State of Ohio
Environmental Protection Agency

Division of Surface Water

Biological and Water Quality Study of the upper Mahoning River and Selected Tributaries 2006

Watershed Assessment Units 05030103 010, 020, 030, and 040.

Columbiana, Mahoning, Portage, Stark and Trumbull Counties

OHIO EPA Technical Report EAS/2008-10-8

December 18, 2008

Ted Strickland, Governor, State of Ohio
Chris Korleski, Director

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TABLE OF CONTENTS

NOTICE TO USERS

Ohio EPA incorporated biological criteria into the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) regulations in February 1990 (effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish assemblage data, and the Invertebrate Community Index (ICI), which is based on macroinvertebrate assemblage data. Criteria for each index are specified for each of Ohio's five ecoregions (as described by Omernik 1988), and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the existing chemical and whole effluent toxicity evaluation methods and criteria, figure prominently in the monitoring and assessment of Ohio's surface water resources.

The following documents support the use of biological criteria by outlining the rationale for using biological information, the methods by which the biocriteria were derived and calculated, the field methods by which sampling must be conducted, and the process for evaluating results:

Ohio Environmental Protection Agency. 1987a. Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1987b. Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. Addendum to Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Plan. & Assess., Ecological Assessment Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989c. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Div. Water Quality Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1990. The use of biological criteria in the Ohio EPA surface water monitoring and assessment program. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale, methods, and application. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Since the publication of the preceding guidance documents, the following new publications by the Ohio EPA have become available. These publications should also be consulted as they represent the latest information and analyses used by the Ohio EPA to implement the biological criteria.

DeShon, J.D. 1995. Development and application of the invertebrate community index (ICI), pp. 217-243. in W.S. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Risk-based Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Ohio Environmental Protection Agency. 2008a. 2008 Updates to Biological criteria for the protection of aquatic life: Volume II and Volume II Addendum. Users manual for biological field assessment of Ohio surface waters. Div. of Surface Water, Ecol. Assess. Sect., Groveport, Ohio.

Ohio Environmental Protection Agency. 2008b. 2008 Updates to Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Div. of Surface Water, Ecol. Assess. Sect., Groveport, Ohio.

Ohio Environmental Protection Agency. 2006a. Methods for assessing habitat in flowing waters: Using the Qualitative Habitat Evaluation Index (QHEI). Ohio EPA Tech. Bull. EAS/2006-06-1. Revised by the Midwest Biodiversity Institute for Div. of Surface Water, Ecol. Assess. Sect., Groveport, Ohio.

Rankin, E. T. 1995. The use of habitat assessments in water resource management programs, pp. 181-208. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. Biological criteria program development and implementation in Ohio, pp. 109-144. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. Biological response signatures and the area of degradation value: new tools for interpreting multimetric data, pp. 263-286. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. 1995. Policy issues and management applications for biological criteria, pp. 327-344. in W. Davis and T. Simon (eds.). Biological Assessment and

Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. The role of biological criteria in water quality monitoring, assessment, and regulation. Environmental Regulation in Ohio: How to Cope With the Regulatory Jungle. Inst. of Business Law, Santa Monica, CA. 54 pp.

Yoder, C.O. and M.A. Smith. 1999. Using fish assemblages in a State biological assessment and criteria program: essential concepts and considerations, pp. 17-63. in T. Simon (ed.). Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities. CRC Press, Boca Raton, FL.

Copies of this report are located on the Ohio EPA internet web page (www.epa.state.oh.us/dsw/document_index/psdindx.html) or may be available on CD from:

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FOREWORD

What is a Biological and Water Quality Survey?

A biological and water quality survey, or “biosurvey”, is an interdisciplinary monitoring effort coordinated on a waterbody specific or watershed scale. This effort may involve a relatively simple setting focusing on one or two small streams, one or two principal stressors, and a handful of sampling sites or a much more complex effort including entire drainage basins, multiple and overlapping stressors, and tens of sites. Each year the Ohio EPA conducts biosurveys in 4-5 watersheds study areas with an aggregate total of 350-400 sampling sites.

The Ohio EPA employs biological, chemical, and physical monitoring and assessment techniques in biosurveys in order to meet three major objectives: 1) determine the extent to which use designations assigned in the Ohio Water Quality Standards (WQS) are either attained or not attained; 2) determine if use designations assigned to a given water body are appropriate and attainable; and 3) determine if any changes in key ambient biological, chemical, or physical indicators have taken place over time, particularly before and after the implementation of point source pollution controls or best management practices. The data gathered by a biosurvey is processed, evaluated, and synthesized in a biological and water quality report. Each biological and water quality study contains a summary of major findings and recommendations for revisions to WQS, future monitoring needs, or other actions which may be needed to resolve existing impairment of designated uses. While the principal focus of a biosurvey is on the status of aquatic life uses, the status of other uses such as recreation and water supply, as well as human health concerns are also addressed.

The findings and conclusions of a biological and water quality study may factor into regulatory actions taken by the Ohio EPA (*e.g.,* NPDES permits, Director’s Orders, the Ohio Water Quality Standards [OAC 3745-1], Water Quality Permit Support Documents [WQPSDs]), and are eventually incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d]).

Hierarchy of Indicators

A carefully conceived ambient monitoring approach, using cost-effective indicators consisting of ecological, chemical, and toxicological measures, can ensure that all relevant pollution sources are judged objectively on the basis of environmental results. Ohio EPA relies on a tiered approach in attempting to link the results of administrative activities with true environmental measures. This integrated approach includes a hierarchical continuum from administrative to true environmental indicators (Figure 1). The six “levels” of indicators include: 1) actions taken by regulatory agencies (permitting, enforcement, grants); 2) responses by the regulated community (treatment works, pollution prevention); 3) changes in discharged quantities (pollutant loadings); 4) changes in ambient conditions (water quality, habitat); 5) changes in uptake and/or assimilation (tissue contamination, biomarkers, wasteload allocation); and, 6) changes in health, ecology, or other effects (ecological condition, pathogens). In this process the results of administrative activities (levels 1 and 2) can be linked to efforts to improve water quality (levels 3, 4, and 5) which should translate into the environmental “results” (level 6). Thus, the aggregate effect of billions of dollars spent on water pollution control since the early 1970s can now be determined with quantifiable measures of environmental condition.

Superimposed on this hierarchy is the concept of stressor, exposure, and response indicators. *Stressor* indicators generally include activities which have the potential to degrade the aquatic environment such as pollutant discharges (permitted and unpermitted), land use effects, and habitat modifications. *Exposure* indicators are those which measure the effects of stressors and can include whole effluent toxicity tests, tissue residues, and biomarkers, each of which provides evidence of biological exposure to a stressor or bioaccumulative agent. *Response* indicators are generally composite measures of the cumulative effects of stress and exposure and include the more direct measures of community and population response that are represented here by the biological indices which comprise Ohio’s biological criteria. Other response indicators could include target assemblages, *i.e.,* rare, threatened, endangered, special status, and declining species or bacterial levels which serve as surrogates for the recreational uses. These indicators represent the essential technical elements for watershed-based management approaches. The key, however, is to use the different indicators *within* the roles which are most appropriate for each.

Describing the causes and sources associated with observed impairments revealed by the biological criteria and linking this with pollution sources involves an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and biological response signatures within the biological data itself. Thus the assignment of principal causes and sources of impairment represents the association of impairments (defined by response indicators) with stressor and exposure indicators. The principal reporting venue for this process on a watershed or subbasin scale is a biological and water quality report. These reports then provide the foundation for aggregated assessments such as the Integrated Report, the Ohio Nonpoint Source Assessment, and other technical bulletins.

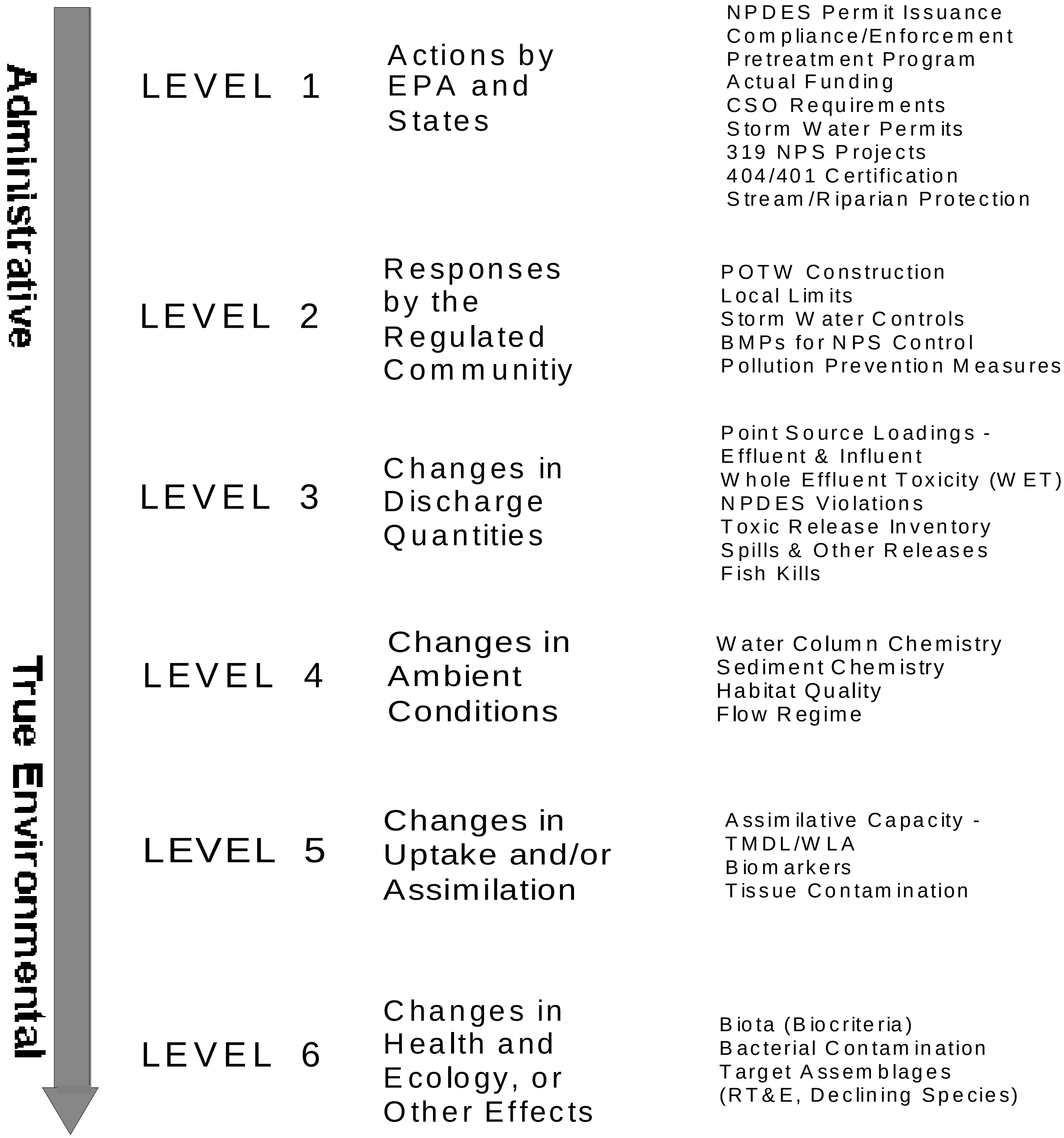

Figure 1. Hierarchy of administrative and environmental indicators which can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by the U.S. EPA.

Ohio Water Quality Standards: Designated Aquatic Life Use

The Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) consist of designated uses and chemical, physical, and biological criteria designed to represent measurable properties of the environment that are consistent with the goals specified by each use designation. Use designations consist of two broad groups, aquatic life and non-aquatic life uses. In applications of the Ohio WQS to the management of water resource issues in Ohio's rivers and streams, the aquatic life use criteria frequently result in the most stringent protection and restoration requirements, hence their emphasis in biological and water quality reports. Also, an emphasis on protecting for aquatic life generally results in water quality suitable for all uses. The five different aquatic life uses currently defined in the Ohio WQS are described as follows:

1) *Warmwater Habitat (WWH)* - this use designation defines the "typical" warmwater assemblage of aquatic organisms for Ohio rivers and streams; *this use represents the principal restoration target for the majority of water resource management efforts in Ohio.*

2) *Exceptional Warmwater Habitat (EWH)* - this use designation is reserved for waters which support "unusual and exceptional" assemblages of aquatic organisms which are characterized by a high diversity of species, particularly those which are highly intolerant and/or rare, threatened, endangered, or special status (*i.e.,* declining species); *this designation represents a protection goal for water resource management efforts dealing with Ohio's best water resources.*

3) *Cold water Habitat (CWH)* - this use is intended for waters which support assemblages of cold water organisms and/or those which are stocked with salmonids with the intent of providing a put-and-take fishery on a year round basis which is further sanctioned by the Ohio DNR, Division of Wildlife; this use should not be confused with the Seasonal Salmonid Habitat (SSH) use which applies to the Lake Erie tributaries which support periodic "runs" of salmonids during the spring, summer, and/or fall.

4) *Modified Warmwater Habitat (MWH)* - this use applies to streams and rivers which have been subjected to extensive, maintained, and essentially permanent hydromodifications such that the biocriteria for the WWH use are not attainable *and where the activities have been sanctioned by state or federal law;* the representative aquatic assemblages are generally composed of species which are tolerant to low dissolved oxygen, silt, nutrient enrichment, and poor quality habitat.

5) *Limited Resource Water (LRW)* - this use applies to small streams (usually <3 mi^2 drainage area) and other water courses which have been irretrievably altered to the extent that no appreciable assemblage of aquatic life can be supported; such waterways generally include small streams in extensively urbanized areas, those which lie in watersheds with extensive drainage modifications, those which completely lack

water on a recurring annual basis (*i.e.,* true ephemeral streams), or other irretrievably altered waterways.

Chemical, physical, and/or biological criteria are generally assigned to each use designation in accordance with the broad goals defined by each. As such the system of use designations employed in the Ohio WQS constitutes a “tiered” approach in that varying and graduated levels of protection are provided by each. This hierarchy is especially apparent for parameters such as dissolved oxygen, ammonia-nitrogen, temperature, and the biological criteria. For other parameters such as heavy metals, the technology to construct an equally graduated set of criteria has been lacking, thus the same WQS criteria may apply to two or three different use designations.

Ohio Water Quality Standards: Non-Aquatic Life Uses

In addition to assessing the appropriateness and status of aquatic life uses, each biological and water quality survey also addresses non-aquatic life uses such as recreation, water supply, and human health concerns as appropriate. The recreation uses most applicable to rivers and streams are the Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR) uses. The criterion for designating the PCR use can be having a water depth of at least one meter over an area of at least 100 square feet or, lacking this, where frequent human contact is a reasonable expectation. If a water body does not meet either criterion, the SCR use applies. The attainment status of PCR and SCR is determined using bacterial indicators (*e.g.,* fecal coliform, *E. coli)* and the criteria for each are specified in the Ohio WQS.

Attainment of recreation uses are evaluated based on monitored bacteria levels. The Ohio Water Quality Standards state that all waters should be free from any public health nuisance associated with raw or poorly treated sewage (Administrative Code 3745-1-04, Part F). Additional criteria (Administrative Code 3745-1-07) apply to waters that are designated as suitable for full body contact such as swimming (PCR- primary contact recreation) or for partial body contact such as wading (SCR- secondary contact recreation). These standards were developed to protect human health, because even though fecal coliform bacteria are relatively harmless in most cases, their presence indicates that the water has been contaminated with fecal matter.

Water supply uses include Public Water Supply (PWS), Agricultural Water Supply (AWS), and Industrial Water Supply (IWS). Public Water Supplies are simply defined as segments within 500 yards of a potable water supply or food processing industry intake. The Agricultural Water Supply (AWS) and Industrial Water Supply (IWS) use designations generally apply to all waters unless it can be clearly shown that they are not applicable. An example of this would be an urban area where livestock watering or pasturing does not take place, thus the AWS use would not apply. Chemical criteria are specified in the Ohio WQS for each use and attainment status is based primarily on chemical-specific indicators. Human health concerns are additionally addressed with fish tissue data, but any consumption advisories are issued by the Ohio Department of Health.

MECHANISMS FOR WATER QUALITY IMPAIRMENT

The following paragraphs are provided to present the varied causes of impairment that affect the resource quality of lotic systems in Ohio. While the various perturbations are presented under separate headings, it is important to remember that they are often interrelated and cumulative in terms of the detrimental impact that can result.

Habitat and Flow Alterations

Habitat alteration, such as channelization, impacts biological communities directly by limiting the complexity of living spaces available to aquatic organisms. Consequently, fish and macroinvertebrate communities are not as diverse. Indirect impacts include the removal of riparian trees and field tiling to facilitate drainage. Following a rain event, most of the water is quickly removed from tiled fields rather than filtering through the soil, recharging ground water, and reaching the stream at a lower volume and more sustained rate. As a result, small streams more frequently go dry or become intermittent.

Tree shade is important because it limits the energy input from the sun, moderates water temperature, and limits evaporation. Removal of the tree canopy further degrades conditions because it eliminates an important source of coarse organic matter essential for a balanced ecosystem. Erosion impacts channelized streams more severely due to the lack of a riparian buffer zone to slow runoff, trap sediment and stabilize banks. Additionally, deep trapezoidal channels lack a functioning flood plain and therefore cannot expel sediment as would occur during flood events along natural watercourses.

The lack of water movement under low flow conditions can exacerbate impacts from organic loading and nutrient enrichment by limiting reaeration of the stream. The amount of oxygen soluble in water decreases as temperature increases. This is one reason why tree shade is so important. The two main sources of oxygen in water are diffusion from the atmosphere and plant photosynthesis. Turbulence at the water surface is critical because it increases surface area and promotes diffusion, but channelization eliminates turbulence produced by riffles, meanders, and debris snags. Plant photosynthesis produces oxygen, but at night, respiration reverses the process and consumes oxygen. Oxygen is also used by bacteria that decay dead organic matter. Nutrient enrichment can promote the growth of nuisance algae that subsequently dies and serves as food for bacteria. Under these conditions, oxygen can be depleted unless it is replenished from the air.

Sedimentation

Whenever the natural flow regime is altered to facilitate drainage, increased amounts of sediment are likely to enter streams either by overland transport or increased bank erosion. The removal of wooded riparian areas furthers the erosion process. Channelization keeps all but the highest flow events confined within the artificially high banks. As a result, areas that were formerly flood plains and allowed for the removal of sediment from the primary stream channel no longer serve this function. As water levels fall following a rain event, interstitial spaces between larger rocks fill with sand and silt and the diversity of available habitat to support fish and macroinvertebrates is reduced. Silt also can clog the gills of both fish and macroinvertebrates, reduce visibility thereby excluding site feeding fish species, and smother the nests of lithophilic fishes. Lithophilic spawning fish require clean substrates with interstitial voids in which to deposit eggs. Conversely, pioneering species benefit. They are generalists and best suited for exploiting disturbed and less heterogeneous habitats. The net result is a lower diversity of aquatic species compared with a typical warmwater stream with natural habitats.

Sediment also impacts water quality, recreation, and drinking water. Nutrients absorbed to soil particles remain trapped in the watercourse. Likewise, bacteria, pathogens, and pesticides which also attach to suspended or bedload sediments become concentrated in waterways where the channel is functionally isolated from the landscape. Community drinking water systems address these issues with more costly advanced treatment technologies.

Nutrients

The element of greatest concern is phosphorus because it critical for plant growth and it is often the limiting nutrient. The form that can be readily used by plants and therefore can stimulate nuisance algae blooms is orthophosphate (PO_4^{-3}). The amount of phosphorus tied up in the nucleic acids of food and waste is actually quite low. This organic material is eventually converted to orthophosphate by bacteria. The amount of orthophosphate contained in synthetic detergents is a great concern however. It was for this reason that the General Assembly of the State of Ohio enacted a law in 1990 to limit phosphorus content in household laundry detergents sold in the Lake Erie drainage basin to 0.5 % by weight. Inputs of phosphorus originate from both point and nonpoint sources. Most of the phosphorus discharged by point sources is soluble. Another characteristic of point sources is they have a continuous impact and are human in origin, for instance, effluents from municipal sewage treatment plants. The contribution from failed on-lot septic systems can also be significant, especially if they are concentrated in a small area. The phosphorus concentration in raw waste water is generally 8-10 mg/l and after secondary treatment is generally 4-6 mg/l. Further removal requires the added cost of chemical addition. The most common methods use the addition of lime or alum to form a precipitate, so most phosphorus (80%) ends up in the sludge.

A characteristic of phosphorus discharged by nonpoint sources is that the impact is intermittent and associated with storm water runoff. Most of this phosphorus is bound tightly to soil particles and enters streams from erosion, although some comes from tile drainage. Urban storm water is more of a concern if combined sewer overflows are involved. The impact from rural storm water varies depending on land use and management practices and includes contributions from livestock feedlots and pastures and row crop agriculture. Crop fertilizer includes granular inorganic types and organic types such as manure or sewage sludge. Pasture land is especially a concern if the livestock have access to the stream. Large feedlots with manure storage lagoons create the potential for overflows and accidental spills. Land management is an issue because erosion is worse on streams without any riparian buffer zone to trap runoff. The impact is worse in streams that are channelized because they no longer have a functioning flood plain and cannot expel sediment during flooding. Oxygen levels must also be considered, because phosphorus is released from sediment at higher rates under anoxic conditions.

There is no numerical phosphorus criterion established in the Ohio Water Quality Standards, but there is a narrative criterion that states phosphorus should be limited to the extent necessary to prevent nuisance growths of algae and weeds (Administrative Code, 3745-1-04, Part E). Phosphorus loadings from large volume point source dischargers in the Lake Erie drainage basin are regulated by NPDES permit limits. The permit limit is a concentration of 1.0 mg/l in final effluent. Research conducted by the Ohio EPA indicates that a significant correlation exists between phosphorus and the health of aquatic communities (Association Between Nutrients, Habitat, and Aquatic Biota in Ohio Rivers and Streams, MAS/1999-1-1). It was concluded that biological community performance in headwater and wadeable streams was highest where phosphorus concentrations were lowest. It was also determined that the lowest phosphorus concentrations were associated with the highest quality habitats, supporting the notion that habitat is a critical component of stream function. The report recommends WWH biocriteria of 0.08 mg/l in headwater streams (<20 mi^2 watershed size), 0.10 mg/l in wadeable streams (>20-200 mi^2) and 0.17 mg/l in small rivers (>200-1000 mi^2).

Organic Enrichment and Low Dissolved Oxygen

The amount of oxygen soluble in water is low and it decreases as temperature increases. This is one reason why tree shade is so important. The two main sources of oxygen in water are diffusion from the atmosphere and plant photosynthesis. Turbulence at the water surface is critical because it increases surface area and promotes diffusion. Drainage practices such as channelization eliminate turbulence produced by riffles, meanders, and debris snags. Although plant photosynthesis produces oxygen by day, it is consumed by the reverse process of respiration at night. Oxygen is also consumed by bacteria that decay organic matter, so it can be easily depleted unless it is replenished from the air. Sources of organic matter include poorly treated waste water, sewage bypasses, and dead plants and algae.

Dissolved oxygen criteria are established in the Ohio Water Quality Standards to protect aquatic life. The minimum and average limits are tiered values and linked to use designations (Administrative Code 3745-1-07, Table 7-1).

Ammonia

Ammonia enters streams as a component of fertilizer and manure run-off and wastewater effluent. Ammonia gas (NH_3) readily dissolves in water to form the compound ammonium hydroxide (NH_4OH). In aquatic ecosystems an equilibrium is established as ammonia shifts from a gas to undissociated ammonium hydroxide to the dissociated ammonium ion (NH_4^{+1}). Under normal conditions (neutral pH 7 and 25 C) almost none of the total ammonia is present as gas, only 0.55% is present as ammonium hydroxide, and the rest is ammonium ion. Alkaline pH shifts the equation toward gaseous ammonia production, so the amount of ammonium hydroxide increases. This is important because while the ammonium ion is almost harmless to aquatic life, ammonium hydroxide is very toxic and can reduce growth and reproduction or cause mortality.

The concentration of ammonia in raw sewage is high, sometimes as much as 20-30 mg/l. Treatment to remove ammonia involves gaseous stripping to the atmosphere, biological nitrification and de-nitrification, and assimilation into plant and animal biomass. The nitrification process requires a long detention time and aerobic conditions like that provided in extended aeration treatment plants. Under these conditions, bacteria first convert ammonia to nitrite (*Nitrosomonas*) and then to nitrate (*Nitrobacter*). Nitrate can then be reduced by the de-nitrification process (*Pseudomonas*) and nitrogen gas and carbon dioxide are produced as by-products.

Ammonia criteria are established in the Ohio Water Quality Standards to protect aquatic life. The maximum and average limits are tiered values based on sample pH and temperature and linked to use designations (Administrative Code 3745-1-07, Tables 7-2 through 7-8).

Metals

Metals can be toxic to aquatic life and hazardous to human health. Although they are naturally occurring elements many are extensively used in manufacturing and are by-products of human activity. Certain metals like copper and zinc are essential in the human diet, but excessive levels are usually detrimental. Lead and mercury are of particular concern because they often trigger fish consumption advisories. Mercury is used in the production of chlorine gas and caustic soda and in the manufacture of batteries and fluorescent light bulbs. In the environment it forms inorganic salts, but bacteria convert these to methyl-mercury and this organic form builds up in the tissues of fish. Extended exposure can damage the brain, kidneys, and developing fetus. The Ohio Department of Health (ODH) issued a statewide fish consumption advisory in 1997 advising women of child bearing age and children six and under not to eat more than one meal per week of any species of fish from waters of the state because of mercury. Lead is used in batteries, pipes, and paints and is emitted from burning fossil fuels. It affects the central nervous system and damages the kidneys and reproductive system. Copper is mined extensively and used to manufacture wire, sheet metal, and pipes. Ingesting large amounts can cause liver and kidney damage. Zinc is a by-product of mining, steel production, and coal burning and used in alloys such as brass and bronze. Ingesting large amounts can cause stomach cramps, nausea, and vomiting.

Metals criteria are established in the Ohio Water Quality Standards to protect human health, wildlife, and aquatic life. Three levels of aquatic life standards are established (Administrative Code 3745-1-07, Table 7-1) and limits for some elements are based on water hardness (Administrative Code 3745-1-07, Table 7-9). Human health and wildlife standards are linked to either the Lake Erie (Administrative Code 3745-1-33, Table 33-2) or Ohio River (Administrative Code 3745-1-34, Table 34-1) drainage basins. The drainage basins also have limits for additional elements not established elsewhere that are identified as Tier I and Tier II values.

Bacteria

High concentrations of either fecal coliform bacteria or Escherichia coli (E. coli) in a lake or stream may indicate contamination with human pathogens. People can be exposed to contaminated water while wading, swimming, and fishing. Fecal coliform bacteria are relatively harmless in most cases, but their presence indicates that the water has been contaminated with feces from a warm-blooded animal. Although intestinal organisms eventually die off outside the body, some will remain virulent for a period of time and may be dangerous sources of infection. This is especially a problem if the feces contained pathogens or disease producing bacteria and viruses. Reactions to exposure can range from an isolated illness such as skin rash, sore throat, or ear infection to a more serious wide spread epidemic. Some types of bacteria that are a concern include *Escherichia*, which cause diarrhea and urinary tract infections, *Salmonella*, which cause typhoid fever and gastroenteritis (food poisoning), and *Shigella*, which cause severe gastroenteritis or bacterial dysentery. Some types of viruses that are a concern include polio, hepatitis A, and encephalitis. Disease causing microorganisms such as cryptosporidium and giardia are also a concern.

Since fecal coliform bacteria are associated with warm-blooded animals, there are both human and animal sources. Human sources, including effluent from sewage treatment plants or discharges by on-lot septic systems, are a more continuous problem. Bacterial contamination from combined sewer overflows are associated with wet weather events. Animal sources are usually more intermittent and are also associated with rainfall, except when domestic livestock have access to the water. Large livestock farms store manure in holding lagoons and this creates the potential for an accidental spill. Liquid manure applied as fertilizer is a runoff problem if not managed properly and it sometimes seeps into field tiles.

Bacteria criteria are established in the Ohio Water Quality Standards to protect human health. The maximum and average limits are tiered values and linked to use designation, but only apply during the May 1-October 15 recreation season (Administrative Code 3745-1-07, Table 7-13). The standards also state that streams must be free of any public health nuisance associated with raw or poorly treated sewage during dry weather conditions (Administrative Code 3745-1-04, Part F).

Sediment Contamination

Chemical quality of sediment is a concern because many pollutants bind strongly to soil particles and are persistent in the environment. Some of these compounds accumulate in the aquatic food chain and trigger fish consumption advisories, but others are simply a contact hazard because they cause skin cancer and tumors. The physical and chemical nature of sediment is determined by local geology, land use, and contribution from manmade sources. As some materials enter the water column they are attracted to the surface electrical charges associated with suspended silt and clay particles. Others simply sink to the bottom due to their high specific gravity. Sediment layers form as suspended particles settle, accumulate, and combine with other organic and inorganic materials. Sediment is the most physically, chemically, and biologically reactive at the water interface because this is where it is affected by sunlight, current, wave action, and benthic organisms. Assessment of the chemical nature of this layer can be used to predict ecological impact.

The Ohio EPA evaluation of sediment chemistry results are evaluated using a dual approach, first by ranking relative concentrations based on a system developed by Ohio EPA (2005) and then by determining the potential for toxicity based on guidelines developed by MacDonald et al (2000). The Ohio EPA system was derived from samples collected at ecoregional reference sites. Specific Reference Values are site specific ecoregional based metals concentrations and are used to identify contaminated stream reaches. The MacDonald guidelines are consensus based using previously developed values. The system predicts that sediments below the threshold effect concentration (TEC) are absent of toxicity and those greater than the probable effect concentration (PEC) are toxic.

Sediment samples collected by the Ohio EPA are measured for a number of physical and chemical properties. Physical attributes included % particle size distribution (sand $\geq$60 μ, silt 5-59 μ, clay $\leq$4 μ), % solids, and % organic carbon. Due to the dynamics of flowing water, most streams do not contain a lot of sediment and samples often consist mostly of inert sand. This scenario changes if the stream is impounded by a dam or channelized. Chemical attributes included metals, volatile and semi-volatile organic compounds, pesticides, and poly-chlorinated biphenyls (PCBs).

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Columbus OH 43215

INTRODUCTION

Ambient biological, water column chemical and sediment sampling was conducted in the upper Mahoning River basin from June to October 2006 with additional fish sampling conducted in September 2007 as part of the five-year basin approach for monitoring, assessment, issuance of National Pollution Discharge Elimination System (NPDES) permits and to facilitate a Total Maximum Daily Load (TMDL) assessment. This study area included over 55 miles of the Mahoning River beginning in the headwaters and extending to the Leavittsburg dam. Subwatersheds within the study area included the headwaters of the Mahoning River (WAU 05030103010), Deer Creek (WAU 05030103020), Eagle Creek (WAU 05030103030), and West Branch Mahoning River (WAU 05030103040). To the extent possible, tributary streams with at least 4 mi^2 of drainage were sampled.

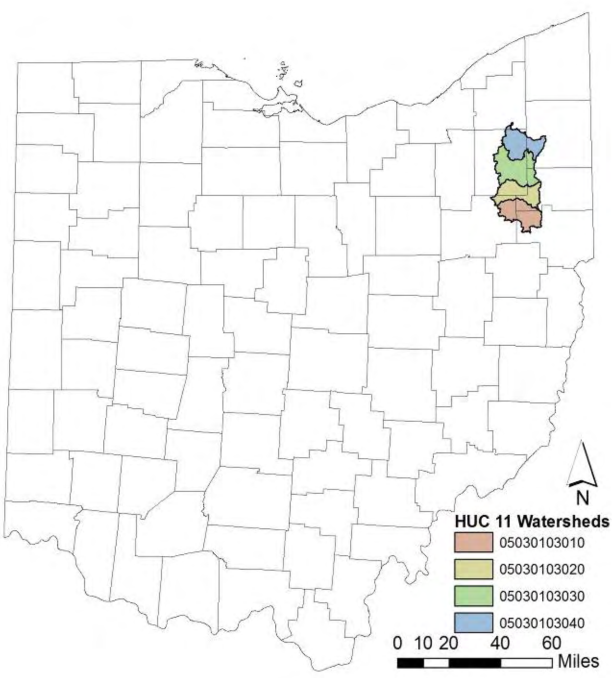


Figure 2. Study area location in Ohio.

Specific objectives of this evaluation were to:

1 Monitor and assess the chemical, physical and biological integrity of the streams within the 2006 upper Mahoning River study area;

2) Characterize the consequences of various land uses on water quality within the upper Mahoning River watershed;

3) Evaluate the influence of the Beloit, Sebring, and other wastewater treatment plants (WWTPs) and unsewered communities;

4) Evaluate the potential impacts from spills, nonpoint source pollution (NPS), and habitat alterations on the receiving streams; and

5) Determine the attainment status of the current designated aquatic life uses and non-aquatic use designations and recommend changes where appropriate.

The findings of this evaluation factor into regulatory actions taken by the Ohio EPA (*e.g.*, NPDES permits, Director's Orders, the Ohio Water Quality Standards [OAC 3745-1], Water Quality Permit Support Documents [WQPSDs]) and are incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d]).

SUMMARY

Watershed Overview

The Mahoning River basin has been segmented by Ohio EPA into upper and lower drainage areas for purposes of monitoring and assessment (Ohio EPA 1996). The upper Mahoning River basin extends from river mile (RM) 45.57 at the confluence of Duck Creek (~100 feet below the Leavittsburg dam) upstream to the headwaters located in western Columbiana County. The flow of the river originates from a wetland (Watercress Marsh) in Butler Township, Columbiana County. The length of the mainstem of the Upper Mahoning River is 62.73 miles; drainage area is 804.1 mi^2 (Martin, 2004), which represents 73.7% of the total drainage area for the Mahoning River in Ohio. The Upper Mahoning River basin is located partially within six counties including Columbiana, Stark, Mahoning, Trumbull, Portage, and a small section of southern Geauga (Figure 3). It is divided into four 11-Digit Hydrologic Unit Code (HUC) assessment units (AU) for purposes of reporting required by the Clean Water Act Section 303(d) (Table 1). For the purposes of this report, the four 11-Digit HUC units will be referred to as Watershed Assessment Units (WAUs).

The predominant land use in the Upper Mahoning River basin is agriculture (Table 2), with cropland and pasture comprising 62.70% of the total land area (Martin, 2004). The Source Water Protection Plan (SWAP) for the village of Sebring (Ohio EPA, 2002a) estimates that the watershed area upstream from the Water Treatment Plant (WTP) intake (RM 93.23, Knox-School Rd.) is 51.58% pasture/hay and 21.39% row crop, totaling 72.97% of the upstream watershed area. Noteworthy population centers include Alliance, Atwater, Beloit, Craig Beach, Garrettsville, Hiram, Limaville, Newton Falls, Sebring, Windham and parts of eastern Ravenna. Three urban areas (Alliance, Newton Falls and Ravenna) are covered by Phase II NPDES storm water control regulations (Table 3).

The bedrock geology of the Mahoning River in Ohio consists of layered sedimentary rocks that represent former sands, silts, and mud, deposited 280 million to 400 million years ago. Rocks exposed in the watershed are primarily from Mississippian and Pennsylvanian Age systems. Rocks of the Mississippian system, including thick shale, sandstone, and interbedded shale and sandstone, are exposed over most of Trumbull County. Rocks of the Pennsylvanian system, composed of a sequence of sandstones, shale, siltstones, coal, clay, and limestone, are exposed throughout Mahoning County. The entire watershed was at one time covered by glaciers, with the last major advance being about 20,000 years ago. The glaciers scoured and eroded the soils and bedrock as they advanced and accumulated an unsorted mixture of clay, sand, and gravel. This material was deposited in front of the ice sheet or left behind when the glaciers melted (Martin, 2004).

The availability of underground water varies from east to west with yields ranging from 25-100 to 5-25 gallons/min. in a westerly direction. A zone of higher water yields ranging from 100-500 gallons/min. is located along the Mahoning River mainstem extending roughly from the Mahoning-Columbiana county line upstream to Berlin Reservoir (Ohio DNR, 1961).

A number of large reservoirs are located within the Upper Mahoning River basin (Table 4). Berlin Reservoir, Lake Milton and the M. J. Kirwan (aka West Branch) Reservoir are large impoundments on the Mahoning River mainstem that provide flood control, flow augmentation and recreation opportunities in the form of fishing, boating, and swimming. Berlin Reservoir is an emergency water supply for the Mahoning Valley Sanitary District that provides drinking water for Youngstown and surrounding areas. M. J. Kirwan Reservoir also is used as a source of public drinking water. The West Branch WTP serves about 1,400 persons as a transient non-community system and is operated by the Ohio Department of Natural Resources (Ohio DNR). Deer Creek Reservoir is the public drinking water supply for Alliance. In addition to reservoirs, the mainstem of the Mahoning River is used as a source of public drinking water by Sebring (~RM 93.23) and Newton Falls (~RM 58.13).

The United States Geological Survey historically has maintained stream flow gaging stations within the Upper Mahoning River basin (Table 5). Six USGS gage stations were in operation during the 2006-2007 survey recording stream discharge (cfs) and/or gage height information. The USGS gage station at Leavittsburg is located immediately downstream from the upper Mahoning River study area. The Ohio EPA has conducted long term ambient sampling at the Leavittsburg sample location (STORET no. 602280) and additional chemical samples were collected during the 2006 survey. Although the Leavittsburg station is downstream from the boundary of the Upper Mahoning River survey area (because it includes the flow from Duck Creek), trends in chemical water quality were assessed using data from this ambient station.

A previous survey of the Mahoning River basin was conducted by the Ohio EPA in 1994 (Ohio EPA, 1996). A survey of the Lower Mahoning River segment was conducted from 1980-1984 (Ohio EPA 1984). The US EPA (2004) conducted a fecal coliform bacteria total maximum daily load (TMDL) study for the lower five WAUs (05030103-040 to -080). Characteristics and attainment status of streams within the Upper Mahoning River basin that were assessed during the 2006 survey and also are named in the Ohio Water Quality Standards (WQS) OAC Chapter 3745-1-25 are given in Table 6.

The upper Mahoning River watershed lies within the Erie-Ontario Lake Plain (EOLP) ecoregion, which is characterized by a rolling landscape composed of low rounded hills with scattered end moraines and kettles in the southern two-thirds of the watershed. Urban-industrial areas such as Alliance, as well as dairy, livestock, corn and soybean farming are common, and many ridges and lowlands are wooded. The northern third of the study area, from roughly Newton Falls northward, is characterized by poor drainage, wetlands, low-gradient streams, and moisture tolerant woodlands. It is nearly flat and underlain by clayey till and fine lacustrine deposits. The Ravenna Training and Logistics Site (RTLS), (a.k.a. Ravenna Arsenal) lies in the western portion of the northern third, while the remaining land use is a mix of dairy farms, woodlots and scattered residential areas (Omernick 1987).

The Mahoning River, between Alliance and the low-head dam in Leavittsburg, changes from a small headwaters stream to a small river. Two large reservoirs, Berlin Lake and Lake Milton, impound approximately 20 river miles of the mainstem between RMs 84.0 and 64.0. The construction of these large reservoirs and low-head dams on the Mahoning River has significantly altered the natural riverine habitat and created an alternating series of free-flowing and impounded segments.

Tributary streams reflect the landscape with wetland-type streams present in the northern portion of the watershed, while streams in the southern two-thirds of the study area are a combination of low gradient and end moraine streams. The only free flowing portion of Deer Creek is downstream from Walburn Reservoir and upstream from the Berlin Lake backwaters. The West Branch Mahoning River is also divided into free flowing and impounded reaches by Kirwan Reservoir.

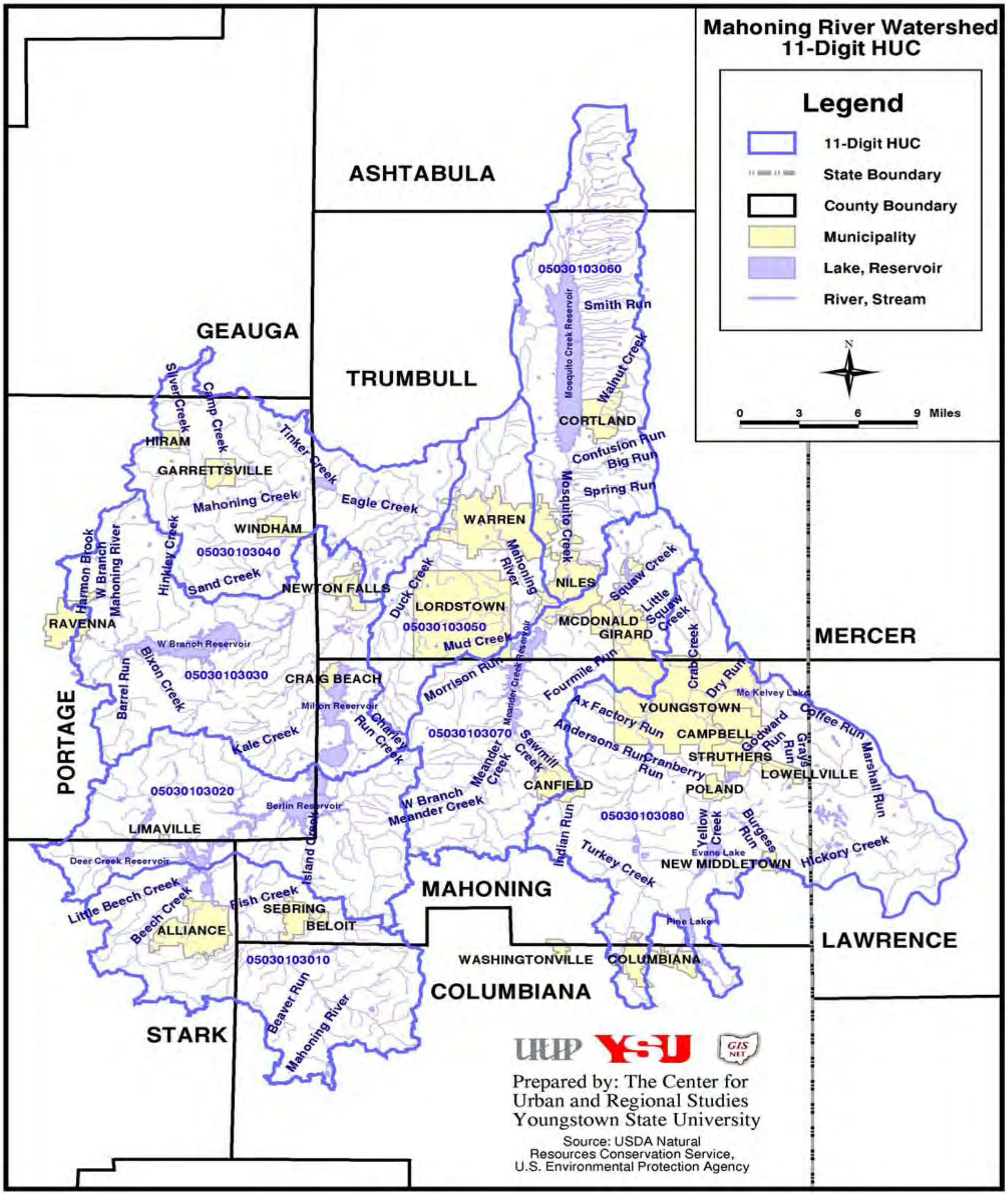


Figure 3**.** Mahoning River basin showing WAUs. Source: Martin, S.C. 2004. Mahoning River Watershed Action Plan, August 2004. Youngstown State University.

Table 1. 11-Digit Hydrologic Unit Code assessment units for the upper Mahoning River basin in Ohio.

