | Moderately Intolerant |
| 80-014 | <i>Etheostoma nigrum</i><br>Johnny darter               | 5   | 0.025 | --                    |
| 80-015 | <i>Etheostoma blenniodes</i><br>Greenside darter        | 7   | 0.050 | Moderately Intolerant |
| 80-022 | <i>Etheostoma caeruleum</i><br>Rainbow darter           | 36  | 0.070 | Moderately Intolerant |
| 80-016 | <i>Etheostoma zonale</i><br>Banded Darter               | 1   | 0.003 | Intolerant            |
| 90-002 | <i>Cottus bairdi</i><br>Mottled Sculpin                 | 1   | 0.006 | --                    |
| Totals |   | 172 | 2.638 |                       |

\*DELT anomalies were observed on

Index of Biotic Integrity (IBI) =  
Modified Index of Well-Being (MIwb) =

Shannon Diversity Index, no.  
Shannon Diversity Index, wt.

N

B

0.58

34

9.0

2.29

2.0

819

14.1

% of the fish collected.

(Marginally Good)

(Very Good)

**Appendix Table 3**

MAIS Metrics and Scores from Great Miami River Sites

2014

| Macroinvertebrate Aggregate Index for Streams Metrics |              |                           |                           |                         |                               |  |                      |                      |                          |            |
|---|--------------|---------------------------|---------------------------|-------------------------|-------------------------------|--|----------------------|----------------------|--------------------------|------------|
| Site  | EPT richness | #<br><i>Ephemeroptera</i> | %<br><i>Ephemeroptera</i> | % 5<br>dominant<br>taxa | Simpson<br>Diversity<br>Index | Modified<br><i>Hilsenhoff</i><br>Biotic<br>Index | # Intolerant<br>Taxa | %<br><i>Scrapers</i> | %<br><i>Haptobenthos</i> | MAIS Score |
| Great<br>Miami<br>River<br>RM:<br>79.7                | 8 (2)        | 4 (2)                     | 14 (1)                    | 95 (1)                  | 0.54 (0)                      | 5.90 (0)   | 13 (2)               | 2 (1)                | 87 (2)                   | 11         |

**Appendix Table 4**

Macroinvertebrate Species and Relative Numbers Collected from

Great Miami River Sites 2014

| Table 4.1<br>GMR - MA Below<br>September 10, 2014 |                   |                  |                  |       |
|---|-------------------|------------------|------------------|-------|
| Collection Method: Kick and Sweep Net             |                   |                  |                  |       |
| Code  | Taxon             | Abundance<br>(n) | Feeding<br>Group | Habit |
| E162  | Hydropsychidae    | 24752            | CF               | CG    |
| E117  | Baetidae          | 4795             | CG               | CG    |
| E198  | Chironomidae      | 4274             | CG               | BU    |
| E197  | Simuliidae        | 1479             | CF               | CG    |
| E189  | Elmidae           | 500              | SC               | CG    |
| E090  | Talitridae        | 456              | CG               | CR    |
| E160  | Hydroptilidae     | 357              | MP               | CR    |
| E11C  | Tricorythidae     | 298              | CG               | SP    |
| E170  | Pyrilidae         | 281              | SH               | CG    |
| F110  | Sphaeriidae       | 143              | CF               | BU    |
| F014  | Pleuroceridae     | 114              | SC               | CG    |
| E192  | Tipulidae         | 110              | SH               | BU    |
| E16H  | Polycentropodidae | 100              | CF               | CG    |
| E20   | Hydracarina       | 86               | PR               | CR    |
| E119  | Heptageniidae     | 77               | SC               | CG    |
| E19J  | Empididae         | 55               | PR               | CR    |
| E1211   | Lestidae          | 55               | PR               | CL    |
| E134  | Veliidae          | 48               | PR               | SK    |
| F000  | Physidae          | 16               | CG               | SP    |
| E132  | Gerridae          | 15               | PR               | SK    |
| F111  | Corbiculidae      | 10               | CF               | BU    |
| E187  | Psephenidae       | 6                | SC               | CG    |
| E110  | Ephemeridae       | 5                | CG               | BU    |
| 50  | Turbellaria       | 3                | CG               |       |
| E130  | Belostomatidae    | 2                | PR               | CI    |
| E19B  | Tabanidae         | 2                | PR               | BU    |
| E199  | Ceratopogonidae   | 1                | PR               | Bu    |
| E183  | Gyrinidae         | 1                | PR               | GN    |
| E184  | Hydrophilidae     | 1                | PR               | GN    |
| E163  | Rhyacophilidae    | 1                | PR               | CR    |
|   |                   |                  |                  |       |