WAU	Description	Also known as
Upper Mahoning River Basin (RMs 45.57 – 108.3)		
05030103 010	Mahoning River (headwaters to downstream from Beech Creek)	Headwaters of the Mahoning River subwatershed
05030103 020	Mahoning River (downstream from Beech Creek to downstream from Berlin Dam)	Deer Creek subwatershed
05030103 030	Mahoning River (downstream from Berlin Dam to downstream from and including West Branch Mahoning River)	West Branch Mahoning River subwatershed
05030103 040	Mahoning River (downstream from West Branch Mahoning River including Eagle Creek to upstream from Duck Creek)	Eagle Creek subwatershed

Table 2. Major land uses in the Upper Mahoning River basin. (Data Source: calculated from information in the 2004 Mahoning River Watershed Action Plan, S. C. Martin, Youngstown State University).

Land Use Categories	Area (mi^2)	% in Upper Mahoning River
Cropland & Pasture	504.193	62.70
Forest Land (Deciduous, Evergreen, Mixed)	111.727	13.89
Residential	70.154	8.72
Commercial & Service (mostly Ravenna Arsenal)	32.563	4.05
Wetlands (Forested, Non-Forested)	26.543	3.30
Natural Lakes & Reservoirs	16.188	2.01
Urban & Built-Up	11.948	1.49
Strip Mines	11.067	1.37
Transportation, Utilities	10.748	1.34
Industrial	4.438	0.55
Transitional Areas	4.530	0.56
Total in Upper Mahoning River basin	804.099	100.0 %

Table 3. Incorporated areas, counties and townships within the Upper Mahoning River basin, and Phase II storm water status. (Martin, S.C. 2004. Mahoning River Watershed Action Plan, August 2004. Youngstown State University; Ohio EPA Storm Water Phase II program information, 2/2008 update).

Community/County	Phase II Status	Population 2000 Census
Sebring Village / Mahoning	No	4,912
Garrettsville Village / Portage	No	2,262
Windham Village / Portage	No	2806
Craig Beach Village/ Mahoning	No	1,254
Hiram Village/ Portage	No	1,242
Beloit Village / Mahoning	No	1,024
Limaville Village / Stark	No	193
Alliance City / Stark	Yes [b]	23,353
Ravenna City / Portage	Yes	11,771 [a]
Newton Falls Village/ Trumbull	Yes	5,002
Geauga County [c]	Yes	
Stark County [c]	Yes	
Mahoning County [c]	Yes	
Portage County	Yes (includes listed townships)	
Ravenna Township		
Rootstown Township		
Trumbull County	Yes (includes listed townships)	
Champion Township		
Newton Township		
Warren Township		

a - The watershed boundary passes through the city or village; thus, a portion of this population lives outside the Mahoning River watershed.
b - Phase II status will become effective with the 2008 NPDES storm water permit renewal.
c - All townships in these counties within the Upper Mahoning River basin are exempt from Phase II regulations. Phase II rules apply only to County owned sewers.

Table 4. Reservoirs in the Upper Mahoning River Watershed. (Ohio EPA 1996 Water Resource Inventory, Vol. III, Ohio's Public Lakes, Ponds, and Reservoirs; Ohio DNR, Division of Water, 1961, Water Inventory of the Mahoning and Grand River Basins; Ohio EPA, 1982, 305(b) Report, (ed.) J. Youger).

Reservoir (Date)/ Owner/ STORET ID	Surface Area (acres)	Storage Capacity (acre/feet)	Drainage Area (mi^2)	Uses[a]
Westville Lake (1915) (Sebring) (OH01 30-071)	90	934	7.8	WS (backup), R
Deer Creek Reservoir (1954) (Alliance) (OH01 29-348)	313	3,070	36.0	WS (primary), R
Dale Walburn Reservoir (1971) (Alliance) (OH01 29-349)	670	5,860	32.0	WS (secondary), R
Lake Milton (1917) (State of Ohio) (OH01 22-230)	1,685	29,770	273	F, R, L
Berlin Reservoir (1943) (Army Corps of Engineers) (OH01 24-307)	3,590	91,200	248	WS (backup) F, R, L
M.J.Kirwan Reservoir (1966) (Army Corps of Engineers) (OH01 14-309)	2,650	52,900	81	WS (primary), F, R, L

a F = flood control; WS, drinking water supply; R = recreation; L = low flow augmentation.

Table 5. USGS flow gaging stations in the Upper Mahoning River basin including the downstream Leavittsburg gage. "Flow" data include estimated discharge (cfs) and gage height. Real time USGS flow data are available at: http://waterdata.usgs.gov/oh/nwis/current?type=flow

USGS Gage Number	Location	Period of Record (discharge or gage ht. only)
03086500	Mahoning R. at Alliance	1942-1992 (flow), 1992-2008 (gage ht.)
03087000	Beech Creek near Bolton	1944-1950 (flow)
03088000	Deer Creek at Limaville	1942-1950 (flow)
03091500	Mahoning R. at Pricetown	1930-2008 (flow)
03090500	Mahoning R. below Berlin Dam	1931-1990 (flow), 1990-2008 (gage ht.)
03092000	Kale Creek Near Pricetown	1942-1992 (flow), 1992-2008 (gage ht.)
03092090	West Br. Mahoning R. near Ravenna	1966-1992 (flow), 1992-2008 (gage ht.)
03092500	West Br. Mahoning R. near Newton Falls	1927-1980 (flow)
03093000	Eagle Creek at Phalanx Station	1927-2008 (flow)
03094000	Mahoning R. at Leavittsburg [a]	1941-2008 (flow)

a - This station is located immediately downstream from the Upper Mahoning River basin, and includes flow from Duck Creek.

Aquatic Life Use Attainment Status and Trends

The Mahoning River study area included four Watershed Assessment Units (Figure 2). These were: headwaters of Mahoning River (headwaters to downstream Beech Creek [RM 80.35]); Deer Creek (Mahoning River - downstream Beech Creek to downstream Berlin Dam [RM 80.35 to RM 69.18]); West Branch Mahoning River (Mahoning River - downstream Berlin Dam to downstream West Branch Mahoning River [RM 69.18 to RM 53.75]); and Eagle Creek (Mahoning River - downstream West Branch Mahoning River to Duck Creek, excluding mainstem greater than 500mi^2 [RM 53.75 to RM 43.84]).

During 2006 and 2007, fish and/or macroinvertebrate sampling was conducted at 76 locations in the Mahoning River watershed ranging in drainage area from 3.2 mi^2 to 542 mi^2 (Table 7 and Figure 4). The survey resulted in the assessment of aquatic life use attainment at 73 sites. The Aquatic Life Use Attainment table provides biological index scores for each of the sampled locations and causes and sources of impairment (Table 6). Twenty-eight (38.4%) of the evaluated sites fully met the existing or recommended aquatic life use. Seventeen (23.2%) of the sites partially met and twenty-eight (38.4%) of the sites were not attaining their designated or recommended use.

Along the Mahoning River mainstem only the four upstream most stations (RM 102.24 to RM 93.23) were in full attainment of the existing WWH aquatic life use, with both the fish and macroinvertebrate community indices (IBI, MIwb, and ICI) meeting the biological criteria. One additional station upstream from Alliance (RM 89.4) exhibited full attainment, but this was based on only one organism group (macroinvertebrates). Five stations exhibited partial attainment and four stations exhibited non-attainment of the WWH biocriteria. Within the free-flowing sections of the upper mainstem, from King Road (RM 100.57) to Winona Road (RM 102.24) CWH communities were established and resulted in the recommendation of the CWH Aquatic Life Use (ALU) within this reach.

As the Mahoning River flowed into Alliance, both organism groups failed to attain the WWH criteria at Webb Road (RM 85.51). Further downstream, two large reservoirs (Berlin Lake and Lake Milton) and two low-head dams (Newton Falls, and Leavittsburg), contributed to the significant physical alteration of the free-flowing riverine habitat. Non-attaining sites were impacted to some extent by both industrial (RM 84.99) and municipal (RM 56.53) wastewater discharges; however, most impairments to the biological community were related to alterations in flow regime as a result of multiple dams along the river. The Mahoning River was in partial or non-attainment of the WWH biological criteria as a result of these structures throughout the remaining portion of the study area.

Throughout the Mahoning River mainstem, as anthropogenic influences increased, fish community integrity decreased. The highest fish community scores were noted where large riparian buffers were present adjacent to the stream (RM 102.24) and depressed scores were noted in impounded conditions (RM 85.51). The highly altered flow regime from the presence of the dams continues to impact the fish community throughout the Mahoning River from north of the Alliance to Leavittsburg.

In addition to the dams on the Mahoning River mainstem, several tributaries also had dams which affected both fish migration and overall fish community integrity; Deer Creek, West Branch Mahoning River, Turkey Broth Creek, and tributary to West Branch Mahoning River (RM 8.28). Other anthropogenic factors also negatively affected fish community performance on tributaries throughout the study area. Agriculture influences such as siltation and nutrient enrichment resulted in lower quality fish communities at tributary to Mahoning River (RM 98.71), Mill Creek RM 6.28, Kale Creek RM 3.38, and Tinker Creek. Agricultural activities and channelization from other sources also lowered the quality of habitat in some streams, thereby reducing the quality of the fish communities in Naylor Ditch, Beech Creek RM 10.50, Little Beech Creek, Willow Creek RM 8.13, Island Creek, Garfield Ditch, Turkey Broth Creek, Nelson Ditch, and Chocolate Run. Point sources including WWTPs negatively affected the fish communities of Mahoning Creek, and Fish Creek. Despite these factors, where habitat quality was high, fish community scores were also high: examples included; Beaver Run, Mill Creek RM 3.64, West Branch Mahoning River, Hinkley Creek, Silver Creek (tributary to West Branch), Eagle Creek, Silver Creek (tributary to Eagle Creek), Camp Creek, South Fork Eagle Creek, and Harmon Brook. In addition, over 16% of fish community of Camp Creek was comprised by cold water species; including mottled sculpin (9.6%), redside dace (7.2%), brook stickleback (0.6%), and central mudminnow (0.1%).

The quality of the macroinvertebrate communities of the Mahoning River displayed a longitudinal pattern of decline. Exceptional, cold water-adapted communities were collected at the two headwater sites, and benthic performance continued to meet WWH criteria until the river reached the Alliance. From the Alliance to the Leavittsburg dam pool, attainment of ecoregional expectations was limited to only two sampling stations. Non-attaining sites were impacted by both industrial (RM 84.99) and municipal (RM 56.53) wastewater discharges; however, most impairments to the macroinvertebrate community were related to alterations in flow regime as a result of multiple dams along the river. Low head dams in Alliance, Newton Falls, and Leavittsburg account for nearly 17 miles of sluggish waters on the Mahoning River mainstem. Unless these structures can be removed and the river restored to a free-flowing stream, it is unlikely that ambient macroinvertebrate performance will improve enough to meet the designated WWH aquatic life use and Clean Water Act goals.

Unlike the mainstem, the tributaries to the Upper Mahoning River hosted lower quality macroinvertebrate communities in the headwaters, and continued to improve in a downstream direction. In the two uppermost assessment units (Headwaters Mahoning River and Deer Creek-Mahoning River), 70.8% of the tributary stations sampled were found to be impaired, which included 9 of the 11 macroinvertebrate communities evaluated as poor in the survey. Many of these sites were of small drainage area (<10mi²) and located in rural, agricultural areas, making them susceptible to either hydromodification, agricultural runoff, or both. Two of these streams were also recipients of municipal WWTP discharges from the villages of Beloit and Sebring (Unnamed Trib. to Mahoning River at RM 91.21 and Fish Creek, respectively), which led to impairments via nutrient enrichment. Mill Creek at RM 3.64, scoring an ICI of 46, was the only exceptional quality community collected on the tributaries of these two sub-watersheds.

In contrast to its upper counterparts, the tributaries of the two lower assessment units (West Branch and Eagle Creek) displayed much higher benthic quality, with only 26.3% of the sampled communities showing impairment. Undeniably, these two sub-watersheds were aided by the inclusion of the Upper Mahoning River's largest and highest quality tributaries, the West Branch and Eagle Creek. Most of the sampling effort in these two assessment units was dedicated to these large streams and their associated tributaries. Of the 12 tributary sites that were found to be exceptional in the survey, 11 were located within the West Branch and Eagle Creek watersheds. Habitat quality appeared to play the largest role regarding impairment of macroinvertebrate communities, ranging from beaver dams, Kirwan Reservoir, channelization, and natural conditions. Discharge from either septic outlets or small package WWTPs was affecting the benthic quality of three streams – Harmon Brook, Mahoning Creek, and Chocolate Run.

Of interest in this survey was the discovery of 4 cold water-adapted benthic communities. Two were located in the headwaters of the Mahoning River, and the other two were found on small tributaries to Eagle Creek. The Mahoning River communities were found at the two uppermost sites, RM 102.24 and RM 100.57. A combined total of 9 cold water taxa were found at these two sites, including the state threatened cased caddisfly *Psilotreta indecisa*. Additionally, the cold water flathead mayfly *MacCaffertium ithaca* was collected only in the headwaters of the Mahoning River. In the Eagle Creek watershed, Camp Creek and Silver Creek at RM 0.79 were found to host 7 and 4 cold water taxa, respectively. Included among Camp Creek's taxa was also the state-threatened caddisfly, *Psilotreta indecisa*. Silver Creek is currently assigned the Cold water Habitat (CWH) aquatic life use, and the headwaters of the Mahoning River and Camp Creek are being recommended to receive CWH protection. Future sampling of Class III primary headwater streams that feed into these watercourses should be conducted in order to further classify and protect their high water resource quality.

Table 6. Aquatic life use attainment status for stations sampled in the Upper Mahoning basin based on data collected June-October 2006. Three sites were sampled in 2007 and their associated scores are indicated in *italics*. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and Invertebrate Community Index (ICI) yield scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community.

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
Mahoning River				*EOLP Ecoregion - WWH Existing, CWH Recommended*			
N01K28 (102.24)[H]	50	N/A	VG	62.0	FULL		
N01S14 (100.57)[H]	36[NS]	N/A	E	74.5	FULL		
				EOLP Ecoregion - WWH Existing			
N01K26 (97.69)[H]	41	N/A	52	75.5	FULL		
N01S01 (93.23)[W]	38	7.4[NS]	MG[NS]	59.0	FULL		
N01K19 (91.11)[W]	34[NS]	<u>5.3</u>*	MG[NS]	33.0	**NON**	Siltation Alteration in stream side vegetative cover	Agriculture Loss of riparian habitat
200349 (89.4)	N/A	N/A	46	N/A	(FULL)		
602420 (85.51)[B]	*30**	*8.0**	<u>12*</u>	55.0	**NON**	Flow regime alteration	Dam pool
N01S12 (84.99)[W]	38	8.5	LF*	60.5	PARTIAL	Sedimentation	Municipal (urbanized high density area), historical industrial?
N01S11 (70.75)[B]	*30**	*8.7*	30[NS]	78.5	PARTIAL	Flow regime alteration	Influenced by upstream/downstream dam releases
602310 (62.68)[B]	*28**	*9.4*	34	80.5	PARTIAL	Flow regime alteration	Upstream impoundment
N02K30 (58.13)[B]	33*	7.4*	LF*	41.5	**NON**	Flow regime alteration	Newton Falls Dam backwater; Newton Falls PWS intake

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
N02S12 (56.53) [B]	45	9.5	26*	60.5	PARTIAL	Flow regime alteration	Downstream Newton Falls Dam
N02S11 (54.73) [B]	41	8.6[NS]	22*	58.5	PARTIAL	Flow regime alteration	Leavittsburg Dam backwater
N03S64 (45.73) [B]	40	7.7*	20*	48.5	**NON**	Flow regime alteration	Leavittsburg dam pool
Tributary to Mahoning River (RM 98.71)				*EOLP Ecoregion - WWH Recommended*			
N01K27 (4.59) [H]	34*	N/A	G	62.0	PARTIAL	Siltation Nutrient/eutrophication biological indicators	Agriculture
Tributary to Mahoning River (RM 97.11)				*EOLP Ecoregion - WWH Recommended*			
N01K25 (1.15)	N/A	N/A	LF*	N/A	N/A	Siltation Nutrient/eutrophication biological indicators	Agriculture: Horse farm upstream
Beaver Run				*EOLP Ecoregion - WWH Existing*			
N01K24 (1.19) [H]	38[NS]	N/A	F*	70.5	PARTIAL	Nutrient/eutrophication biological indicators Siltation	Unknown Loss of riparian habitat
Naylor Ditch				*EOLP Ecoregion - WWH Recommended*			
N01K23 (3.63) [H]	34*	N/A	F*	39.0	**NON**	Nutrient/eutrophication biological indicators Direct habitat alteration	Municipal (urbanized high density area) Channelization
N01K22 (1.35) [H]	<u>20</u>*	N/A	<u>P*</u>	45.5	**NON**	Nutrient/eutrophication biological indicators Past fish kill	Agriculture

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
Trib. to Mahoning R. (RM 91.21)				*EOLP Ecoregion - WWH Recommended*			
N01K20(2.39) [H]	28*	N/A	P*	54.0	**NON**	Nutrient/eutrophication biological indicators	Agriculture Municipal point source discharge (Beloit WWTP)
Fish Creek				*EOLP Ecoregion - WWH Existing*			
N01S05 (3.56) [H]	20*	N/A	P*	47.0	**NON**	Nutrient/eutrophication biological indicators Direct habitat alteration	Municipal point source discharge (Sebring WWTP discharge via Sulphur Ditch) Channelization
N01K18 (2.00) [H]	24*	N/A	F*	56.5	**NON**	Siltation Nutrient/eutrophication biological indicators	Municipal point source discharge (Sebring WWTP)
N01K17 (0.36) [H]	24*	N/A	P*	42.5	**NON**	Siltation	Swamp stream (low-gradient)
Beech Creek				*EOLP Ecoregion - WWH Existing*			
N01K16 (10.50) [H]	32*	N/A	F*	31.0	**NON**	Siltation Direct habitat alteration	Agriculture Channelization
N01K15 (8.34) [H]	38[NS]	N/A	MG [NS]	65.0	FULL		
N01K14 (3.54) [H]	42	N/A	G	60.5	FULL		
Little Beech Creek				*EOLP Ecoregion - WWH Existing*			
N01K13 (1.83) [H]	32*	N/A	F*	39.5	**NON**	Siltation Nutrient/eutrophication biological indicators	Agriculture Unrestricted cattle access

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
Deer Creek				*EOLP Ecoregion - WWH Existing*			
N01K12 (10.87)	N/A	N/A	P*	N/A	N/A	Flow regime alteration	Walborn Reservoir
N01K10 (4.48) [W]	36[NS]	6.7*	32[NS]	67.0	PARTIAL	Flow regime alteration Nutrient/eutrophication biological indicators	Influenced by upstream dam releases
300025 (2.90) [W]	32*	7.3*	36	79.5	**NON**	Flow regime alteration	Influenced by upstream dam releases
Willow Creek				*EOLP Ecoregion - WWH Existing*			
N01K08 (8.13) [H]	32*	N/A	LF*	34.0	**NON**	Siltation Nutrient/eutrophication biological indicators Alterations in stream side vegetative cover	Channelization Municipal (urbanized high density area)
300062 (3.74) [H]	38	N/A	MG [NS]	54.5	FULL		
Island Creek				*EOLP Ecoregion - WWH Existing*			
N01K06 (2.65) [H]	30*	N/A	P*	43.5	**NON**	Siltation Nutrient/eutrophication biological indicators	Agriculture
Mill Creek				*EOLP Ecoregion – WWH Existing*			
N01K04 (6.28) [H]	26*	N/A	LF*	56.5	**NON**	Siltation	Unrestricted cattle access
300061 (3.64) [H]	47	N/A	46	74.0	FULL		

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
Tributary to Mill Creek at RM 3.67				*EOLP Ecoregion - WWH Recommended*			
N01K03 (1.10) [H]	20*	N/A	LF*	54.5	**NON**	Siltation Interstitial / Intermittent flow	Channelization Natural
Garfield Ditch (Trib to Mill Creek at RM 8.0)				*EOLP Ecoregion - WWH Recommended*			
N01K05 (0.66) [H]	24*	N/A	P*	39.5	**NON**	Siltation	Channelization
Turkey Broth Creek				*EOLP Ecoregion - WWH Existing*			
N01K01 (3.36) [H]	34*	N/A	P*	35.5	**NON**	Siltation Flow regime alteration Nutrient/eutrophication biological indicators	Small dam impounds stream Unrestricted cattle access
Kale Creek				*EOLP Ecoregion - WWH Existing*			
3000150 (13.57)	N/A	N/A	G	N/A	N/A		
N02K32 (13.08) [H]	32*	N/A	F*	51.0	**NON**	Alterations in stream side vegetative cover Siltation	Upstream agriculture Loss of riparian habitat
N02W09 (11.27) [H]	26*	N/A	F*	54.0	**NON**	Siltation Low dissolved oxygen	Unknown Failing septic?
N02W08 (6.05) [H]	32*	N/A	MG [NS]	51.0	PARTIAL	Natural conditions (flow and habitat)	Natural sources (impounded by beaver dam and log jam)
N02W07 (3.38) [W]	29*	7.3	42	65.0	PARTIAL	Low dissolved oxygen Turbidity	Agriculture

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
Trib to Kale Creek at RM 5.29				*EOLP Ecoregion - WWH Recommended*			
N02K31 (1.08) [H]	34*	N/A	G	56.5	PARTIAL	Siltation	Stream bank destabilization Bank erosion (natural?)
West Branch Mahoning River				*EOLP Ecoregion - WWH Existing*			
N02K28 (27.92) [H]	48	N/A	MG [NS]	64.5	FULL		
N02K27 (24.35) [H]	48	N/A	E	72.0	FULL		
300022 (20.94) [W]	49	9.3	52	82.0	FULL		
300056 (11.39) [W]	44	7.4[NS]	22*	76.0	PARTIAL	Flow regime alteration	Influenced by upstream dam release
N02K15 (3.15)[B]	29*	6.6*	<u>10*</u>	34.5	**NON**	Flow regime alteration	Dam pool
N02P12 (0.36) [B]	46	8.3	42	78.5	FULL		
Harmon Brook				*EOLP Ecoregion - WWH Existing*			
N02K26 (0.49) [H]	54	N/A	LF*	77.0	PARTIAL	Siltation Organic enrichment (sewage) biological indicators Nutrient/eutrophication biological indicators	Agriculture On-site treatment systems (septic systems and similar decentralized systems) Upstream impoundments
Barrel Run				*EOLP Ecoregion - WWH Existing*			
N02K24 (5.31) [H]	28*	N/A	MG [NS]	67.5	PARTIAL	Flow regime alteration	Small dam encountered ½ way through zone
N02K23 (3.65) [H]	44	N/A	G	61.5	FULL		

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
Hinkley Creek				*EOLP Ecoregion - WWH Existing*			
N02K22 (0.70) [H]	48	N/A	E	60.5	FULL		
Silver Creek (Trib to W. Branch)				*EOLP Ecoregion - WWH Existing*			
N02K21 (3.46) [H]	48	N/A	G	67.0	FULL		
N02K20 (1.83) [H]	42	N/A	G	68.0	FULL		
Trib to a Trib to West Branch Mahoning River at RM 9.63/0.74				*EOLP Ecoregion - WWH Existing*			
N02K17 (0.60) [H]	33*	N/A	46	40.5	PARTIAL	Direct habitat alteration	Channelization
Trib to West Branch Mahoning River at RM 8.28				*EOLP Ecoregion – WWH Recommended*			
N02K16 (0.27) [H]	32*	N/A	MG[NS]	42.5	PARTIAL	Siltation Flow regime alteration	Influenced by dam releases from West Branch Mahoning River
Trib to West Branch Mahoning River at RM .01				*EOLP Ecoregion - WWH Existing*			
N02K14 (2.10) [H]	28*	N/A	F*	67.5	**NON**	Siltation	Storm water from road
Eagle Creek				*EOLP Ecoregion - WWH Existing*			
N02S02 (22.44) [H]	34*	N/A	F*	54.0	**NON**	Natural conditions (flow and habitat) Oil and grease?	Natural source (beaver dam) Source Unknown
N02P07 (17.61) [W]	51	9.6	46	81.5	FULL		
N02K10 (15.04) [W]	40	7.4	48	61.5	FULL		
300348 (12.10)	N/A	N/A	42	N/A	FULL		
N02K05 (10.10) [W]	46	7.5	*VG*	53.0	FULL		

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
N02Q01 (7.20)	N/A	N/A	38	N/A	FULL		
N02P08 (5.60) [B]	42	9.4	G	65.0	FULL		
Silver Creek (trib. to Eagle Creek)				*EOLP Ecoregion - CWH Existing*			
N02S04 (2.27) [H]	42	N/A	52	66.0	FULL		
N02S03 (0.79) [H]	41	N/A	54	64.0	FULL		
Camp Creek				*EOLP Ecoregion - WWH Existing, CWH Recommended*			
N02K11 (3.16) [H]	44	N/A	E	74.0	FULL		
Mahoning Creek				*EOLP Ecoregion - WWH Recommended*			
N02K09 (0.70) [H]	<u>18</u>*	N/A	<u>P</u>*	54.0	**NON**	Siltation Nutrient/eutrophication biological indicators	Natural Source (Wetland Stream) Package plant (Downstream MHP WWTP)
South Fork Eagle Creek				*EOLP Ecoregion - WWH Existing*			
N02K08 (3.86) [H]	44	N/A	46	66.5	FULL		
N02K06 (2.30) [W]	41	7.5	52	61.0	FULL		
Tinker Creek				*EOLP Ecoregion - WWH Existing*			
N02K04 (5.45) [H]	<u>24</u>*	N/A	G	68.0	**NON**	Nutrient/eutrophication biological indicators	Agriculture
N02K02 (2.50) [H]	34*	N/A	G	68.5	PARTIAL	Nutrient/eutrophication biological indicators	Agriculture
Nelson Ditch				*EOLP Ecoregion - WWH Existing*			
300148 (0.30) [H]	34*	N/A	LF*	44.0	**NON**	Siltation Direct habitat alteration	Channelization

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
Chocolate Run				*EOLP Ecoregion - WWH Existing*			
N02K01 (0.11) [H]	32*	N/A	LF*	46.5	**NON**	Siltation Direct habitat alteration Nutrient/eutrophication biological indicators	Channelization

Ecoregion Biocriteria: Erie-Ontario Lake Plain

	IBI			MIwb			ICI		
Site Type	**WWH**	**EWH**	**MWH**	**WWH**	**EWH**	**MWH**	**WWH**	**EWH**	**MWH**
Headwaters	40	50	24				34	46	22
Wading	38	50	24	7.9	9.4	6.2	34	46	22
Boat	40	48	24	8.7	9.6	6.6	34	46	22

H - Headwater electrofishing site.

W - Wading electrofishing site.

B - Boat electrofishing site.

a - MIwb is not applicable to headwater streams with drainage areas $\leq$ 20 mi^2.

b - A narrative evaluation of the qualitative sample based on attributes such as EPT taxa richness, number of sensitive taxa, and community composition was used when quantitative data were not available or considered unreliable. VP=Very Poor, P=Poor, LF=Low Fair, F=Fair, MG=Marginally Good, G=Good, VG=Very Good, E=Exceptional

c - Attainment status is given for both existing and proposed use designations.

ns - Nonsignificant departure from biocriteria ($\leq$4 IBI or ICI units, or $\leq$0.5 MIwb units).

* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

Trends: 1994-2006

Longitudinal plots of biological index scores for Mahoning River mainstem sites revealed similar patterns of performance in both 1994 and 2006 (Figure 5). This consistency can be attributed mainly to the continued presence of numerous dams and reservoirs that irretrievably alter the natural flow pattern of the river. The only mechanism that would allow for profound improvement of the fish and benthos would be the removal of these structures, thus restoring the Mahoning River to a free-flowing stream. While removal is not feasible for large flood control structures such as the Berlin or Lake Milton dams, investigation of the removal of several smaller low head dams on the mainstem should be initiated. These include dams in the cities of Alliance, Newton Falls, and Leavittsburg.

For the fish community, there is concern beyond the numerous dams. In the headwaters of the Mahoning River (WAU 010), although IBI scores showed slight improvement since 1994, MIwb scores have declined. The MIwb measures species' relative weights and numbers and how evenly those relative weights and numbers are distributed among the species. It is sensitive to the total number and biomass of fish, excluding tolerant species, and to the uneven distribution of individuals and biomass within the community assemblage. The general decline in the MIwb over time within WAU 010 indicates an unstable fish community. If steps are not taken to address the impacts from agricultural activities in this area, the scores may continue to decline in the future.

The fish community at King Road (RM 100.57) scored 15 points lower on the IBI in 2006 than in 1994. Tolerant fish comprised a greater percentage of the population in 2006, from an average of 38% in 1994 to 64% of the population in 2006, and fewer insectivorous fish were present, from 50% in 1994 to only 34% in 2006. While the site still met WWH expectations, the significant drop warrants further investigation. The site at Knox School Road (RM 93.23) had a lower score than the 1994 results both in the IBI and MIwb, indicating a negative shift in fish community integrity in this area.

Contiguous to the West Branch Mahoning River basin (WAU 030) and the Eagle Creek basin (WAU 040), the Mahoning River has shown general fish community improvement. The MIwb indicated an improved distribution of individuals and biomass within the community assemblage. However, the IBI continued to score below WWH expectations as a result of the strong influence of the dams on the hydrologic regime and fish migration in the area.

The only Mahoning River site showing significant decline in the macroinvertebrate community from the 1994 survey was at RM 56.53, where the ICI score dropped from a 42 to a 26. Wet weather bypasses from the old Newton Falls WWTP were likely responsible for the decline in ICI. Further details regarding the performance of this station can be found in the West Branch WAU section. A new, upgraded Newton Falls WWTP went online in 2007. It is recommended that RM 56.53 be resampled in order to determine if the plant upgrades have translated into improved community performance.

Trend information for tributary streams may be found in each subwatershed section. Macroinvertebrate taxa identification and enumeration data from each sampled location are provided in Appendix Table A-1. Fish species collection and relative number information are provided in Appendix Table A-2.

Prior to 1994, no large scale chemical water quality surveys of the Upper Mahoning River basin had been conducted by the Ohio EPA. The survey conducted in 1994 included 14 sampling locations on the Mahoning River mainstem, from King Rd at RM 100.6 to upstream from the Leavittsburg dam (RM 45.7), and single samples near the mouths of three tributary streams (Eagle Creek, West Branch Mahoning River, and Silver Creek). A survey of Eagle Creek and Silver Creek was conducted in 1981 (Ohio EPA, 1982, Comprehensive Water Quality Report for Silver and Eagle Creeks, Mahoning River Basin, Division of Wastewater Pollution Control, Columbus, Ohio). Biological and chemical samples were collected at six sampling location upstream and downstream from the Hiram and Garrettsville WWTPs.

Given the near absence of historical data to compare against the more extensive number of sample locations in 2006, analysis of historical trends must be limited to the Mahoning River mainstem. A review of chemical data from 1994 and 2006 does not show any significant difference in chemical water quality at the extremes of the mainstem. For example, mean total phosphorus in the Mahoning River headwaters at RM 100.6 (King Rd) was 0.082 mg/l in 1994 and 0.081 mg/l in 2006. Mean total phosphorus at the downstream boundary of the basin at RM 45.7 (upstream Leavitt Rd. dam) was 0.058 mg/l in 1994 and 0.070 mg/l in 2006.

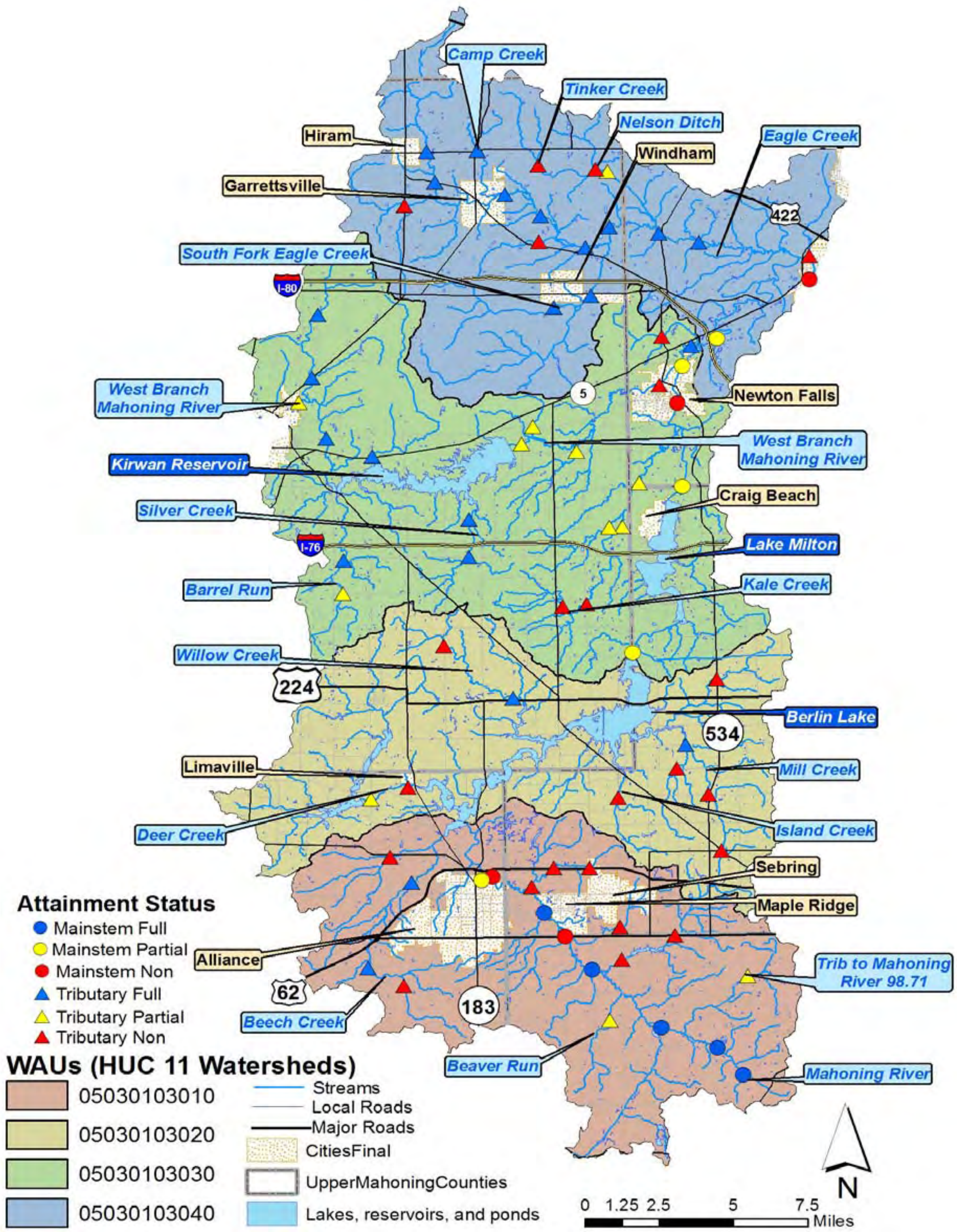


Figure 4. Aquatic Life Use attainment status of sites in the Mahoning River watershed sampled in 2006 and 2007.

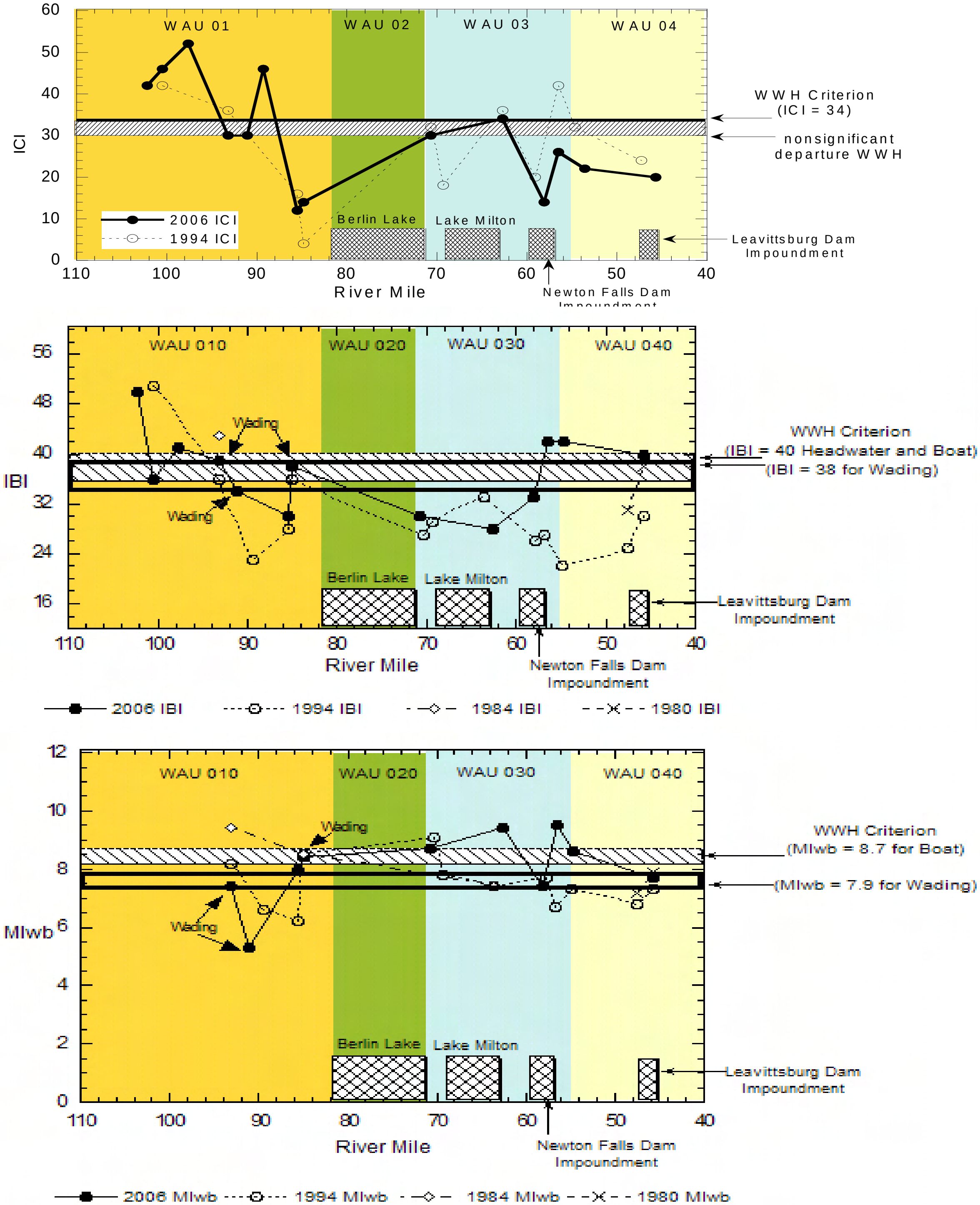


Figure 5. Longitudinal plots of IBI, MIwb, and ICI scores for the Mahoning River, 2006, 1994, 1984, and 1980. Fish community headwater sites are located at RMs 102.24, 100.57, and 97.69. Fish community wading sites are located at RMs 93.23, 91.11, and 84.99. The site at RM 85.51 and the remaining downstream sites are all fish community boat sites.

Table 7. Sampling locations in the Upper Mahoning River study area in 2006 and 2007. (C-conventional water chemistry, B-bacteria, S-sediment, D-datasonde continuous monitors, M- macroinvertebrates, F–fish, G–gage height/flow station). Precise river mile (RM) locations for each sample type may vary slightly.

River Mile	Station ID	Sample Type	Latitude	Longitude	Drain. (mi^2)	Location	USGS Topo
Mahoning River Mainstem							
102.24	N01K28	CBFM	40.8281	-80.9354	3.2	Winona Rd	Hanoverton
100.57	N01S14	CBFM	40.8428	-80.9516	8.0	King Rd	Hanoverton
97.69	N01K26	CBFM	40.8534	-80.9876	19.8	Georgetown-Damascus Rd	Hanoverton
93.23	N01S01	CBFMGD	40.8838	-81.0313	52.7	Knox-School Rd	Alliance
91.11	N01K19	CBFMD	40.9015	-81.0484	63.0	US RT 62	Alliance
89.4	200349	M	40.9139	-81.0619	74.0	Lake Park Rd	Alliance
85.51	602420	CBFMGD	40.9328	-81.0947	89.0	Webb Ave, upst low head dam	Alliance
84.99	N01S12	CBFM	40.9314	-81.1019	90.0	Gaskill Rd, dwst low head dam	Alliance
72.74	602440	CBG	41.0228	-81.0050	246.0	US RT 224, Berlin Lake, surface sample	Deerfield
70.75	N01S11	CBFMGD	41.0483	-81.0017	248.0	Dwst Berlin Lake, at USGS gage	Deerfield
62.68	602310	CBFMGD	41.1342	-80.9675	274.0	Cable Line Rd at USGS gage	Newton Falls
58.13	N02K30	CBFM	41.1775	-80.9701	306.0	End of Starr Rd, upst PWS intake	Newton Falls
57.35	N02K29	BD	41.1865	-80.9724	307.0	Broad St	Newton Falls
56.53	N02S12	CBFM	41.1967	-80.9664	307.1	Dwst dam & Newton Falls WWTP	Newton Falls
54.73	N02S11	CBFM	41.2106	-80.9439	417.0	SR 5, dwst I-80	Newton Falls
45.73	N03S64	CBFMD	41.2400	-80.8833	542.0	Upst Leavitt Rd dam at livery	Newton Falls
HUC12 - 05030103-010							
Beaver Run							
1.19	N01K24	CBFM	40.8577	-81.0207	4.8	Center Rd	Homeworth
RM 91.21 Tributary to Mahoning River							
2.39	N01K20	CBFMD	40.9016	-81.0270	4.5	12th St	Alliance

River Mile	Station ID	Sample Type	Latitude	Longitude	Drain. (mi^2)	Location	USGS Topo
RM 97.11 Tributary to Mahoning River							
1.15	N01K25	CBFM	40.8430	-80.9896	4.3	Georgetown Rd	Hanoverton
RM 98.71 Tributary to Mahoning River							
4.59	N01K27	CBFM	40.8796	-80.9312	5.3	Whitacre Rd	Damascus
Sulphur Ditch							
0.47	N01S07	CBFM	40.9322	-81.0250	0.8	Allied Rd	Alliance
Sebring WWTP Effluent (3PC00011)							
	N01S08	CB	40.9317	-81.0272		Discharge to Sulphur Ditch, RM 0.49	Alliance
Fish Creek							
0.36	N01K17	CBFM	40.9274	-81.0694	9.0	Lexington Rd	Alliance
2.00	N01K18	CBFMD	40.9388	-81.0508	4.5	Courtney Rd, second dwst crossing	Alliance
3.56	N01S05	CBFMD	40.9367	-81.0319	3.0	Johnson Rd	Alliance
Beloit WWTP Effluent (3PB00005)							
	N01K21	CB	40.9167	-81.0056		Discharge to RM 91.21 trib. to Mahoning River	Alliance
Naylor Ditch							
1.35	N01K22	CBFMD	40.8891	-81.0123	8.3	12th St	Alliance
3.63	N01K23	CBFMD	40.9014	-80.9754	4.5	Heritage Dr	Damascus
Beech Creek							
3.54	N01K14	CBFM	40.9307	-81.1467	17.4	Vine St	Limaville
8.34	N01K15	CBFM	40.8865	-81.1757	8.6	Beech St	Limaville
10.50	N01K16	CBFM	40.8769	-81.1528	4.0	Bayton St	Limaville
Little Beech Creek							
1.83	N01K13	CBFM	40.8773	-81.1605	9.0	SR 619	Limaville

River Mile	Station ID	Sample Type	Latitude	Longitude	Drain. (mi^2)	Location	USGS Topo
HUC 12 - 05030103-020							
Atwater WWTP Effluent (3PH00033)							
	N01K11	CB	41.0225	-81.1692		Discharge to Deer Cr, RM 10.33	Atwater
Deer Creek							
2.90	300025	CBFMGD	40.9799	-81.1481	30.1	Atwater Rd	Limaville
4.48	N01K10	CBFMD	40.9741	-81.1720	27.9	McCallum Rd (dwst Walborn Resv.)	Limaville
10.87	N01K12	CBFM	41.0238	-81.1561	3.5	Waterloo Rd (upst Walborn Resv.)	Atwater
Willow Creek							
8.13	N01K08	CBFMD	41.0533	-81.1234	3.5	Porter Rd	Deerfield
3.74	300062	CBFMGD	41.0256	-81.0795	7.2	Notman Rd	Deerfield
Island Creek							
2.65	N01K06	CBFM	40.9732	-81.0127	19.1	12th St	Alliance
Mill Creek							
6.28	N01K04	CBFM	40.9723	-80.9543	9.9	West Calla Rd	Damascus
3.64	300061	CBFMD	40.9999	-80.9684	19.1	Leffingwell Rd	Damascus
RM 3.67 Tributary to Mill Creek							
1.10	N01K03	CBFM	40.9987	-80.9474	3.7	Western Reserve Rd	Damascus
Turkey Broth Creek							
3.36	N01K01	CBFM	41.0339	-80.9478	4.9	SR 534	Lake Milton
Garfield Ditch							
0.66	N01K05	CBFM	40.9449	-80.9466	4.0	SR 165	Damascus
HUC 12 - 05030103-030							
Newton Falls WWTP Effluent (3PD00015)							
	N02K13	CB	41.1922	-80.9694		Discharge to Mahoning R, RM 56.50	Newton Falls

River Mile	Station ID	Sample Type	Latitude	Longitude	Drain. (mi^2)	Location	USGS Topo
Kale Creek							
3.38	N02W07	CBFMG	41.1364	-80.9956	21.9	Canal Rd at USGS gage	Newton Falls
6.05	N02W08	CBFM	41.1134	-81.0069	14.4	Whippoorwill Rd	Deerfield
11.27	N02W09	CBFM	41.0732	-81.0317	9.1	Williams Rd	Deerfield
13.08	N02K32	CBFM	41.0727	-81.0463	4.1	Lane off SR 225	Deerfield
RM 5.29 Tributary to Kale Creek							
1.08	N02K31	CBFM	41.1134	-81.0154	3.4	Whippoorwill Rd	Deerfield
Harmon Brook							
0.49	N02K26	CBFM	41.1806	-81.2148	4.1	Peck Rd	Ravenna
West Branch Mahoning River							
0.36	N02P12	CBFMD	41.2072	-80.9603	103.0	CR 114 A (First St)	Newton Falls
3.15	N02K15	CBFMS	41.1870	-80.9813	101.0	Broad St/6th St Park	Newton Falls
11.39	300056	CBFMGD	41.1574	-81.0713	81.7	Wayland Rd, at USGS gage	Windham
20.94	300022	CBFMGSD	41.1616	-81.1974	21.8	Newton Falls Rd, at USGS gage	Ravenna
24.35	N02K27	CBFMS	41.1934	-81.2062	9.4	SR 88	Ravenna
27.92	N02K28	CBFM	41.2260	-81.2017	5.0	Cooley Rd	Ravenna
Barrel Run							
3.65	N02K23	CBFM	41.0984	-81.1876	10.2	Tallmadge Rd	Atwater
5.31	N02K24	CBFM	41.0810	-81.1880	5.1	Giddings Rd	Atwater
RM 1.62 Tributary to Hinkley Creek							
0.08	300093	CS	41.1630	-81.1535	1.5	Newton Falls Rd	Ravenna
Hinkley Creek							
0.70	N02K22	CBFMS	41.1629	-81.1328	10.8	SR 5	Ravenna
Silver Creek, a Tributary to West Branch Mahoning River							
2.03	N02K20	CBFM	41.1188	-81.1060	9.3	Calvin Rd	Deerfield
3.46	N02K21	CBFM	41.0992	-81.1063	5.5	Tallmadge Rd	Deerfield

River Mile	Station ID	Sample Type	Latitude	Longitude	Drain. (mi^{2})	Location	USGS Topo
Tributary to West Branch Mahoning River RM 0.01							
2.10	N02K14	CBFMS	41.2118	-80.9793	4.1	SR 534	Newton Falls
Tributary to West Branch Mahoning River RM 8.28							
0.27	N02K16	CBFM	41.1532	-81.0357	5.1	Gilbert Rd	Windham
Tributary to West Branch Mahoning River RM 4.85							
0.5	300094	S	41.1886	-81.0183	0.3	South Patrol Rd (at weir)	Windham
Tributary to West Branch Mahoning River RM 9.63							
1.8	200372	CS	41.1692	-81.0717	1.0	Wayland Rd	Windham
Tributary to RM 9.63 Tributary of West Branch Mahoning River RM 0.74							
0.60	N02K17	CBFMS	41.1662	-81.0638	1.6	Newton Falls Rd	Windham
HUC 12 - 05030103-040							
Eagle Creek							
5.60	N02P08	CBFMGD	41.2608	-80.9542	97.6	CR 114, at USGS gage	Southington
10.10	N02K05	CBFM	41.2692	-81.0119	74.0	Silica Sand Rd, dwst South Fork	Garrettsville
15.04	N02K10	CBFM	41.2756	-81.0565	36.0	Hopkins Rd	Garrettsville
17.61	N02P07	CBFM	41.2869	-81.0794	32.0	Brosius Rd, dwst Garrettsville WWTP	Garrettsville
22.44	N02S02	CBFM	41.2821	-81.1446	5.2	SR 700, upst Garrettsville WWTP	Mantua
Garrettsville WWTP Effluent (3PB00016)							
	N02K12	CBFM	41.2853	-81.0872		Discharge to Eagle Cr at RM 18.02	
Silver Creek (Eagle Creek Tributary)							
0.79	N02S03	CBFMS	41.2940	-81.1240	11.2	SR 82, dwst Hiram WWTP discharge	Garrettsville

River Mile	Station ID	Sample Type	Latitude	Longitude	Drain. (mi^{2})	Location	USGS Topo
2.27	N02S04	CBFM	41.3095	-81.1297	8.8	SR 305, upst Hiram WWTP discharge	Mantua
Hiram WWTP Effluent (3PB00020)							
	N02K34	CB	41.3071	-81.1486		Discharge to RM 1.1 trib. of Silver Cr	Mantua
Camp Creek							
3.16	N02K11	CBFM	41.3100	-81.0967	4.2	SR 305	Garrettsville
Mahoning Creek							
1.27	N02P04	D	41.2617	-81.0669	3.3	SR 82, upst PM Estates MHP	Garrettsville
0.70	N02K09	CBFMD	41.2624	-81.0578	3.7	Dwst PM Estates MHP discharge	Garrettsville
South Fork Eagle Creek							
3.86	N02K08	CFMS	41.2280	-81.0488	7.5	RAAP property, Windham Rd	Windham
2.30	N02K06	CBFMS	41.2339	-81.0250	23.5	SR 303, dwst Windham WWTP	Windham
Windham WWTP Effluent (3PC00019)							
	N02K07	CB	41.2331	-81.0328		Discharge to South Fork at RM 2.60	Windham
Nelson Ditch							
1.11	N02K03	CBFM	41.2986	-81.0145	3.9	SR 305	Garrettsville
Tinker Creek							
2.50	N02K02	CBFM	41.2982	-81.0127	11.2	Nicholson Rd	Garrettsville
5.45	N02K04	CBFM	41.3018	-81.0573	4.4	Center Rd	Garrettsville
Chocolate Run							
0.11	N02K01	CBFM	41.2527	-80.8828	4.4	Eagle Creek Rd	Southington

Recreation Use Attainment Status

Water quality criteria for determining whether rivers and streams are suitable for the designated recreation use are established in the Ohio Water Quality Standards (Table 7-13 in OAC 3745-1-07) and based upon the presence or absence of bacteria indicators in the water column. In Ohio, indicator organisms used for these determinations are fecal coliform bacteria and *Escherichia coli*. Fecal coliform bacteria are microscopic organisms that are present in large numbers in the feces and intestinal tracts of humans and other warm-blooded animals including mammals and birds. The *E. coli* are a subgroup of the fecal coliform. These microorganisms can enter water bodies where there is a direct discharge or runoff of human and animal wastes. No simple way exists to differentiate between human and animal sources of fecal bacteria in surface waters.

Pathogenic (disease causing) organisms typically are present in the environment in such small amounts that it is impractical to monitor them directly. Although some strains of *E. coli* can cause serious illness, fecal coliform bacteria, including *E. coli*, by themselves usually are not pathogenic (disease causing). Fecal coliform and *E. coli* bacteria groups instead are used as indicators of the potential presence of pathogenic organisms that enter the environment through the same pathways. When fecal coliform or *E. coli* are present in high numbers in a water sample, it invariably means that the water has received fecal matter from one source or another. Swimming or other recreation-based contact with water having a high *E. coli* count may result in ear, nose, and throat infections, as well as stomach upsets, skin rashes, and diarrhea. Young children, the elderly, and those with depressed immune systems are most susceptible to infection.

Designations of recreation uses for water bodies in the Mahoning River basin are listed in OAC Rule 3745-1-25, Table 25-1. All water bodies in the Upper Mahoning River basin (upstream from RM 45.7 at the Leavitt Rd dam), with the exception of the "Hiram tributary" (confluence with Silver Creek at RM 1.10), are designated for Primary Contact Recreation (PCR), which "...*are waters that, during the recreation season, are suitable for <u>full-body contact</u> recreation such as ... swimming, canoeing, and SCUBA diving with minimal threat to public health as a result of water quality*" [OAC 3745-1-07 (B)(4)(b)]. The Hiram tributary to Silver Creek is designated for Secondary Contact Recreation (SCR). The village of Hiram WWTP discharges to the Hiram tributary. Secondary Contact Recreation (SCR) means "…*waters that, during the recreation season, are suitable for <u>partial body contact</u> recreation such as…wading with minimal threat to public health*…"

The bacteria data collected for the 2006 upper Mahoning River survey were evaluated against the PCR criteria, including those streams that are un-designated in OAC 3745-1-25. The rationale for this approach is that the drainage areas of the undesignated streams were similar to the drainage areas of streams currently protected for PCR, and thus present the same potential for full-body contact. Streams with small watersheds can have pools of water, especially downstream from road culverts, where full-body contact is possible for young children. The applicable water quality criteria for the PCR use are given in Table 8. Bacteriological results from environmental samples are reported as colony forming units (cfu) per 100 ml of water.

Table 8. Primary Contact Recreational Use Water Quality Criteria applicable to the upper Mahoning River study area (Table 7-13 of OAC 3745-1-07). At least one of the two bacteriological standards (fecal coliform or *E. coli*) must be met. These criteria apply outside of the mixing zone.

Fecal coliform – geometric mean fecal coliform content (either MPN or MF), based upon not less than five samples within a thirty-day period, shall not exceed 1,000 per 100 ml and fecal coliform content (either MPN or MF) shall not exceed 2,000 per 100 ml in more than ten percent of the samples taken during any thirty-day period.

E. coli – geometric mean *E. coli* content (either MPN or MF), based upon not less than five samples within a thirty-day period, shall not exceed 126 per 100 ml and *E. coli* content (either MPN or MF) shall not exceed 298 per 100 ml in more than ten percent of the samples taken during any thirty-day period.

For purposes of determining attainment of the PCR use for the Upper Mahoning River survey, all data collected during the recreation season (May 1 through October 15, 2006) were included in the analysis. The data collected at each sampling location were compared to the PCR criteria for each organism group to determine attainment status. The wording in OAC 3745-1-07, Table 7-13, states that if either of the two indicator groups (fecal coliform or *E. coli*) is in attainment of both criteria from the same water sample, then the water body is in full attainment of the PCR use with minimal threat to human health. Consequently, when both fecal coliform and *E. coli* data were available from a stream sample, both sets of data were used to determine attainment status of the recreational use since one group may exceed criteria while the other does not.

The following protocol was used to evaluate bacteria data to determine attainment of the recreation use. For each location where five samples were collected within a thirty-day period, these data were applied directly to the applicable PCR criteria in Table 8. However, because fewer than five bacteria samples were collected at the majority of sampling locations, the 2000/100 ml fecal coliform and the 298/100 ml *E. coli* “10% criterion” was used to determine attainment of recreation use. To meet reporting requirements for Section 303(d) of the Clean Water Act, the protocol adopted for the 2008 Ohio EPA Integrated Report was used to evaluate recreation attainment for each of the four WAUs that comprise the Upper Mahoning River basin. This protocol requires that a minimum of 15 fecal coliform data points are available for analysis within each WAU from at least 3 different stream sampling stations. Two statistics are calculated from these pooled data, the 75th and 90th percentile. If the 75th

percentile exceeds the 2000/100 ml fecal coliform criterion then the WAU is determined to be impaired for recreation. Where the 75th percentile is not exceeded, but the 90th percentile exceeds 2000/100 ml fecal coliform counts, the WAU also is listed as impaired for primary contact recreational use.

The colony forming units (cfu) per 100 ml of water for fecal coliform and *E. coli* bacteria collected at each sampling location for the Upper Mahoning River survey are given in Appendix Table 3. All bacteria samples within each WAU were collected on the same day which aids in the interpretation of data. Determination of attainment status, and the identification of suspected sources where elevated levels of bacteria were recorded, is given in Appendix Table 4. The discussion below is summarized first by the Mahoning River mainstem, then by the four subwatersheds (WAUs).

Mahoning River (RMs 102.24 to 45.73)
Full attainment of the PCR use was recorded in the mainstem of the Mahoning River from the Lake Milton dam downstream to the Leavitt Road dam (from RMs 72.74 to 45.73), with the exception of elevated maximum bacteria counts at the RM 54.73 station downstream from the Newton Falls. There are 25 CSOs within the Newton Falls that are potential sources of bacteria. The Newton Falls has submitted a CSO plan that requires 85% capture of CSO discharge with containment in a newly constructed flow equalization basin at the WWTP (on line as of September 2007). The Arhaven Estates MHP WWTP discharges to the Mahoning River less than one mile upstream from RM 54.73 and is another potential source of the elevated bacteria recorded at this location. Additional sampling will be needed to identify the relative contribution of different sources of bacteria and to monitor the effectiveness of the Newton Falls WWTP upgrades on load reductions from CSOs.

Full attainment of PCR was recorded at the Leavitt Rd canoe livery boat dock (RM 45.73) where public contact with stream water is high. Previous sampling at an upstream location showed elevated bacteria (640,000/100 ml fecal coliform, 7-29-1996) adjacent to a storm sewer discharge of wastewater from failing home sewage treatment systems (HSTS) in the Meadowbrook (Leavittsburg) unsewered area of Trumbull County. This problem, plus other discharges of wastewater high with bacteria in the Meadowbrook area, has been referred to the Trumbull County Health Department and the Ohio Attorney General Office for corrective actions.

Bacteria data from the mainstem of the Mahoning River from the headwaters in Columbiana County to upstream from Berlin Reservoir (RMs 102.24 to 84.99) show a patchwork pattern of non and full attainment of the PCR designated use (Figure 6). Four of seven (57%) sample locations in the headwaters Mahoning River WAU showed non-attainment of the recreation use (Appendix Table 4). Possible sources of bacteria include activities associated with both urban and rural land uses.

Non-attainment of PCR for the Mahoning River was observed at the most headwater station at Winona Rd. (RM 102.24) based on a single sample maximum violation, however the fecal coliform geometric mean was relatively low (FC mean = 356/100 ml, n=4). Full attainment was found at the next downstream location at King Rd (FC mean = 713/100 ml). These data suggest minimal problems with bacteria in the very headwaters of the Mahoning River (~8.0 mi^2) downstream to King Rd. (RM 100.57). Full attainment of PCR also was found at the RM 97.11 Tributary (RM 1.15) upstream from Lake Placentia.

The geometric mean fecal coliform count increased significantly to 2432/100 ml at the next downstream location at Georgetown-Damascus Rd (RM 97.69), which indicates sources of bacteria contributing to the Mahoning River between RMs 100.57 and 97.69. The RM 97.69 location is downstream from pastures within Columbiana County. Cattle were observed with direct access to the stream (Figure 7). This station also is downstream from the RM 98.71 tributary that receives runoff from the unsewered Sevakeen Lake area. Elevated bacteria levels also were found at Whitacre Rd. upstream from Sevakeen Lake. It is recommended that a bacteria survey be conducted in the Sevakeen Lake area to determine the sources of bacteria.

Elevated fecal coliform counts continued at the next downstream Mahoning River station at RM 93.23 (Knox-School Rd.), which is located immediately upstream from the Sebring public drinking water intake. The geometric mean was 2386/100 ml (n= 10 samples) during the recreation season (June 12 to September 19), well above the goal of 1000/100 ml. The Knox-School Rd. sampling location is downstream from the unsewered Westville Lake area that drains into Naylor Ditch, which enters the Mahoning River at RM 93.68. Bacteria data from Naylor Ditch downstream from Westville Lake showed full attainment for PCR, which suggests that widespread agricultural activities in the upper Mahoning River watershed are the primary sources of the elevated bacteria counts found at Knox-School Rd. The data from the 2006 survey at Knox-School Rd. compare favorably with the fecal coliform counts recorded from a 1994 survey (mean = 2600/100 ml, n=2). There does not appear to be any change in bacteria levels on average over the past 22 years. It is recommended that a survey be conducted to identify localized sources of bacteria to the mainstem of the Mahoning River upstream from the Sebring public drinking water intake at Knox-School Rd. (RM 93.23). Percent reductions in bacteria should be allocated for the various agricultural land uses to attain background loads measured at the upstream King Rd. (RM 100.57) location.

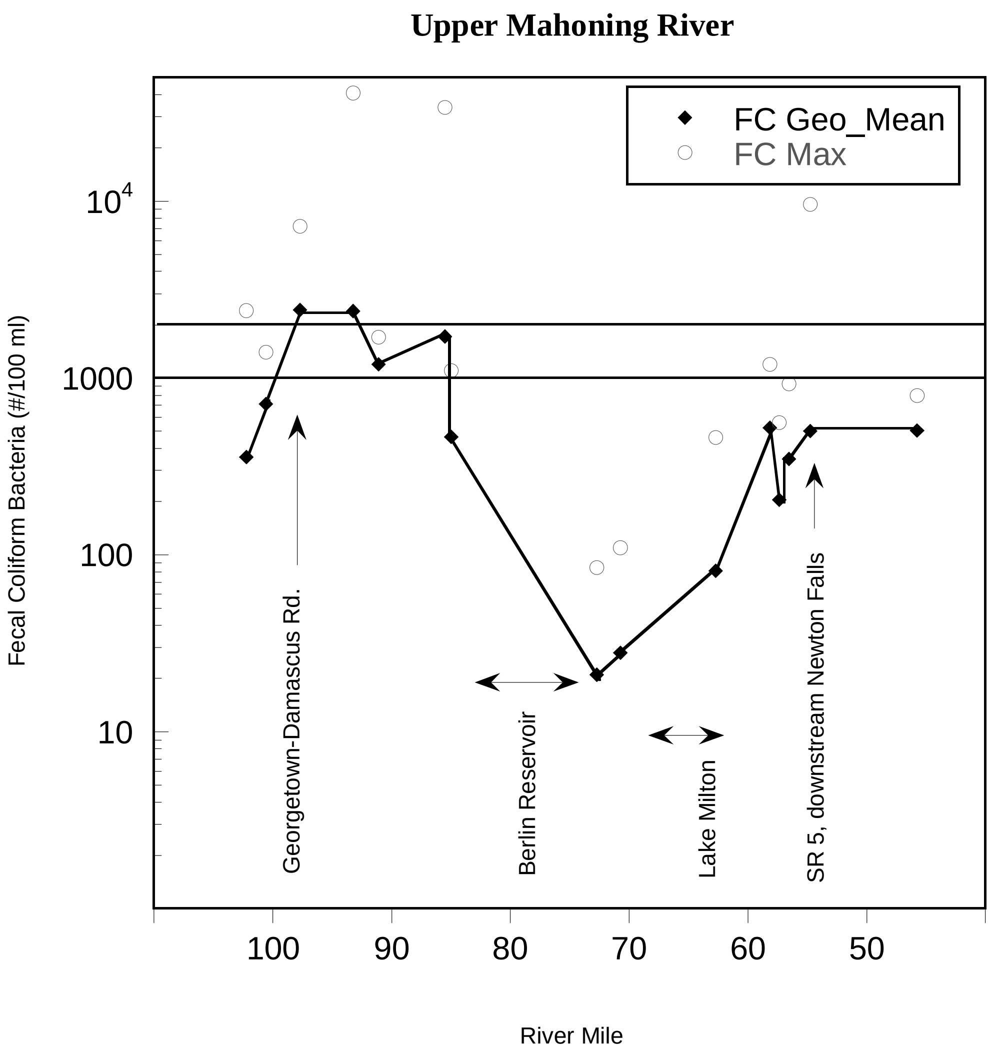


Figure 6. Concentrations of fecal coliform bacteria from the mainstem Mahoning River within the 2006 survey area. Lines show the limits of the 1000-2000/100 ml fecal coliform Primary Contract Recreation (PCR) criteria. Circles represent maximum values; diamonds are the geometric mean of all samples collected over the recreation season at each location.

Full attainment of PCR criteria was found at the next downstream Mahoning River station (RM 91.11) at State Route 62, however, non-attainment was recorded further downstream at Webb Ave. (RM 85.51) within the Alliance. The difference in bacteria quality between these two locations was due to lower maximum counts of fecal coliforms at the RM 91.11 station; the geometric mean numbers were similar. Urban runoff from the cities of Sebring and Beloit are sources that could contribute to the higher counts of bacteria in the mainstem of the Mahoning River at RM 85.51 (Webb Ave.). Although Fish Creek enters the Mahoning River between these two sampling stations it is not a likely significant source of bacteria to the Mahoning River because full attainment of PCR criteria was found near the mouth of Fish Creek (RM 0.36) at Lexington Rd.

Full attainment of PCR was recorded for the Mahoning River at RM 84.99 (Gaskill Rd.), the final mainstem sample location before the river enters Berlin Reservoir. These data suggest that the bacteria problems within the Alliance are localized to the dam pool area upstream from Webb Ave. It is recommended that a detailed inventory be conducted of all pipes and sewers and tributary streams that empty into the Webb Ave. dam pool, upstream to State Route 62, to identify and take corrective actions for all unauthorized discharges of bacteria.

The status of the recreation use for each subwatershed within the study area is provided within each Watershed Assessment Unit report.

Figure 7. Mahoning River at Georgetown-Damascus Road (RM 97.69). Cattle were observed at this site with direct access to stream water. This station showed the highest average count of fecal coliform bacteria (2432/100 ml) of all 14 sampling locations along the upper Mahoning River mainstem (RMs 102.24 to 45.73).

Chemical Water Quality

Grab water samples were collected from seventy-six sampling locations from June to September within the four WAUs that comprise the Upper Mahoning River basin (Table 7). Chemical sampling locations were selected near biological stations in an attempt to associate potential chemical stressors with biological response variables. Sample locations also were selected at sites previously sampled (Ohio EPA, 1994) to assess trends in water quality. More frequent chemical sampling was conducted at eleven “sentinel site” locations (Table 9) under various stream flow conditions. Data from these sentinel sites were used for Total Maximum Daily Load (TMDL) modeling efforts. Chemical data were compared against OAC 3745-1 Water Quality Standards (WQS) criteria and target nutrient values adopted in previous Ohio EPA TMDL reports as sample medians (NO_2-NO_3 = 1.50 mg/l; TP = 0.08 mg/l for watersheds < 20 mi^2, 0.10 mg/l for watersheds > 20 < 200 mi^2) to help identify potential chemical stressors on biology.

A list of chemical parameters that exceeded aquatic life WQS during the 2006 survey is presented in Table 10. Raw chemical data are given in Appendix Table 3.

Upper Mahoning River Mainstem (RM 102.24 – RM 45.73)

Grab water samples were collected from fourteen locations along the mainstem of the Upper Mahoning River. Chemical WQS criteria (OAC Section 3745-1) rarely were exceeded at the mainstem sampling locations (Table 10). A single violation of the human health mercury criterion was recorded at RM 97.69 (Hg = 0.23ug/l). A sample collected under high stream flow at RM 85.51 (Webb Ave.) when the water was turbid, and TSS elevated (194 mg/l), had elevated total iron (6,930 ug/l, exceeding the agricultural WQS criterion) and total lead (14.1 ug/l, exceeding the aquatic life WQS criterion).

Total phosphorus and total nitrate concentrations were less than TMDL targets at all sample locations downstream from Berlin Reservoir (Figure 8). Upstream from Berlin Reservoir, with the exception of total nitrate-nitrite at RM 97.69 and total phosphorus at RM 102.24, both nutrient parameters were within the range of statistical error of TMDL nutrient target goals (Figure 8).

Non-attainment of biological communities was found at RM 91.11 where both total phosphorus and total nitrates were elevated. The RM 91.11 sampling location was downstream from the RM 91.21 tributary that receives the effluent discharge from the village of Beloit WWTP. The level of total phosphorus in this tributary ranged from 0.141 to 0.512 mg/l (n=3), which is well above the TMDL target of 0.08 mg/l for a headwater watershed. It is recommended that a Waste Load Allocation TMDL model be developed for the Beloit WWTP to determine what reductions in nutrient loadings are needed to protect the biological communities of downstream waters.

Four of the 14 Mahoning River mainstem sampling locations were within pools of water created by low head dams (RMs 93.23, 85.51, 58.13 and 45.73). Concentrations of dissolved oxygen as percentage saturation was depressed in all four of these dam pools compared to free flowing stream segments (Figure 9). It is likely that dissolved oxygen is depressed to levels below the 5.0 mg/l OMZA 24-hour WQS criterion during the night when photosynthesis is not active. Non-attainment of biology was recorded within three of the dam pools (RMs 85.51, 58.13, 45.73). Although loss of habitat diversity as measured by QHEI would be a significant reason for the non-attainment in dam pool areas, additional stress on biological communities from depressed levels of oxygen in summer months is another distinct possibility. Full biological attainment was found immediately downstream from the RM 93.23 low head dam; the dam pool habitat was not sampled for biology.

The removal of dams is a documented restoration method to improve the integrity of biological communities in streams (Tuckerman and Zawiski, 2007). Three of the low head dams along the upper Mahoning River currently are used as primary or emergency sources of public drinking water (RM 93.23, Sebring, RM 85.51, Alliance and RM 58.13, Newton Falls). Consequently, these dams cannot be recommended for removal until an alternative source of drinking water is provided for the communities. However, it is recommended that a study be conducted to determine the feasibility of removing the Mahoning River dam at Leavittsburg (RM 45.73). Removal of this dam has the potential to result in biological communities that fully attain WWH criteria within the nearly ten mile section of the Mahoning River that is currently impounded.

Surface water samples were collected from Berlin Reservoir at RM 72.74 (US Rt. 224) from the upper 30 cm of lake water. As shown in Figure 10, the Berlin Reservoir acts to significantly lower the water hardness (as measured by $CaCO_3$) of the upper Mahoning River mainstem. A similar trend was observed in the 1994 survey of the Upper Mahoning River (Ohio EPA, 1996, Fig. 36, p. 138). The large reduction in water hardness can be explained by the biological process of algal productivity resulting in decalcification of surface waters high in calcium and subsequent precipitation of $CaCO_3$ to lake sediments. A detailed study is recommended to determine the mechanism for how calcium is being biologically removed from lake water. One consequence of lower water hardness in the Mahoning River downstream from Berlin Reservoir would be increased toxicity to various heavy metals if present in high enough concentrations. However, no hardness dependent heavy metals exceeded chemical WQS criteria in any of the Mahoning River mainstem sample locations in 2006. As shown in Figure 10, water hardness increased gradually from the headwaters of the mainstem down to Berlin Reservoir, perhaps due to the use of lime for crop production in the highly agricultural land use upstream from Berlin Reservoir.

The range of total phosphorus from surface water samples collected from Berlin Reservoir at St. Rt. 244 was <0.01 to 0.025 mg/l (n=7, mean = 0.017 mg/l).

These values are within the range expected for lakes commonly classified as having mesotrophic algal production (defined as TP range from 0.09 – 0.024 mg/l, Ohio EPA, 1996). The Ohio DNR also collected samples from Berlin Reservoir in 2006 from a location near the lake dam (communication with Matt Wolfe, ODNR, Division of Wildlife). The concentration of TP was on average 0.035 mg/l (range 0.024-0.0460 mg/l, n = 7) from the Ohio DNR samples that were collected using an integrated sampler to a depth of 2 m. Taken together, the 2006 data from Ohio EPA and Ohio DNR indicate average TP ranging from 0.017-0.035 mg/l in the lower basin of Berlin Reservoir. These numbers are somewhat lower than was found in the 1989 Ohio EPA survey of Berlin Reservoir (range 0.015 – 0.090 mg/l, n=4, mean = 0.040 mg/l) collected at two sample locations, L-1 (near dam) and L-2 (upstream Penn Central railroad bridge), which bracket the 2006 samples.

The Alliance WWTP discharges to Beech Creek where it joins the Mahoning River to form the upper impounded waters of the Berlin Reservoir. The Alliance WWTP is a major sewage treatment plant with design flow of 7.5 mgd, adding a significant load of nutrients to Berlin Reservoir on a daily basis. In 1997 the WWTP added alum treatment to reduce total phosphorus (TP) to meet new NPDES limits of 42.6 kg/day TP on a daily average and 28.4 kg/day TP monthly.

Reduced daily TP loadings from the Alliance WWTP (1997 to 2007) may help to explain the lower levels of phosphorus recorded in Berlin Reservoir in 2006 compared to 1989. It is recommended that a nutrient survey of Berlin Reservoir be conducted at more locations to determine its trophic condition spatially.

Biological surveys conducted at the two headwater sample locations on the Mahoning River (RMs 102.24 and 100.57) documented the presence of fish (mottled sculpin and brook stickleback) and benthic macroinvertebrates (seven total taxa) adapted to cool-cold water habitats. Stream water temperature from June to September (Figure 11) ranged from 18 to 21 C^o at these two locations, which was significantly cooler than downstream locations, and within a thermal range that would allow for reproductive success of cool-cold adapted species.

It is recommended that the designated use for the upper Mahoning River, from RM 100.57 to RM 108.3 be changed from Warmwater Habitat (WWH) to Cold water Habitat (CWH). Cold water habitats are rare and unique for the upper Mahoning River basin, the only other documented community of cool-cold water adapted species is found in the Silver Creek watershed, a tributary of Eagle Creek.

It also is recommended that a classification survey be conducted for primary headwater streams (e.g., those streams < 1.0 mi^2, see Ohio EPA, 2002b) that drain into the upper 8.0 mi^2 watershed of the Mahoning River (e.g., upstream from King Rd.). The purpose of this survey would be to identify the locations of Class III PHWH streams of cool-cold perennial flowing water that are critical to maintaining the thermal conditions required to support the cool-cold water biology documented within the Mahoning River mainstem. Land use plans should be developed to protect any Class III primary headwater habitats identified.

The high percent of agricultural land use in the upper Mahoning River basin (Table 2) suggests the potential for the runoff of soil into streams and ditches during rain events. As shown in Figure 12, there was a significant increase in the concentration of total suspended solids (TSS) in the Mahoning River between RMs 100.57 (King Rd.) and RM 97.69 (Georgetown-Damascus Rd.). Land use upstream from RM 97.69 is largely agriculture (Figure 13). The concentration of TSS in the Mahoning River remained in the range of 10-20 mg/l fifteen miles downstream to Berlin Reservoir. The lowest average TSS concentration was recorded at RM 62.68 downstream from Lake Milton. The highest average TSS was at RM 45.73, upstream from the Leavittsburg dam. A survey is recommended to help identify sources of suspended solids in the Upper Mahoning River basin between RMs 62.68 and 45.73.

Concentrations of heavy metals in the upper Mahoning River mainstem were below laboratory detection limits for priority pollutant parameters (e.g., T-Cu, T-Cd, T-Cr, T-Pb, T-Ni, T-Zn), or at background levels for non-priority parameters, although total iron (T-Fe) exceeded the agricultural water supply criterion of 5,000 ug/l in a single sample at RM 85.51. Levels of total mercury were above the human health criterion of 0.012 ug/l in a single sample at RM 97.69, and mercury was detected in six tributary streams in the Upper Mahoning River survey area (Table 10). The most likely source of mercury in the basin is from atmospheric deposition resulting from coal burning activities. Because the laboratory detection limit for mercury was 0.20 ug/l, which is higher than the 0.012 ug/l human health criterion, it is recommended that additional tests for mercury be conducted in the Upper Mahoning River basin using a lower laboratory detection limit of at least 0.012 ug/l.

There was an increase in total lead (T-Pb) in the Mahoning River at RM 93.23 (King Rd.) downstream to RM 84.99 (Gaskill Rd.). T-Pb was detected in 50% of samples at RM 85.51 (Webb Ave.) and 100% of samples downstream at RM 84.99. The highest single T-Pb concentration was recorded at Webb Ave (14 ug/l), which exceeded the OMZA water quality criterion. Although, relatively low concentrations of lead were recorded throughout the Mahoning River mainstem (average T-Pb < 4.0 ug/l), the detection of lead at 100% of samples collected RM 84.99 (Gaskill Rd.) is a cause for concern. Possible sources of lead include the urbanized areas of Sebring and Alliance. The PTC Alliance Company (NPDES no. 3ID00043) and Transue & Williams Steel Forging Division (NPDES no. 3ID00069) discharge upstream from RM 84.99 and are potential sources of oils and heavy metals. A few auto recycler-junkyards also are located in this area. The data from the biological surveys at RM 84.99 indicate less than full attainment for the benthic macroinvertebrate community. Bottom sediment samples were not collected. It is recommended that a survey be conducted to identify sources of lead in the Alliance segment of the Mahoning River (from RM 93.23 to 84.99), including samples of the stream sediment. Elevated lead was found in the RM 91.21 tributary that empties into the Mahoning River just upstream from the RM 91.11 sample location at St. Rt. 62, although specific sources are currently unknown.

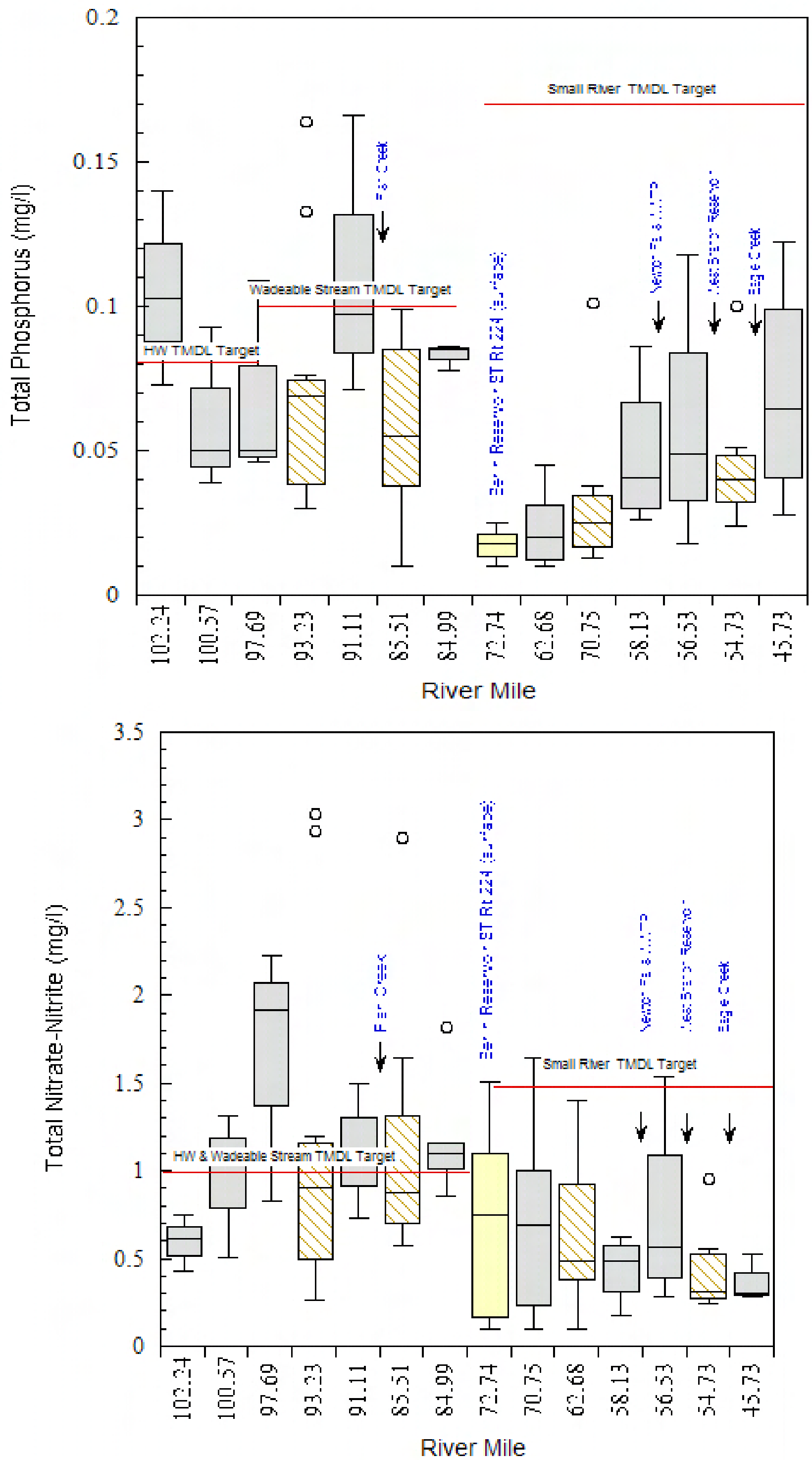


Figure 8. Trends in total phosphorus and nitrate-nitrite along the Upper Mahoning River mainstem (2006 data). Solid box plots (n = 4-5 samples/location). Striped box plots represent sentinel sites (n = 8-10 samples/location); Berlin Reservoir sample size (n=7).

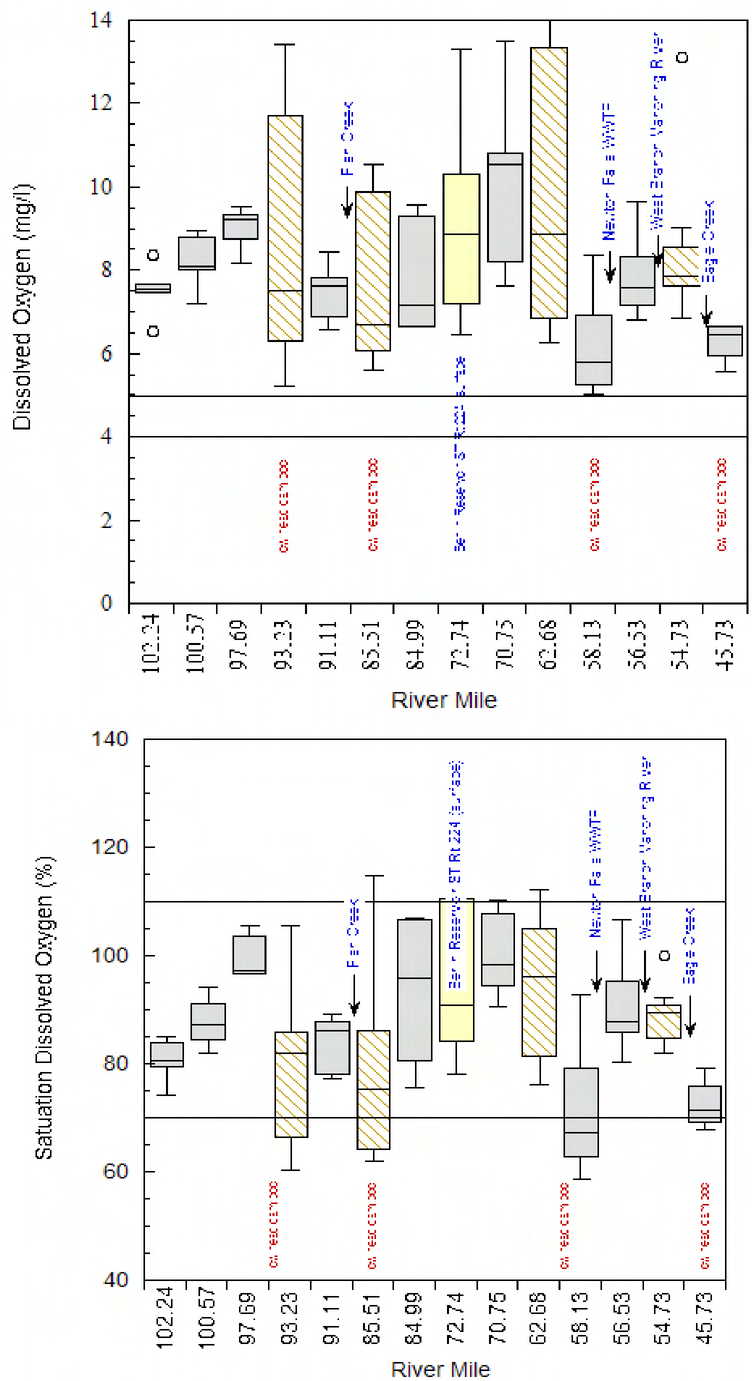


Figure 9. Trends in concentration of dissolved oxygen and percent saturation along the Upper Mahoning River mainstem (2006 data). Solid box plots (n = 4-5 samples/location). Striped box plots represent sentinel sites (n = 8-10 samples/location); Berlin Reservoir sample size (n=7). For top graph, lines represent average and minimum water quality standard criteria for protection of aquatic life. For bottom graph, lines represent saturation ranges to protect against gas bubble disease (maximum) and chronic effects of low oxygen availability (minimum).

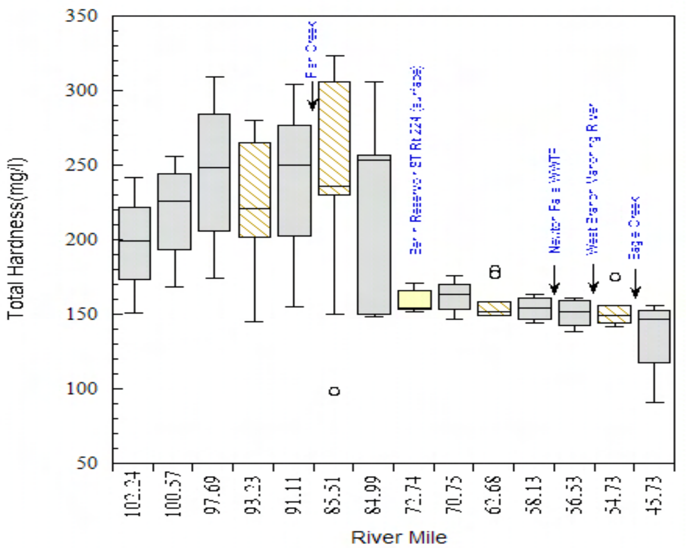


Figure 10. Trends in water hardness as $CaCO_3$ along the Upper Mahoning River mainstem (2006 data). Solid box plots (n = 4-5 samples/location). Striped box plots represent sentinel sites (n = 8-10 samples/location); Berlin Reservoir sample size (n=7). No water quality standard criteria exist for this parameter. Note the significant and sustained reduction in water hardness downstream from the Berlin Reservoir dam. Note also the gradual increase in water hardness from the headwaters down to Berlin Reservoir, potentially resulting from use of lime in agricultural activities for crop production.

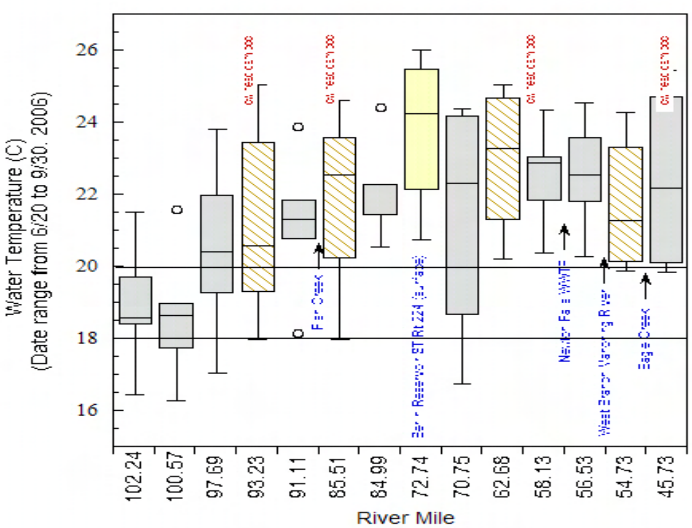


Figure 11. Trends in water temperature along the Upper Mahoning River mainstem (2006 data). Solid box plots (n = 4-5 samples/location). Striped box plots represent sentinel sites (n = 8-10 samples/location); Berlin Reservoir sample size (n=7). Lines represent seasonal average (June to September) thermal limits that predict the potential for reproducing populations of cool-cold water adapted obligate aquatic species.