| Table 4.2                       |                   |               |               |       |
|---------------------------------|-------------------|---------------|---------------|-------|
| GMR - MA Below                  |                   |               |               |       |
| September 10, 2014              |                   |               |               |       |
| Collection Method: Hester-Dendy |                   |               |               |       |
| Code                            | Taxon             | Abundance (n) | Feeding Group | Habit |
| E162                            | Hydropsychidae    | 933           | CF            | CG    |
| E198                            | Chironomidae      | 746           | CG            | BU    |
| E119                            | Heptageniidae     | 228           | SC            | CG    |
| E117                            | Baetidae          | 100           | CG            | CG    |
| E11C                            | Tricorythidae     | 58            | CG            | SP    |
| F014                            | Pleuroceridae     | 10            | SC            | CG    |
| E16H                            | Polycentropodidae | 8             | CF            | CG    |
| E189                            | Elmidae           | 2             | SC            | CG    |
| E170                            | Pyralidae         | 2             | SH            | CG    |
| E160                            | Hydroptilidae     | 1             | MP            | CR    |

| Table 4.3                       |                   |               |               |       |
|---------------------------------|-------------------|---------------|---------------|-------|
| GMR - MA Above                  |                   |               |               |       |
| September 10, 2014              |                   |               |               |       |
| Collection Method: Hester-Dendy |                   |               |               |       |
| Code                            | Taxon             | Abundance (n) | Feeding Group | Habit |
| E198                            | Chironomidae      | 1259          | CG            | BU    |
| E119                            | Heptageniidae     | 318           | SC            | CG    |
| E090                            | Talitridae        | 104           | CG            | CR    |
| E1211                           | Lestidae          | 26            | PR            | CL    |
| E11C                            | Tricorythidae     | 25            | CG            | SP    |
| E16H                            | Polycentropodidae | 22            | CF            | CG    |
| E162                            | Hydropsychidae    | 20            | CF            | CG    |
| E189                            | Elmidae           | 8             | SC            | CG    |
| F014                            | Pleuroceridae     | 5             | SC            | CG    |
| X                               | Viviparidae       | 1             | X             | X     |

**Appendix Table 5**

QHEI Metrics and Scores from Great Miami River Sites

2015



# Qualitative Habitat Evaluation Index and Use Assessment Field Sheet

**QHEI Score:** 46.5 "FAIR"

**Stream & Location:** Great Miami River - Above Monument **RM:** \_\_\_\_\_ **Date:** 1 / 06  
**Avenue low dam - in dam pool** **Scorer's Full Name & Affiliation:** Sarah Stodder, Telford Community School - UD  
**River Code:** 14-001-000 **STORET #:** \_\_\_\_\_ **Lat./Long.:** \_\_\_\_\_ **Office:** Northtown Jacobson

## 1) SUBSTRATE

Check ONLY two substrate TYPE BOXES:  
 estimate % of each every type present

| BEST TYPES  | POOL RIFFLE                         | OTHER TYPES                             | POOL RIFFLE                         | ORIGIN                                       | QUALITY  |
|---|-------------------------------------|---|-------------------------------------|--|--|
| <input type="checkbox"/> BLDG / SLABS [10]  | <input type="checkbox"/>            | <input type="checkbox"/> HARDPAN [4]    | <input type="checkbox"/>            | <input type="checkbox"/> LIMESTONE [1]       | <input checked="" type="checkbox"/> HEAVY [-2]     |
| <input type="checkbox"/> BOULDER [9]  | <input type="checkbox"/>            | <input type="checkbox"/> DETRITUS [3]   | <input type="checkbox"/>            | <input checked="" type="checkbox"/> SILT [1] | <input checked="" type="checkbox"/> MODERATE [-1]  |
| <input type="checkbox"/> CORBLE [8]   | <input type="checkbox"/>            | <input type="checkbox"/> MUCK [2]       | <input checked="" type="checkbox"/> | <input type="checkbox"/> WETLANDS [0]        | <input type="checkbox"/> NORMAL [0]                |
| <input checked="" type="checkbox"/> GRAVEL [7]  | <input checked="" type="checkbox"/> | <input type="checkbox"/> SILT [2]       | <input checked="" type="checkbox"/> | <input type="checkbox"/> HARDPAN [9]         | <input type="checkbox"/> FREE [1]                  |
| <input type="checkbox"/> SAND [6]   | <input checked="" type="checkbox"/> | <input type="checkbox"/> ARTIFICIAL [0] | <input checked="" type="checkbox"/> | <input type="checkbox"/> SANDSTONE [0]       | <input checked="" type="checkbox"/> EXTENSIVE [-2] |
| <input type="checkbox"/> BEDROCK [5]  | <input type="checkbox"/>            |   |                                     | <input type="checkbox"/> RIP/RAP [0]         | <input type="checkbox"/> MODERATE [-1]             |
| (Score natural substrates; ignore stuff from point sources)   |                                     |   |                                     | <input type="checkbox"/> LACUSTURINE [0]     | <input type="checkbox"/> NORMAL [0]                |
| <b>NUMBER OF BEST TYPES:</b> <input type="checkbox"/> 4 or more [2] <input checked="" type="checkbox"/> 3 or less [0] |                                     |   |                                     | <input type="checkbox"/> SHALE [-1]          | <input type="checkbox"/> NONE [1]                  |
| <b>Comments:</b>  |                                     |   |                                     | <input type="checkbox"/> COAL FINES [-2]     |  |