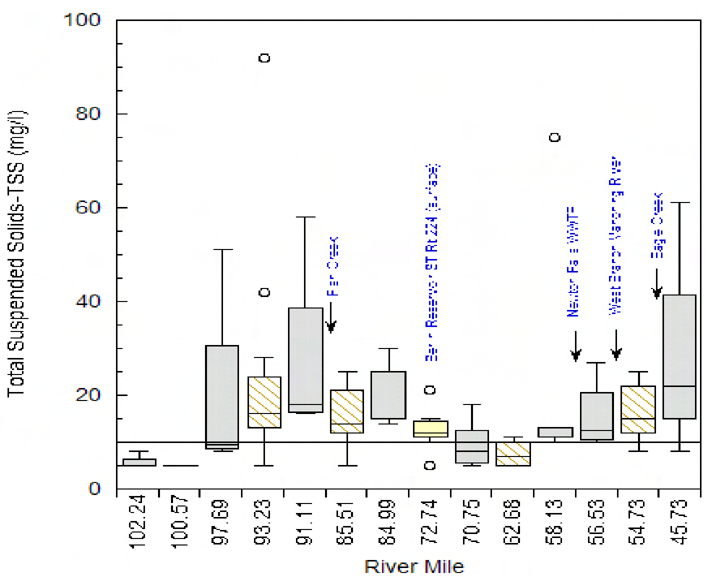


Figure 12. Trends in total suspended solids (TSS) along the Upper Mahoning River mainstem (2006 data). Solid box plots (n = 4-5 samples/location). Striped box plots represent sentinel sites (n = 8-10 samples/location). Berlin Reservoir sample size (n=7). No water quality standard criteria exist for this parameter, background concentration < 10 mg/l TSS as represented by the line.

Table 9. List of sentinel chemical sampling locations used for TMDL modeling in the Upper Mahoning River basin area. RM = river mile.

WAU_8/11/14	STREAM	AREA mi^2	RM	LAT.	LONG.	STORET
05030103/ 010/020	Mahoning River, Webb Ave. at USGS gage	89.0	85.51	40.9328	-81.0947	602420
05030103/ 010/020	Mahoning River, Knox-School Rd.	52.7	93.23	40.8838	-81.0313	N01S01
05030103/ 020/010	Deer Creek at Atwater Rd.	30.1	2.90	40.9799	-81.1481	300025
05030103/ 020/020	Willow Creek, Notman Rd.	7.2	3.74	41.0256	-81.0795	300062
05030103/ 020/040	Mill Creek, Leffingwell Rd.	19.1	3.64	40.9999	-80.9684	300061
05030103/ 030/010	Mahoning River, dwst Berlin Reservoir at USGS gage	248.0	70.75	41.0483	-81.0017	N01S11
05030103/ 030/010	Mahoning River, Pricetown at USGS gage	274.0	62.68	41.1342	-80.9675	602310
05030103/ 030/020	Kale Creek, Canal Rd. at USGS gage	21.9	3.38	41.1364	-80.9956	N02W07
05030103/ 030/030	West Br. Mahoning River, Newton Falls Rd. at USGS gage.	21.8	20.94	41.1616	-81.1974	300022
05030103/ 030/080	West Br. Mahoning River, CR 114A (First St.)	103.0	0.36	41.2072	-80.9603	N02P12
05030103/ 040/010	Eagle Creek, CR 114 at USGS gage	97.6	5.6	41.2608	-80.9542	N02P08

Table 10. List of sampling locations where chemical parameters exceed water quality standard criteria as listed in OAC Section 3745-1. 2006 survey data. Symbols identify specific criteria exceeded.

Stream name River Mile	(Aquatic Life Use designation, existing or recommended) Parameter (all events/sample location reported)

Upper Mahoning River (mainstem RM 102.24 to RM 45.73)

Mahoning River (WWH existing, CWH recommended upst. RM 100.57; AWS existing)

97.69	Hg (0.23 ug/l) ▲▲
85.51	Fe (6,930 ug/l) ▲
	Pb (14.1 ug/l) *

WAU 05030103-010

Tributary to Mahoning River RM 91.21 (WWH recommended)

2.39	D.O. (4.75 mg/l) *

Naylor Ditch (WWH recommended)

3.63	D.O. (4.37 mg/l) *

WAU 05030103-020

Deer Creek (WWH existing)

10.87	D.O. (4.94 mg/l) *
2.90	Hg (0.25 ug/l) ▲▲

Willow Creek (WWH existing)

8.13	D.O. (4.71 mg/l) *

Island Creek (WWH existing)

2.65	D.O. (2.31 mg/l) ◊
	Hg (0.34 ug/l) ▲▲

Mill Creek (WWH existing)

6.28	Hg (0.32 ug/l) ▲▲
3.64	Hg (0.23 ug/l) ▲▲

Tributary to Mill Creek RM 3.67 (WWH recommended)

1.10	D.O. (3.22 mg/l ◊; 4.14 mg/l *)
	Hg (0.26 ug/l) ▲▲

Turkey Broth Creek (WWH existing)

3.36	D.O. (2.85 mg/l, 3.41 mg/l) ◊
	Hg (0.21 ug/l) ▲▲

Table 10 cont. List of sampling locations within the Upper Mahoning River basin where chemical parameters exceed water quality standard criteria as listed in OAC Section 3745-1. 2006 survey data. Symbols identify specific criteria that are exceeded.

Stream name River Mile	(Aquatic Life Use designation, existing or recommended) Parameter (all events/sample location reported)
Garfield Ditch (WWH existing; AWS existing)	
0.66	D.O. (3.93 mg/l, 3.94 mg/l) ◊
	Hg (0.33 ug/l) ▲▲
	Fe (5,360 ug/l) ▲
	WAU 05030103-030
Kale Creek (WWH existing)	
11.27	D.O. (3.81 mg/l) ◊
6.05	D.O. (4.14 mg/l) *
3.38	D.O. (4.98 mg/l) *
Harmon Brook (WWH existing)	
0.49	D.O. (4.65 mg/l) *
West Branch Mahoning River (WWH existing)	
27.92	D.O. (4.70 mg/l; 4.71 mg/l) *
Tributary to West Branch Mahoning River RM 0.01 (WWH recommended)	
2.10	D.O. (3.38 mg/l ◊; 4.55 mg/l *)
	WAU 05030103-040
Nelson Ditch (WWH existing)	
1.11	D.O. (4.75 mg/l) *
Eagle Creek (WWH existing)	
10.10	Pb (46.0 ug/l) *
5.60	Zn (261 ug/l) *

* Aquatic life outside mixing zone average (OMZA) (this is actually not a 30 day avg., but is based on a single value)

▲ Protection of agricultural uses (OMZA)

▲▲Protection of human health non drinking water risk exposure (OAC Section 3745-1-34)

◊ Less than minimum WWH criteria for dissolved oxygen (OMZM not less than 4.0 mg/l)

CWH=Cold water Habitat, EWH=Exceptional Warmwater Habitat, AWS- Agricultural Water Supply

Sediment Quality

Sediments were analyzed from three reference sites for heavy metals and at ten locations that receive runoff water from the Ravenna Training and Logistics Site (aka Ravenna Army Ammunition Plant). Organic compounds were also analyzed at the three sediment reference locations. Reference sites are located in drainages typical of the region's prevailing land use and geography but are in areas considered "least impacted" by point or non-point pollution sources. No sediment samples were collected from the Mahoning River mainstem. All samples were collected in accordance to Ohio EPA's Sediment Sampling Guide and Methodologies (Nov. 2001). Sediment evaluations were conducted using guidelines established in MacDonald *et al.* (2000), along with a comparison of metals results to Ohio Sediment Reference Values (Ohio EPA 2003).

Sample analysis indicated all sediment metals were within normal ranges for Ohio streams in the EOLP ecoregion (Table 11). Sediment organic compounds were below detection limits at all of the sample locations.

Biologically, all three of the sediment reference sites were in full attainment. Of the ten streams sampled near the Ravenna Training and Logistic Site, biological surveys were conducted at seven locations. Four of these seven sediment sampling locations showed less than full biological attainment (STORET nos. 200372, N02K17, N02K15, N02K14), however, factors other than sediment such as poor habitat or chemical water quality were identified as the main causal factors for the non-attainment. In summary, the data indicate background sediment quality was not a significant or widespread stressor on biological quality of tributary streams in the Upper Mahoning River study area.

Table 11. Sediment heavy metal concentrations for select reference streams sampled in the Upper Mahoning River basin. Sediment evaluations were conducted using guidelines established in MacDonald *et al.* (2000).

Heavy Metals Data: Sediment Samples (all values in mg/kg)

Al TOC	Ba NH_3	Cr TP	Cu	Fe	Mn	Ni	Sr	Zn	Pb	Hg	Cd	As	Na	K	Ca	Mg	**% Solids**
	Sediment quality guidelines (MacDonald *et al*. 2000)																
		Cr	**Cu**			**Ni**		**Zn**	**Pb**	**Hg**	**Cd**	**As**					
		111	**149**			**48.6**		**459**	**128**	**1.06**	**4.98**	**33.0**					
	STORET # N02K22 (Hinkley Creek at SR 5)																
1790	**17.7**	**<14**	**<4.8**	**7080**	**324**	**<19**	**<14**	**29.3**	**<19**	**<0.027**	**<0.096**	**4.43**	**<2400**	**<960**	**1650**	**848**	**77.2**
0.5	**21**	**220**															
	STORET # N02S03 (Silver Creek at SR 82)																
2470	**24.5**	**<13**	**4.5**	**10300**	**239**	**<17**	**<13**	**29.5**	**<17**	**<0.022**	**0.088**	**9.11**	**<2160**	**<865**	**1060**	**804**	**73.4**
1.3	**44**	**328**															
	STORET # N02K27 (West Branch Mahoning River at SR 88)																
1480	**16.0**	**<13**	**<4.3**	**6560**	**364**	**<17**	**<13**	**27.4**	**<17**	**<0.023**	**<0.086**	**3.61**	**<2160**	**<864**	**1080**	**620**	**78.5**
0.3	**22**	**172**															

Fish Tissue

The Ohio Department of Health (ODH) issued a statewide fish consumption advisory in 2006 recommending all persons limit consumption of sport fish caught from all waterbodies in Ohio to one meal per week, unless there is a more restrictive advisory. When the statewide advisory was initially promulgated it was directed at sensitive populations, including women of child bearing age and children under age 15. The advisory was extended to all persons in 2003 due to the statewide/nationwide mercury advisory for sensitive populations and the increasing number of location-specific one meal per week advisories. Table 12 details the consumption advisories specific to the upper Mahoning River watershed. For additional information related to fish consumption advisories, see the Fish Consumption Advisory webpage at http://www.epa.state.oh.us/dsw/fishadvisory/index.html.

Table 12. Specific fish consumption advisories present in the upper Mahoning River basin.

Mahoning River	Rockhill Avenue NE (Alliance) to Pennsylvania State Line (Mahoning, Portage, Stark, Trumbull Counties)	Channel Catfish 21" and over, Smallmouth Bass 15" and over	Do Not Eat	PCBs
		Channel Catfish under 21", Common Carp, Smallmouth Bass under 15"	2 Months	PCBs
		Largemouth Bass	Month	Mercury
		Walleye	Month	PCBs
Walborn Reservoir	All Waters (Portage, Stark Counties)	Largemouth Bass	Month	Mercury
Berlin Lake	All Waters (Mahoning, Portage, Stark Counties)	Channel Catfish	Month	PCBs
		Common Carp	Month	Lead, PCBs
West Branch Reservoir	All Waters (Portage County)	Largemouth Bass	Month	Mercury

Restoration and Protection Actions

The quality of surface waters in Ohio continues to improve as efforts are taken to regulate pollutant loads from point source dischargers through the federal NPDES permit system. Today, the primary source of Ohio's chemical water pollutants at levels that result in impaired biological communities come from non-point sources—storm water run-off that transports contaminants from broad areas of a landscape. Programs to control non-point sources that are being implemented and specific non-point source pollution concerns in the Upper Mahoning River basin, include the following:

Watershed Action Plan

A draft Watershed Action Plan for the Mahoning River watershed has been developed (Martin, 2004). This document provides useful information on non-point source issues in the Upper Mahoning River basin. It is available for review at the Ohio EPA Northeast District Office, Division of Surface Water.

Section 319 Implementation Projects

There have been two Section 319 implementation projects that have been funded by the Ohio EPA for the Upper Mahoning River basin since the last watershed survey was conducted (Ohio EPA, 1996). From 1995 to 1998 the Mahoning County Health Department implemented a 319 project to transfer information for home sewage treatment systems HSTS into a computer data base. This project also involved random inspections of HSTS, new regulations, point of sale inspections and registration of septage haulers. From 1998 to 2001 the Columbiana County Health Department implemented a 319 project to encourage the use of new and innovative home sewage treatment systems (HSTS) within their county such as the Franklin mound system, the infiltrator leaching system and the wetlands treatment system.

Agriculture: Farms/Orchards/Nurseries

As documented in the watershed action plan for the Upper Mahoning River basin (Martin, 2004), agriculture is the predominant land use (Table 2), with cropland and pasture comprising 62.70 % of the total basin area. Each of the county Soil and Water Conservation Districts that are located within the Upper Mahoning River basin have implemented a variety of best management practices (BMP) to address non-point source issues, as summarized below:

Mahoning County SWCD (contact: Vince Trinckes, Kathleen Vrable-Bryan)
The Mahoning County SWCD office has implemented the following non-point source BMPs in the Upper Mahoning River basin from 1999 to 2007:

Year	BMP Implemented	Location
1999	wetlands reserve easement program	Beloit
2000	agricultural easement	Salem
2001	agricultural easement	Salem
2004	nutrient management plan	Salem
	wetlands reserve easement	Alliance
2005	animal waste storage facility	Berlin Center
	heavy use area protection	Berlin Center
	grass waterway	Beloit
2006	agricultural easement	Salem
	nutrient management plan (3)	Beloit
	grass waterway (2)	Beloit
	grass waterway	Salem
	animal waste storage facility	North Benton
	cold water spring development	North Benton
	subsurface drainage	North Benton
	watering system	North Benton
2007	heavy use protection	Berlin Center
	animal waste storage facility (2)	Salem
	filter strip	Salem
	animal waste storage facility	Beloit

Trumbull County SWCD (contact: Amy Reeher)
The Trumbull County SWCD office has been involved in a variety of non-point source projects targeted toward agriculture. As part of the Agricultural Cost-Share Programs through the 2002 Farm Bill they implemented an EQIP funded Compost Facility for Beef Conservation Plan (15 acres) and an EQIP funded Heavy Use Protection Pad to combat erosion (26.9 acres). The district is very involved with environmental education programs. From 1998-2001 they conducted 113 presentations with an average yearly audience of 2,850. Average number of education programs for 2001-2004 was 182 with an average yearly audience of 4,656. Within the Eagle Creek watershed alone, between 1998 and 2005, they conducted 130 educational programs that reached 3,519 individuals. These programs included topics such as minimum control measures for erosion and sediment control, a Stream Watch project targeted for Youth Education, and brochures.

Portage County SWCD (contact: Jennifer White)
The Portage County SWCD office has implemented the following BMPs within the Upper Mahoning River Basin from 2004 to 2007:
Comprehensive Nutrient Management- 2,462.5 acres.
Waste Storage Facilities Installed – 3.
Grazing Plans & Pasture Management - 47.7 acres.
Livestock Heavy Use Area Protection - 0.83 acres.
Livestock Exclusion Fencing (from stream or wetland areas) - 8,045 feet.
Filter Strip & Critical Area Planting - 1.5 acres.
Forest Stand Improvement - 17 acres.

Conservation Easements held by either by the Portage SWCD or USDA include:
Wetland/Riparian - 515.16 acres; Agricultural - 127 acres; Wooded - 23 acres

Columbiana County SWCD (contact: Pete Conkle)
The Columbiana County SWCD office has implemented the following non-point source BMPs within the Upper Mahoning River basin from 2000 to 2007:
Sand-filter bed for milk house waste treatment for 35 cow dairy.
2400 sq. ft. concrete heavy use pad for a 40 cow dairy.
2700 ft of fencing to exclude livestock from streams.
Two spring developments with concrete stock tanks.
1200 sq ft. of stream crossings (limited access, stone crossings).
Milk house treatment system; pump and pipeline to wetland cells.
Comprehensive Nutrient Management Plan-1 farm.
Approximately six miles of grassed waterways have been installed since 2003.

Stark *County SWCD* (contacts: Andy Bayham, Brian Prunty)
The Stark County SWCD office has implemented the following non-point source BMPs within the Upper Mahoning River basin from 1997 to 2007:

1 roofed feedlot,
10 grassed waterways,
1 wooded constructed wetland,
2 manure storage facilities,
1 milk house waste system installed,
3 Comprehensive Nutrient Management Plans applied,
1 filter strip installed along stream.

A number of urban BMPs have been implemented in the county including Erosion & Sediment Controls (ESC) regulations adopted for construction sites 5 or more acres, 2003 ESC regulation changes to construction sites 1 acre or greater, and 2008 water quality regulations to treat urban storm water.

Failing Home Sewage Treatment Systems (HSTS)
Mahoning County Health Department (contact: Wesley Vins)
To address issues with HSTS the Mahoning County Health Department developed a wastewater advisory committee of twenty member organizations to help the health district with review of new proposed rules and practices for HSTS. Results of this process have included reminders sent to residents for any property that has not had their septic tank pumped within the preceding 36 months, and multiple sewage contractor training seminars. Specific improvements include the installation of sanitary sewers and removal of HSTS in the Damascus area and along the east and northwest sides of Lake Milton. Sanitary sewers have also been installed to connect HSTS in Sebring and the county is in the planning stage (2008) of a community wide sanitary sewer system to serve the East Alliance area. The county has assembled financial assistance packets for residents that need to replace a failing HSTS or connect to a new sanitary sewer. From 1997 to 2007 the number of failing HSTS replaced or repaired by township are: Berlin 55, Goshen 72, Milton 41, Smith 91.

Trumbull County Health Department (contacts: Frank Migliozzi, Sharon O'Donnell)
In November of 2002, a moratorium was passed in Trumbull County for off-lot discharges of all new HSTS. The only exception is when an existing HSTS needs to be upgraded and off-lot is the only option. All replacement off-lot systems must install a filtered tertiary unit (sand filter), a fail safe system, UV or chlorine/dechlor, plus maintain a service contract for at least two visits per year. The Trumbull County Health Department conducts one unannounced visit and sampling on an annual basis for each off-lot system. Currently there are nearly 2500 HSTS in Trumbull County in this inspection program.

In July of 2003, a new county regulation prohibited installation of any septic system within a 100 year floodplain. All HSTS are required to maintain at least a 50 foot buffer from streams, lakes and rivers. Plus required percolation tests must show at least one vertical foot between the bottom of the HSTS leaching lines and the seasonal high water table. The Trumbull County Health Department and the Ohio EPA have set up a revolving loan program to assist home owners with low interest loans for repair of failing HSTS. From 2000 to 2008 the following actions concerning HSTS were taken within the Eagle Creek watershed: 27 off-lot replacement systems, 31 on-lot new or upgraded systems.

Portage County Health Department (contacts: Kevin Watson, Tom Brannon)
On February 6, 2008, Portage County Health Department employees provided the following information about home sewage treatment systems (HSTS) and semi-public sewage treatment systems within the Eagle Creek watershed:

Nuisance Complaints between 2002 and 2005

Township	HSTS Upgraded	Types of Upgrades
Hiram	4	1 holding tank/2 aeration/1 soil absorb
Nelson	4	4 aeration
Freedom	3	3 aeration
Windham	3	I graywater tie-in/2 soil absorb

Home Sales Inspections between 2002 and 2005

Township	HSTS Upgraded	Types of Upgrades
Hiram	3	3 replacement units
Nelson	3	3 replacement units
Freedom	3	1 graywater tie-in/ 2 replacement
Windham	2	2 replacement units

Columbiana County Health Department (contacts: Lori Barnes, Paula Cope)
Headwaters of the Mahoning River originate in Columbiana County. The Alliance/Sebring sub watershed of the Upper Mahoning River basin encompasses major portions of Knox and Butler townships. On February 26, 2008, the Columbiana County Health Department provided the following information about county regulation changes and new/upgraded home sewage treatment systems (HSTS):

In 2001, there was a county regulation change which required pre-site soil evaluations by a certified soil scientist of all new HSTS. Drainage diversion systems are now required around HSTS in high water tables. This same year, new stricter septage regulations went into effect. In 2002, regulations went into effect requiring installation of failsafe systems. In 2007, regulations require only on-lot HSTS. The only exception being a failing HSTS which needs to be upgraded and off-lot is the only practical option.

In 1998, the Columbiana County Health Department (CCHD) was awarded a Section 319 Grant from the Ohio EPA. The primary focus of this grant was to assist homeowners with failing HSTS within the Upper Mahoning River basin (within Columbiana County). This grant provided financial assistance to the homeowners and gave the CCHD an opportunity to install and research innovative HSTS. In 2000 and 2001, the CCHD installed a total of 33 innovative HSTS within the Upper Mahoning River basin. These system upgrades included:

Franklin County Mound System, Supplemental Curtain Drains, Infiltrator Leaching System, and Wetlands Treatment System. The CCHD continues to monitor these systems, some of these innovative HSTS have failed, which has helped provide better knowledge towards future regulations. Between 2000 and 2007, the following HSTS were installed in Knox and Butler Townships of Columbiana County to help protect or improve water quality:

Township	# of HSTS Installed	Types of HSTS
Knox	49	New on-lot units
Knox	03	New off-lot units
Knox	29	Replacement on-lot units
Knox	77	Replacement off-lot units
Butler	56	New on-lot units
Butler	05	New off-lot units
Butler	22	Replacement on-lot units
Butler	26	Replacement off-lot units
Total	267	

Stark County Health Department (contact: Todd Paulus, Nick Hammer)
A time line of regulatory improvements that relate to HSTS was provided by the Stark County Health Department. From 1970-1994, off-lot discharge was permitted. New construction discharges were permitted by variance only. Soil test were required to be conducted on every new lot by soil scientist. In 1992, HB110 inspection program was implemented.

From 1994-2006, all off-lot discharges of HSTS were prohibited for new construction in Stark County. Effluent quality standards were tightened to 10 mg/l CBOD and 12 mg/l TSS for replacement systems that require off-lot discharge. Failsafe devices were required to prevent the discharge of untreated sewage. The design of off-lot discharge systems required the incorporation of trash trap and filters to further improve effluent quality and lessen maintenance needs. Discharges were installed as a last resort. Soils test were required for every new and replacement system, (except repairs with lack of space). Operation and maintenance inspections were required for all additions to homes. Septage disposal regulations adopted in 1997. In 2002 acreage minimums were implemented in poor soils to lessen density of homes. Subsequently township zoning in Lexington and Marlboro Townships increased lot size to 2 and 3 acres respectively. The 2007 state and local sewage rules no longer spelled out minimum lot size.

From 2007-2008, design standards improved, especially for severe soil. Off-lot discharge systems permitted through OEPA's Memorandum Of Understanding (MOU) NPDES program; thus effluent quality improved. O&M program expanded to include: property transfer inspections, tank pumping database and reminders, aerobic treatment system inspection and service requirements.

A variety of activities are scheduled for the Upper Mahoning River basin area. Sanitary Sewers are to be installed south of Alliance in the allotment south near the intersection of Easton and Beechwood, due to failing septic systems. This project is nearing completion (spring 2008) and will serve 114 homes. A computer permitting database for HSTS came on-line around 2004. The list below shows the number of permits that have been issued since that time. The list differentiates new and repair/replacement, then further lists if the repair was a discharge. Only those properties in the Mahoning River Watershed within each township are included.

Township	New HSTS	Repair	# discharge repairs
Lexington	65	104	83
Marlboro	40	23	11
Washington	33	71	47

Sanitary Landfills

The BFI Willow Creek landfill, which had a discharge to an unnamed tributary to Berlin Reservoir, closed in August 2001. The only active sanitary landfill during the survey of the Upper Mahoning River basin was the Central Waste Inc. landfill. This facility has storm water discharge to Fish Creek regulated under NPDES permit (NPDES permit no. 3IN00313). Data collected from Fish Creek upstream and downstream from the tributary that receives storm water runoff from the Central Waste landfill did not show a negative impact on biological communities.

Mine Drainage

Surface and underground coal mining activities were at one time prevalent in the Upper Mahoning River basin. Currently there are no active coal mines in the basin. The results of the 2006 did not identify any significant problems with chemicals associated with strip mine activities in the survey area.

Timber Harvesting Operations

All of the watershed areas that comprise the Upper Mahoning River basin have experienced historical timbering activities. Poor road layout and construction activities can contribute large amounts of sediment to streams during active timber operations. No specific problems with timber harvesting were identified during the 2006 survey.

Riparian Corridor Protection

Vegetation along the embankments of streams and lakes offer many water quality benefits such as stream bank stabilization, filtration of run-off waters, food sources, cooler water temperatures and habitat enhancement for biological communities. Conservation easements, land trusts, education and responsible legislation are valuable tools for riparian corridor protection. The development of watershed plans and implementing best management practices are equally important.

Urban Storm Water NPDES Program

The Ohio EPA administers the NPDES storm water program. Within the Upper Mahoning River basin a number of communities are regulated by the Phase II NPDES program (Table 3).

RECOMMENDATIONS

Aquatic Life Uses Recommendations

Current and recommended aquatic life, water supply and recreation uses are presented in Table 13. A number of the tributary streams evaluated in this study were originally designated for aquatic life use in the 1978 and 1985 Ohio WQS; others were previously undesignated. The current biological assessment methods and numerical criteria did not exist then. This study, as an objective and robust use evaluation, is precedent setting in comparison to the 1978 and 1985 designations. Several subbasin streams have been evaluated for the first time using a standardized biological approach as part of this study. Ohio EPA is obligated by a 1981 public notice to review and evaluate all aquatic life use designations outside of the Warmwater Habitat (WWH) use prior to basing any permitting actions on the existing, unverified use designations. Thus, some of the following aquatic life use recommendations constitute a fulfillment of that obligation.

Previous biological and habitat evaluations of selected streams in the upper Mahoning River watershed resulted in the application of the WWH aquatic life use for the Mahoning River, Chocolate Run, Tinker Creek, Nelson Ditch, Silver Creek (tributary to West Branch Mahoning River), Barrel Run, Harmon Brook, Kale Creek, Mill Creek, Turkey Broth Creek, Island Creek, Willow Creek, Duck Creek, Beech Creek, Little Beech Creek, Fish Creek, and Beaver Creek. Sampling conducted in 2006 confirmed WWH designation.

Several streams were sampled for the first time in 2006 and had biological communities indicating the potential for the stream to attain WWH standards. The streams are therefore being recommended for WWH. Mahoning Creek, unnamed tributary to Kale Creek RM 5.29, unnamed tributary to Mill Creek RM 3.67, Garfield Ditch, unnamed tributary to Mahoning River RM 91.21, unnamed tributary to Mahoning River RM 97.11, unnamed tributary to Mahoning River RM 98.71, and Naylor Ditch.

In addition to the numerous WWH designations, the upper reach of the Mahoning River and Camp Creek were found to support sufficient CWH communities to warrant the CWH designation. The Mahoning River communities were found at the two uppermost sites, RM 102.24 and RM 100.57. A combined total of 9 cold water macroinvertebrate taxa were found at these two sites, including the state threatened cased caddisfly *Psilotreta indecisa*. Additionally, the cold water flathead mayfly *MacCaffertium ithaca* was collected only in the headwaters of the Mahoning River. Camp Creek was found to host 7 cold water macroinvertebrate taxa, including the state-threatened caddisfly, *Psilotreta indecisa*. Additionally, over 16% of the fish community of Camp Creek was comprised by cold water species: mottled sculpin (9.6%), redside dace (7.2%), brook stickleback (0.6%), and central mudminnow (0.1%). The Mahoning River upstream from RM 100.57 and Camp Creek should therefore be assigned the Cold water Habitat (CWH) aquatic life use.

The South Fork Eagle Creek also demonstrated CWH potential in 2003, when the stream was sampled extensively within the Ravenna Training and Logistics Site (RTLS). Three of the four communities collected included at least the requisite four cold water macroinvertebrate taxa to be considered for the CWH aquatic life use (RM 6.2-8, RM 5.5-7, and RM 2.7-4). As such, South Fork Eagle Creek from its headwaters to RM 2.7 is recommended for the CWH aquatic life use.

Table 13. Waterbody use designations for the upper Mahoning River basin. Designations based on the 1978 and 1985 water quality standards appear as asterisks (*). Designations based on Ohio EPA biological field assessments appear as a plus sign (+). Designations based on the 1978 and 1985 standards for which results of a biological field assessment are now available are displayed to the right of existing markers. A delta (Δ) indicates a new recommendation based on the findings of this report.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
I I I I I I I I I														
Mahoning river - at RMs 56.47, 69.18, 83.55, and 91.50		*+						o	*+	*+		*+		PWS intakes - Newton Falls (RM 56.47), Mahoning valley sanitary district (emergency intake, RM 69.18), Alliance (emergency intake, RM 83.55) and Sebring (RM 91.50)
-Headwaters to RM 100.57						Δ			+	+		+		
- all other segments		+							+	+		+		
Chocolate run		*+							*+	*+		*+		
Eagle creek	+	+							+	+		+		
Tinker creek	*+	*+							*+	*+		*+		
Nelson ditch	*+	*+							*+	*+		*+		
South fork		+							+	+		+		
-Headwaters to RM 2.7						Δ			+	+		+		

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
I I I I I I I I														
- all other segments		+							+	+		+		
Unnamed tributary (South fork RM 6.34)		+							+	+		+		
Sand creek	*	+							+	+		+		
Unnamed tributary (Sand creek RM 2.22)		+							+	+		+		
Unnamed tributary (Sand creek RM 3.25)		+							+	+		+		
Unnamed tributary (Sand creek RM 4.84)		+							+	+		+		
Mahoning Creek		Δ							Δ	Δ		Δ		
Camp creek	*	*				Δ			*+	*+		*+		
Silver creek	+					+			+	+		+		
Hiram tributary		+							+	+			+	
Black creek	*	*							*	*		*		
West branch - at RM 13.25		+						o	+	+		+		PWS intake - West branch tower state park
- all other segments		+							+	+		+		
Unnamed tributary (West branch RM 0.01) - RM 3.8 to the mouth		+							+	+		+		
Unnamed tributary (West Branch RM 8.28)		+							+	+		+		
Unnamed tributary (West branch RM 9.63)														

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
I I I I I I I I														
Unnamed tributary (unnamed tributary RM 0.74)		+							+	+		+		
Silver creek		*+							*+	*+		*+		
Hinkley creek		+							+	+		+		
Bixon creek		*							*	*		*		
Barrel run		*+							*+	*+		*+		
Harmon brook		*+							*+	*+		*+		
Kale creek		*+							*+	*+		*+		
Unnamed tributary to Kale Creek RM 5.29		Δ							Δ	Δ		Δ		
Charley Run creek		*							*	*		*		
Mill creek		*+							*+	*+		*+		
Unnamed tributary to Mill Creek RM 3.67		Δ							Δ	Δ		Δ		
Turkey Broth creek		*+							*+	*+		*+		
Garfield Ditch		Δ							Δ	Δ		Δ		
Island creek		*+							*+	*+		*+		
Willow creek		*+							*+	*+		*+		
Deer creek - at RM 0.54		*						o	*	*		*		PWS intake - Alliance
- all other segments		*+							*+	*+		*+		

	Use Designations													
		Aquatic Life Habitat						Water Supply			Recreation			
Water Body Segment	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	Comments
Beech creek		*+							*+	*+		*+		
Little Beech creek		*+							*+	*+		*+		
Fish creek		*+							*+	*+		*+		
Unnamed tributary to Mahoning River 91.21		Δ							Δ	Δ		Δ		
Naylor Ditch		Δ							Δ	Δ		Δ		
Beaver run		*+							*+	*+		*+		
Unnamed tributary to Mahoning River 97.11		Δ							Δ	Δ		Δ		
Unnamed tributary to Mahoning River 98.71		Δ							Δ	Δ		Δ		

SRW = state resource water; WWH = warmwater habitat; EWH = exceptional warmwater habitat; MWH = modified warmwater habitat; SSH = seasonal salmonid habitat; CWH = cold water habitat; LRW = limited resource water; PWS = public water supply; AWS = agricultural water supply; IWS = industrial water supply; BW = bathing water; PCR = primary contact recreation; SCR = secondary contact recreation.

METHODS

All chemical, physical, and biological field, EPA laboratory, data processing, and data analysis methods and procedures adhere to those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 2006b), Biological Criteria for the Protection of Aquatic Life, Volumes II - III (Ohio Environmental Protection Agency 1987b, 1989a, 1989b, 2008a, 2008b), The Qualitative Habitat Evaluation Index (QHEI); Rationale, Methods, and Application (Rankin 1989), and Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (Ohio EPA 2006a). Sampling locations are listed in Table 2.

Determining Use Attainment Status

Use attainment status is a term describing the degree to which environmental indicators are either above or below criteria specified by the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1). Assessing aquatic use attainment status involves a primary reliance on the Ohio EPA biological criteria (OAC 3745-1-07; Table 7-15). These are confined to ambient assessments and apply to rivers and streams outside of mixing zones. Numerical biological criteria are based on multimetric biological indices including the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), indices measuring the response of the fish community, and the Invertebrate Community Index (ICI), which indicates the response of the macroinvertebrate community. Three attainment status results are possible at each sampling location - Full, partial, or non-attainment. Full attainment means that all of the applicable indices meet the biocriteria. Partial attainment means that one or more of the applicable indices fails to meet the biocriteria. Non-attainment means that none of the applicable indices meet the biocriteria or one of the organism groups reflects poor or very poor performance. An aquatic life use attainment table (Table 1) is constructed based on the sampling results and is arranged from upstream to downstream and includes the sampling locations indicated by river mile, the applicable biological indices, the use attainment status (*i.e.,* full, partial, or non), the Qualitative Habitat Evaluation Index (QHEI), and a sampling location description.

Habitat Assessment

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1995, Ohio EPA 2006a). Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates, amount and quality of instream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the habitat characteristics used to determine the QHEI score which generally ranges from 20 to less than 100. The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas whereas scores less than 45 generally cannot support a warmwater assemblage consistent with the WWH biological criteria. Scores greater than 75 frequently typify habitat conditions which have the ability to support exceptional warmwater faunas.

Sediment and Surface Water Assessment

Fine grain sediment samples were collected in the upper 4 inches of bottom material at each location using decontaminated stainless steel scoops. Decontamination of sediment sampling equipment followed the procedures outlined in the Ohio EPA sediment sampling guidance manual (Ohio EPA 2001). Sediment grab samples were homogenized in stainless steel pans (material for VOC analysis was not homogenized), transferred into glass jars with teflon lined lids, placed on ice (to maintain $4^{o}C$) in a cooler, and shipped to the Ohio EPA Division of Environmental Services. Sediment data is reported on a dry weight basis. Surface water samples were collected, preserved and delivered in appropriate containers to either an Ohio EPA contract lab or the Ohio EPA Division of Environmental Services. Surface water samples were evaluated using comparisons to Ohio Water Quality Standards criteria, reference conditions, or published literature. Sediment evaluations were conducted using guidelines established in MacDonald *et al.* (2000) and Ohio Specific Reference Values (2003).

Macroinvertebrate Community Assessment

Macroinvertebrates were collected from artificial substrates and from the natural habitats. The artificial substrate collection provided quantitative data and consisted of a composite sample of five modified Hester-Dendy multiple-plate samplers colonized for six weeks. At the time of the artificial substrate collection, a qualitative multihabitat composite sample was also collected. This sampling effort consisted of an inventory of all observed macroinvertebrate taxa from the natural habitats at each site with no attempt to quantify populations other than notations on the predominance of specific taxa or taxa groups within major macrohabitat types (e.g., riffle, run, pool, margin). Detailed discussion of macroinvertebrate field and laboratory procedures is contained in Biological Criteria for the Protection of Aquatic Life: Volume III, Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities (Ohio EPA 1989b, Ohio EPA 2008b).

Fish Community Assessment

Fish were sampled using pulsed DC electrofishing methods. Fish were processed in the field, and included identifying each individual to species, counting, weighing, and recording any external abnormalities. Discussion of the fish community assessment methodology used in this report is contained in

Biological Criteria for the Protection of Aquatic Life: Volume III, Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities (Ohio EPA 1989b, Ohio EPA 2008b).

Causal Associations

Using the results, conclusions, and recommendations of this report requires an understanding of the methodology used to determine the use attainment status and assigning probable causes and sources of impairment. The identification of impairment in rivers and streams is straightforward - the numerical biological criteria are used to judge aquatic life use attainment and impairment (partial and non-attainment). The rationale for using the biological criteria, within a weight of evidence framework, has been extensively discussed elsewhere (Karr *et al.* 1986; Karr 1991; Ohio EPA 1987a,b; Yoder 1989; Miner and Borton 1991; Yoder 1991; Yoder 1995). Describing the causes and sources associated with observed impairments relies on an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, land use data, and biological results (Yoder and Rankin 1995). Thus the assignment of principal causes and sources of impairment in this report represent the association of impairments (based on response indicators) with stressor and exposure indicators. The reliability of the identification of probable causes and sources is increased where many such prior associations have been identified, or have been experimentally or statistically linked together. The ultimate measure of success in water resource management is the restoration of lost or damaged ecosystem attributes including aquatic community structure and function. While there have been criticisms of misapplying the metaphor of ecosystem "health" compared to human patient "health" (Suter 1993), in this document we are referring to the process for evaluating biological integrity and causes or sources associated with observed impairments, not whether human health and ecosystem health are analogous concepts.

WATERSHED ASSESSMENT UNIT REPORTS

Mahoning River Headwaters WAU

The Mahoning River flows through the agricultural lands of the southeastern portion of the headwaters of the Mahoning River WAU before entering the developed urban landscape of Alliance (Figure 13). The dominant agricultural land use (51%) has resulted in siltation and nutrient enrichment in tributaries such as Little Beech Creek, Beech Creek, tributary to Mahoning River at RM 98.71, tributary to Mahoning River at RM 97.11, tributary to Mahoning River at RM 91.21, and Naylor Ditch (Table 14). The urbanized landscape of Alliance contributed to the severe sedimentation within the Mahoning River near RM 84.99, while just upstream the river was in non-attainment of WWH criteria due to impounded conditions from the local dam.

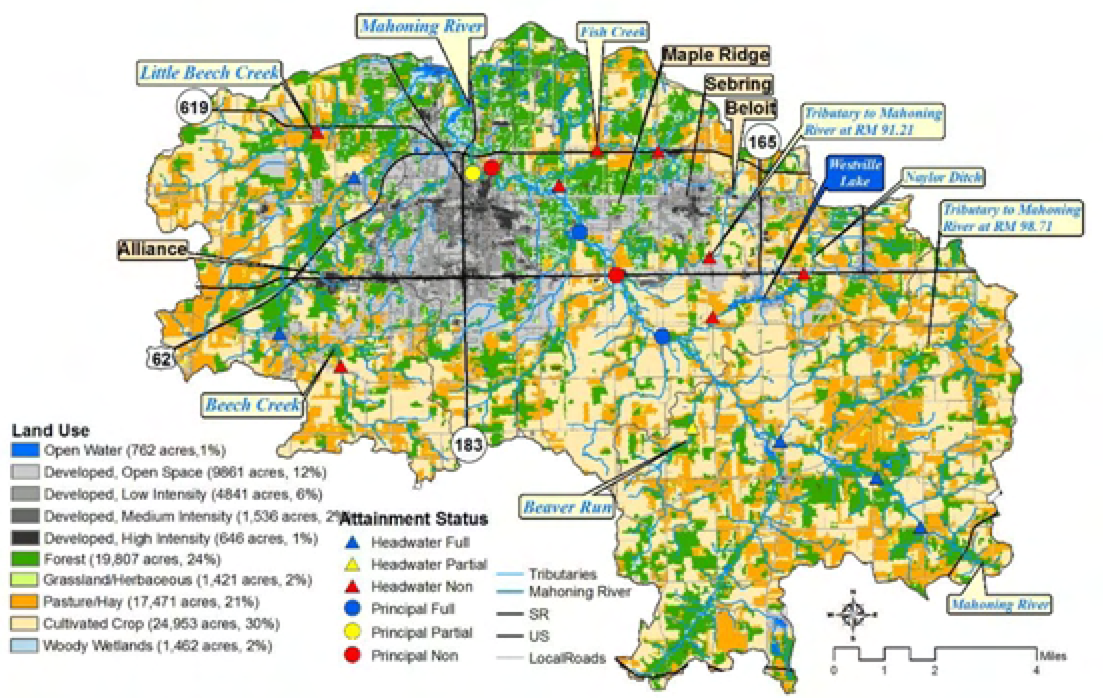


Figure 13. Attainment status and land use coverage of the headwaters of the Mahoning River WAU, 2006.

Table 14. Aquatic life use attainment status for stations sampled in the headwaters of the Mahoning River WAU based on data collected June-October 2006. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community.

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
HUC 12 – 050301030101 Beaver Run-Mahoning River							
Mahoning River				*EOLP Ecoregion - WWH Existing, CWH Recommended*			
N01K28 (102.24)[H]	50	N/A	VG	62.0	FULL		
N01S14 (100.57)[H]	36[NS]	N/A	E	74.5	FULL		
				EOLP Ecoregion - WWH Existing			
N01K26 (97.69)[H]	41	N/A	52	75.5	FULL		
Tributary to Mahoning River (RM 98.71)				*EOLP Ecoregion - WWH Recommended*			
N01K27 (4.59)[H]	34*	N/A	G	62.0	PARTIAL	Siltation Nutrient/eutrophication biological indicators	Agriculture
Beaver Run				*EOLP Ecoregion - WWH Existing*			
N01K24 (1.19)[H]	38[NS]	N/A	F*	70.5	PARTIAL	Nutrient/eutrophication biological indicators Siltation	Unknown Loss of riparian habitat
HUC 12– 050301030102 Beech Creek							
Beech Creek				*EOLP Ecoregion - WWH Existing*			
N01K16 (10.50)[H]	32*	N/A	F*	31.0	**NON**	Siltation Direct habitat alteration	Agriculture Channelization
N01K15 (8.34)[H]	38[NS]	N/A	MG[NS]	65.0	FULL		
N01K14 (3.54)[H]	42	N/A	G	60.5	FULL		

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
Little Beech Creek				*EOLP Ecoregion - WWH Existing*			
N01K13 (1.83) [H]	32*	N/A	F*	39.5	**NON**	Siltation Nutrient/eutrophication biological indicators	Agriculture Unrestricted cattle access
HUC 12 – 050301030103 Fish Creek – Mahoning River							
Mahoning River				*EOLP Ecoregion - WWH Existing*			
N01S01 (93.23)[W]	38	7.4[NS]	MG [NS]	59.0	FULL		
N01K19 (91.11) [W]	34[NS]	<u>5.3</u>*	MG [NS]	33.0	**NON**	Siltation Alteration in stream-side vegetative cover	Agriculture Loss of riparian habitat
200349 (89.4)	N/A	N/A	46	N/A	(FULL)		
602420 (85.51)[B]	*30**	*8.0**	<u>12*</u>	55.0	**NON**	Flow regime alteration	Dam pool
N01S12 (84.99) [W]	38	8.5	LF*	60.5	PARTIAL	Sedimentation	Municipal (urbanized high density area), historical industrial?
Tributary to Mahoning River (RM 97.11)				*EOLP Ecoregion - WWH Recommended*			
N01K25 (1.15)	N/A	N/A	LF*	N/A	N/A	Siltation Nutrient/eutrophication biological indicators	Agriculture: Horse farm upstream
Naylor Ditch				*EOLP Ecoregion - WWH Recommended*			
N01K23 (3.63) [H]	34*	N/A	F*	39.0	**NON**	Nutrient/eutrophication biological indicators Direct habitat alteration	Municipal (urbanized high density area) Channelization

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
N01K22 (1.35) [H]	20*	N/A	P*	45.5	**NON**	Nutrient/eutrophication biological indicators Past fish kill	Agriculture
Trib. to Mahoning R. (RM 91.21)				*EOLP Ecoregion - WWH Recommended*			
N01K20(2.39) [H]	28*	N/A	P*	54.0	**NON**	Nutrient/eutrophication biological indicators	Agriculture Municipal point source discharge (Beloit WWTP)
Fish Creek				*EOLP Ecoregion - WWH Existing*			
N01S05 (3.56) [H]	20*	N/A	P*	47.0	**NON**	Nutrient/eutrophication biological indicators Direct habitat alteration	Municipal point source discharge (Sebring WWTP discharge via Sulphur Ditch) Channelization
N01K18 (2.00) [H]	24*	N/A	F*	56.5	**NON**	Siltation Nutrient/eutrophication biological indicators	Municipal point source discharge (Sebring WWTP)
N01K17 (0.36) [H]	24*	N/A	P*	42.5	**NON**	Siltation	Swamp stream (low-gradient)

Ecoregion Biocriteria: Erie-Ontario Lake Plain

	IBI			MIwb			ICI		
Site Type	**WWH**	**EWH**	**MWH**	**WWH**	**EWH**	**MWH**	**WWH**	**EWH**	**MWH**
Headwaters	40	50	24				34	46	22
Wading	38	50	24	7.9	9.4	6.2	34	46	22
Boat	40	48	24	8.7	9.6	6.6	34	46	22

H - Headwater electrofishing site.

W - Wading electrofishing site.

B - Boat electrofishing site.

a - MIwb is not applicable to headwater streams with drainage areas $\leq$ 20 mi^2.

b - A narrative evaluation of the qualitative sample based on attributes such as EPT taxa richness, number of sensitive taxa, and community composition was used when quantitative data was not available or considered unreliable. VP=Very Poor, P=Poor, LF=Low Fair, F=Fair, MG=Marginally Good, G=Good, VG=Very Good, E=Exceptional

c - Attainment status is given for both existing and proposed use designations.

ns - Nonsignificant departure from biocriteria ($\leq$4 IBI or ICI units, or $\leq$0.5 MIwb units).

* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

Point Source Dischargers

Village of Beloit WWTP 3PB00005 (RM 91.21 Tributary to Mahoning River)

Treatment processes include bar screen, comminutor, scum removal, flow equalization, extended aeration/activated sludge, Aero-mod clarifier, ultraviolet disinfection. The design flow is 0.190 mgd. The plant was last modified in 1983 from the original 1960 design. Current monthly NPDES permit limits are cBOD5 (25 mg/l; 18.0 kg/day); TSS summer (20 mg/l; 14.0 kg/day)—TSS winter (30 mg/l; 22 kg/day); and summer ammonia-N (4.9 mg/l; 3.5 kg/day). The WWTP does not treat to remove phosphorus. The effluent discharge is to a small tributary (RM 3.25) that enters the RM 91.21 tributary of the Mahoning River.

A compliance inspection letter dated September 21, 2006 indicated that the plant was in general compliance with its NPDES permit. No violations of the permit were identified for the July 2005 through July 2006 time period. However, periodic bypasses of the secondary treatment process from the equalization tank were noted. WWTP bypasses reported during the time period of the Upper Mahoning River survey were 05/17/2006 and 07/05/2006. A pump station at 5th Street has a periodic overflow. This overflow is located upstream from the WWTP discharge. Effluent flow and concentrations of select parameters have been constant for the 1999 to 2007 period of record (Figure 14). Sewage sludge has been historically noted to be present in downstream waters during compliance inspections. The results of the biological survey indicated very poor biological communities downstream from the Beloit WWTP discharge. Dissolved oxygen was depressed and nutrients (nitrates and phosphorus) were elevated.

Mahoning County Damascus WWTP 3PA00037 (Tributary to Naylor Ditch)

This plant is operated by the Mahoning County Engineers office. It was put on line in 2001 to replace 146 failing home sewage treatment systems identified by the Mahoning County Health Department within the village of Damascus. The WWTP discharge is to an unnamed tributary of Naylor Ditch. Treatment processes include equalization tank, extended aeration, fixed media clarifiers, slow sand filters, and ultra-violet disinfection. The design flow is 0.080 mgd. Current monthly NPDES permit limits are cBOD5 (10 mg/l; 3.0 kg/day); TSS (12 mg/l; 3.6 kg/day); and summer ammonia-N (1.0 mg/l; 0.3 kg/day).

A compliance inspection report dated March 9, 2006 indicated that the plant was in general compliance with its NPDES permit. It was noted that the clarifiers were in need of cleaning and the sand filters were not draining as expected. Effluent flow and concentration of select chemical parameters has gradually increased from 2002 to 2007 (Figure 15). Biological communities were in non-attainment of biological criteria in Naylor Ditch downstream from the WWTP discharge, and upstream from Westville Lake.

Village of Sebring WWTP 3PC00011 (Sulphur Ditch to Fish Creek)

Treatment processes include bar screen, comminutor, aerated grit chamber, oxidation ditch, final clarifier, extended aeration treatment, clarifiers, equalization basin, and ultraviolet disinfection. The design flow is 1.500 mgd. The discharge is to an unnamed tributary of Sulphur Ditch. Current monthly NPDES permit limits are cBOD5 (10 mg/l; 56.7 kg/day); TSS (12 mg/l; 68.1 kg/day); summer ammonia-N (1.5 mg/l; 8.5 kg/day); winter ammonia (8.6 mg/l; 48.9 kg/day). The plant does not treat to remove phosphorus. NPDES permit violations were identified for zinc (n=2) and copper (n=2) for the time period of July 2005 to May 2006. Copper was identified as a potential stressor on biology in the segment of the Mahoning River downstream from Fish Creek.

A compliance inspection report dated June 23, 2006 indicated that the plant was in general compliance with its NPDES permit. The WWTP has both a headwork bypass and an EQ basin bypass which are activated during rain events. The headwork bypass is to be eliminated, and the frequency of discharge from the EQ bypass reduced, with construction of a new EQ basin to be completed by January 2010. Sand filters and phosphorus removal are scheduled for the next permit renewal. Effluent flows and concentration of select chemical parameters have been relatively constant for the 2000 to 2007 period of record (Figure 16).

Alliance WWTP 3PD00000 (Beech Creek to Mahoning River to Berlin Reservoir)
The Alliance WWTP is a major waste water treatment plant with design flow of 7.500 mgd. Treatment processes include influent screening, grit removal, flow equalization, extended aeration, clarification, and chlorination plus dechlorination. The effluent discharges to the mouth of Beech Creek, just upstream from where it enters the Mahoning River within the impounded area of the Berlin Reservoir dam. Due to the lake-like nature of the receiving water, no biological survey was conducted in the vicinity of the Alliance WWTP discharge. Current monthly NPDES permit limits are cBOD5 (10 mg/l; 284 kg/day); TSS (20 mg/l; 568 kg/day); summer ammonia-N (2.0 mg/l; 56.8 kg/day); and total phosphorus (1.0 mg/l; 28.4 kg/day).

In a final Consent Order from December 2004 the city agreed to address the elimination of bypasses of raw influent and from the EQ basin. A compliance inspection report dated April 19, 2006 indicated that the plant was producing what appeared to be a satisfactory quality effluent. A review of effluent data submitted for the period January 2004 through February 2006 showed NPDES permit violations for phosphorus (one in 2004, one in 2005) and chlorine (one in 2004). Effluent flow has remained relatively constant from 2000 to 2007, however, spikes of ammonia-N and total suspended solids were recorded from 2006 through 2007 (Figure 17).

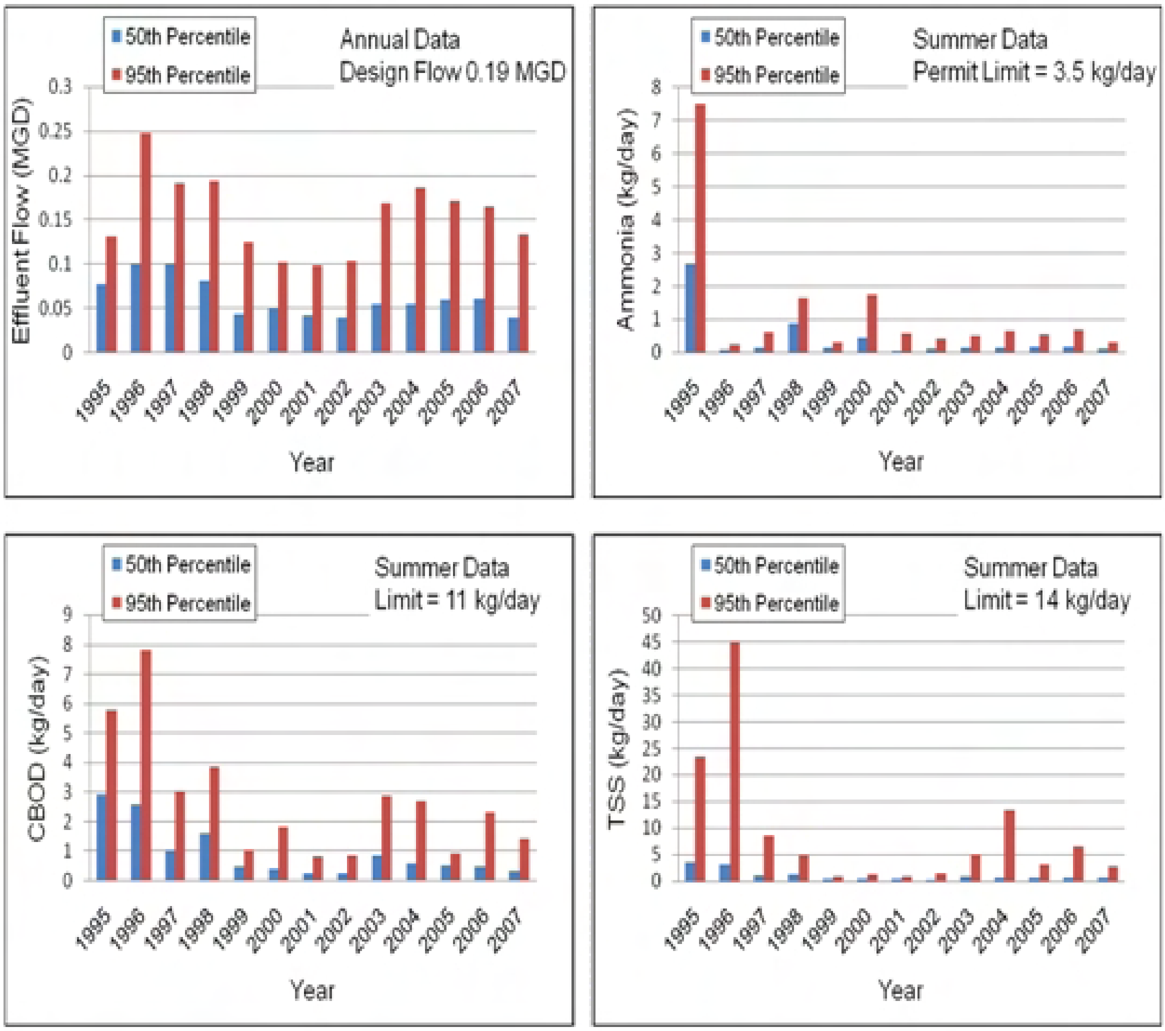


Figure 14. Annual flows, ammonia, carbonaceous biochemical oxygen demand (CBOD), and total suspended solids loadings for the Beloit WWTP treated effluent 1995-2007. Permit #3PB00005.

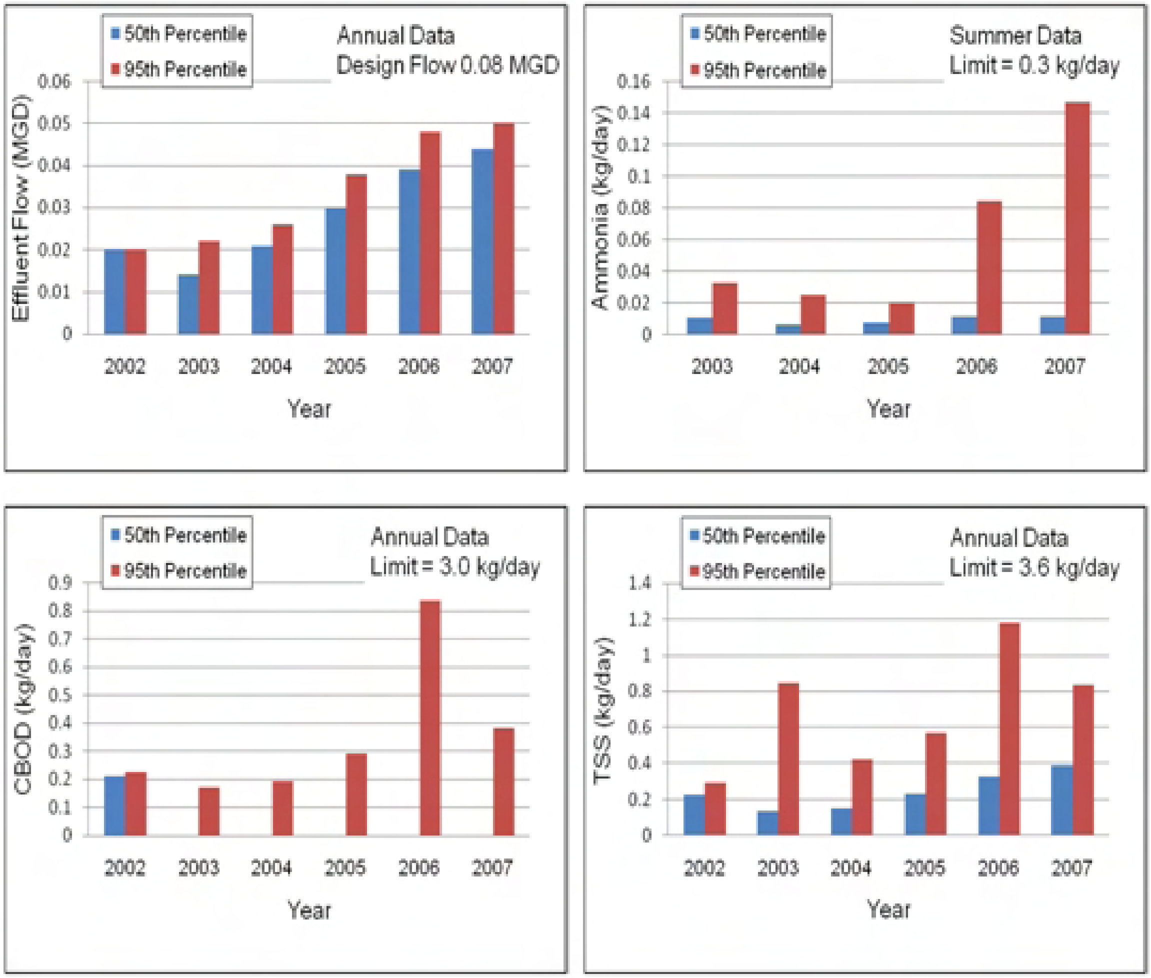


Figure 15. Annual flows, ammonia, carbonaceous biochemical oxygen demand (CBOD), and total suspended solids loadings for the Mahoning Co. Damascus WWTP treated effluent 2002-2007. Permit #3PA00037.

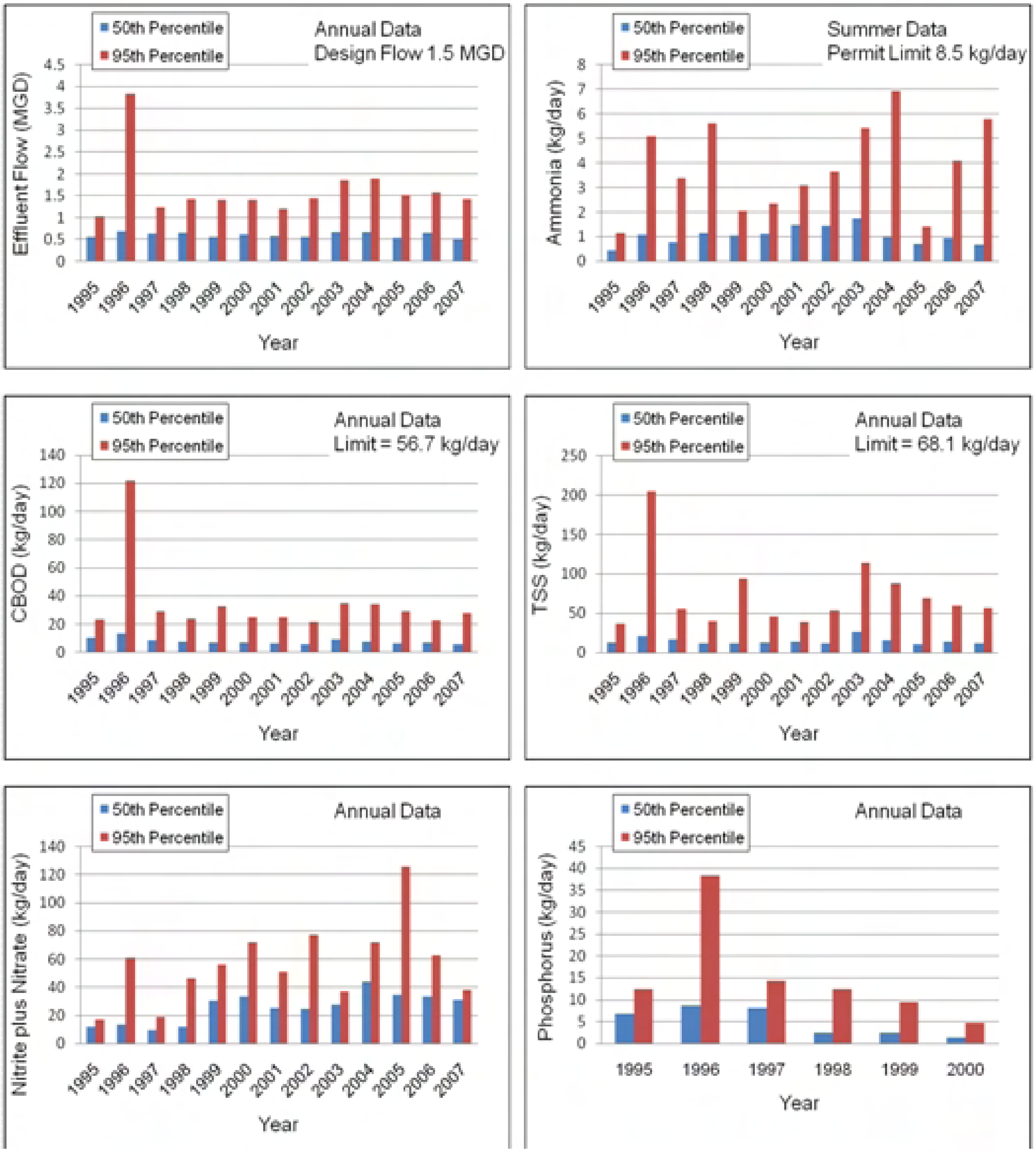


Figure 16. Annual flows, ammonia, carbonaceous biochemical oxygen demand (CBOD), total suspended solids, nitrite plus nitrate, and phosphorous loadings for the Sebring WWTP treated effluent 1995-2007. NPDES Permit #3PC00011.

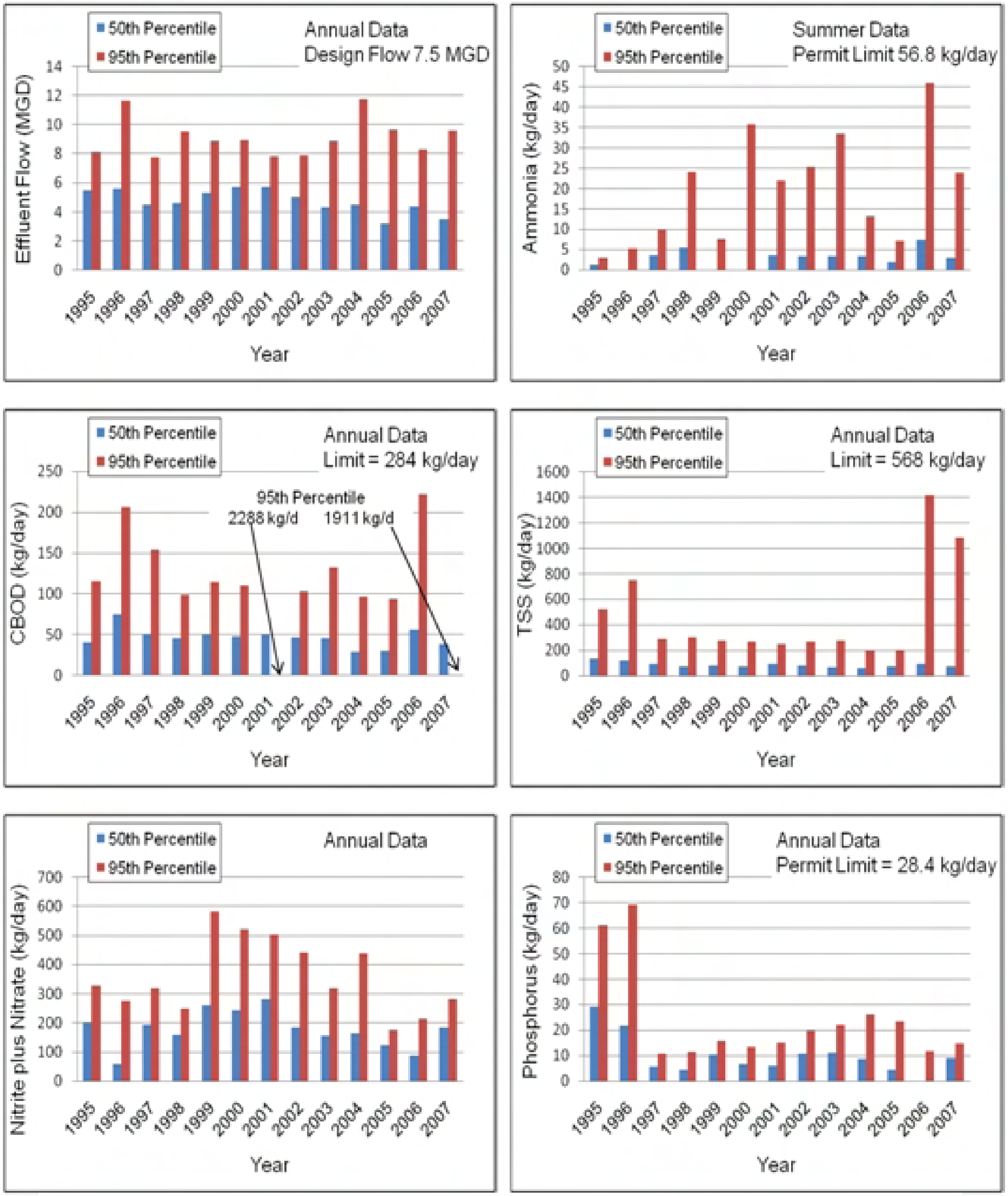


Figure 17. Annual flows, ammonia, carbonaceous biochemical oxygen demand (CBOD), total suspended soils, nitrite plus nitrate, and phosphorus loadings for the Alliance WWTP treated effluent, 1995-2007. Permit #3PD00000.

Recreation Use

Four of seven (57%) sampling locations along the mainstem of the Mahoning River within this WAU showed non-attainment of the PCR use. Three of fourteen (21%) samples collected from select tributaries were in non-attainment of PCR use (Appendix Table 4).

Tributary streams with elevated bacteria in this WAU were within a small geographic area: (1) RMs 2.00 and 3.56 along Fish Creek, and (2) at the mouth of Sulphur Ditch, a headwater tributary of Fish Creek, downstream from the Sebring WWTP discharge. Although the Sebring WWTP is an obvious potential source of bacteria to these sample locations, samples collected from the WWTP effluent on the same day that bacteria counts were elevated in both Sulphur Ditch and Fish Creek showed very low levels of fecal coliform in the WWTP effluent. It is possible that there is a source of bacteria not related to activities at the Sebring WWTP. It is recommended that additional bacteria samples be collected to determine background loadings in the upper Fish Creek watershed area.

No violations of PCR criteria were recorded from two sample locations along Naylor Ditch, upstream and downstream from the unsewered Westville Lake area. The Mahoning County Damascus WWTP discharges to a tributary of Naylor Ditch upstream from Westville Lake. No water quality samples were collected from Westville Lake during the 2006 survey, although fish kills have been previously reported. Observations during the summer of 2007 indicate that Westville Lake does not overflow at times in the summer (Figure 18). This can stress fish and lead to fish kills downstream from the lake due to reduced flows and subsequent low dissolved oxygen concentrations.

Figure 18. Overflow structure for Westville Lake showing zero discharge conditions on July 3, 2007 (photo by Chris Hunt, Ohio EPA).

Chemical Water Quality

Grab water samples were collected at twelve sampling locations within this WAU to support the results of the biological surveys (excluding the Mahoning River mainstem). These samples were collected from eight streams that are tributaries to the Upper Mahoning River mainstem. All chemical samples were collected on the same day within the WAU, thus controlling for the effect of stream flow on the interpretation of data from each sample run. Additional chemical samples were collected from the Beloit and Sebring WWTP effluents, and from Sulphur Ditch and the RM 97.11 tributary where complete biological surveys were not conducted (Table 7).

Impaired biological communities were found at eighty three percent (10/12) of the sample locations in this WAU. The only region within the WAU showing full biological attainment was a small 8.8 mi^2 drainage area of Beech Creek (from RM 8.34 to RM 3.54). Chemical data were compared against OAC 3745-1 water quality criteria and TMDL target nutrient values as sample medians (NO_2-NO_3 = 1.50 mg/l; TP = 0.08 mg/l for watersheds < 20 mi^2, 0.10 mg/l for watersheds > 20 < 200 mi^2) to help identify potential chemical stressors on biology.

Fish Creek & Sulphur Ditch

The village of Sebring WWTP discharges to the headwaters of Fish Creek via Sulphur Ditch. Significantly impaired biological communities were recorded at all three sample locations along Fish Creek (RMs 3.56, 2.00, 0.36) downstream from Sulphur Ditch. A biological survey was not conducted for Sulphur Ditch. Nuisance growths of aquatic macrophytes were observed in Fish Creek at RM 3.56 and Sulphur Ditch (RM 0.47), an indication of excessive nutrient enriched conditions, and a violation of the water quality standards. According to OAC Section 3745-1-04 (E), all waters of state should be “free from nutrients entering the waters as a result of human activity in concentrations that create nuisance growths of aquatic weeds and algae”.

The Sebring WWTP has a design flow of 1.5 mgd and does not treat to remove nutrients. As shown in Table 15, both total phosphorus and nitrates were elevated in samples collected from the WWTP effluent and downstream in Fish Creek. Although nutrients decreased in Fish Creek from RM 3.56 to RM 0.36 as they were assimilated by aquatic plants, they never dropped to TMDL target goals. It is recommended that a Waste Load Allocation TMDL assessment be conducted for the Sebring WWTP to determine appropriate nutrient load reductions that will be needed to attain TMDL target values and help bring biological communities into full attainment in Fish Creek.

Both total manganese and sulfates increased in Fish Creek at RM 0.36 when compared to RM 2.00 and at levels that suggest the inflow of acid mine drainage (average T-Mn = 593 mg/l; T-SO_4 = 335 mg/l). Strip mining is known to have occurred in the watershed area of Fish Creek north of Courtney Rd. (see 1978 revised USGS Alliance topographic map). These historic mining areas are the likely sources of the elevated manganese and sulfates. No water quality criteria exist for these two parameters, but the concentrations are at levels that suggest only minimal potential impact on water quality (USDA, SCS, undated, “Assessment and treatment of areas in Ohio impacted by abandoned mines”). The Central Waste Inc. landfill is covered by a NPDES permit to discharge storm water from sedimentation ponds to a small tributary that empties into Fish Creek at RM 0.70. Compliance inspections conducted in 2006 and 2007 indicate no violations of NPDES permit limits from landfill operations. The chemical water quality in Fish Creek upstream and downstream from the RM 0.7 tributary was similar and did not indicate an impact on chemical water quality from landfill operations.

Table 15. Concentration of nutrients recorded in Fish Creek and Sulphur Ditch downstream from the village of Sebring WWTP discharge. Median values reported with sample size (n). TMDL median target goals for NO_2-NO_3 = 1.50 mg/l; TP = 0.080 mg/l. All sample locations were above TMDL targets for both nutrient parameters.

Stream (*RM*)	NO_2-NO_3 (mg/l)	TP (mg/l)
Sebring WWTP effluent	18.80 (n=4)	2.145 (n=4)
Sulphur Ditch		
0.47	7.05 (n=4)	1.885 (n=4)
Fish Creek		
3.56	13.70 (n=3)	1.540 (n=3)
2.00	12.07 (n=4)	1.357 (n=4)
0.36	4.44 (n=3)	0.203 (n=4)

Beech Creek

The upstream sample location at RM 10.50 showed impaired biology, in large part explained by very poor habitat (QHEI = 31.0). However, additional evidence of chemical stress from nitrogen compounds is indicated by the detection of ammonia-N in three of four samples and nitrate-nitrite on average at 1.50 mg/l, above the TMDL nitrate target of 1.0 mg/l. Total phosphorus was at background levels (range 0.040-0.067 mg/l). These data suggest the possible use of an ammonia based fertilizer in the upper watershed.

Full biological attainment was found at RM 3.54 on Beech Creek where total phosphorus was elevated above the TMDL target of 0.08 mg/l (range TP from 0.117 – 0.251, n=4). QHEI was 60.5 at this location. These data suggest that an intact riparian buffer can help to mitigate the negative effects of elevated total phosphorus on biological communities.

Beaver Run

No significant problems with water chemistry were observed at RM 1.19. The total phosphorus median concentration was 0.077 mg/l which is slightly below the 0.080 mg/l TMDL target. Ammonia-N was detected at a maximum value of 0.130 mg/l and nitrate-nitrite was at a maximum of 1.28 mg/l. QHEI was high (70.5).

Little Beech Creek

The level of total phosphorus was elevated at RM 1.83 (TP median = 0.129 mg/l), above the TMDL target goal of 0.08 mg/l, and the habitat quality was highly depressed (QHEI = 39.5). Throughout the survey it was observed that the stream water was consistently turbid. TSS averaged 29.0 mg/l, which is well above background conditions in Beech Creek where full biological attainment was observed (TSS background = 5.0 mg/l). Elevated nutrients and TSS coupled with poor QHEI are documented chemical and physical stressors on biology.

Naylor Ditch

Chemical samples were collected at RM 3.63, upstream from Westville Lake, and at RM 1.35 downstream from the lake. Poor QHEI habitat conditions were recorded at both locations (QHEI = 39.0 upst, QHEI = 45.5 dwst). During the survey it was observed that Westville Lake completely stops the flow of Naylor Ditch thus hydromodification is an additional significant stress on biology in Naylor Ditch downstream from the Westville Lake dam.

The village of Damascus WWTP discharges to a tributary of Naylor Ditch upstream from Westville Lake. Evidence of both organic and nutrient enrichment was observed at the RM 3.63 sample location upstream from the lake. A low reading for dissolved oxygen was recorded (DO = 4.37 mg/l) and median total phosphorus was at 0.122 mg/l, above the TMDL target of 0.08 mg/l. Nitrate-nitrite also was elevated (median = 1.45 mg/l). No samples were collected from Westville Lake during the survey. There are a number of homes in the Westville Lake area that are served by home sewage treatment systems (HSTS). It is recommended that an inventory be conducted of the HSTS in the Westville Lake area to determine how many may be discharging to surface waters that could be connected to the Damascus WWTP sewerage system.

RM 91.21 Tributary to Mahoning River (downstream Beloit WWTP)

Very poor biology was observed at RM 2.39. This headwater stream receives storm water runoff and WWTP discharge from the village of Beloit as well as storm water from the village of Sebring. Row crop agriculture also is present in the watershed. A number of chemical stressors were recorded. A low dissolved oxygen reading (4.75 mg/l) indicated organic enrichment. Nitrate-nitrate (median = 2.82 mg/l, n=3) and phosphorus (median = 0.459, n=3) were elevated, with both values above TMDL targets. It is recommended that a Waste Load Allocation TMDL assessment be conducted for the Beloit WWTP to determine nutrient load reductions that will be required to meet TMDL target goals.

This tributary had the highest mean concentration of total lead of any sample location within the Upper Mahoning River basin (T-Pb median 7.97 ug/l, range 4.0-10.8). The specific sources of lead are unknown but are most likely related to storm water runoff, or some unknown industrial discharge. Lead was not detected in samples collected from the Beloit WWTP discharge. The RM 91.21 tributary is a significant source of the elevated lead found in the downstream waters of the Mahoning River mainstem. It is recommended that a survey be conducted of this tributary and its watershed to identify sources of lead that are being discharged to the stream.

RM 97.11 Tributary to Mahoning River
A full biological survey was not conducted at this location. The benthic macroinvertebrates indicated fair conditions. Slightly elevated total phosphorus was recorded (TP median = 0.084 mg/l). Horses were observed adjacent to the stream downstream from Georgetown Road which was upstream from where the grab water samples were taken.

RM 98.71 Tributary to Mahoning River
Partial biological attainment was found at RM 4.59 upstream from Sevakeen Lake, with the fish community impaired, while the benthic macroinvertebrate community was in good condition. Land use in the watershed is highly agricultural. No significant problems were found in the chemical quality. Nitrate-nitrite was slightly elevated (median = 1.92 mg/l, n=3) but total phosphorus was less than TMDL target goal. Fecal coliform bacteria were elevated perhaps from upstream agriculture activities.

Physical Habitat
The physical habitat of 19 locations within the upper Mahoning River basin was evaluated with the QHEI. As Figure 19 shows, the majority of sites scored within the fair to good range. Four of the five sites that scored less than fair were <10mi^2 in drainage area. Agriculture activities including livestock with access to the stream and channelization were two of the primary causes of the lower habitat scores. In addition, Fish Creek RM 0.36 appeared to be a naturally low gradient swamp stream and Naylor Ditch RM 3.63 had been channelized in relation to urbanization. The only site >10mi^2 in drainage area that received a QHEI score in the poor range was Mahoning River RM 91.11, which had not recovered from past channelization activities or the loss of its riparian habitat as a result of agricultural activities.

The Mahoning River mainstem had an average QHEI of 59.7 (range of 33 to 75.5) and the tributaries had an average QHEI of 51.3 (range of 31.0 to 70.5). The majority of habitat conditions indicate the ability of the Mahoning River to support WWH communities, however, loss of riparian habitat and siltation from agricultural activities negatively affect biological community performance. The ability of the Mahoning River mainstem to support WWH communities decreases downstream from station N01S01 (RM 93.23) as the ratio of MWH to WWH attributes exceeds 1 (Figure 20). Analysis of QHEI data and aquatic community scores has found that a ratio of MWH to WWH attributes exceeding 1, or more than one high-influence MWH attribute at a given site strongly predicts that the physical habitat is too simplified to support a typical WWH fauna (Rankin 1989, Ohio EPA 1999).

For tributary streams, the combination of agricultural activities and urbanization influences on stream habitat characteristics negatively influence biological community performance. Little Beech Creek, Fish Creek, Naylor Ditch and the tributary to Mahoning River at RM 91.21 all had multiple high-influence MWH attributes that indicated simplified habitat which could detrimentally affect the stream's ability to support WWH communities. High gradients (>20.0 ft/mile) present on the tributary to Mahoning River at RM 98.71, Beaver Run, and Beech Creek at RM 8.3 enabled these streams to limit the amount of silt being deposited in riffles. This increased their ability to support WWH communities.

Mahoning River

The upper reach of the Mahoning River, from Winona Road (RM 102.24) to Knox School Road (RM 93.23), drains a mixed landscape of forest, agricultural fields and scattered residential areas. Stream substrates were dominated by sand, gravel and cobble, though boulders and hardpan were also noted. Silt was more often noted and the substrates became more embedded in a downstream direction. This trend coincided with a decrease in forested riparian habitat and an increase in agricultural land use adjacent to the stream. However, the stream channel integrity appeared mostly intact within this upper reach. The stream exhibited moderate to high sinuosity with good to excellent channel development and no evidence of channelization activities. The only area showing evidence of channelization was a small section of stream downstream from the dam at Knox School Road. Throughout the upper reach of the Mahoning River, diverse instream habitat including undercut banks, overhanging vegetation, shallows, rootmats, deep pools (>70cm), boulders and woody debris provided refuge for aquatic organisms. The combination of these features indicated the upper reach of the Mahoning River should be able to support WWH communities.

As the Mahoning River flowed further westward towards Alliance, agricultural fields and small subdivisions dominated the landscape. Silt ranged in depths from 10-60cm throughout the stream near US 62 (RM 91.11), reflecting the poor riparian habitat quality present. No riffles or runs were present, and the stream appeared to have little flow, appearing as more of a long pool than a flowing stream. Instream habitat was sparse throughout the reach, with only occasional logs and overhanging vegetation present as refugia. As Figure 20 shows, only 1 WWH attribute was associated with this site while all other sites had at least 4 WWH attributes. In addition, this site had 3 high influence MWH attributes associated with it. This combined with the lack of instream cover and poor channel development decreased the likelihood that the stream could support WWH communities in this reach.

Within the eastern portion of the Alliance, the river was impounded by a dam near Webb Avenue (RM 85.5). The surrounding riparian corridor was primarily wooded wetlands with occasional residential intrusion. Moderate instream cover was provided by undercut banks, overhanging vegetation, rootmats, deep pools (>70cm), rootwads, aquatic macrophytes and logs. However, the altered flow regime from the dam resulted in slack water conditions without any riffles or runs present. The impounded conditions provided an area for upstream bed materials to deposit, so the dominant substrate noted was a combination of silt and detritus material. The lack of diverse flow regimes combined with the extensively embedded substrates and fair channel development limited the ability of the stream to support WWH communities within this reach.

Downstream from the dam (RM 84.99), riffles and runs combined with deep pools and shallows provided a varied assortment of habitat conditions for aquatic organisms. Instream cover included overhanging vegetation, rootmats, boulders, and woody debris. However, historical channelization of the stream for the surrounding industrial and residential landscape had disconnected the stream from its floodplain and only a narrow line of trees was present between the stream and the surrounding high intensity land use. The combination of instream cover and varying flow indicate that the stream may be able to support WWH communities. However, storm water influences from the surrounding land could negatively affect aquatic communities within this reach.

In conclusion, the habitat quality of the Mahoning River mainstem within WAU 05030103010 directly reflected the surrounding landscape. In the most upper reaches where land use was a mixture of forest and agricultural lands with scattered residential homes, instream habitat and channel integrity provided adequate habitat for aquatic communities. WWH attributes were abundant in the upper reach and became less abundant in the lower reach. In areas with few trees adjacent to the stream, and anthropogenic influences through agricultural activities or urbanization were intensified, the habitat quality decreased for aquatic communities and the presence of MWH attributes increased (Figure 20).

Tributaries

The physical habitat of several tributary streams in the headwaters of the Upper Mahoning basin appeared sufficient to support WWH communities. The tributary to the Mahoning River at RM 98.71 (RM 4.59), Beaver Run, and the two lower sites of Beech Creek (RMs 8.34 and 3.54, respectively), all had QHEI scores >60. The streams in these areas were characterized by diverse stream substrates including a combination of cobble, gravel, sand and occasionally bedrock, hardpan, boulders and detritus. This mixture of substrates provided varied sizes of interstitial spaces that could provide habitat for aquatic macroinvertebrates or small fish (darter species). Although silt was present, it was rarely found in heavy deposits at these sites. Moderate amounts of instream cover included overhanging vegetation, rootmats, rootwads, and boulders.

Though a portion of the site in the tributary to Mahoning River at RM 98.71 (RM 4.59) was channelized, it and the natural section still contained varying physical habitat features of riffles, runs, and pools. Beaver Run and the two lower sites of Beech Creek appeared free from channelization activities with fair to good channel development. The combination of diverse habitat features with abundant instream cover and few anthropogenic influences documented the ability of these streams to support WWH communities.

Several tributaries within the headwaters of the Upper Mahoning River basin received QHEI scores less than 60 but greater than 45. These streams had four or less WWH attributes with five or more moderate influence MWH attributes (Figure 20). These streams are less likely to support WWH communities until the causes and sources of stress listed in the attainment table are addressed. The tributary to Mahoning River at RM 91.21 (RM 2.39) received a QHEI score of 54.0. Sand and silt were the two dominant substrates intermixed with gravel, cobble, hardpan and boulders. However, all of the substrates were extensively embedded with silt. Silt reduced the amount of interstitial spaces available for aquatic organisms. A strong sewage odor was also noted throughout the upper half of the reach. Channel development was poor and no riffles or runs were present. The stream was comprised of a long slow pool containing aquatic macrophytes, undercut banks, overhanging vegetation, rootmats and woody debris. While instream cover was adequate, the lack of varied currents, and excessive siltation decreased the likelihood of the stream being able to support WWH communities.

Similar to the above tributary, Fish Creek had a combination of less than ideal habitat conditions. The average QHEI score for Fish Creek was 48.7 (range of 47.0 to 56.5). QHEI scores increased from the most upper site (RM 3.56) to Courtney Road (RM 2.0). Hardpan was the dominant substrate type at the most upstream location though silt was heavy and small areas of cobble and sand were also noted. Silt and sand were the dominant substrates near RM 2.0, and the stream developed weak riffles where upstream there had been none. Moderate amounts of instream cover were present at all locations and included overhanging vegetation, shallows, rootmats, woody debris and occasional aquatic macrophytes or undercut banks. At the most downstream location, the bottom of the stream was covered in silt. A few areas of sand, hardpan, and detritus were also noted, but the stream was generally very swampy. No riffles or runs were present as the stream was just a long, slow pool. The low gradient conditions present decreased the likelihood that Fish Creek could support WWH communities.

The physical habitat of the remaining sites within the headwaters of the Upper Mahoning basin suffered from anthropogenic influences to the point that maintaining WWH communities is not likely until these issues are addressed. These sites had two or more high influence MWH attributes with 5 or more moderate influence MWH attributes. Naylor Ditch had an average QHEI score of

42.3 (39.0 upstream and 45.5 downstream). The upper portion had been partially channelized within a residential subdivision. Though areas of cobble, gravel and sand were noted, observations of silt 10-50 cm deep were common throughout the upper reach. Residential yards extended to both stream banks, and only sparse amounts of instream cover were noted within the stream channel. Similar to the upstream site, the downstream site contained copious amounts of silt which clogged the interstitial spaces of the gravel, cobble, and sand. In addition, the downstream site had farm fields and residential yards extending to either bank, and a strong sewage smell was noted along the right descending bank. Excessive algae indicated nutrient enrichment. A fish kill occurred in 2005 at this location due to a silage leak from an upstream farmer. While the excessive silt and lack of a treed riparian corridor diminished the quality of the habitat, these issues could be addressed along with the other concerns mentioned to increase the potential of the stream to support WWH communities.

The most upper site of Beech Creek and the site on Little Beech Creek both suffered habitat alterations that reduced their ability to support WWH communities. The upper site of Beech Creek (RM 10.50) received a QHEI score of 31.0 as a result of channelization, both from agricultural activities and residential homes. Silt lined the stream bottom and was observed to be as deep as 50cm in several areas. The majority of the stream was pool/glide, though two small sand and gravel riffles were noted. Instream cover was sparse and consisted of overhanging vegetation, shallows, aquatic macrophytes and woody debris. The lack of recovery from past channelization activities limited the ability of the upper portion of Beech Creek to support WWH communities.