Check ONE (Or 2 & average) **QUALITY**

**Substrate** 7.0 **Maximum** 20

## 2) INSTREAM COVER

Indicate presence 0 or 3. 0-Absent, 1-Very small amounts or if more common or marginal quality, 2-Moderate amounts, but not of highest quality or in small amounts of highest quality, 3-Highest quality in moderate or greater amounts (e.g., very large boulder in deep or fast water, large diameter log that is stable, well developed rockweed in deep / fast water, or deep / fast water, functional logs, etc.)

| COVER   | AMOUNT   |
|---|--|
| <input type="checkbox"/> UNDERCUT BANKS [1]           | <input type="checkbox"/> EXTENSIVE > 75% [1]         |
| <input type="checkbox"/> OVERHANGING VEGETATION [1]   | <input type="checkbox"/> MODERATE 25-75% [7]         |
| <input type="checkbox"/> SHALLOWS (IN SLOW WATER) [1] | <input checked="" type="checkbox"/> SPARSE 5-25% [3] |
| <input type="checkbox"/> RODENTS [4]                  | <input type="checkbox"/> NEARLY ABSENT < 5% [1]      |
| <input type="checkbox"/> POOLS > 70cm [2]             |  |
| <input type="checkbox"/> ROOTWADS [1]                 |  |
| <input type="checkbox"/> BOULDERS [1]                 |  |
| <input type="checkbox"/> OXBOWS, BACKWATERS [1]       |  |
| <input type="checkbox"/> AQUATIC MACROPHYTES [1]      |  |
| <input type="checkbox"/> LOGS OR WOODY DEBRIS [1]     |  |

**Channel** 7.0 **Maximum** 20

## 3) CHANNEL MORPHOLOGY

Check ONE in each category (Or 2 & average)

| SINUOSITY                                   | DEVELOPMENT                                  | CHANNELIZATION                                     | STABILITY  |
|---|--|--|--|
| <input type="checkbox"/> HIGH [4]           | <input type="checkbox"/> EXCELLENT [7]       | <input type="checkbox"/> NONE [6]                  | <input checked="" type="checkbox"/> HIGH [3]     |
| <input type="checkbox"/> MODERATE [3]       | <input type="checkbox"/> GOOD [5]            | <input checked="" type="checkbox"/> RECOVERED [4]  | <input checked="" type="checkbox"/> MODERATE [2] |
| <input checked="" type="checkbox"/> LOW [2] | <input checked="" type="checkbox"/> FAIR [3] | <input checked="" type="checkbox"/> RECOVERING [3] | <input type="checkbox"/> LOW [1]                 |
| <input type="checkbox"/> NONE [1]           | <input type="checkbox"/> POOR [1]            | <input type="checkbox"/> RECENT OR NO RECOVERY [1] |  |

**Channel** 11.0 **Maximum** 20

## 4) BANK EROSION AND RIPARIAN ZONE

Check ONE in each category for EACH BANK (Or 2 per bank & average)

| EROSION   | RIPARIAN WIDTH                                | FLOOD PLAIN QUALITY                                      |
|---|---|--|
| <input checked="" type="checkbox"/> NONE / LITTLE [3] | <input type="checkbox"/> WIDE > 60m [4]       | <input type="checkbox"/> FOREST, SWAMP [3]               |
| <input type="checkbox"/> MODERATE [2]                 | <input type="checkbox"/> MODERATE 10-60m [3]  | <input type="checkbox"/> SHRUB OR OLD FIELD [2]          |
| <input type="checkbox"/> HEAVY / SEVERE [1]           | <input type="checkbox"/> NARROW 5-10m [2]     | <input type="checkbox"/> RESIDENTIAL, PARK, NEWFIELD [1] |
|   | <input type="checkbox"/> VERY NARROW < 5m [1] | <input type="checkbox"/> FENCED PASTURE [1]              |
|   | <input checked="" type="checkbox"/> NONE [0]  | <input type="checkbox"/> OPEN PASTURE, ROWCROP [0]       |
|   |   | <input type="checkbox"/> CONSERVATION TILLAGE [1]        |
|   |   | <input type="checkbox"/> URBAN OR INDUSTRIAL [0]         |
|   |   | <input type="checkbox"/> MINING / CONSTRUCTION [0]       |

Indicate predominant land use/cover past 100m riparian. **Riparian** 3.5 **Maximum** 10

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

Check ONE (Or 2 & average)

| MAXIMUM DEPTH                                | CHANNEL WIDTH   | CURRENT VELOCITY                                 | Recreation Potential     |
|--|---|--|--------------------------|
| <input checked="" type="checkbox"/> > 1m [6] | <input type="checkbox"/> POOL WIDTH > RIFFLE WIDTH [2]            | <input type="checkbox"/> TORRENTIAL [-1]         | <b>Primary Contact</b>   |
| <input type="checkbox"/> 0.7-1m [4]          | <input type="checkbox"/> POOL WIDTH = RIFFLE WIDTH [1]            | <input checked="" type="checkbox"/> SLOW [1]     | <b>Secondary Contact</b> |
| <input type="checkbox"/> 0.4-0.7m [2]        | <input checked="" type="checkbox"/> POOL WIDTH < RIFFLE WIDTH [0] | <input type="checkbox"/> VERY FAST [1]           |                          |
| <input type="checkbox"/> 0.2-0.4m [1]        |   | <input type="checkbox"/> FAST [1]                |                          |
| <input type="checkbox"/> < 0.2m [0]          |   | <input checked="" type="checkbox"/> MODERATE [1] |                          |
|  |   | <input type="checkbox"/> INTERMITTENT [-2]       |                          |
|  |   | <input type="checkbox"/> EDDIES [1]              |                          |

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species. **Pool / Current** 8.0 **Maximum** 12

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species. **NO RIFFLE (matrix=0)**

| RIFFLE DEPTH   | RUN DEPTH                                   | RIFFLE / RUN SUBSTRATE  | RIFFLE / RUN EMBEDDEDNESS                          |
|--|---|---|--|
| <input type="checkbox"/> BEST AREAS > 10cm [2]       | <input type="checkbox"/> MAXIMUM > 50cm [2] | <input type="checkbox"/> STABLE (e.g., Cobble, Boulder) [2]     | <input type="checkbox"/> NONE [2]                  |
| <input type="checkbox"/> BEST AREAS 5-10cm [1]       | <input type="checkbox"/> MAXIMUM < 50cm [1] | <input type="checkbox"/> MOD. STABLE (e.g., Large Gravel) [1]   | <input type="checkbox"/> LOW [1]                   |
| <input type="checkbox"/> BEST AREAS < 5cm [matrix=0] |   | <input type="checkbox"/> UNSTABLE (e.g., Fine Gravel, Sand) [0] | <input type="checkbox"/> MODERATE [0]              |
|  |   |   | <input checked="" type="checkbox"/> EXTENSIVE [-1] |

**Riffle / Run** 0 **Maximum** 8

## 6) GRADIENT

**DRAINAGE AREA** **Gradient** **Maximum** 10

**% POOL:** 20 **% GLIDE:** 20 **% RUN:** 0 **% RIFFLE:** 0



# Qualitative Habitat Evaluation Index and Use Assessment Field Sheet

**QHEI Score:** 170

*"Good"*
**Stream & Location:** Great Miami River - Below Monument Ave

**RM:**
**Date:** 1 / 1 / 06

**Bridge and low dam**
**Scorer's Full Name & Affiliation:** Sarah Stalder + Jeff Kavanagh - UD

**River Code:** 1-001-000 STORET #:

**Lat / Long:**
**18**
**Office verified location**
**1) SUBSTRATE** Check ONLY two substrate TYPE BOXES, estimate % of note every type present

**Check ONE (Or 2 & average):**

| BEST TYPES   |                                      | POOL RIFFLE                         |                                     | OTHER TYPES                       |                                      | POOL RIFFLE                          |                                       | ORIGIN                            |                                   | QUALITY                                 |  |   |                                       |                                      |  |                                     |  |                                     |  |                                     |   |                                     |                                   |   |  |                                   |
|--|--------------------------------------|-------------------------------------|-------------------------------------|-----------------------------------|--------------------------------------|--------------------------------------|---------------------------------------|-----------------------------------|-----------------------------------|---|--|---|---------------------------------------|--------------------------------------|--|-------------------------------------|--|-------------------------------------|--|-------------------------------------|---|-------------------------------------|-----------------------------------|---|--|-----------------------------------|
| <input type="checkbox"/> BLOR (SLABS) [10]               | <input type="checkbox"/> BOULDER [8] | <input type="checkbox"/> COBBLE [8] | <input type="checkbox"/> GRAVEL [7] | <input type="checkbox"/> SAND [8] | <input type="checkbox"/> BEDROCK [5] | <input type="checkbox"/> HARDPAN [4] | <input type="checkbox"/> DETRITUS [3] | <input type="checkbox"/> MUCK [2] | <input type="checkbox"/> SILT [2] | <input type="checkbox"/> ARTIFICIAL [0] | <input type="checkbox"/> LIMESTONE [1] | <input type="checkbox"/> TILLS [1]  | <input type="checkbox"/> WETLANDS [0] | <input type="checkbox"/> HARDPAN [0] | <input type="checkbox"/> SANDSTONE [0] | <input type="checkbox"/> RIPRAP [0] | <input type="checkbox"/> LACUSTURINE [0] | <input type="checkbox"/> SHALE [-1] | <input type="checkbox"/> COAL FINES [-2] | <input type="checkbox"/> HEAVY [-2] | <input checked="" type="checkbox"/> MODERATE [-1] | <input type="checkbox"/> NORMAL [0] | <input type="checkbox"/> FREE [1] | <input type="checkbox"/> EXTENSIVE [-2] | <input type="checkbox"/> MODERATE [-1] | <input type="checkbox"/> NONE [1] |
| <b>NUMBER OF BEST TYPES:</b> 4 or more [2] 3 or less [0] |                                      |                                     |                                     |                                   |                                      |                                      |                                       |                                   |                                   |   |  | <b>Substrate</b><br><div style="border: 1px solid black; padding: 5px; display: inline-block;">17</div><br>Maximum 25 |                                       |                                      |  |                                     |  |                                     |  |                                     |   |                                     |                                   |   |  |                                   |