Similar to the upper site of Beech Creek, Little Beech Creek received a QHEI score of 39.5 as a direct result of agricultural activities. However, livestock with access to the stream was the primary source of degradation. Sparse instream cover was provided by a little overhanging vegetation, shallows, and deep pools (>70cm). No riffles were evident, nor were any trees present to help stabilize banks or provide shade to the stream. Fencing the cattle out of the stream and revegetating the banks may help address the poor habitat quality observed in Little Beech Creek.

In conclusion, the tributaries of the headwaters of the Upper Mahoning basin contain habitats that could potentially support WWH communities. Several of the streams are currently realizing that potential, while others need to have issues addressed before the potential could be realized. Specifically, outreach to farmers to encourage fencing livestock out of streams and crop set backs from streams should occur. Investigations to locate failing septic systems should occur where sewage odors were noted, and steps should be taken to address the nutrient enrichment observed in many of the streams. Homeowners should also be encouraged to allow vegetation to grow adjacent to streams to minimize erosion and siltation within streams.

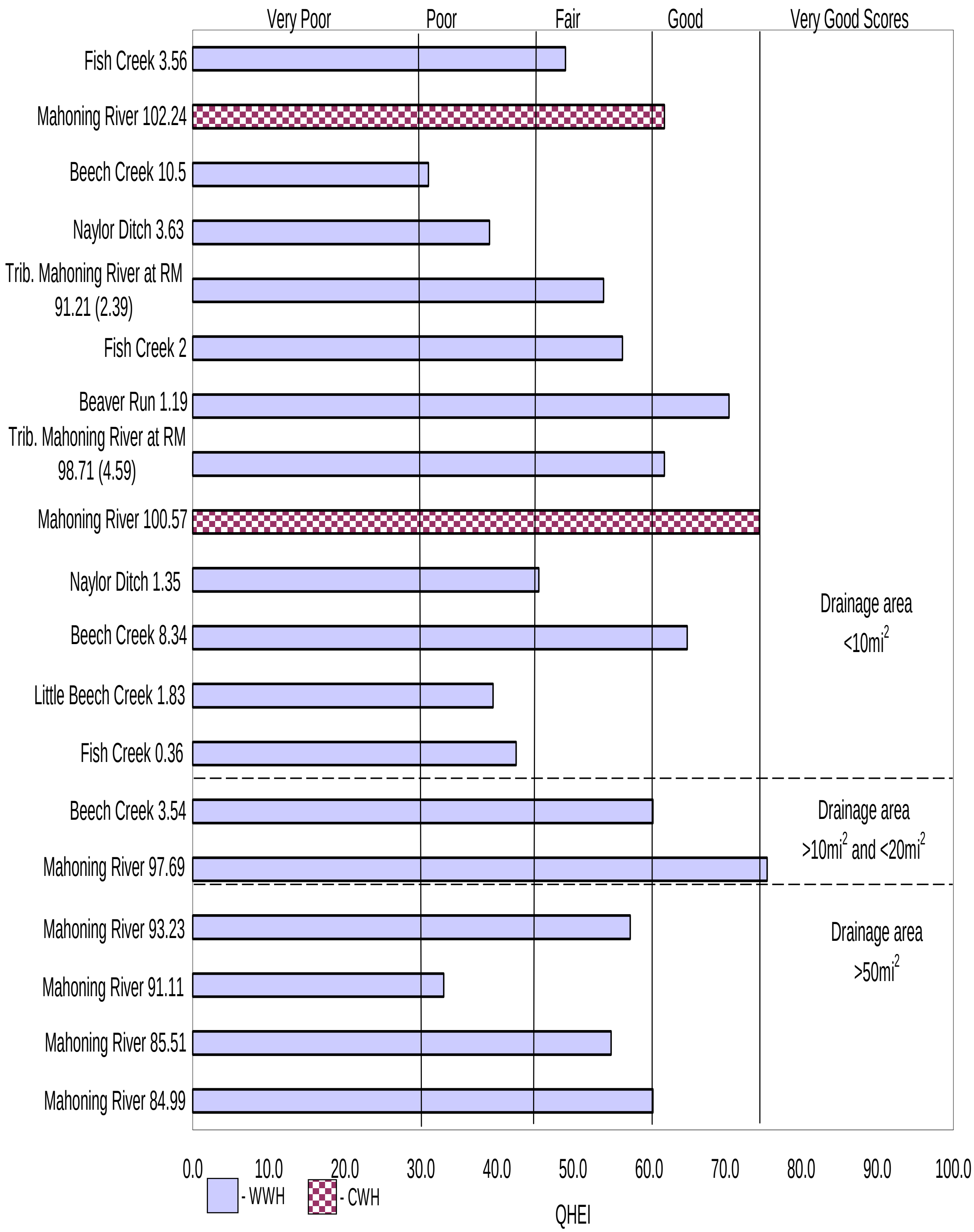


Figure 19. QHEI scores by drainage area for the Upper Mahoning River basin (WAU 05030103010).

Mahoning River

Key: QHEI Components

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	MWH Attributes, High Influence: Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	MWH Attributes, Moderate Influence: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(18-001) Mahoning River																																		
Year: 2007																																		
85.5	57.5	0.10		■			■	■			■		4						0	●	●			●	●			●	●		●	7	0.20	1.60
Year: 2006																																		
102.2	62.0	57.14	■	■		■	■	■	■	■		■	8					♦	1	●												1	0.22	0.33
100.6	74.5	14.71	■	■		■	■	■			■		6						0		●							●	●	●		4	0.14	0.71
97.7	74.5	18.69	■	■		■	■	■	■		■		7						0		●								●	●		3	0.13	0.50
93.3	57.5	4.83		■			■	■	■		■		5	♦					1		●			●					●	●		4	0.33	1.00
91.1	33.0	3.26									■		1	♦	♦		♦		3		●			●	●			●	●		●	6	2.00	5.00
85.5	55.0	0.10	■	■				■			■		4		♦				1		●			●	●			●	●		●	6	0.40	1.60
84.8	60.5	4.00		■				■	■		■		4	♦					1		●			●	●				●	●		5	0.40	1.40
(18-061) Beech Creek																																		
Year: 2006																																		
10.5	31.0	13.88											0	♦	♦	♦	♦	♦	5		●			●				●	●	●	●	6	6.00	*.**
8.3	65.0	25.64	■	■			■	■			■		5						0		●			●				●	●	●		5	0.17	1.00
3.5	60.5	10.87	■	■				■			■		4			♦			1		●			●				●	●	●		5	0.40	1.40
(18-062) Little Beech Creek																																		
Year: 2006																																		
1.8	39.5	8.13									■		1	♦		♦	♦		3		●			●				●	●		●	5	2.00	4.50
(18-063) Fish Creek																																		
Year: 2006																																		
3.6	47.0	7.69	■					■			■		3		♦	♦			2		●		●	●				●	●		●	6	0.75	2.25
2.0	56.5	8.77	■					■			■	■	4		♦	♦			2		●		●	●				●	●			5	0.60	1.60
0.4	42.5	8.33	■				■	■			■		4		♦				1		●		●	●				●	●		●	6	0.40	1.60
(18-064) Beaver Run																																		
Year: 2006																																		
1.1	70.5	21.28	■	■		■	■	■	■		■		7						0		●		●						●	●		4	0.13	0.63
(18-066) Naylor Ditch																																		
Year: 2006																																		
3.6	39.0	3.85		■							■		2	♦	♦	♦	♦		4		●			●				●	●	●		5	1.67	3.33
1.4	45.5	6.29	■				■	■			■		4	♦	♦				2		●			●				●	●	●		5	0.60	1.60

02/25/2008 1

Figure 20. QHEI attributes for streams within WAU 05030103010.

Mahoning River

Key QHEI Components

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	MWH Attributes, High Influence: Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	MWH Attributes, Moderate Influence: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(18-090) Trib. to Mahoning R. (RM 91.21)																																		
Year: 2006																																		
2.4	54.0	8.13	■					■			■		3		◆	◆			2		●			●				●	●		●	5	0.75	2.00
(18-091) Trib. to Mahoning R. (RM 98.71)																																		
Year: 2006																																		
4.6	62.0	22.22	■	■		■		■			■		5	◆		◆			2		●			●				●	●	●		5	0.50	1.33

02/25/2008 1

Figure 20 continued. QHEI attributes for streams within WAU 05030103010.

Biological Community: Fish

The fish communities of the headwaters of the Upper Mahoning basin (WAU 05030103010) were sampled in 19 locations. A comparison of fish community scores to habitat scores indicated that where better quality habitat was available, fish communities generally performed better (Figure 21). However, many fish communities within the basin were underperforming the habitat available, which indicates that additional factors beyond habitat may be influencing the fish community. Where habitat conditions were poor, fish communities performed below WWH expectations, reflecting the poor habitat conditions.

The Mahoning River mainstem had an average IBI score of 36.7 (range of 34 to 38) for wading sites, 42.3 (range of 36 to 50) for headwater sites and the one boat site received an IBI of 26. The average MIwb for the wading sites was 7.1 (range of 5.3 to 8.5) and the MIwb for the boat site was 6.3. Examining the average IBI scores for the sampling method used, which is related to the size of the stream, it is clear that the fish communities in the upper reaches of the Mahoning River were performing stronger than those downstream. For tributary streams, the average IBI was 30.5 (range of 20 to 42). All of the tributary sampling locations were <20mi^2, so the headwater WWH criteria (IBI of 40) apply to them. The low average IBI score for tributary streams indicate that the fish communities were generally performing below WWH expectations.

Mahoning River

The fish community of the Mahoning River generally reflected the habitat conditions present. The most upstream site near Winona Road (RM 102.24) received an IBI score of 50, the highest IBI score of any site on the mainstem. Less than two miles further downstream, the IBI score dropped to 36 at King Road (RM 100.57). While an IBI score of 36 still meets WWH criteria, it was a 15 point drop from the IBI of 51 recorded at that site in 1994. Only thirteen species of fish were collected in 2006, while a total of 19 species were collected in 1994. In addition, tolerant fish comprised 64% of the community in 2006, up from an average 37.5% in 1994. Interestingly, the QHEI score was exactly the same, 74.5, for both years. A brief examination of aerial photography from 2006, National Land Cover Dataset from 2001, and a USGS topographic map from 1994, does not indicate any dramatic land use change that would account for the decline in fish community scores. Declines in fish community scores such as this often reflect a water chemistry issue or a toxic spill. However, review of water chemistry data and Ohio EPA's Spills database (Ohio EPA, Division of Emergency and Remedial Response) did not provide any insight for the decline in fish community scores. This area should be investigated further to determine what may be affecting the fish community.

Fish community scores increased near Georgetown-Damascus Road to an IBI of 41 with an average of 21 species collected. The MIwb was 7.4 at this site, indicating a well balanced fish community. However, the MIwb dropped to 5.3 near Knox School Road (RM 91.11), though the IBI remained within WWH limits at 34. The MIwb measures relative number, weight, and how evenly the relative number and weight is distributed among species. It is sensitive to the total number and biomass of fish excluding tolerant species and to the uneven distribution of individuals and biomass within the community assemblage. Thus, the significant drop in MIwb indicates an unbalanced fish community. While tolerant fish comprised only 40% of the fish community here, only 133 and 83 fish, respectively, were collected in each sampling pass. This may be directly attributed to the poor habitat available as the site received the lowest QHEI score on the Mahoning River, a QHEI of 33.

Further downstream, the fish community within the Webb Avenue dam pool (RM 85.51) was sampled. The impounded conditions resulted in an IBI of 26 and MIwb of 6.3, neither of which meet WWH criteria. Below the dam near Gaskill Road (RM 84.99), IBI scores improved to 38 and MIwb scores improved to 8.5, both within WWH criteria. The marked improvement downstream from the dam is directly related to the improved habitat conditions typified specifically as going from an impounded to free-flowing condition.

Throughout the Mahoning River mainstem, as anthropogenic influences increased, fish community integrity decreased. The highest fish community scores were noted where large riparian buffers were adjacent to the stream (RM 102.24). Worse scores were noted in impounded segments (RM 85.51). However, the low fish score obtained near King Road (RM 100.57) warrants future attention.

Tributaries

A few streams within the headwaters of the Upper Mahoning River basin attained WWH expectations. Beaver Run and the lower two sites on Beech Creek all met WWH expectations. Beaver Run received an IBI of 38 and had a total of 18 species collected. While this reflects the high QHEI score of 70.5, the nutrient issue noted affecting the macroinvertebrate community may be beginning to cause a disruption in the fish community as 77% of the individuals were considered pollution tolerant.

While the two lower sites of Beech Creek met WWH criteria like Beaver Run, the most upper site on Beech Creek did not. Fish community scores increased in a downstream direction along Beech Creek. The most upper site near Bayton Street (RM 10.50) received an IBI score of 32, while the two lower sites received IBI scores of 38 and 42, respectively. Presence of tolerant fish declined in a downstream direction, from a high of 81% of the fish collected near Bayton Street, to 54% and then 45%, respectively downstream. The improvement in overall score and decline in tolerant individuals reflected both the improved habitat conditions downstream and the increased distance from the anthropogenic influences noted near Bayton Street.

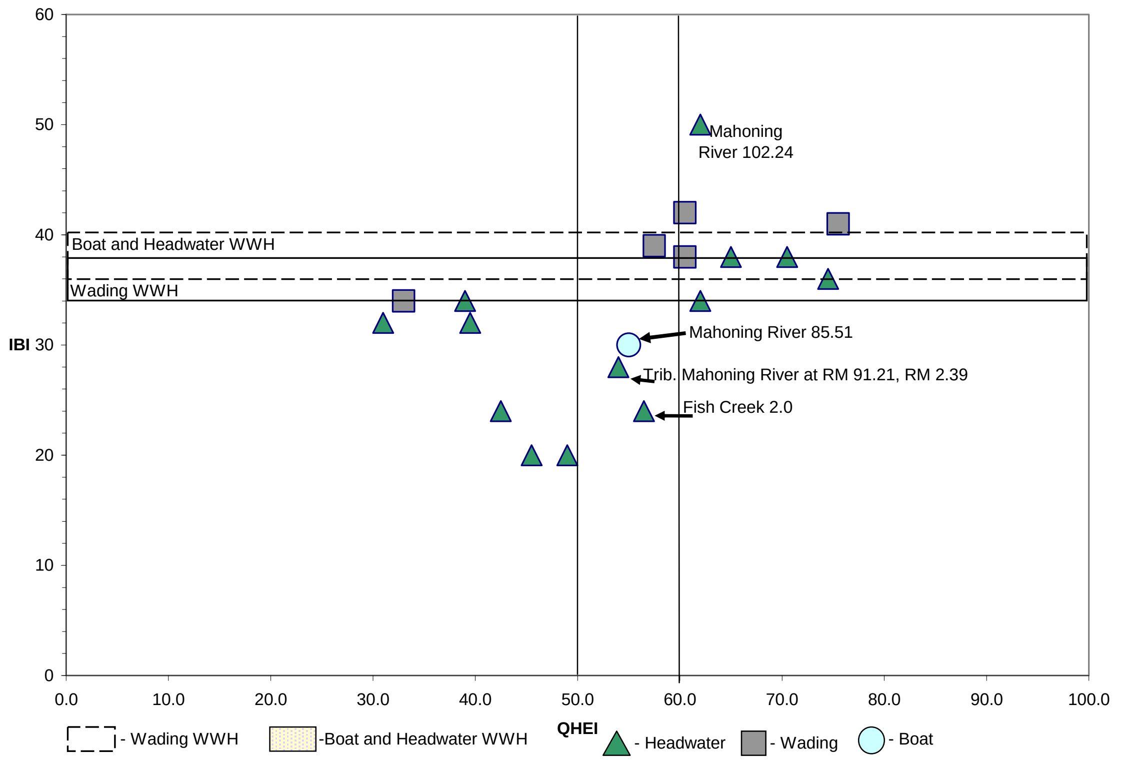
Fish communities in all of the remaining tributary sites did not meet WWH criteria. Little Beech Creek, Naylor Ditch, and the two tributaries to the Mahoning River (one at 98.71 and the other at 91.21) had IBI scores between 20 and 34. Tolerant fish comprised 73% of the community in Little Beech Creek (IBI=32) with no sensitive species collected. This reflected the impacts from livestock access to the stream. Sixteen species were collected, eight 8 of those species are considered pollution tolerant. However, the total number of species indicates a high amount of diversity for such a small watershed (9.0 mi^2 drainage area).

Naylor Ditch had a drainage area of 8.3mi^2 at its lower site (RM 1.35) and a drainage area of 4.5 mi^2 at its most upper site (RM 3.63). IBI scores decreased downstream, from a 34 near Heritage Drive (RM 3.63) to a 20 near 12th Street. The upper site had one darter species (Johnny darter), insectivores comprised 89% of the fish community, tolerant fish comprised 55% of the fish community, and the relative number of fish collected was 312. Insectivorous fish are specialist feeders, often sight feeders, so having them comprise a significant portion of the population indicates some stability in the community. In contrast, the lower site did not have any darter species, tolerant fish comprised 76% of the fish community, insectivores comprised only 33% of the fish community, and the relative number of fish collected was only 140. A silage spill occurred upstream from the lower site in 2005 resulting in a fish kill. This likely influenced the markedly lower fish community score observed at the lower site. However, the poor habitat quality throughout Naylor Ditch will strongly influence the ability of the fish community to recover from the spill and meet WWH criteria.

Fish community scores for Fish Creek included an IBI of 20 near Johnson Road (RM 3.56) and scores of 24 near Courtney Road (RM 2.00) and Lexington Road (RM 0.36). The total number of species did not vary much from site to site, from 9 at the most upper site, 11 near Courtney Road, and 10 at the most lower site. Tolerant fish comprised 91%, 90%, and finally 59%, respectively in a downstream direction, of the fish community. These results indicate a poor fish community throughout Fish Creek. However, the fish community has actually improved compared to sampling conducted in 1987. In 1987, Fish Creek was sampled near Courtney Road (RM 2.00) and near Lexington Road (RM 0.36). At that time, both sites received an IBI of 12, which is the lowest IBI score possible indicating a seriously compromised fish community. Less than 50 individuals were collected near Courtney Road, indicating potential toxicity issues from the Sebring WWTP. Only three species of fish were collected near Courtney Road, and only four species near Lexington Road. Of these species, 100% were tolerant near Courtney Road, while 98% of the fish community was considered tolerant near Lexington Road. So while the fish community of Fish Creek would still be considered degraded from problems associated with habitat conditions and the Sebring WWTP, it has actually improved in the last 20 years.

In conclusion, the fish communities of tributaries within the headwaters of the Upper Mahoning River basin were generally underperforming WWH criteria.

Poor habitat quality combined with point source dischargers were the primary causes of impairment within the fish communities.



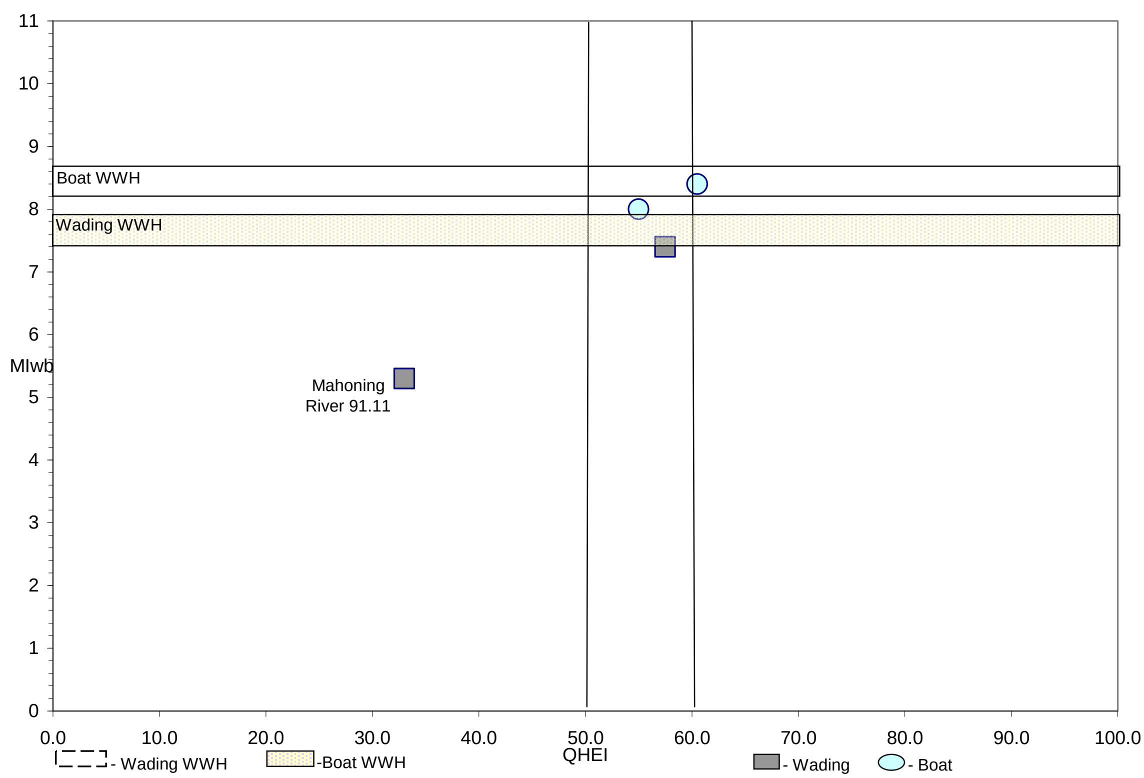


Figure 21. IBI and MIwb scores compared to QHEI scores for the headwaters of the Upper Mahoning basin (WAU 05030103010).

Biological Community: Macroinvertebrates

Twenty-two sites were sampled in the Headwaters Mahoning River basin (WAU 05030103-01) in order to determine the biotic integrity of extant macroinvertebrate communities. Eight of these sites were located on the Mahoning River mainstem and the remaining 14 sites on small tributaries draining less than 10 square miles (Table 16). This assessment unit was characterized by a dramatic shift in land use, shifting from primarily rural in the headwaters to highly urbanized in the lower portion upstream from Berlin Lake. Such a shift provides potential for a broad number of influences on the macroinvertebrate communities, and subsequently there was a broad range of assemblages encountered in this watershed. Overall, there were 3 exceptional, 1 very good, 2 good, 3 marginally good, 5 fair, 2 low fair, and 5 poor macroinvertebrate assemblages in this assessment unit. The distribution of these evaluations can be further categorized according to the sub-basin in which they occur. In the Headwaters Mahoning River basin, there are three sub-basins – Beaver Run-Mahoning River, Fish Creek-Mahoning River, and Beech Creek. Each sub-basin is discussed separately in the sections that follow.

Beaver Run-Mahoning River
HUC 12 - 05030103 01 01

Figure 22 compares aggregate distributions of qualitative sensitive taxa, qualitative EPT[1] taxa, and narrative evaluations for each sub-basin within the Headwaters Mahoning River basin. The Beaver Run – Mahoning River sub-basin demonstrated the highest level of biotic integrity among the three sampled. Out of six stations sampled, three macroinvertebrate communities achieved scores or evaluations that met EWH criteria for the Erie Ontario Lake Plain ecoregion. All three were located on the Mahoning River mainstem, which is currently assigned the WWH aquatic life use. The remaining three sites, which were located on three small tributaries, received narrative evaluations of good, fair, and low fair. The two sites that did not meet their current or recommended WWH aquatic life use – located on Beaver Run and Unnamed Tributary to Mahoning River at RM 97.11 – were assessed as fair and low fair, respectively. Both communities exhibited low numbers of EPT and sensitive taxa and were predominated by facultative flatworms. The Unnamed Tributary to Mahoning River at RM 97.11 was impacted by horses upstream having unrestricted access to the stream. Silt-laden, embedded substrates and filamentous algae were present at the site, corroborating the impact observed in the benthos. A similar scenario was encountered in Beaver Run, with upstream agricultural effects exacerbated locally by the removal of riparian vegetation. Exclusion of livestock from the stream in the Unnamed Tributary and restoration of riparian cover in Beaver Run may well mitigate the impacts observed in these two streams.

[1] EPT stands for Ephemeroptera, Plecoptera, and Trichoptera – the family names of mayflies, stoneflies and caddisflies, respectively. Their increased dominance as a group is generally indicative of high biotic integrity.

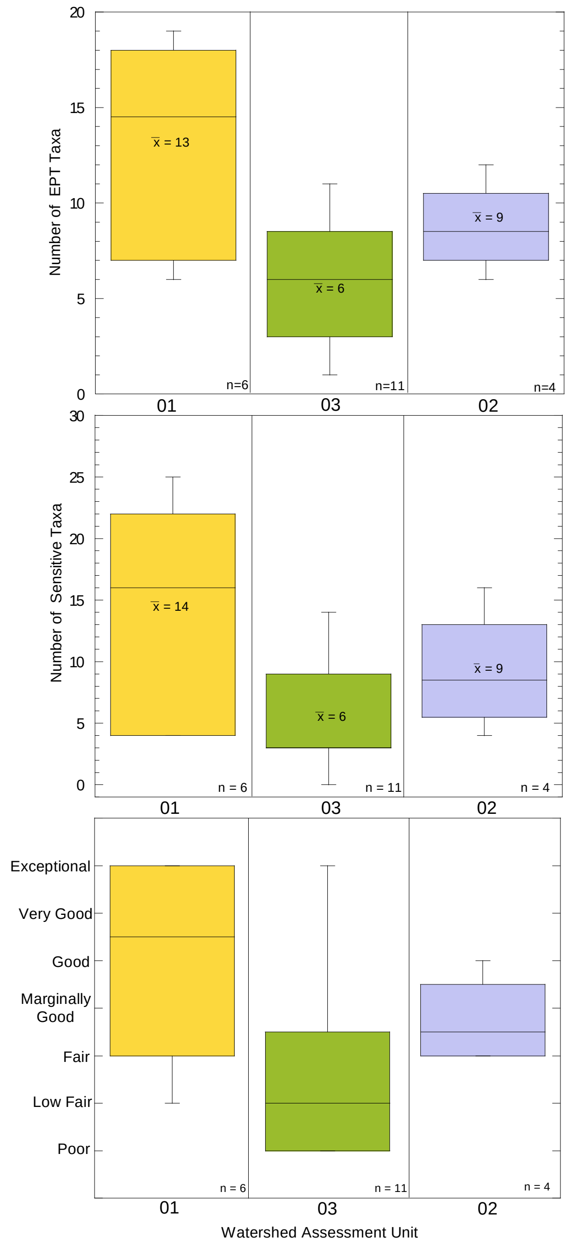


Figure 22. Box and whisker plots showing, from top to bottom: EPT taxa, sensitive taxa, and narrative assessment distributions for sites in each of the three HUC-12 assessment units in the Headwaters Mahoning River watershed.

Table 16. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Headwaters Mahoning River watershed (WAU 05030103 01), June to September, 2006.

Stream RM[a]	mi^2	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Ranges in Parentheses	ICI	Narrative Evaluation
HUC 12 - 05030103 01 01										
Mahoning River										
102.24	3.2	--	46	16	21	M	6	Net-spinning and case-building caddisflies (I-F), mayflies (MI-F), craneflies (MI), blackflies (F)	n/a	Very Good
100.57	8.0	--	49	19	25	H-M	5	Net-spinning and case-building caddisflies (I-F), mayflies (MI-F), craneflies (MI), riffle beetles (MI-F), waterpennies (MI)	n/a	Exceptional
97.69	19.8	--	48	18/20	22/36	M/1553	2	Net-spinning caddisflies (MI-F), mayflies (MI-F), riffle beetles (MI-F)	52	Exceptional
Unnamed Trib. to Mahoning River at RM 98.71										
4.59	5.3	--	40	13	11	M	1	Minnow mayflies (F-MT), net-spinning caddisflies (MI-F)	n/a	Good
Unnamed Trib. to Mahoning River at RM 97.11										
1.15	4.3	--	33	6	4	M-L	0	Minnow mayflies (MT-F), net-spinning caddisflies (F), flatworms (F)	n/a	Low Fair
Beaver Run										
1.19	4.8	--	33	7	4	M	1	Minnow mayflies (MT-F), blackflies (F), flatworms (F)	n/a	Fair
HUC 12 - 05030103 01 03										
Mahoning River										
93.23	52.7	--	41	9	11	L	0	Sowbugs (MT), flathead mayflies (I-F), Net-spinning caddisflies (F), minnow mayflies (F)	n/a	Marg. Good
91.11	63.0	--	31	8	9	M-L	0	Net-spinning caddisflies (I-F), riffle beetles (MI)	n/a	Marg. Good

Stream RM[a]	mi^2	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Ranges in Parentheses	ICI	Narrative Evaluation
89.4	74.0	--	49	11/14	14/21	M/571	0	*Rheotanytarsus sp.* midges (MI), minnow mayflies (MI-F), net-spinning caddisflies (MI-F), flathead mayflies (MI-F)	46	Exceptional
85.51	89.0	2,8	21	3/5	3/4	L/222	0	Sowbugs (MT), Scuds (F), Midges (MI-T)	12	Poor
84.99	90.0	16	29	6	3	M	0	Net-spinning caddisflies (MI-F), capshell snails (F)	n/a	Low Fair
Naylor Ditch										
3.63	4.5	--	44	9	9	M	0	Net-spinning caddisflies (F), minnow mayflies (MT-MI), scuds (F), beetles (MT-F), flatworms (F)	n/a	Fair
1.35	8.3	--	26	3	2	H	0	Blackflies (F), flatworms (F)	n/a	Poor
Unnamed Trib to Mahoning River at RM 91.21										
2.39	4.5	--	30	1	4	M-L	1	Midges (VT-MI), scuds (F), fingernail clams (F)	n/a	Poor
Fish Creek										
3.56	3.0	--	25	2	0	M	0	Scuds (F), Sowbugs (MT)	n/a	Poor
2.00	4.5	--	37	7	3	M-L	0	Net-spinning caddisflies (MI-F), minnow mayflies (F-MT), Red midges (F)	n/a	Fair
0.36	9.0	--	25	3	3	M-L	0	Sowbugs (MT), crayfish (F), midges (F-MI)	n/a	Poor
HUC 12 - 05030103 01 02										
Beech Creek										
10.50	4.0	--	41	8	7	M	0	Net-spinning caddisflies (F), minnow mayflies (F)	n/a	Fair
8.34	8.6	--	37	9	10	M	0	Minnow mayflies (F), net-spinning caddisflies (MI-F), flatworms (F)	n/a	Marg. Good

Stream RM[a]	mi^2	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Ranges in Parentheses	ICI	Narrative Evaluation
3.54	17.4	--	48	12	16	M-L	3	Minnow mayflies (F), net-spinning caddisflies (MI-F), craneflies (MI)	n/a	Good
Little Beech Creek										
1.83	9.0	--	31	6	4	M-L	1	Minnow mayflies (F), net-spinning caddisflies (MI-F), blackflies (F), flatworms (F)	n/a	Fair

RM: River Mile.
Dr. Ar.: Drainage Area
Data Codes: 8=Non-Detectable Current, 9=Intermittent or Near-Intermittent Conditions, 12=Suspected High Water Influence/Disturbance, 13=Suspected Disturbance by Vandalism, 15=Current >0.0 fps but <0.3 fps, 29=Primary Headwater Habitat Stream.
Ql.: Qualitative sample collected from the natural substrates.
Sensitive Taxa: Taxa listed on the Ohio EPA Macroinvertebrate Taxa List as MI (moderately intolerant) or I (intolerant).
Qt.: Quantitative sample collected on Hester-Dendy artificial substrates, density is expressed in organisms per square foot.
Qualitative sample relative density: L=Low, M=Moderate, H=High.
CW: Coolwater/Cold water.
Tolerance Categories: VT=Very Tolerant, T=Tolerant, MT=Moderately Tolerant, F=Facultative, MI=Moderately Intolerant, I=Intolerant

a – The RM indicated may differ slightly from the RM located in the Attainment Tables throughout this document. The RMs in this table are the Absolute Location Points (ALPs) which are the actual location where the data was collected. Each RM included in the Attainment Tables represents a Point of Record (POR) which is defined as a sampling station whereby ALPs representing the station may be linked.

The overall superior performance of the benthos in this sub-basin appears to have been driven by two factors. The first of these is land use. The landscape of this sub-watershed is mostly rural, which accounts for relatively little impervious surface runoff and a lack of point source discharges. The second of these appears to be a strong ground water influence, as evidenced by the presence of cold water taxa. This was particularly apparent at the two uppermost sites of the Mahoning River, RMs 102.24 and 100.57. Both sites exceeded the 4 cold water taxa requisite to be assigned the CWH (recommended) aquatic life use. Included among these indicator taxa were the state threatened cased caddisfly *Psilotreta indecisa* and the infrequently collected flathead mayfly *MacCaffertium ithaca*, which was only encountered in the Mahoning River sites of this sub-basin.

Fish Creek-Mahoning River
HUC 12 - 05030103 01 03
The biotic integrity of this sub-basin showed a dramatic downward shift from its headwater counterpart. This seems to parallel a landscape shift from rural to urban, with the emergence of the Alliance and the villages of Beloit and Sebring. The influences of urbanization are dramatically evident in the Mahoning River mainstem when qualitative macroinvertebrate sensitive, EPT and tolerant taxa are plotted longitudinally, as in Figure 23. The HUC 12 boundary between 01 and 03 more or less coincides with a gradual increase in population and the subsequent change in land use. Sensitive and EPT taxa begin a gradual decline, and tolerant taxa increase. Consequently, index scores decrease, bottoming out in the poor range within Alliance. All communities evaluated as poor in the Headwaters Mahoning River assessment unit were found in this sub-basin.

RM 89.4 seems to represent the point at which the Mahoning River begins to drain a more heavily urbanized landscape. Not coincidentally, RM 89.4 is also the last station on the Mahoning River to meet WWH expectations in the watershed, and the last to meet EWH criteria on the mainstem as a whole. The next downstream station at RM 85.51 was impounded by a low head dam located at RM 85.3 that is used as a backup drinking water source for Alliance. The impounded habitat created by this structure resulted in a poor ICI (12). The next station at RM 84.99 resumed its free-flowing nature, but the macroinvertebrate community only showed a slight improvement into the low fair range. Historically, this segment has been impaired by industrial waste discharges from Ryan’s Run, particularly in 1994 in which a very poor ICI of 4 was attained. There has been improvement in this reach. Sampling efforts in 1994 yielded no EPT taxa at this station, in contrast to the six taxa found in 2006. This reach is definitely impaired by urban influences. Nonpoint source impervious surface runoff contributes to the impact. A more detailed assessment of the area should be conducted to identify other specific sources of impairment.

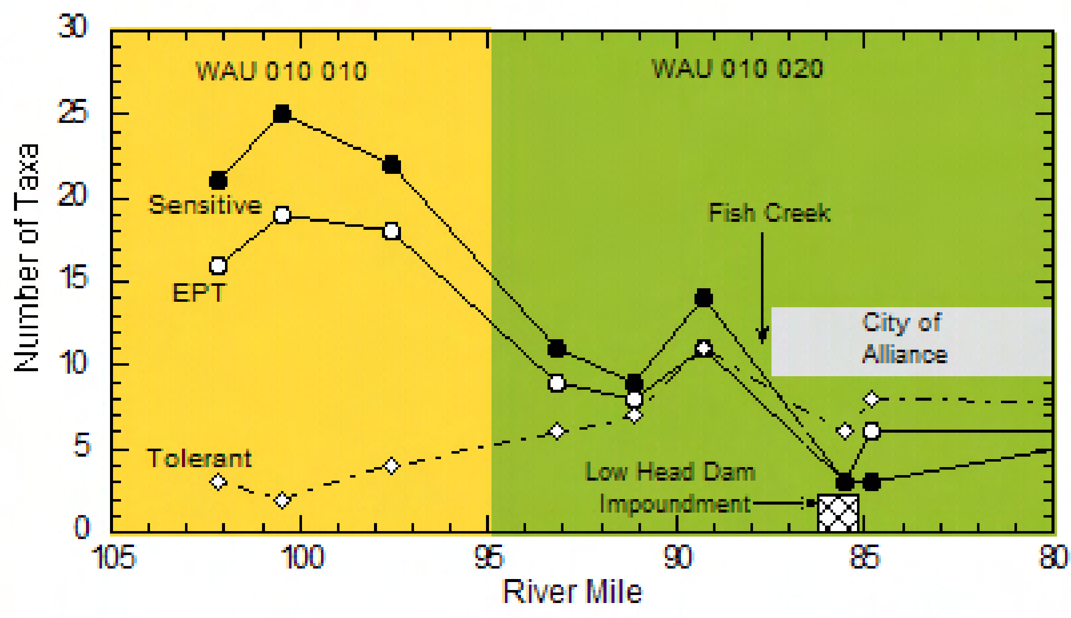


Figure 23. Longitudinal performance of the Headwaters Mahoning River mainstem in terms of sensitive, tolerant, and EPT taxa, 2006.

The impaired macroinvertebrate communities within two of the three tributaries sampled in this sub-basin further demonstrate the increased influence of urbanization in terms of municipal point source discharges. All three sites on Fish Creek were below WWH criteria. Fish Creek throughout its length is generally low gradient, with primarily muck substrates and poor riffle development. Riffles were only encountered at RM 2.00, which likely accounts for the slightly more favorable evaluation of fair. However, effluent from the village of Sebring WWTP via Sulphur Ditch further intensified impairment, particularly at RM 3.56. Nearly half of the macroinvertebrate community collected at this station was comprised of tolerant organisms (12 of 25), many of which are adapted to organically enriched conditions. No sensitive taxa were collected at this site.

Similar conditions were observed in the Unnamed Tributary to Mahoning River at RM 91.21, where a large portion of the collected fauna were tolerant organisms (12 of 30), also reflective of poor conditions. This stream appears to be negatively influenced by the village of Beloit's WWTP discharge, which is discharged upstream from the sampling site at RM 3.25. Instream water column chemistry downstream from both Sebring and Beloit WWTPs indicated elevated nutrients above benchmark values.

A third tributary, Naylor Ditch, was impacted by both urban and agricultural influences. The upper reach, including RM 3.63, flows through residential areas surrounding US Route 62. This segment was channelized and stripped of riparian buffer, resulting in a fair macroinvertebrate community. Downstream from Westville Lake at RM 1.35, the macroinvertebrate community reflected poor quality conditions instream. Very high numbers of facultative blackfly larvae and flatworms dominated the natural substrates, indicating enriched conditions. An upstream manure spill from a small dairy operation was reported to Ohio EPA on September 18, 2005. The effects of this incident were likely still impairing the macroinvertebrate community, although there may also have been an enrichment effect from Westville Lake, whose outlet is located about a half mile upstream and also receives WWTP discharge from the village of Damascus.

Beech Creek
HUC 12 - 05030103 01 02
The Beech Creek sub-basin included only Beech Creek and Little Beech Creek. The Mahoning River mainstem is not a part of this watershed. Longitudinally, Beech Creek displayed a pattern of downstream improvement. The headwater site at RM 10.50 was evaluated as fair, as the macroinvertebrate community at this location was displaying some imbalance, with 8 EPT versus only 7 sensitive taxa. This community also had the highest number of tolerant taxa collected in all of the Beech Creek sub-watershed. Siltation as a result of channelization is the likely source of impairment. Once removed from the channelized areas, Beech Creek improved to marginally good at RM 8.34, and then to good at RM 3.54. Alliance operates a WWTP that discharges to Beech Creek at RM 0.36. Due to impounded habitat conditions in this reach (Berlin Lake backwaters); this facility was not evaluated biologically.

One station was evaluated on Little Beech Creek, at RM 1.83. This site was located on a segment of stream that traverses a beef farm operation. In addition to being channelized with little riparian cover, it was discovered that livestock were permitted access to the stream. The cumulative effects of these impacts resulted in a fair community assemblage, with mostly facultative organisms inhabiting the natural substrates. Filamentous algae were also observed, indicating nutrient enrichment. Restoration of riparian cover and the exclusion of livestock from the stream would likely mitigate the impairment observed in this reach and achieve WWH goals.

Deer Creek WAU

The Mahoning River within the Deer Creek sub-basin was the impoundment of Berlin Lake and as such, no stream sampling was conducted on the mainstem (Figure 24). Siltation was a common cause of impairment of the tributary streams sampled and occurred as a result of agricultural practices, which accounted for 48% of the land use. The biological communities of Deer Creek were negatively influenced by the upstream and downstream dams.

The streams within the Deer Creek subwatershed were sampled in 11 locations. Only two sites, Mill Creek RM 3.64 and Willow Creek RM 3.74, were found to be in full attainment (Table 17). Seven of the remaining sites were in non-attainment and one site was in partial attainment.

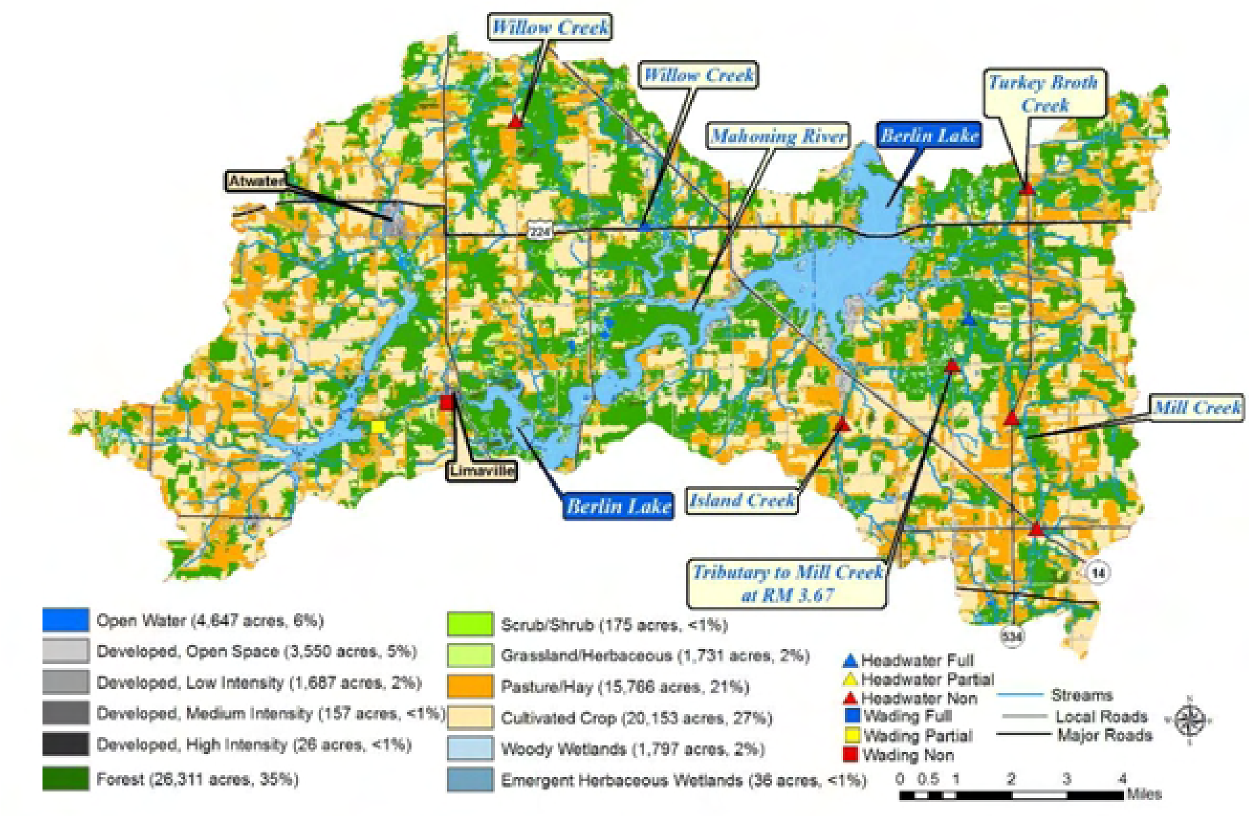


Figure 24. Land use and biological attainment status of sampling locations within the Deer Creek basin.