**2) INSTREAM COVER** Indicate presence 0 to 5. 0-Absent, 1-Very small amount or if more common of highest quality, 2-Moderate amounts, but not of highest quality or in small amounts of highest quality, 3-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed rootwad in deep / fast water, or deep, well-defined, functional pools)

| AMOUNT  |   |
|---|---|
| <input type="checkbox"/> UNDERCUT BANKS [1]           | <input type="checkbox"/> POOLS > 70cm [2]         |
| <input type="checkbox"/> OVERHANGING VEGETATION [1]   | <input type="checkbox"/> ROOTWADS [1]             |
| <input type="checkbox"/> SHALLOWS (IN SLOW WATER) [1] | <input type="checkbox"/> ROOTWADS [1]             |
| <input type="checkbox"/> ROOTMATS [1]                 | <input type="checkbox"/> LOGS OR WOODY DEBRIS [1] |

**Comments:**

**Channel**  

12

  
 Maximum 25

**3) CHANNEL MORPHOLOGY** Check ONE in each category (Or 2 & average)

| SINUOSITY                                   | DEVELOPMENT                                  | CHANNELIZATION                                     | STABILITY  |
|---|--|--|--|
| <input type="checkbox"/> HIGH [4]           | <input type="checkbox"/> EXCELLENT [7]       | <input type="checkbox"/> NONE [5]                  | <input checked="" type="checkbox"/> HIGH [3]     |
| <input type="checkbox"/> MODERATE [3]       | <input type="checkbox"/> GOOD [5]            | <input type="checkbox"/> RECOVERED [4]             | <input checked="" type="checkbox"/> MODERATE [2] |
| <input checked="" type="checkbox"/> LOW [2] | <input checked="" type="checkbox"/> FAIR [3] | <input checked="" type="checkbox"/> RECOVERING [3] | <input type="checkbox"/> LOW [1]                 |
| <input type="checkbox"/> NONE [1]           | <input type="checkbox"/> POOR [1]            | <input type="checkbox"/> RECENT OR NO RECOVERY [1] |  |

**Comments:**

**Channel**  

10.5

  
 Maximum 25

**4) BANK EROSION AND RIPARIAN ZONE** Check ONE in each category for EACH BANK (Or 2 per bank & average)

| EROSION   |   | RIPARIAN WIDTH                               |  | FLOOD PLAIN QUALITY                                       |  |
|---|---|--|--|---|--|
| <input checked="" type="checkbox"/> NONE / LITTLE [3] | <input type="checkbox"/> MODERATE 10-50m [3]  | <input type="checkbox"/> WIDE > 80m [4]      | <input type="checkbox"/> MODERATE 10-50m [3] | <input type="checkbox"/> FOREST, SWAMP [3]                | <input type="checkbox"/> CONSERVATION TILLAGE [1]  |
| <input type="checkbox"/> MODERATE [2]                 | <input type="checkbox"/> NARROW 5-10m [2]     | <input type="checkbox"/> MODERATE 10-50m [3] | <input type="checkbox"/> MODERATE 10-50m [3] | <input type="checkbox"/> SHRUB OR OLD FIELD [2]           | <input type="checkbox"/> URBAN OR INDUSTRIAL [0]   |
| <input type="checkbox"/> HEAVY / SEVERE [1]           | <input type="checkbox"/> VERY NARROW < 5m [1] | <input type="checkbox"/> MODERATE 10-50m [3] | <input type="checkbox"/> MODERATE 10-50m [3] | <input type="checkbox"/> RESIDENTIAL, PARK, NEW FIELD [1] | <input type="checkbox"/> MINING / CONSTRUCTION [0] |
|   | <input checked="" type="checkbox"/> NONE [0]  | <input type="checkbox"/> MODERATE 10-50m [3] | <input type="checkbox"/> MODERATE 10-50m [3] | <input type="checkbox"/> FENCED PASTURE [1]               |  |
|   |   | <input type="checkbox"/> MODERATE 10-50m [3] | <input type="checkbox"/> MODERATE 10-50m [3] | <input type="checkbox"/> OPEN PASTURE, ROWCROP [0]        |  |

**Comments:**

**Riparian**  

4.0

  
 Maximum 10

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

| MAXIMUM DEPTH                                |   | CHANNEL WIDTH                                    |  | CURRENT VELOCITY   |  |
|--|---|--|--|--|--|
| <input checked="" type="checkbox"/> > 1m [6] | <input type="checkbox"/> POOL WIDTH > RIFFLE WIDTH [2]            | <input type="checkbox"/> TORRENTIAL [-1]         | <input checked="" type="checkbox"/> SLOW [1]   | <b>Recreation Potential</b><br><b>Primary Contact</b><br><b>Secondary Contact</b><br>(Indicate one and only one on each)     |  |
| <input type="checkbox"/> 0.7-1m [4]          | <input checked="" type="checkbox"/> POOL WIDTH = RIFFLE WIDTH [1] | <input type="checkbox"/> VERY FAST [1]           | <input type="checkbox"/> INTERSTITIAL [-1]     |  |  |
| <input type="checkbox"/> 0.4-0.7m [2]        | <input checked="" type="checkbox"/> POOL WIDTH > RIFFLE WIDTH [0] | <input checked="" type="checkbox"/> FAST [1]     | <input type="checkbox"/> INTERMITTENT [-2]     |  |  |
| <input type="checkbox"/> 0.2-0.4m [1]        |   | <input checked="" type="checkbox"/> MODERATE [1] | <input checked="" type="checkbox"/> EDDIES [1] |  |  |
| <input type="checkbox"/> < 0.2m [0]          |   |  |  | <b>Pool / Current</b><br><div style="border: 1px solid black; padding: 5px; display: inline-block;">10.5</div><br>Maximum 15 |  |

**Comments:**

**Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:**

| RIFFLE DEPTH  |  | RIFFLE / RUN SUBSTRATE   |  | RIFFLE / RUN EMBEDDEDNESS  |  |
|---|--|--|--|--|--|
| <input checked="" type="checkbox"/> BEST AREAS > 10cm [2] | <input checked="" type="checkbox"/> MAXIMUM > 50cm [2] | <input checked="" type="checkbox"/> STABLE (e.g., Cobble, Boulder) [2]   | <input type="checkbox"/> NONE [2]                | <b>Riffle / Run</b><br><div style="border: 1px solid black; padding: 5px; display: inline-block;">6.0</div><br>Maximum 8 |  |
| <input type="checkbox"/> BEST AREAS 5-10cm [1]            | <input type="checkbox"/> MAXIMUM < 50cm [1]            | <input checked="" type="checkbox"/> MOD. STABLE (e.g., Large Gravel) [1] | <input checked="" type="checkbox"/> LOW [1]      |  |  |
| <input type="checkbox"/> BEST AREAS < 5cm [0]             |  | <input type="checkbox"/> UNSTABLE (e.g., Fine Gravel, Sand) [0]          | <input checked="" type="checkbox"/> MODERATE [0] |  |  |

**Comments:**

**6) GRADIENT** (3 m/m) ☐ VERY LOW - LOW [2-4] ☐ MODERATE [5-10] ☒ HIGH - VERY HIGH [10-5]

**DRAINAGE AREA** (m<sup>2</sup>)






**% POOL:**  **% GLIDE:**  **% RIFFLE:**  **% RUN:**

**Gradient**  

10

  
 Maximum 15

Table 2. General narrative ranges assigned to QHEI scores. Ranges vary slightly in headwater ( $\leq 20$  sq mi) vs. larger waters.

| Narrative Rating |   | QHEI Range |                |
|------------------|---|------------|----------------|
|                  |   | Headwaters | Larger Streams |
| Excellent        |  | $\geq 70$  | $\geq 75$      |
| Good             |  | 55- to 69  | 60 to 74       |
| Fair             |  | 43 to 54   | 45 to 59       |
| Poor             |  | 30 to 42   | 30 to 44       |
| Very Poor        |  | $< 30$     | $< 30$         |
|                  |   |            |                |