Table 17. Aquatic life use attainment status for stations sampled in the Deer Creek WAU based on data collected June-October 2006. One site was sampled in 2007 and its associated scores are indicated in *italics*. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community.

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
HUC 12 – 050301030203 Mill Creek							
Mill Creek				*EOLP Ecoregion – WWH Existing*			
N01K04 (6.28) [H]	26*	N/A	LF*	56.5	**NON**	Siltation	Unrestricted cattle access
300061 (3.64) [H]	47	N/A	46	74.0	FULL		
Tributary to Mill Creek at RM 3.67				*EOLP Ecoregion - WWH Recommended*			
N01K03 (1.10) [H]	20*	N/A	LF*	54.5	**NON**	Siltation Interstitial / Intermittent flow	Channelization Natural
Garfield Ditch (Trib to Mill Creek at RM 8.0)				*EOLP Ecoregion - WWH Recommended*			
N01K05 (0.66) [H]	24*	N/A	P*	39.5	**NON**	Siltation	Channelization
Turkey Broth Creek				*EOLP Ecoregion - WWH Existing*			
N01K01 (3.36) [H]	34*	N/A	P*	35.5	**NON**	Siltation Flow regime alteration Nutrient/eutrophication biological indicators	Small dam impounds stream Unrestricted cattle access
HUC 12 – 050301030204 Island Creek – Mahoning River							
Island Creek				*EOLP Ecoregion - WWH Existing*			
N01K06 (2.65) [H]	30*	N/A	P*	43.5	**NON**	Siltation Nutrient/eutrophication biological indicators	Agriculture

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
HUC 12 – 050301030202 Willow Creek							
Willow Creek				*EOLP Ecoregion - WWH Existing*			
N01K08 (8.13) [H]	32*	N/A	LF*	34.0	**NON**	Siltation Nutrient/eutrophication biological indicators Alterations in stream side vegetative cover	Channelization Municipal (urbanized high density area)
300062 (3.74) [H]	38	N/A	MG [NS]	54.5	FULL		
HUC 12 – 050301030201 Deer Creek							
Deer Creek				*EOLP Ecoregion - WWH Existing*			
N01K12 (10.87)	N/A	N/A	P*	N/A	N/A	Flow regime alteration	Walborn Reservoir
N01K10 (4.48) [W]	36[NS]	6.7*	32[NS]	67.0	PARTIAL	Flow regime alteration Nutrient/eutrophication biological indicators	Influenced by upstream dam releases
300025 (2.90) [W]	32*	7.3*	36	79.5	**NON**	Flow regime alteration	Influenced by upstream dam releases

Ecoregion Biocriteria: Erie Ontario Lake Plain

	IBI			MIwb			ICI		
Site Type	**WWH**	**EWH**	**MWH**	**WWH**	**EWH**	**MWH**	**WWH**	**EWH**	**MWH**
Headwaters	40	50	24				36	46	22
Wading	38	50	24	7.9	9.4	6.2	36	46	22
Boat	40	48	24	8.7	9.6	6.6	36	46	22

H - Headwater electrofishing site.

W - Wading electrofishing site.

B - Boat electrofishing site.

a - MIwb is not applicable to headwater streams with drainage areas $\leq$ 20 mi^2.

b - A narrative evaluation of the qualitative sample based on attributes such as EPT taxa richness, number of sensitive taxa, and community composition was used when quantitative data was not available or considered unreliable. VP=Very Poor, P=Poor, LF=Low Fair, F=Fair, MG=Marginally Good, G=Good, VG=Very Good, E=Exceptional

c - Attainment status is given for both existing and proposed use designations.

ns - Nonsignificant departure from biocriteria ($\leq$4 IBI or ICI units, or $\leq$0.5 MIwb units).

* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

Point Source Discharges

Portage County Atwater WWTP 3PH00033 (Tributary to Deer Creek to Deer Creek to Dale Walborn Reservoir)

This plant is operated by the Portage County Engineers office. Treatment processes include comminutor, extended aeration, secondary clarification, tertiary filters, and ultraviolet disinfection. Current monthly NPDES permit limits are cBOD5 (10 mg/l; 7.6 kg/day); TSS (12 mg/l; 9.1 kg/day); summer ammonia-N (2.0 mg/l; 1.5 kg/day); and total phosphorus (5.0 mg/l; 3.8 kg/day). The discharge is to an unnamed tributary of Deer Creek that enters the Dale Walborn Reservoir. The WWTP was allocated a load limit for phosphorus in their 2007 NPDES permit renewal because the discharge is upstream from the Alliance public drinking water supply intake located in Deer Creek Lake. No additional treatment processes were required since the current plant design apparently allows for the 5.0 mg/l TP effluent limit to be met.

No samples were collected downstream from the Atwater WWTP discharge during the survey given its location within the pooled backwaters of the Dale Walborn Reservoir. Effluent samples collected 6/15 and 8/17, 2006 indicated the WWTP was in compliance with NPDES discharge limits. Effluent flows and concentration of select chemical parameters have been relatively constant for the 1995 to 2007 period of record (Figure 25).

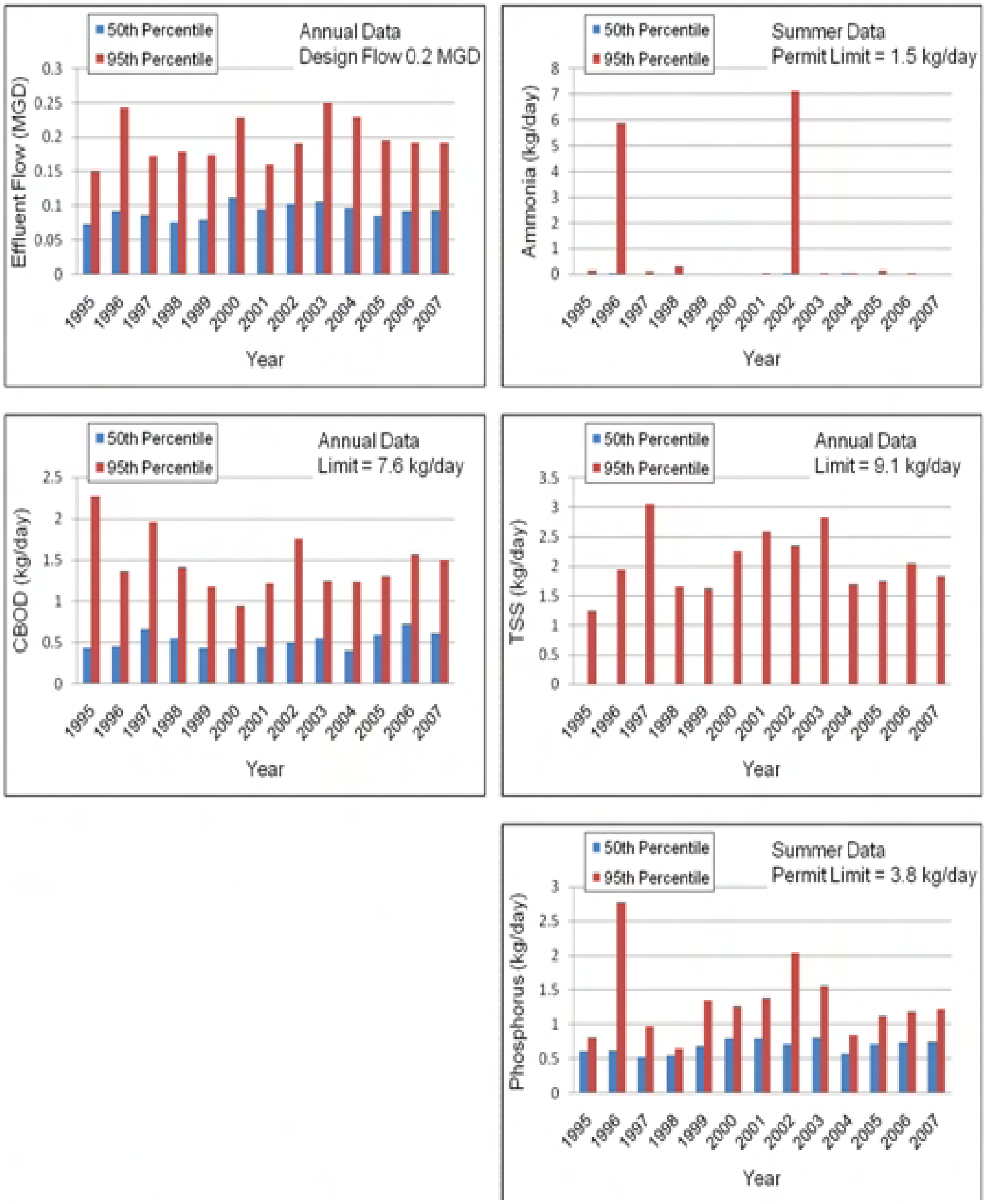


Figure 25. Annual flows, ammonia, carbonaceous biochemical oxygen demand (CBOD), total suspended solids, and phosphorus loadings for the Portage Co. Atwater WWTP treated effluent 1995-2007. NPDES Permit # 3PH00033.

Recreation Use
This WAU is unique because the entire mainstem of the Mahoning River is within the backwater pool of the Berlin Reservoir dam, spanning a distance of about ten miles. Bacteria samples collected from the surface waters of Berlin Reservoir at US Route 224 showed the lowest fecal coliform counts recorded from surface waters anywhere within the Upper Mahoning River survey area (FC mean = 21/100 ml, n=6).

Widespread non-attainment of PCR was recorded in samples from select tributaries that drain into Berlin Reservoir; 9 of 11 (82%) tributary sampling locations were in violation of PCR criteria (Appendix Table 4). Elevated bacteria were found in at least one location in each of the four HUC 12 sub-watersheds.

The highest average levels of bacteria within tributary streams were from Mill Creek at West Calla Rd. (RM 6.28) and Leffingwell Rd. (RM 3.64). Agricultural related activities are the most likely sources of bacteria in the upstream watershed, although specific problem areas are unknown at this time. Evidence of bacteria entering Deer Creek from the unsewered area of Limaville is indicated by much higher mean and maximum counts at Atwater Rd. (RM 2.90) compared to the upstream sampling location at McCallum Rd. (RM 4.48). The Atwater Rd. site for Deer Creek was in non-attainment of PCR criteria. Non-attainment of PCR was recorded at both Willow Creek sampling locations (RMs 8.13, 3.74) and near the mouth of Garfield Ditch (RM 0.66); no specific sources have been identified for these problem areas. Elevated bacteria counts found in Turkey Broth Creek at RM 3.36 (State Route 534) can be explained in part by cows observed in an upstream pasture with access to stream water.

In summary, the bacteria data from this WAU indicate widespread problems with elevated bacteria from numerous tributary streams that flow into Berlin Reservoir. It is recommended that a future survey be conducted to identify specific sources of bacteria and corrective actions taken to reduce loadings to background levels. Samples also should be taken within the Berlin Reservoir at locations where tributaries known to have elevated bacteria counts enter the lake.

Chemical Water Quality
Grab water samples were collected at eleven sampling locations within this WAU to support the results of the biological surveys (excluding the Mahoning River mainstem). These samples were collected from seven streams that are tributaries to the Upper Mahoning River. All chemical samples were collected on the same day within the survey area, thus controlling for the effect of stream flow on the interpretation of data from each sample run. Additional chemical samples were collected from the village of Atwater WWTP effluent discharge (Table 7).

Within this WAU the entire mainstem of the Mahoning River is impounded by the backwaters of the Berlin Reservoir dam, which is owned by the Army Corps of Engineers. This dam was constructed in 1943 to provide flood control and low flow augmentation for the extensive steel making operations in the greater Warren and Youngstown areas located in the Lower Mahoning River basin. It is also a popular recreation area and is used as an emergency supply of public drinking water by the Mahoning Valley Sanitary District which serves the greater Youngstown area. The dam discharges daily from gates located near the lake bottom unless the reservoir is at full pool stage. In summer, an odor of hydrogen sulfide was evident in the stream valley below the dam caused by the release of anoxic bottom waters.

Impaired biological communities were found at eighty percent (8/10) of the biological sample locations within the WAU. Chemical data were compared against OAC 3745-1 water quality criteria and TMDL target nutrient values as sample medians (NO_2-NO_3 = 1.50 mg/l; TP = 0.08 mg/l for watersheds < 20 mi^2, 0.10 mg/l for watersheds > 20 < 200 mi^2) to help identify potential chemical stressors on biology.

Deer Creek

The hydrology of this stream has been altered significantly by the Deer Creek Lake and Dale Walborn Reservoir dams. Impaired biology (fish community only) was found at two sample locations from a short segment of Deer Creek that connects the two lakes, although good local habitat quality was available (QHEI = 67.0 at RM 4.48; QHEI = 79.5 at RM 2.90;). Although nutrients were on average higher in Deer Creek at RM 2.90 downstream from Limaville, both nitrates and phosphorus were below TMDL targets. Fecal coliform bacteria were elevated at RM 2.90 but not on average, which suggests an intermittent source(s) of bacteria. The concentrations of BOD_5 were higher at the upstream RM 4.48 location. This location is downstream from Dale Walborn Reservoir which would release algae and decayed organic matter, the most likely source of the elevated BOD_5.

Chemical samples collected from Deer Creek at RM 10.87, upstream from the Dale Walborn Reservoir, indicated slightly elevated phosphorus (TP median = 0.086 mg/l) above the TMDL target value. Only benthic macroinvertebrates were sampled at this location and the community was poor. The stream sediment had an orange discoloration most likely caused by precipitation of iron compounds. A large wetland is located upstream from RM 10.87 and may be the source of both nutrients and iron, although agricultural land also is present in the upstream watershed. Fecal coliform bacteria were elevated but not on average, which suggests an intermittent source(s) of bacteria. Additional sampling will be required to identify the extent of biological non-attainment in the headwater section of Deer Creek upstream from Dale Walborn Reservoir.

Two effluent samples collected from the Atwater WWTP showed total phosphorus in the range of 2.5 to 3.0 mg/l. This WWTP discharges into the impounded wetland habitat of Dale Walborn Reservoir. Future chemical sampling of Dale Walborn Reservoir will be required to determine if nutrient load reductions will be required at the Atwater WWTP.

During the 2006 survey three samples were collected from Deer Creek Lake near the Alliance public drinking water supply intake. Additional sampling in Deer Creek Lake and Dale Walborn Reservoir is scheduled for 2008. Data collected in 2006 will be incorporated into a future report on the conditions of these two lakes.

Willow Creek
Samples were collected at two locations, RM 8.13 and RM 3.74. Biology was impaired at the RM 8.13 location where habitat was highly depressed (QHEI = 34.0), but full biological attainment was found at RM 3.74 at Notman Rd. A number of chemical stressors were recorded at the upstream RM 8.13 location. Dissolved oxygen was found below water quality criteria (minimum of 4.71 mg/l). COD (mean=39.5, n=4) and ammonia-N (range 0.074-0.396) were elevated, both of which exert an oxygen demand and remove dissolved oxygen ions from water. Total phosphorus also was elevated (median TP = 0.129 mg/l, n=4) above the TMDL target value. In contrast, normal levels of phosphorus were recorded at the downstream RM 3.74 location (TP mean = 0.028 mg/l, n=7) where biology was in full attainment. Fecal coliform bacteria levels were higher at the downstream RM 3.74 location, an indication of impact from failing home sewage treatment systems.

Island Creek
Poor biology was found at the RM 2.65 sampling location, in large part explained by poor habitat (QHEI = 43.5). Evidence of additional chemical stress is provided by a very depressed measurement of dissolved oxygen (2.31 mg/l), elevated ammonia-N (maximum of 0.688 mg/l) and total phosphorus at levels above the TMDL target value (TP median = 0.143 mg/l). Mercury was detected in one of four samples (Hg = 0.39 ug/l). Fecal coliform bacteria counts were elevated, but not on average, which suggests an intermittent source(s) of bacteria.

Mill Creek
Poor biology was found at the upper most sampling location (RM 6.28) with full biological attainment downstream at RM 3.64. There was very little difference in chemical quality between these two sample locations, however, total phosphorus was higher at RM 6.28 (TP median = 0.101 mg/l, n=4) compared to RM 3.64 (TP median = 0.075 mg/l, n=6). QHEI was significantly lower at RM 6.28 compared to RM 3.64 (QHEI = 56.5 vs 74.0), which suggests that restoration measures will be needed to improve habitat at RM 6.28 and to lower nutrient loading. Fecal coliform bacteria were elevated on average at both Mill Creek locations, which suggests a continuous source(s) of bacteria being discharged to the stream.

RM 3.67 Tributary to Mill Creek
Poor biology was found at the RM 1.10 sample location. QHEI was depressed below WWH expectations (QHEI = 54.5), and intermittent/interstitial flow was

observed. There also was evidence of chemical stress. Fifty percent of samples showed low dissolved oxygen below 5.0 mg/l, with a minimum recorded value of 3.22 mg/l. The cause of low dissolved oxygen appears to be related to the presence of elevated ammonia-N, rather than carbon based organic matter since BOD was low. Ammonia-N will remove oxygen from water as it converts to nitrates, and nitrate-nitrite was elevated (median = 2.08 mg/l, n=4), above the TMDL target of 1.50 mg/l. Total phosphorus was not elevated. The data suggest the use of an ammonia based fertilizer is employed in the upstream watershed that is making its way to the stream.

Turkey Broth Creek
Poor biology was found at RM 3.36 in large part due to very poor habitat potential (QHEI = 35.5). The stream was impounded and cattle were observed in the upstream watershed. Fecal coliform bacteria were elevated on average, which suggests a continuous source of bacteria being discharged to the stream. Evidence of chemical stress included fifty percent of samples with dissolved oxygen below water quality criteria (2.85 mg/l minimum DO), elevated ammonia as high as 1.38 mg/l, and elevated total phosphorus (TP median = 0.125, n=4) above the TMDL target goal, while nitrate-nitrites were not elevated.

Garfield Ditch
Poor biology was found at RM 0.66 in large part resulting from poor habitat potential (QHEI = 39.5). During the survey a segment of the stream's riparian buffer upstream from St. Rt. 165 was clear cut and graded which allowed soil to wash into the stream. This action resulted in elevated levels of TSS (TSS range from 22-76 mg/l), well above background values. Observations in late 2006 indicated that the stream bank had been seeded and grass was present, although there was no riparian cover. Additional evidence of chemical stress included fifty percent of the samples with dissolved oxygen values below water quality criteria (3.93 minimum DO) and the presence of elevated ammonia and total phosphorus above the TMDL target goal (TP median = 0.156 mg/l, n=4). There also was evidence of mine drainage at this site due to elevated levels of iron, manganese, and sulfates. Fecal coliform bacteria were elevated but not on average, which suggests an intermittent source(s) of bacteria.

Physical Habitat
The physical habitat of 10 locations within the Deer Creek basin was evaluated with the QHEI. As Figure 26 shows, sites <10mi^2 drainage area scored within the poor to fair range, while large drainage area streams scored within the good to very good range. The two sites on Deer Creek received some of the highest QHEI scores within the Deer Creek basin, 67.0 at the upper site and 79.5 at the downstream location. While these scores indicate the potential of each site to support WWH communities, their location between reservoirs may affect their ability to support and maintain WWH communities (Figure 27).

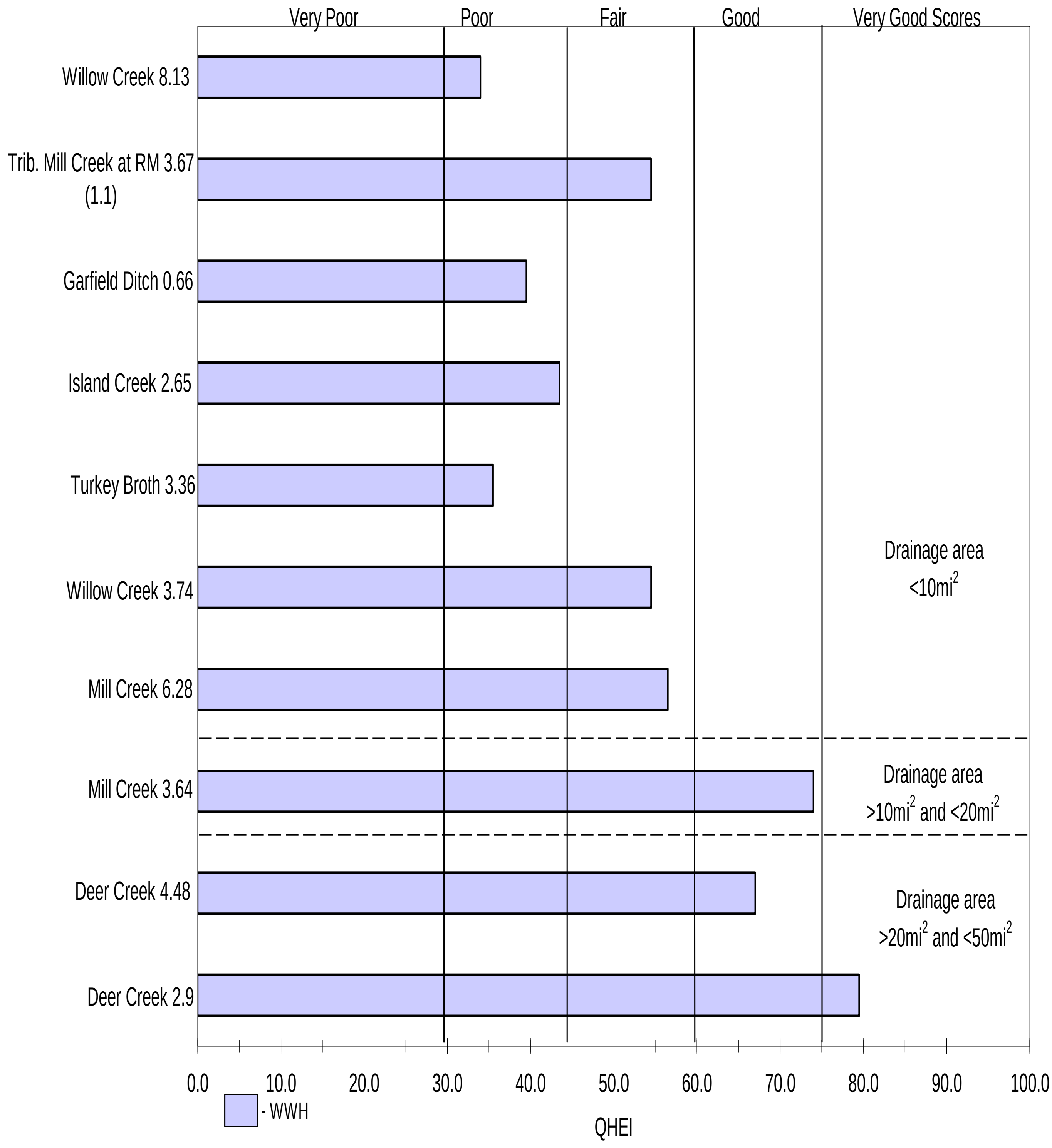


Figure 26. QHEI scores by drainage area for Deer Creek basin, HUC 05030103020.

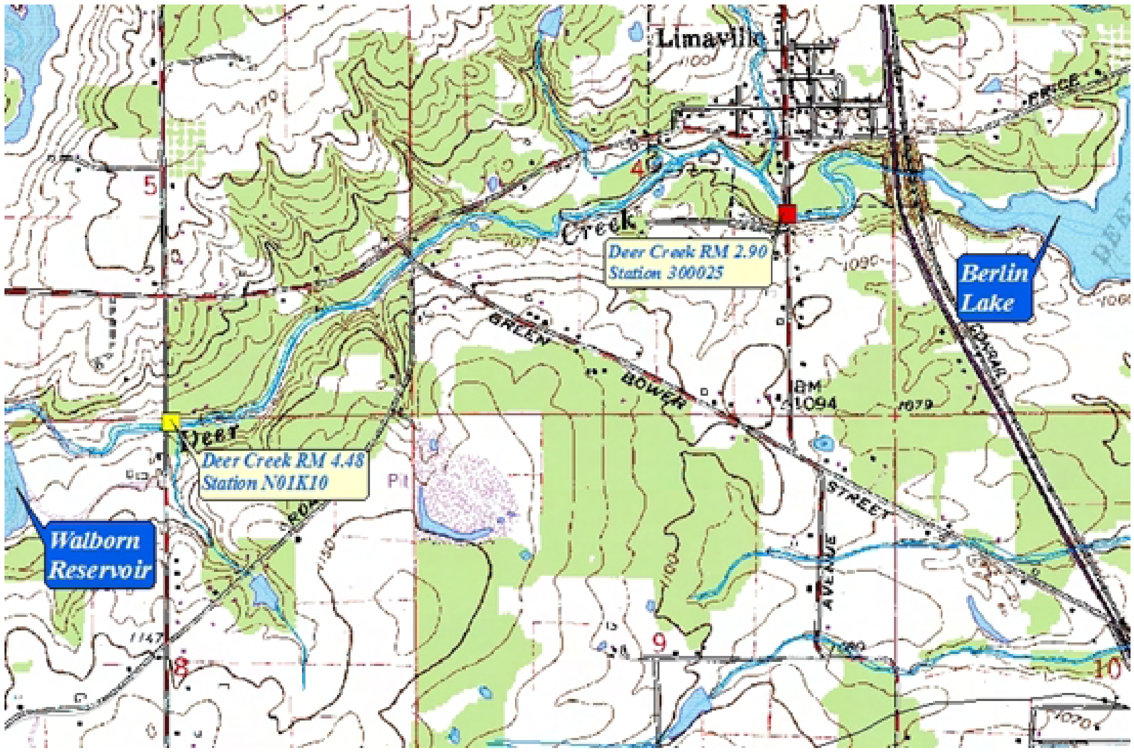


Figure 27. Fish sampling locations on Deer Creek. Note proximity to Walborn Reservoir and Berlin Lake.

The upper site is located downstream from Walborn Reservoir and the lower site is upstream from Berlin Lake. The hydrology of these sites is completely influenced by dam releases from Walborn Reservoir. So, although the upper site is characterized primarily by a long riffle complex of diverse substrates, few riffle species are found. The lower site is characterized by a naturally curvaceous pattern with varied depth, diverse streambed substrates and a plentiful mixture of pool, riffle and run complexes. However, the strong hydrologic influence of the upstream dam diminishes the ability of this site to support WWH communities. In essence, Deer Creek acts more as a water conveyance than a stream between these reservoirs.

The only other site to score above fair within the Deer Creek basin was Mill Creek RM 3.6, which received a QHEI score of 74.0. Diverse stream substrates, combined with moderate sinuosity and extensive instream cover, provided a diverse habitat for aquatic organisms. In addition, only three moderate influence MWH characteristics were noted for the stream (Figure 28).

Three sites received QHEI scores in the fair range, Mill Creek RM 6.3 (QHEI = 56.5), Willow Creek RM 3.7 (QHEI = 54.5), and tributary to Mill Creek at RM 3.67, RM 1.1 (QHEI = 54.5). Streams that score between 50 and 60 on the QHEI are usually considered to have marginal habitat for supporting WWH communities. The site on Willow Creek RM 3.7 had only one high influence

MWH attribute, while Mill Creek RM 6.3 had two and the tributary to Mill Creek at RM 3.67, RM 1.1 had three. Therefore, the upper site on Willow Creek has a greater potential to support WWH communities than the other two sites which received QHEI scores in the 50s.

The remaining streams within the basin scored in the poor range (Figure 26). QHEI scores for these tributaries had a mean value of 38 with a range of 34.0-43.5. Each of these sites had at least one high influence MWH attribute and five or more moderate influence MWH attributes (Figure 28). The physical alterations apparent at these sites diminish the ability of these streams to support WWH communities.

Deer Creek basin 05030103020

Key QHEI Components

River Mile	QHEI	Gradient (ft/mile)	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
			WWH Attributes											MWH Attributes: High Influence						MWH Attributes: Moderate Influence														
(18-056) Mill Creek																																		
Year: 2006																																		
6.3	56.5	16.39	■				■				■	■	4			◆	◆		2		●			●				●	●			4	0.60	1.40
3.6	74.0	9.35	■	■		■	■	■	■		■		7						0		●								●	●		3	0.13	0.50
(18-057) Turkey Broth Creek																																		
Year: 2006																																		
3.4	35.5	12.34									■		1	◆	◆	◆	◆		4		●			●				●	●		●	5	2.50	5.00
(18-058) Island Creek																																		
Year: 2006																																		
2.7	43.5	14.29	■				■	■			■		4		◆				1		●			●				●	●		●	5	0.40	1.40
(18-059) Willow Creek																																		
Year: 2006																																		
8.1	34.0	8.70					■						1	◆		◆	◆	◆	4		●		●	●				●	●		●	6	2.50	5.50
3.7	54.5	10.42	■				■	■			■		4		◆				1		●			●				●	●	●	●	6	0.40	1.60
(18-060) Deer Creek																																		
Year: 2006																																		
4.5	67.0	10.64		■				■			■		3	◆					1		●			●	●			●	●	●		6	0.50	2.00
2.9	79.5	10.00	■	■		■	■	■	■		■		7						0		●			●					●	●		4	0.13	0.63
(18-095) Trib. to Mill Creek (RM 3.67)																																		
Year: 2006																																		
1.1	54.5	21.28		■				■		■			3	◆		◆		◆	3		●			●				●		●		4	1.00	2.00
(18-097) Garfield Ditch																																		
Year: 2006																																		
0.7	39.5	5.85						■			■		2	◆	◆	◆			3		●			●				●	●		●	5	1.33	3.00

Figure 28. QHEI attributes for streams within the Deer Creek basin, HUC 05030103020.

Biological Communities: Fish

The fish communities of Deer Creek basin were sampled at 10 locations. A comparison of fish community scores to habitat scores indicated that where better quality habitat was available, fish communities generally performed better (Figure 29). However, many fish communities within the basin were underperforming the habitat available, which indicates that additional factors beyond habitat may be influencing the fish community. Where habitat conditions were poor, fish communities were performing below WWH expectations, thereby reflecting the poor habitat conditions.

Deer Creek

The McCallum Road site (RM 4.50) is located downstream from Walborn Reservoir and the Atwater Avenue site (RM 2.90) is upstream from Berlin Lake. The hydrology of these sites is completely influenced by dam releases from Walborn Reservoir. So, although the upper site is characterized primarily by a long riffle complex of diverse substrates, few riffle species were found. The complex habitat at the lower site provides more diverse habitat for the fish community than the upper site. However, two fewer species (16 total at the upper site and 14 at total at the lower site) were collected. Each site contained at least 5 Centrarchidae species, though only two darter species, logperch and johnny, were collected at each site. The lack of tributary streams between the reservoirs diminishes the likelihood of fish recruitment from any location other than the reservoirs (Figure 27). Therefore, it is not surprising that the fish community at both sites reflect a reservoir fish community rather than a stream fish community.

Willow Creek

The fish community of Willow Creek directly reflected habitat conditions present. The upstream site near Porter Road (RM 8.13) received an IBI score of 32 which correlated with the QHEI score of 34.0. Downstream near Notman Road (RM 3.74), the fish community performance improved to an IBI score of 38, reflecting the improved habitat conditions noted by the QHEI score of 54.0.

Island Creek

The fish community of Island Creek received an IBI score of 30. This score reflected the poor habitat present which received a QHEI score of 43.5. The channelized nature of the stream was mirrored by the dominance of creek chub (44.2%) and johnny darter (31.0%) in the fish community.

Mill Creek

The fish community of Mill Creek was sampled near West Calla Road (RM 6.3) and Leffingwell Road (RM 3.64). Unrestricted cattle access to the stream along West Calla Road resulted in poor fish community results (IBI=26). The fish community was dominated by white sucker (40.4%) and creek chub (33.0%). Further downstream, habitat conditions improved and the fish community responded to the improved conditions with an IBI of 47. White sucker (5.25%

and creek chub (18.45%) comprised a much smaller percentage of the relative number of individuals, indicating a better balanced fish community.

Tributary to Mill Creek at RM 3.67
The fish community of the tributary to Mill Creek at RM 3.67 (RM 1.10) received an IBI score of 20. The poor community performance reflected the intermittent water flow of the stream. The four fish species found, western blacknose dace, creek chub, green sunfish, and johnny darter, are all common headwater species.

Garfield Ditch
The fish community of Garfield Ditch was sampled near State Route 154 and State Route 165 (RM 0.66). Seventy-five percent of the fish community was pollution tolerant. The poor fish community (IBI of 24) reflected the poor habitat as the QHEI score for the site was 39.5.

Turkey Broth Creek
The fish community of Turkey Broth Creek was sampled near State Route 534 (RM 3.36). Tolerant fish dominated the fish community, comprising 92% of the relative number of individuals. This reflects the poor habitat quality and nutrient enriched conditions evident within Turkey Broth Creek.

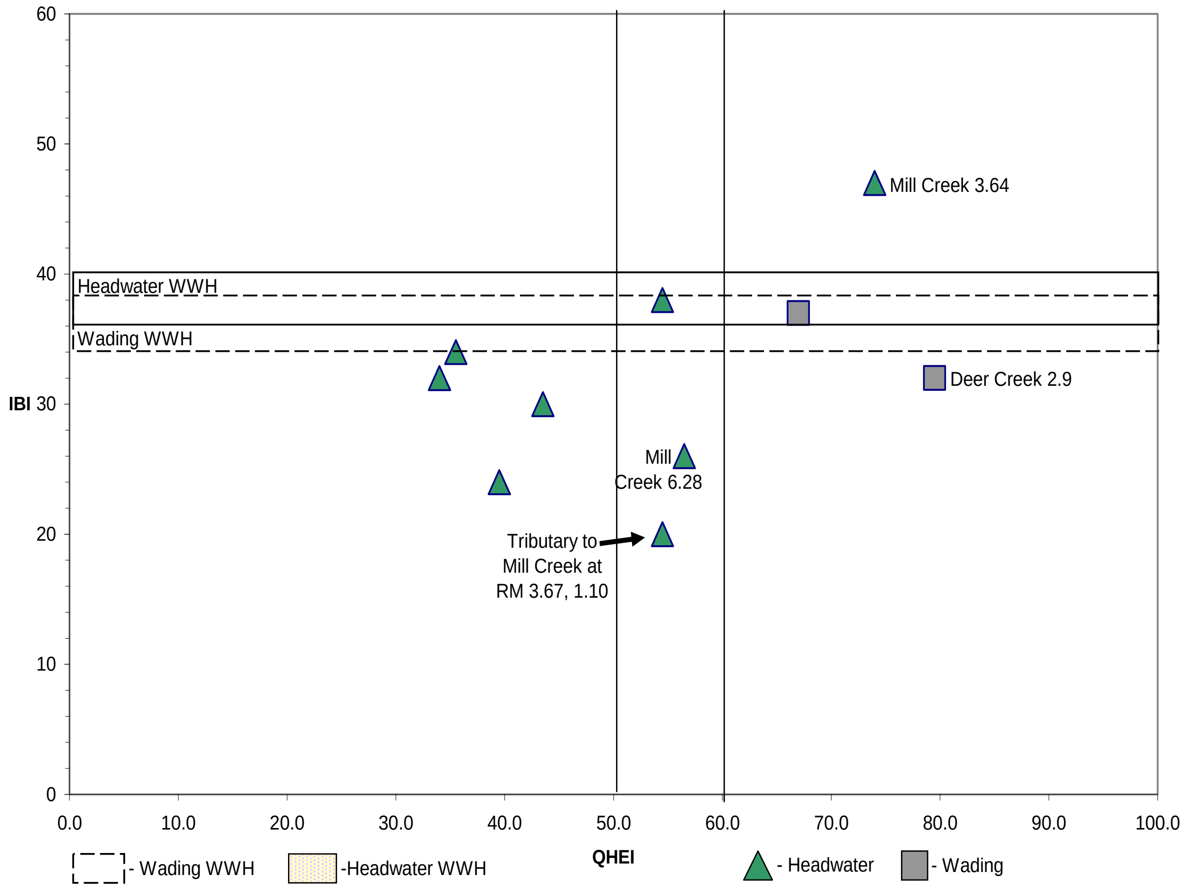


Figure 29. IBI versus QHEI scores for Deer Creek basin, WAU 05030103020.

Biological Community: Macroinvertebrate

Macroinvertebrate sampling was conducted on six tributaries within the Deer Creek-Mahoning River watershed. Berlin Lake accounts for approximately nine river miles of impounded lake habitat on the Mahoning River mainstem, and therefore was not sampled for macroinvertebrates. Furthermore, Berlin Lake also creates backwater conditions in the lower segments of many of its direct tributaries, thereby limiting sampling to the upper portions of these streams.

That said, eleven sites were sampled on six tributaries to assess the condition of instream benthic communities (Table 18). Overall, there was 1 exceptional, 1 good, 2 marginally good, 3 low fair, and 4 poor communities in this watershed. All streams sampled in this watershed are either currently assigned or being recommended the WWH aquatic life use for the Erie Ontario Lake Plain (EOLP) ecoregion. Most of the communities that did not meet WWH criteria were influenced by poor habitat. Four sub-watersheds were sampled in this basin, and are discussed separately in the sections that follow.

Deer Creek

HUC 12 - 05030103 02 01

Three sites on Deer Creek were included in this sub-basin. The upper reach in the headwaters is characterized by wetland habitat conditions: slow to non-detectable current, low gradient, and fine grained substrates. Such was the habitat at RM 10.87, where a poor macroinvertebrate community consisting mostly of facultative beetles, scuds, and hemipterans (true bugs) was collected. The stream conditions observed here may also be influenced to an extent by backwater conditions from the Dale Walborn Reservoir, whose terminus is located at approximately RM 9.7.

The two lower sites on Deer Creek were both located downstream from the Dale Walborn Reservoir, and therefore experienced the opposite effect from that of its upstream counterpart: regular flow. Dam-influenced flow events frequently yield nutrient over-enrichment. Alliance, which owns and operates the reservoir as an alternate source of drinking water for the city, regularly releases surface water over the top of the dam structure following periods of heavy rain (Mike Dreger, personal communication). This release protocol is unique from the other three larger reservoirs in the Upper Mahoning River watershed (Berlin, Milton and Kirwan), which serve as flood control structures and typically release anoxic bottom waters. Due to their exposure to sunlight, surface waters are typically warmer and rich with zooplankton and phytoplankton, which in turn favors high populations of filter-feeding caddisflies and suspension-feeding blackflies, and a reduction in overall taxa richness downstream from their release (Allan 1995; Giller and Malmqvist 1998). Such was the case for Deer Creek RM 4.48, which is located less than a half mile from the reservoir outlet. Although scoring a marginally good ICI of 32, the relative abundance of 8247 organisms/ft² on the artificial substrates was by far the highest of any site quantitatively sampled in the entire survey. This increased productivity was also accompanied by a reduction in overall taxa richness (24 total taxa), indicating an imbalanced, if not unstable, community structure. Natural substrates were predominated by large numbers of blackflies, net-spinning caddisflies of the family Hydropsychidae, and filter-feeding midges of the tribe Tanytarsini. These three organism groups accounted for 84% of all organisms collected on the artificial substrates. When compared to other sites quantitatively sampled downstream from reservoirs in the survey, the effect of surface releases from Walborn Reservoir is definitive (Figure 30).

The influence of the reservoir becomes amplified in light of the improved community performance at RM 2.90. The ICI becomes more stable with a good score of 36, taxa richness improves to 44 total taxa and relative abundance declines to 2633 organisms/ft². Filamentous algae, found in great abundance at RM 4.48, were rare at this site. However, the percentage of blackflies, hydropsychids, and filter-feeding tanytarsini midges found on the artificial substrates remained high at 75%, indicating that recovery from the effects of the reservoir releases was not fully achieved in this reach.

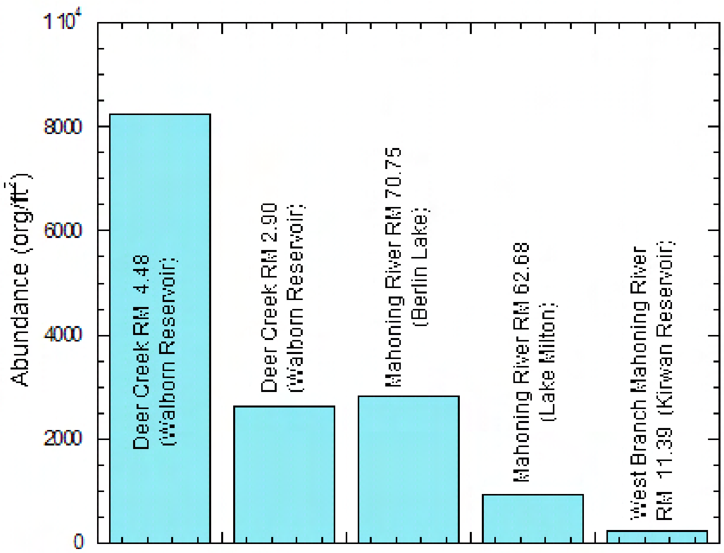


Figure 30. A comparison of relative abundances for five sites influenced by reservoir releases within the Upper Mahoning River watershed. Deer Creek, which is influenced by surface water releases from Dale Walborn Reservoir, exhibits very high abundance at the site immediately downstream from the outlet (RM 4.48).

Willow Creek
HUC 12- 05030103 02 02

The principal factor affecting community performance in Willow Creek was channelization, which accounted for the low fair macroinvertebrate community collected at RM 8.13. Heavy silt and muck predominated instream substrates, and algal blooms covered the water surface. Consequently, mostly scuds and pouch snails were collected. While instream conditions were not conducive to the presence of EPT taxa, 5 taxa were found in a small "riffle" located inside of a culvert at the site. This phenomenon furthers the notion that habitat conditions were the main cause of impairment. When Willow Creek returns to more natural habitat conditions, as at RM 3.74, community performance improves to marginally good accordingly and thus marginally meets WWH criteria for the stream.

Mill Creek
HUC 12- 05030103 02 03
Degraded habitat conditions were primarily responsible for the low fair to poor macroinvertebrate communities collected in 4 of 5 sites in this sub-watershed. Habitat, as indicated by QHEI scores, and narrative assessments were correlated in this sub-basin; the two sites evaluated as poor had a mean QHEI of 37.5 and the two evaluated as low fair had a mean of 55.5. The fifth site, with a QHEI of 74.0, not surprisingly scored an exceptional ICI of 46.

The two poor communities, collected from Garfield Ditch RM 0.66 and Turkey Broth Creek RM 3.6, were similar in composition. Both had only one sensitive taxon and 11 tolerant taxa. However, two different yet equally compromising habitat modifications drove community performance at both locations. Channelization accounted for the impairment in Garfield Ditch, whereas a small dam created an impounded habitat on Turkey Broth Creek. Adding further damage to Turkey Broth Creek was unrestricted livestock access upstream from the sampling area. Elevated ammonia was detected in two water column chemistry samples, further substantiating the degradation exhibited in this stream.

The two low fair sites, Mill Creek at RM 6.28 and Unnamed Tributary to Mill Creek at RM 3.67 at RM 1.10, like the two poor sites, also had similar attributes. Both sites had 3 sensitive versus 6 tolerant taxa, and also had similar numbers of EPT taxa, 4 and 5, respectively. In the case of Mill Creek, a lack of coarse instream substrates readily enabled riffle embeddedness due to excessive siltation caused by upstream pasturage. Net-spinning caddisflies, which rely on the availability of interstitial space in riffles in which to construct their feeding nets, were absent from this stream. Interstitial stream conditions, a natural habitat impairment, were accountable for the benthic performance in the Unnamed Tributary.

The lone exceptional site in this sub-watershed, and in the Deer Creek-Mahoning River watershed as a whole, was located at the Leffingwell Road gaging station on Mill Creek at RM 3.64. In the absence of profound disturbance, this site performed true to its near exceptional QHEI score, with an exceptional ICI of 46. Heterogeneous substrate composition and wide strips of riparian buffer allowed for a community consisting of 58 total taxa, including 16 total EPT and 23 total sensitive taxa. Mayfly and caddisfly species richness was both high and equally distributed relative to the other stations sampled in this sub-basin.