## **Appendix 6**

Water Quality Data Collected Fall of 2015

| Appendix Table 6.1 Water Chemistry Data – Monument Ave. Dam Pool |          |         |       |                   |                              |                      |                         |                 |
|--|----------|---------|-------|-------------------|------------------------------|----------------------|-------------------------|-----------------|
| Location   | Date     | Time    | pH    | Conductivity (ms) | Total Dissolved Solids (ppm) | Dissolved Oxygen (%) | Dissolved Oxygen (mg/L) | Temperature (C) |
| MA-Above   | 9/15/15  | 8:25 AM | 8.28  | 756               | 367                          | 80.64                | 7.6                     | 17.9            |
| MA-Above   | 9/16/15  | 8:15 AM | 8.3   | 750               | 376                          | 83                   | 7.52                    | 18.5            |
| MA-Above   | 9/17/15  | 7:46 AM | 8.37  | 754               | 376                          | 83                   | 7.52                    | 18.6            |
| MA-Above   | 9/18/15  | 7:43 AM | 8.43  | 758               | 378                          | 82.6                 | 7.38                    | 19.4            |
| MA-Above   | 9/19/15  | 6:35 AM | 8.39  | 722               | 361                          | 86.7                 | 7.33                    | 17.5            |
| MA-Above   | 9/20/15  | 8:06 AM | 8.26  | 715               | 353                          | 78.8                 | 7.33                    | 17.6            |
| MA-Above   | 9/21/15  | 6:59 AM | 8.24  | 728               | 363                          | 78.9                 | 7.28                    | 18.3            |
| MA-Above   | 9/22/15  | 7:43 AM | 8.28  | 738               | 370                          | 78.5                 | 7.28                    | 17.4            |
| MA-Above   | 9/23/15  | 6:41 AM | 8.28  | 739               | 369                          | 79.7                 | 7.3                     | 18.8            |
| MA-Above   | 9/24/15  | 7:39 AM | 8.13  | 714               | 357                          | 78.2                 | 7.04                    | 19.3            |
| MA-Above   | 9/25/15  | 7:45 AM | 8.22  | 715               | 358                          | 86.6                 | 7.48                    | 21.4            |
| MA-Above   | 9/26/15  | 7:46 AM | 8.06  | 736               | 367                          | 81.5                 | 7.38                    | 18.9            |
| MA-Above   | 9/27/15  | 7:56 AM | 8.26  | 741               | 371                          | 82.4                 | 7.8                     | 17              |
| MA-Above   | 9/28/15  | 7:44 AM | 8.4   | 710               | 355                          | 90.1                 | 8.83                    | 15.4            |
| MA-Above   | 9/29/15  | 7:16 AM | 8.07  | 693               | 348                          | 83.5                 | 7.95                    | 16.1            |
| MA-Above   | 9/30/15  | 7:01 AM | 7.94  | 705               | 352                          | 80.1                 | 7.6                     | 16.6            |
| MA-Above   | 10/1/15  | 7:01 AM | 7.73  | 717               | 358                          | 79.6                 | 7.42                    | 16.9            |
| MA-Above   | 10/2/15  | 7:10 AM | 8.04  | 719               | 359                          | 78.5                 | 7.35                    | 17.1            |
| MA-Above   | 10/3/15  | 6:58 AM | 7.93  | 724               | 362                          | 79.8                 | 7.79                    | 18.6            |
| MA-Above   | 10/4/15  | 8:33 AM | 7.35  | 674               | 335                          | 78.8                 | 8.1                     | 13.5            |
| MA-Above   | 10/5/15  | 7:40 AM | 7.61  | 480               | 244                          | 94.9                 | 9.96                    | 11.3            |
| MA-Above   | 10/6/15  | 7:46 AM | 7.7   | 603               | 302                          | 93.2                 | 9.93                    | 11.3            |
| MA-Above   | 10/7/15  | 6:56 AM | 7.98  | 720               | 359                          | 84.1                 | 8.45                    | 14.5            |
| MA-Above   | 10/8/15  | 6:54 AM | 7.73  | 728               | 364                          | 85.7                 | 8.46                    | 15.3            |
| MA-Above   | 10/9/15  | 6:58 AM | 7.29  | 440               | 374                          | 79.6                 | 7.52                    | 15.3            |
| MA-Above   | 10/10/15 | 7:43 AM | 7.72  | 680               | 339                          | 90.4                 | 9.77                    | 10.9            |
| MA-Above   | 11/12/15 | 8:05 AM | 7.71  | 687               | 343                          | 90.6                 | 10.09                   | 9.6             |
| MA-Above   | 11/20/15 | 7:58 AM | 7.85  | 659               | 329                          | 90.2                 | 9.41                    | 11.7            |
| AVERAGES   |          | 7:32 AM | 8.019 | 671.326           | 353.178                      | 83.558               | 8.031                   | 16.239          |

| Appendix Table 6.2 Water Chemistry Data – Monument Ave. Dam Free-Flowing |          |         |       |                   |                              |                      |                         |                 |
|--|----------|---------|-------|-------------------|------------------------------|----------------------|-------------------------|-----------------|
| Location   | Date     | Time    | pH    | Conductivity (ms) | Total Dissolved Solids (ppm) | Dissolved Oxygen (%) | Dissolved Oxygen (mg/L) | Temperature (C) |
| MA-Below   | 9/15/15  | 8:30 AM | 8.42  | 707               | 352                          | 91.5                 | 8.5                     | 18              |
| MA-Below   | 9/16/15  | 8:21 AM | 8.45  | 729               | 363                          | 92                   | 8.43                    | 18.8            |
| MA-Below   | 9/17/15  | 7:51 AM | 8.43  | 734               | 366                          | 92                   | 8.31                    | 19.2            |
| MA-Below   | 9/18/15  | 7:49 AM | 8.48  | 740               | 370                          | 90.7                 | 8.06                    | 19.7            |
| MA-Below   | 9/21/15  | 6:51 AM | 8.5   | 701               | 350                          | 90.5                 | 8.39                    | 17.9            |
| MA-Below   | 9/22/15  | 8:11 AM | 8.49  | 693               | 346                          | 90.7                 | 8.95                    | 17.8            |
| MA-Below   | 9/23/15  | 7:09 AM | 8.48  | 715               | 357                          | 86.2                 | 8.14                    | 18.4            |
| MA-Below   | 9/24/15  | 7:59 AM | 8.44  | 723               | 361                          | 89.9                 | 8.05                    | 8.5             |
| MA-Below   | 9/25/15  | 6:58 AM | 8.45  | 721               | 360                          | 85.3                 | 7.79                    | 8.9             |
| MA-Below   | 9/28/15  | 8:00 AM | 8.4   | 689               | 345                          | 88                   | 7.91                    | 19.3            |
| MA-Below   | 9/29/15  | 7:55 AM | 8.35  | 688               | 345                          | 87.4                 | 7.55                    | 21.4            |
| MA-Below   | 9/30/15  | 7:51 AM | 8.33  | 705               | 353                          | 86.8                 | 7.87                    | 18.8            |
| MA-Below   | 10/1/15  | 7:45 AM | 8.28  | 704               | 353                          | 87.3                 | 8.27                    | 16.9            |
| MA-Below   | 10/2/15  | 7:59 AM | 8.22  | 713               | 357                          | 83.7                 | 8.21                    | 15.3            |
| MA-Below   | 10/5/15  | 7:24 AM | 8.29  | 715               | 358                          | 89.2                 | 8.7                     | 15.6            |
| MA-Below   | 10/6/15  | 7:16 AM | 8.18  | 713               | 357                          | 88.1                 | 8.32                    | 16.7            |
| MA-Below   | 10/7/15  | 7:06 AM | 8.22  | 715               | 356                          | 87.2                 | 8.18                    | 17.2            |
| MA-Below   | 10/8/15  | 7:13 AM | 8.13  | 725               | 363                          | 89.4                 | 8.27                    | 17.6            |
| MA-Below   | 10/9/15  | 7:02 AM | 8.14  | 730               | 369                          | 87.9                 | 8.03                    | 18.7            |
| MA-Below   | 10/26/15 | 8:42 AM | 7.59  | 677               | 340                          | 86.6                 | 8.82                    | 13.6            |
| MA-Below   | 10/29/15 | 7:49 AM | 7.91  | 481               | 239                          | 95.5                 | 10.03                   | 11.6            |
| MA-Below   | 10/30/15 | 7:55 AM | 8.07  | 595               | 298                          | 95.5                 | 10.15                   | 11.7            |
| MA-Below   | 11/4/15  | 7:04 AM | 8.06  | 703               | 351                          | 92                   | 9.3                     | 14.1            |
| MA-Below   | 11/5/15  | 7:00 AM | 8.06  | 698               | 349                          | 94.6                 | 9.36                    | 16.1            |
| MA-Below   | 11/6/15  | 7:09 AM | 7.33  | 451               | 369                          | 83.4                 | 7.53                    | 15.5            |
| MA-Below   | 11/10/15 | 8:00 AM | 7.86  | 687               | 343                          | 96                   | 10.46                   | 10.7            |
| MA-Below   | 11/11/15 | 8:17 AM | 8.16  | 697               | 348                          | 95.8                 | 10.64                   | 9.7             |
| MA-Below   | 11/12/15 | 8:05 AM | 7.95  | 681               | 340                          | 96.4                 | 10.22                   | 11.1            |
| AVERAGES   |          | 7:41 AM | 8.202 | 686.785           | 348.5                        | 89.985               | 8.658                   | 15.671          |



**Appendix Table 7**

Accepted Water Chemistry Values for Ohio Region

**Table 6.1 - Accepted Values for Water Chemistry Samples (Behar, 1996)**

| Parameter        | Range                              |
|------------------|------------------------------------|
| Temperature      | 9-25 °C                            |
| pH               | 6.5-8.0                            |
| Conductivity     | 150 to 500 $\mu\text{S}/\text{cm}$ |
| Dissolved Oxygen | 7-11 mg/L                          |

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