Island Creek-Mahoning River
HUC 12- 05030103 02 04
As mentioned previously, the Mahoning River mainstem portion of this watershed is impounded lake habitat. Therefore, only one stream was sampled in this sub-watershed, Island Creek. Island Creek appeared to be in recovery from prior channelization, and was nearing interstitial conditions when sampled. Coarse

substrates were present in the sampled reach, but their inundation with sediment limited macroinvertebrate colonization. Only one sensitive taxon was collected, versus twelve tolerant taxa, leading to a narrative evaluation of poor.

Table 18. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Deer Creek-Mahoning River watershed (WAU 05030103 02), June to September, 2006.

Stream RM[a]	Dr. Ar. (sq. mi.)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Ranges in Parentheses	ICI	Narrative Evaluation
HUC 12 - 05030103 02 01										
Deer Creek										
10.87	3.5	--	31	3	4	M	0	Scuds (F)	--	Poor
4.48	27.9	10,13	19	6/6	2/3	M/8247	0	Blackflies (F), net-spinning caddisflies (F)	32	Marg. Good
2.90	30.1	--	34	7/8	7/13	M/2633	0	Blackflies (F), *Rheotanytarsus sp.* midges (MI)	36	Good
HUC 12 - 05030103 02 02										
Willow Creek										
8.13	3.5	--	29	5	3	H	0	Scuds (F), pouch snails (F)	--	Low Fair
3.74	7.2	--	31	11	9	M	1	Minnow and flathead mayflies (F)	--	Marg. Good
HUC 12 - 05030103 02 03										
Mill Creek										
6.28	9.9	--	30	4	3	M-L	0	Red midges (F)	--	Low Fair
3.64	19.1	15	40	13/16	12/23	M/417	1	Snail case caddisflies (MI), prong-gill mayflies (MI), net-spinning caddisflies (F-MI)	46	Exceptional
Garfield Ditch										
0.66	4.0	--	25	2	1	H	0	Scuds (F-MT)	--	Poor
Unnamed Tributary to Mill Creek at RM 3.67										
1.10	3.7	9	23	5	3	M	0	Beetles (F-T)	--	Low Fair
Turkey Broth Creek										
3.36	4.9	--	26	3	1	L	0	Midges (MI-T), sowbugs (MT)	--	Poor
HUC 12 - 05030103 02 04										
Island Creek										

Stream RM[a]	Dr. Ar. (sq. mi.)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Ranges in Parentheses	ICI	Narrative Evaluation
2.65	4.2	--	38	4	1	L	0	Scuds (F), midges (F-T)	--	Poor

RM: River Mile.
Dr. Ar.: Drainage Area
Data Codes: 8=Non-Detectable Current, 9=Intermittent or Near-Intermittent Conditions, 12=Suspected High Water Influence/Disturbance, 13=Suspected Disturbance by Vandalism, 15=Current >0.0 fps but <0.3 fps, 29=Primary Headwater Habitat Stream.
Ql.: Qualitative sample collected from the natural substrates.
Sensitive Taxa: Taxa listed on the Ohio EPA Macroinvertebrate Taxa List as MI (moderately intolerant) or I (intolerant).
Qt.: Quantitative sample collected on Hester-Dendy artificial substrates, density is expressed in organisms per square foot.
Qualitative sample relative density: L=Low, M=Moderate, H=High.
CW: Coolwater/Cold water.
Tolerance Categories: VT=Very Tolerant, T=Tolerant, MT=Moderately Tolerant, F=Facultative, MI=Moderately Intolerant, I=Intolerant

a – The RM indicated may differ slightly from the RM located in the Attainment Tables throughout this document. The RMs in this table are the Absolute Location Points (ALPs) which are the actual location where the data was collected. Each RM included in the Attainment Tables represents a Point of Record (POR) which is defined as a sampling station whereby ALPs representing the station may be linked.

West Branch WAU

The Mahoning River forms Lake Milton in the eastern portion of the West Branch Mahoning River WAU, while the West Branch Mahoning River is impounded to form Michael J. Kirwan Reservoir in the western portion of the basin (Figure 31). Not surprisingly, the biological communities of these streams are negatively influenced by the dams. Tributary streams are impaired mostly from siltation and direct habitat alterations as a result of agricultural activities or urbanization influences.

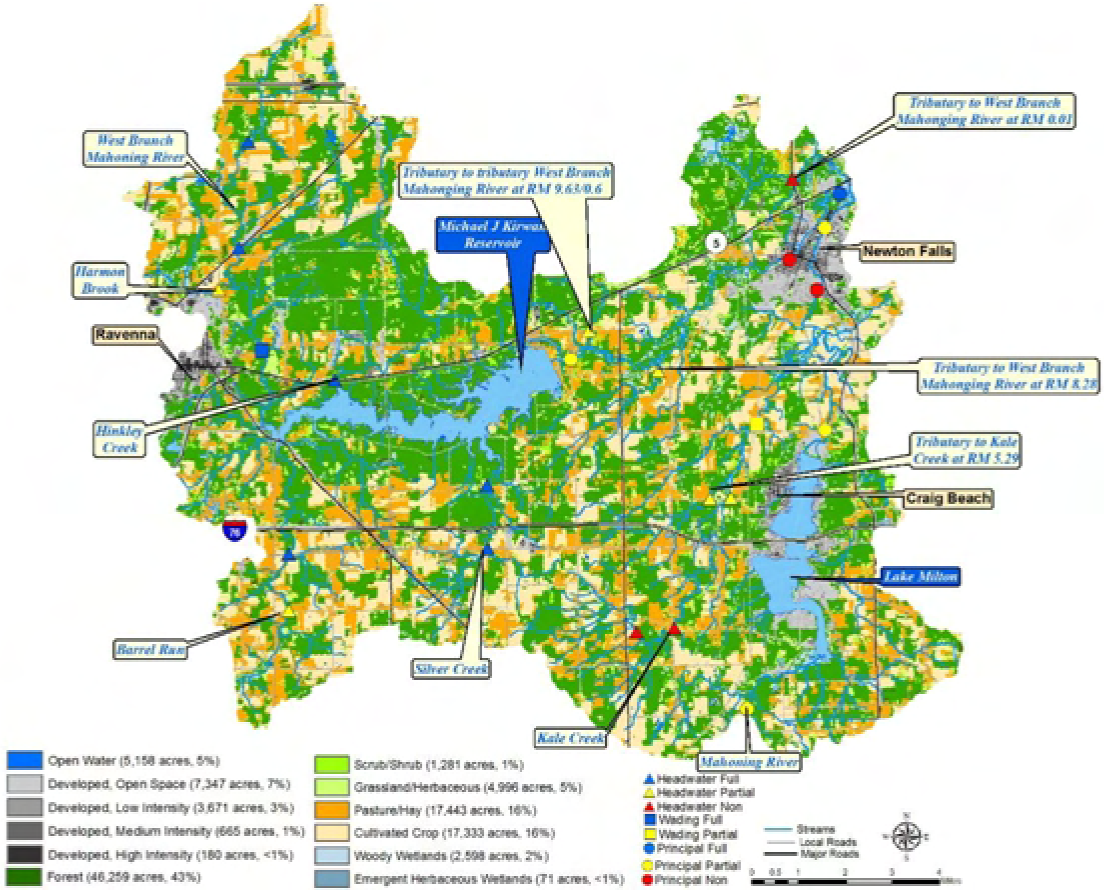


Figure 31. Land use and attainment status of sampling locations within West Branch Mahoning River subwatershed.

Table 19. Aquatic life use attainment status for stations sampled in the West Branch Mahoning River WAU based on data collected June-October 2006. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community.

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
HUC 12 – 050301030301 Kale Creek							
Kale Creek				*EOLP Ecoregion - WWH Existing*			
3000150 (13.57)	N/A	N/A	G	N/A	N/A		
N02K32 (13.08) [H]	32*	N/A	F*	51.0	**NON**	Alterations in stream side vegetative cover Siltation	Upstream agriculture Loss of riparian habitat
N02W09 (11.27) [H]	<u>26</u>*	N/A	F*	54.0	**NON**	Siltation Low dissolved oxygen	Unknown Failing septic?
N02W08 (6.05) [H]	32*	N/A	MG [NS]	51.0	PARTIAL	Natural conditions (flow and habitat)	Natural sources (impounded by beaver dam and log jam)
N02W07 (3.38) [W]	29*	7.3	42	65.0	PARTIAL	Low dissolved oxygen Turbidity	Agriculture
Trib to Kale Creek at RM 5.29				*EOLP Ecoregion - WWH Recommended*			
N02K31 (1.08) [H]	34*	N/A	G	56.5	PARTIAL	Siltation	Stream bank destabilization Bank erosion (natural?)
HUC 12 – 050301030302 Headwaters West Branch Mahoning River							
West Branch Mahoning River				*EOLP Ecoregion - WWH Existing*			
N02K28 (27.92) [H]	48	N/A	MG [NS]	64.5	FULL		
N02K27 (24.35) [H]	48	N/A	E	72.0	FULL		

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
300022 (20.94) [W]	49	9.3	52	82.0	FULL		
Harmon Brook				*EOLP Ecoregion - WWH Existing*			
N02K26 (0.49) [H]	54	N/A	LF*	77.0	PARTIAL	Siltation Organic enrichment (sewage) biological indicators Nutrient/eutrophication biological indicators	Agriculture On-site treatment systems (septic systems and similar decentralized systems) Upstream impoundments
HUC 12 – 050301030303 Barrel Run							
Barrel Run				*EOLP Ecoregion - WWH Existing*			
N02K24 (5.31) [H]	28*	N/A	MG [NS]	67.5	PARTIAL	Flow regime alteration	Small dam encountered ½ way through zone
N02K23 (3.65) [H]	44	N/A	G	61.5	FULL		
HUC 12 - 050301030304							
Hinkley Creek				*EOLP Ecoregion - WWH Existing*			
N02K22 (0.70) [H]	48	N/A	E	60.5	FULL		
Silver Creek (Trib to W. Branch)				*EOLP Ecoregion - WWH Existing*			
N02K21 (3.46) [H]	48	N/A	G	67.0	FULL		
N02K20 (1.83) [H]	42	N/A	G	68.0	FULL		
HUC 12 - 050301030305 Town of Newton Falls – West Branch Mahoning River							
West Branch Mahoning River				*EOLP Ecoregion - WWH Existing*			
300056 (11.39) [W]	44	7.4[NS]	22*	76.0	PARTIAL	Flow regime alteration	Influenced by upstream dam release

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
N02K15 (3.15)[B]	29*	6.6*	10*	34.5	**NON**	Flow regime alteration	Dam
N02P12 (0.36)[B]	46	8.3	42	78.5	FULL		
Trib to a Trib to West Branch Mahoning River at RM 9.63/0.74				*EOLP Ecoregion - WWH Existing*			
N02K17 (0.60)[H]	33*	N/A	46	40.5	PARTIAL	Direct habitat alteration	Channelization
Trib to West Branch Mahoning River at RM 8.28				*EOLP Ecoregion – WWH Recommended*			
N02K16 (0.27)[H]	32*	N/A	MG[NS]	42.5	PARTIAL	Siltation Flow regime alteration	Influenced by dam releases from West Branch Mahoning River
Trib to West Branch Mahoning River at RM .01				*EOLP Ecoregion - WWH Existing*			
N02K14 (2.10)[H]	28*	N/A	F*	67.5	**NON**	Siltation	Storm water from road
HUC 12 - 050301030306 Charley Run Creek – Mahoning River							
Mahoning River				*EOLP Ecoregion - WWH Existing*			
N01S11 (70.75)[B]	*30**	*8.7*	30[NS]	78.5	PARTIAL	Flow regime alteration	Influenced by upstream/downstream dam releases
602310 (62.68)[B]	*28**	*9.4*	34	80.5	PARTIAL	Flow regime alteration	Upstream impoundment
N02K30 (58.13)[B]	33*	7.4*	LF*	41.5	NON	Flow regime alteration	Newton Falls Dam backwater; Newton Falls PWS intake
N02S12 (56.53)[B]	45	9.5	26*	60.5	PARTIAL	Flow regime alteration	Downstream Newton Falls Dam

Ecoregion Biocriteria: Erie Ontario Lake Plain

	IBI			MIwb			ICI		
Site Type	**WWH**	**EWH**	**MWH**	**WWH**	**EWH**	**MWH**	**WWH**	**EWH**	**MWH**
Headwaters	40	50	24				34	46	22
Wading	38	50	24	7.9	9.4	6.2	34	46	22
Boat	40	48	24	8.7	9.6	6.6	34	46	22

H - Headwater electrofishing site.

W - Wading electrofishing site.

B - Boat electrofishing site.

a - MIwb is not applicable to headwater streams with drainage areas ≤ 20 mi^2.

b - A narrative evaluation of the qualitative sample based on attributes such as EPT taxa richness, number of sensitive taxa, and community composition was used when quantitative data were not available or considered unreliable. VP=Very Poor, P=Poor, LF=Low Fair, F=Fair, MG=Marginally Good, G=Good, VG=Very Good, E=Exceptional

c - Attainment status is given for both existing and proposed use designations.

ns - Nonsignificant departure from biocriteria (≤4 IBI or ICI units, or ≤0.5 MIwb units).

* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

Point Source Dischargers

Mahoning County Craig Beach WWTP 3PH00030 (Mahoning River mainstem)
This plant is operated by the Mahoning County Engineers office. The discharge is direct to the Mahoning River downstream from the Lake Milton dam. Treatment processes include bar screens, grit channel, extended aeration/oxidation ditch, clarifiers, and chlorine disinfection with dechlorination. The plant does not treat to remove phosphorus. Current monthly NPDES permit limits are cBOD5 (25 mg/l; 95.0 kg/day); TSS (30 mg/l; 114 kg/day). The WWTP is not limited for summer ammonia-N, however, twice weekly ammonia-N samples are required for compliance monitoring.

A compliance inspection report dated December 12, 2006 indicated that the plant was in general compliance with its NPDES permit. No violations of the NPDES permit were identified for the October 2005 through October 2006 period of record. Effluent flows and concentration of select chemical parameters have decreased over the 1995 to 2007 period of record (Figure 32).

Newton Falls WWTP 3PD00015 (Mahoning River mainstem)
Newton Falls WWTP was originally constructed in 1959. It was modified in 1986 to include manual screening, aerated grit removal, primary settling, rotating biological contractors (RBCs), final settling, and chlorination. The design flow is 0.500 mgd. The sewerage system in 1994 contained 28 CSOs and two points of overflow at the WWTP: locations 039 (influent bypass) and 040 (secondary clarifier bypass). From September 1995 to 2006 there were 182 bypass events at outfall 039 and 199 at outfall 040. Information on bypasses from 2005 to 2007 is given in Figure 33. During the 2006 and 2007 Upper Mahoning River basin survey there were 25 active CSOs and the two WWTP bypasses (see Figure 34, Table 20). There was no treatment to remove ammonia-N at the time of the 2006 survey. As shown in Figure 35, the average flow of the WWTP has consistently been over the 0.5 mgd design flow for many years.

During the survey of the Upper Mahoning River the Newton Falls WWTP was under construction to upgrade treatment processes to add ammonia treatment, expand design flow to 1.5 mgd to address CSO removal projects, and construction of a flow EQ basin to eliminate the two WWTP bypasses (outfalls 039 & 040). For the 2005 permit renewal process, the WWTP was given NPDES effluent limits (ammonia-N monthly limit-7 mg/l, 34 kg/d). Other NPDES permit limits are (TSS monthly 18 mg/l, 102 kg/d; cBOD5 (15 mg/l; 85 kg/day). The upgraded plant will not treat to remove phosphorus. The upgraded Newton Falls WWTP went on line in September 2007. This was after the Upper Mahoning River survey was conducted. The city is moving forward on a long term control plan to address the many CSOs present in their sewerage system.

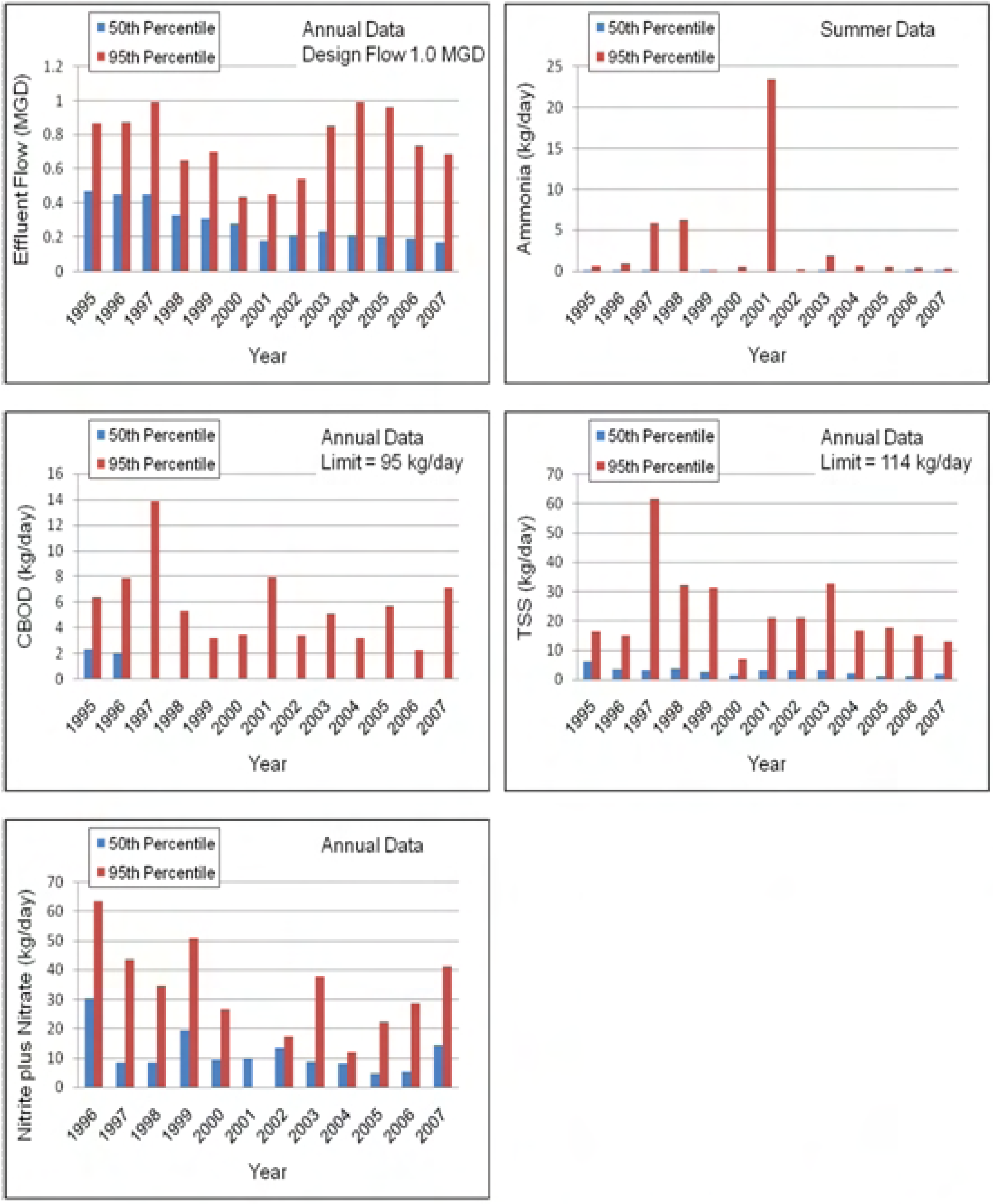
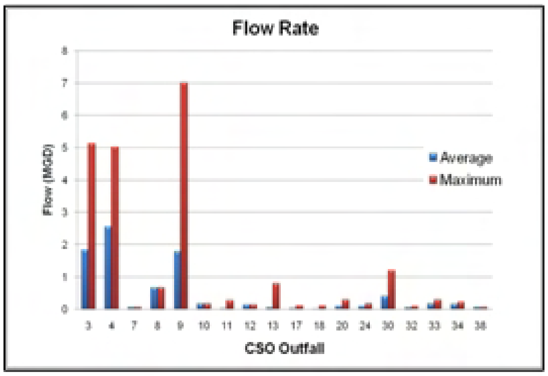
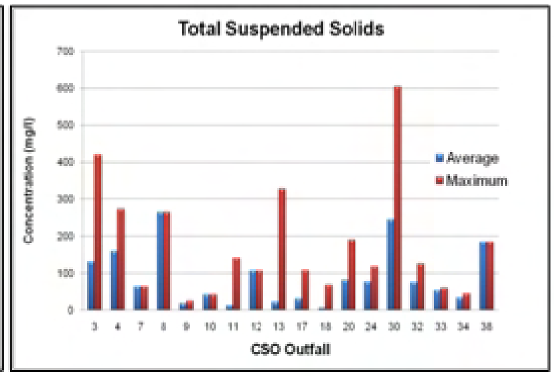


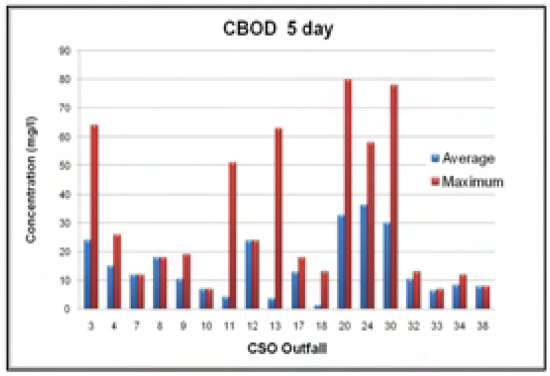
Figure 32. Annual flows, ammonia, carbonaceous biochemical oxygen demand (CBOD), total suspended solids, and nitrite plus nitrate loadings for the Mahoning Co. Craig Beech WWTP treated effluent 1995-2007. NPDES Permit #3PH00030.

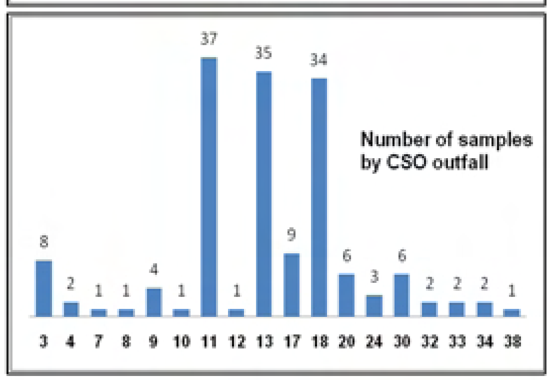




CSO Stations in NPDES Permit

Station Number	Description
3PD00015003	River Street @ Church St
3PD00015004	Church St. by Gas Meter Station
3PD00015007	River St @ Broad (N. of Bridge)
3PD00015008	River St @ Broad (S. of Bridge)
3PD00015009	River St @ Bridge (N. of Bridge)
3PD00015010	River St @ Bridge (S. of Bridge)
3PD00015011	River St @ Jay St
3PD00015012	River St @ Jay St
3PD00015013	River St @ Jay St
3PD00015014	High St @ Division St
3PD00015017	Between M Court & Milton Blvd
3PD00015018	Between S Court & Milton Blvd
3PD00015019	Superior St bet. Milton & E Branch
3PD00015020	Broad St (Fair Price Center)
3PD00015023	Warren Rd @ Tickner Ave
3PD00015024	930 Warren Rd @ Jackson St
3PD00015027	W. 6th Ave @ W. River Blvd
3PD00015028	W. River between W. 5th and 4th
3PD00015030	Newton Falls Pump Station #4
3PD00015032	Newton Falls Pump Station #1
3PD00015033	Ravenna St. @ Bane Ave
3PD00015034	Ravenna St. @ Church St
3PD00015035	Broad St bet. Canal & W. Branch Mahoning
3PD00015037	Newton Falls Pump Station #2
3PD00015038	Water St. @ Olive St





Monitoring Requirements for CSOs

The permittee shall monitor the system overflows identified in Item E at stations 3PD00015002 through 3PD00015038 and report to the Ohio EPA in accordance with the following table:

CHARACTERISTIC			MONITORING REQUIREMENTS	
Reporting			Measurement	
Code	Units	Parameter	Frequency	Sample Type
00530	mg/l	Suspended Solids	1/Month	Grab
50050	Million Gallons	Volume	When discharging	Daily Est.
80082	mg/l	CBOD5	1/Month	Grab
80998	Number/Month	Occurrences	When discharging	Estimate
80999	Hours	Duration	When discharging	Daily Est.

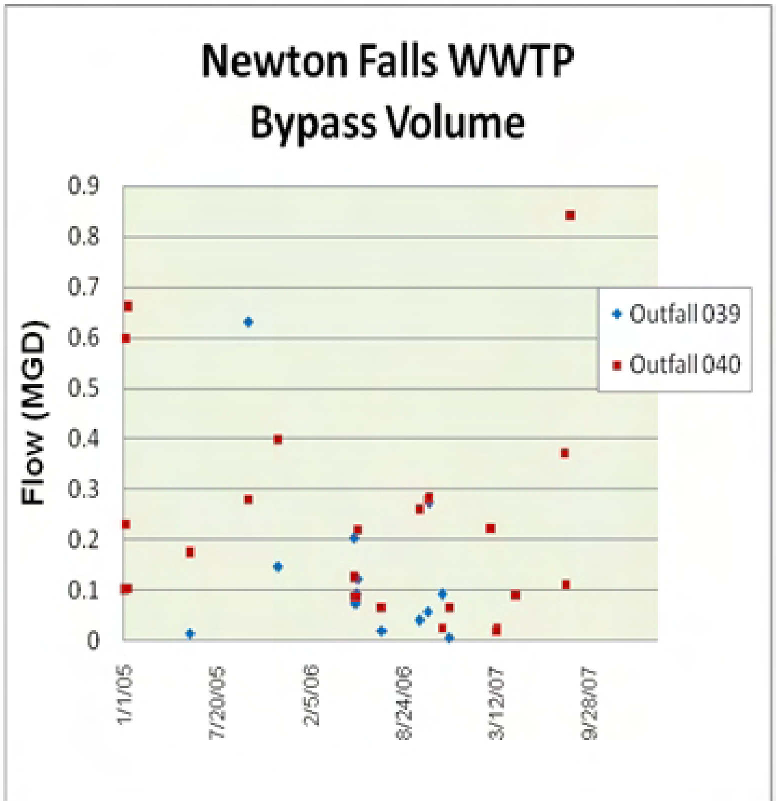
Figure 33. Combined Sewer Overflow (CSO) information for Newton Falls WWTP (NPDES Permit #3PD00015. Information based on data in Ohio EPA database for the time period 1999-2007.

Table 20. Location of CSOs and WWTP plant bypasses for Newton Falls WWTP at the time of the 2006-2007 Upper Mahoning River survey.

Station Number	Description	Receiving Stream	Lat./Long.
3PD00015003	River Street @ Church St.	E. Branch Mahoning River	(41 11 07 / 80 58 50)
3PD00015004	Church St. by Gas Meter Station	E. Branch Mahoning River	(41 11 08 / 80 58 49)
3PD00015007	River St @ Broad (N. of Bridge)	E. Branch Mahoning River	(41 11 14 / 80 58 47)
3PD00015008	River St @ Broad (S. of Bridge)	E. Branch Mahoning River	(41 11 12 / 80 58 50)
3PD00015009	River St @ Bridge (N. of Bridge)	E. Branch Mahoning River	(41 11 20 / 80 58 44)
3PD00015010	River St @ Bridge (S. of Bridge)	E. Branch Mahoning River	(41 11 18 / 80 58 44)
3PD00015011	River St @ Jay St.	E. Branch Mahoning River	(41 11 22 / 80 58 44)
3PD00015012	River St @ Jay St.	E. Branch Mahoning River	(41 11 21 / 80 58 42)
3PD00015013	River St @ Jay St.	E. Branch Mahoning River	(41 11 20 / 80 58 42)
3PD00015014	High St @ Division St.	E. Branch Mahoning River	(41 11 34 / 80 58 40)
3PD00015017	Between M Court & Milton Blvd	E. Branch Mahoning River	(41 10 55 / 80 58 36)
3PD00015018	Between S Court & Milton Blvd	E. Branch Mahoning River	(41 10 50 / 80 58 33)
3PD00015019	Superior St bet. Milton & E. Br.	E. Branch Mahoning River	(41 11 10 / 80 58 48)
3PD00015020	Broad St (Fair Price Center)	E. Branch Mahoning River	(41 11 12 / 80 58 46)
3PD00015023	Warren Rd @ Tickner Ave.	E. Branch Mahoning River	(41 11 36 / 80 58 34)
3PD00015033	Ravenna St. @ Bane Ave.	W. Branch Mahoning River	(41 11 12/ 80 59 25)
3PD00015034	Ravenna St. @ Church St.	W. Branch Mahoning River	(41 11 15/ 80 59 13)
3PD00015035	Broad St bet. Canal & W. Br	W. Branch Mahoning River	(41 11 20/ 80 59 02)
3PD00015037	Newton Falls Pump Station #2	W. Branch Mahoning River	(41 11 44/ 80 58 48)
3PD00015038	Water St. @ Olive St.	W. Branch Mahoning River	(41 11 50/ 80 58 44)
3PD00015039	039 Bypass at plant influent		(Lat: 41W 11' 32"; Long: 80W 58' 40")
3PD00015040	040 Bypass of Secondary Treatment (after primaries)		(Lat: 41N 11' 31"; Long: 80W 58' 40")

Newton Falls NPDES bypass outfalls

3PD00015039 Bypass at plant influent
3PD00015040 Bypass of Secondary Treatment (after primaries)



TSS Data

Outfall	Average	Median	Maximum	Minimum	# of samples
039	240.4	124	820	14	13
040	358.4	182	2000	42	25

cBOD5 Data

Outfall	Average	Median	Maximum	Minimum	# of samples
039	59	30	168	11	13
040	82.9	42	450	18	25

Figure 34. NPDES bypass information for Newton Falls WWTP (NPDES Permits #3PD00015). Information based on data in Ohio EPA database for the time period 2005-2007.

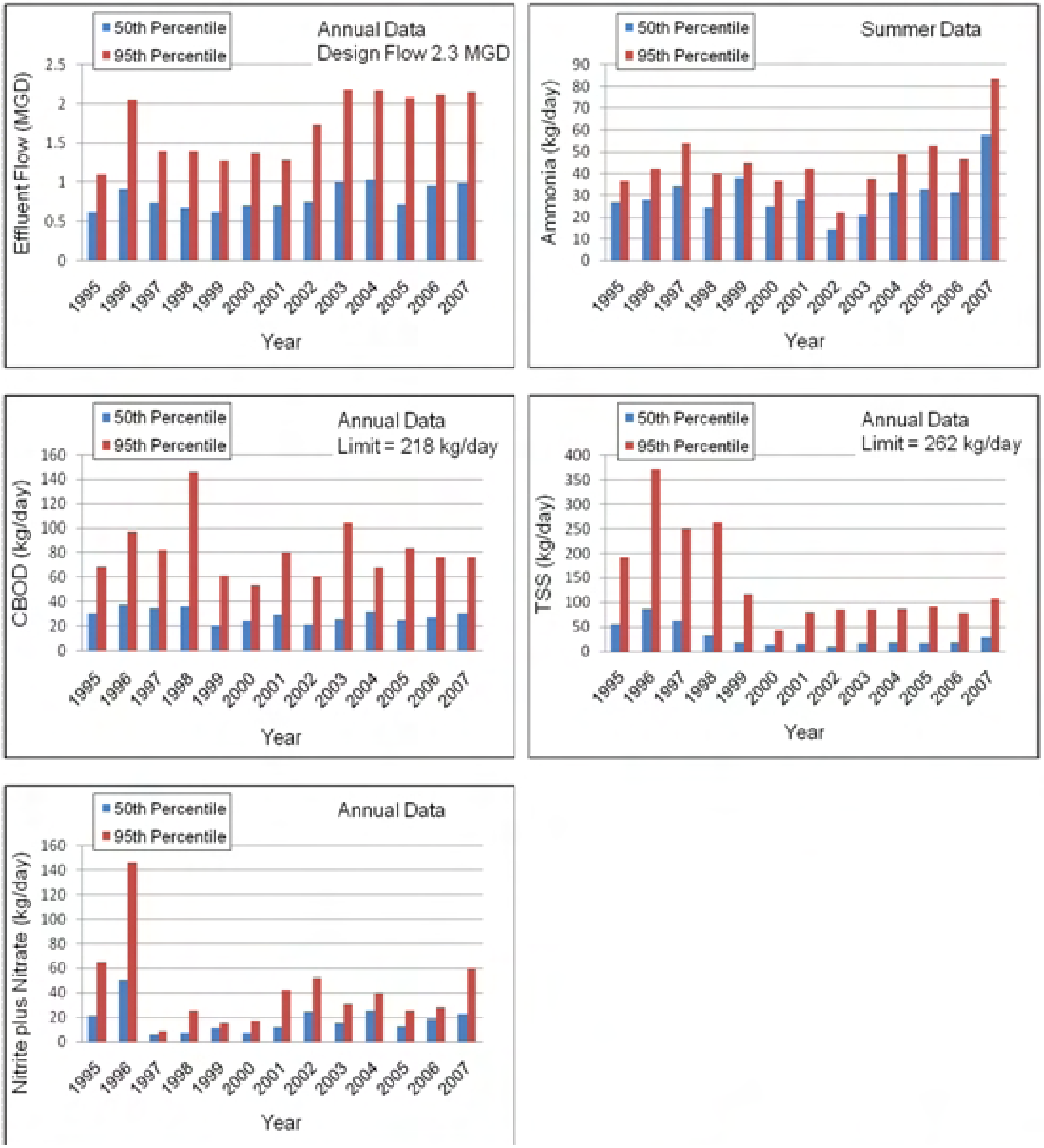


Figure 35. Annual flows, ammonia, carbonaceous biochemical oxygen demand (CBOD), total suspended solids, and nitrite plus nitrate loadings for the Newton Falls WWTP treated effluent 1995-2007. NPDES Permit #3PD00015.

Recreation Use

This WAU covers the drainage area downstream from the Lake Milton dam, including the West Branch Mahoning River, to the point of confluence of the West Branch and mainstem of Mahoning River downstream from Newton Falls. Full attainment of PCR criteria was recorded at all mainstem Mahoning River sample locations within the city limits of Newton Falls.

Widespread non-attainment of PCR was recorded in all HUC-12 sub watersheds except for Hinkley Creek. Fourteen of twenty (70%) tributary sampling locations in the WAU were found to be in non-attainment of PCR. Within the Kale Creek watershed, 4 of 5 (80%) sample locations were in non-attainment. Silver Creek, Harmon Brook, and Barrel Run all showed non-attainment of PCR at 100% of sample locations. Bacteria problems also were noted at the RM 8.28 and RM 9.63 tributaries to the West Branch Mahoning River. Specific sources of bacteria have not been identified for these streams but would include a mixture of agricultural activities, failing home sewage treatment systems (HSTS), and discharges from small WWTPs such as mobile home parks and commercial operations. It is recommended that a survey be conducted to identify the specific sources of bacteria that are causing the widespread non-attainment of the PCR use.

Three of six (50%) of the sampling locations along the mainstem of the West Branch Mahoning River showed non-attainment of PCR. Two locations with elevated bacteria (RMs 24.35, 20.94) are upstream from the M.J. Kirwan West Branch Reservoir dam. Specific sources of bacteria are unknown for the most upstream RM 24.35 location, however, the RM 20.94 location is downstream from Harmon Brook, where elevated bacteria counts were recorded, and downstream from three mobile home parks (Hamlet MHP, Oaks MHP and Maple Dell MHP). It is recommended that a future survey of the West Branch Mahoning River be conducted to identify specific sources of bacteria upstream from the M. J. Kirwan Reservoir.

Bacteria counts fully met PCR criteria in the West Branch Mahoning River downstream from the M.J. Kirwan dam at RM 11.39 (Wayland Rd.), however non-attainment was again recorded near the mouth (RM 0.36) downstream from Newton Falls. CSOs and urban runoff from Newton Falls are potential sources of bacteria observed at RM 0.36. It is recommended that a survey be conducted to identify the impact of CSOs on bacteria quality in the West Branch Mahoning River from the Newton Falls area.

Chemical Water Quality

Grab water samples were collected at twenty three sampling locations within this WAU to support the results of the biological surveys (excluding the Mahoning River mainstem). These samples were collected from thirteen streams that are tributaries to the Upper Mahoning River. All chemical samples were collected on the same day within the WAU, thus controlling for the effect of stream flow on the interpretation of data from each sample run. Additional chemical samples were collected from the Newton Falls WWTP effluent, which has a direct discharge to the Mahoning River mainstem (Table 7).

The M. J. Kirwan Reservoir (aka West Branch Reservoir) is a large impoundment of the West Branch Mahoning River. It is owned by the Army Corps of Engineers and provides flood control and low flow augmentation. It is also a popular recreation area and is used as a source of public drinking water. The West Branch WTP serves about 1,400 persons as a transient non-community system and is operated by the Ohio DNR. The dam discharges mostly from gates located near the middle of the lake (about 85% of total annual discharge), unless the reservoir is at full pool stage. Bottom release from this dam is very rare (communication with Diane Ryszkiewkz of Army Corps).

Biological sampling (for both fish and benthic macroinvertebrates) was conducted at twenty locations within the WAU. Impaired biological communities were found at sixty percent (12/20) of the biological sample locations. Chemical data were compared against OAC 3745-1 water quality criteria and TMDL target nutrients as median values (NO_2-NO_3 = 1.50 mg/l; TP = 0.08 mg/l for watersheds < 20 mi^2, 0.10 mg/l for watersheds > 20 < 200 mi^2) to help identify potential chemical stressors on biology.

Harmon Brook

Biological sampling at RM 0.49 showed an exceptional fish community (IBI = 54) but only a fair community of benthic macroinvertebrates. Potential chemical stressors on the macroinvertebrates include a dissolved oxygen measurement less than the WQS criterion of 5.0 mg/l (4.65 mg/l) and total phosphorus above TMDL target goal (TP median = 0.113 mg/l). Nitrates were not elevated although the detection of ammonia in most samples along with elevated fecal coliform bacteria suggests that failing home sewage treatment systems may be present. Additional sampling in the watershed is recommended to better document the extent of the impairment to the macroinvertebrate community and to identify specific causes and sources.

Barrel Run

Samples were collected at two locations, RM 5.31 and RM 3.65. Full biological attainment was found at the downstream station. The fish community was impaired at the RM 5.31 sample location but the macroinvertebrate community was judged to be marginally good. Potential chemical stressors include nutrients and ammonia-N, phosphorus was just above the TMDL target goal of 0.080 mg/l (TP median = 0.095 mg/l, n=5). Dissolved oxygen was consistently lower at the RM 5.31 station which suggests the presence of organic matter. Fecal coliform bacteria counts were elevated at both sample locations. Additional sampling will need to be conducted upstream from RM 5.31 to identify specific causes and sources to help explain the biological non-attainment.

Hinkley Creek

Full biological attainment was found at RM 0.70. The sample location was downstream from the discharge of the West Branch Mobile Home Park. Hinkley Creek also receives storm water runoff from sections of the Ravenna Army Ammunition Plant (aka Ravenna Army Arsenal). No chemical parameters exceeded water quality criteria and nutrients were below TMDL target goals. Overall this stream was found to be in good biological and chemical condition.

Tributary to Hinkley Creek RM 1.62

No biological sampling was conducted on this stream, which also goes by the name of B-Block Tributary to Hinkley Creek. A grab water sample and sediment sample for heavy metals was collected on 07/20/2006 as part of a cooperative survey between Ohio EPA Division of Emergency and Remedial Response (DERR) and Division of Surface Water (DSW). The purpose of this survey was to assess the chemical quality of ten streams draining from the Ravenna Training and Logistics Site (aka Ravenna Army Ammunition Plant), to provide data for the upper Mahoning River survey, and DERR regulatory responsibilities. The data for this special survey are presented in Appendix D. The results indicate that no heavy metals were found in the samples from the RM 1.62 tributary to Hinkley Creek that exceed either stream water quality criteria or DERR sediment reference concentrations for ecological risk assessment.

Silver Creek (trib to West Branch)

Full biological attainment was found at both sample locations (RM 2.03, RM 3.46). No problems were noted with chemical quality, nutrients were at low concentrations at both locations, well below TMDL targets. However, elevated levels of fecal coliform bacteria were recorded at both locations, although specific sources are unknown. It is recommended that a bacteria survey be conducted in the watershed to identify sources of bacteria.

Kale Creek

Samples were collected at four stream locations along the mainstem of Kale Creek (RMs 3.38, 6.05, 11.27, 13.08). All four sampling locations showed impaired biological conditions. Kale Creek enters the Mahoning River mainstem at RM 59.60, about 1.4 river miles upstream from the Newton Falls public drinking water plant intake. Depressed habitat potential (QHEI = 51.0) is the most likely cause of non-attainment in Kale Creek at the upper most sample location (RM 13.08). No problems with chemical water quality were indicated. Evidence of chemical stress at the next downstream station at RM 11.27 was indicated by a decline in dissolved oxygen between RM 13.08 (Lane off St.Rt. 225) and RM 11.27 (Williams Rd.). On average, dissolved oxygen declined from 7.97 mg/l to 6.20 mg/l with a minimal DO of 3.81 mg/l at RM 11.27, a violation of water quality criteria. Compared to RM 13.08, depressed dissolved oxygen continued at all downstream stations. Total suspended solids increased from an average of 17.0 mg/l to 36.0 mg/l between RM 13.08 and RM 11.27, and continued to be elevated at RM 6.11 (TSS mean = 27.3 mg/l, n=4). TSS decreased to background levels at RM 3.38 (TSS mean = 12.4, n=11). Specific sources of oxygen demanding material and suspended solids are unknown, but likely associated with agricultural activities. There was no evidence of nutrient enrichment in Kale Creek at any sample location. Phosphorus on average ranged from 0.050 mg to 0.071 mg/l at the four sample locations, less than the 0.080 mg/l TMDL target for the Kale Creek watershed. These data suggest that depressed habitat diversity as measured by QHEI, stress from low dissolved oxygen, and elevated TSS combine to help explain the widespread non-attainment of biology in Kale Creek.

Tributary to Kale Creek RM 5.29

Partial biological attainment was recorded with the fish community depressed (IBI = 34). No significant problems were noted with chemical water quality. Both nitrates and total phosphorus were on average below TMDL targets. QHEI was somewhat depressed below WWH potential (QHEI = 56), which may help explain the depressed fish community observed.

West Branch Mahoning River

The West Branch Mahoning River is a major tributary of the Upper Mahoning River basin located within this WAU. It is 29.2 miles in length and drains 108.6 mi^2. In addition to the M. J. Kirwan Reservoir (West Branch Reservoir), there is a low head dam in Newton Falls. Of the six sample locations along the West Branch Mahoning River, four showed full biological attainment, including all stations upstream from the M. J. Kirwan Reservoir, however, the sample locations downstream from the Kirwan Reservoir and a low head dam in Newton Falls reflected impaired conditions.

Partial biological attainment was recorded immediately downstream from the M. J. Kirwan Reservoir dam (RM 11.39) due to poor condition of the macroinvertebrate community; both fish indices showed full attainment. The response of the biological communities suggested a differential stressor (e.g., causes stress to macroinvertebrates but not fish). Analysis of the chemical data suggested that elevated levels of ammonia nitrogen may serve this role. Ammonia on average was 0.112 mg/l at RM 11.39 downstream from the M. J. Kirwan dam, while it was normally below lab detection (< 0.05 mg/l) upstream from the reservoir at RM 20.94. Both phosphorus and nitrates were low at RM 11.39 where ammonia was elevated, thus the data indicated a source of ammonia not associated with sewage. Release of ammonia from the lake is one potential source. However, communication with the Army Corps of Engineers indicates that about 85% of the time the discharge from the M. J. Kirwan Reservoir dam is from flow gates that are located at mid lake depth, and that water is rarely released from the bottom gates. Another possible source of ammonia would be the use of ammonia based fertilizers on agricultural lands that have potential to drain into the West Branch Mahoning River between the lake dam and the sample location at RM 11.39. Algae being released from the M. J. Kirwan Reservoir, perhaps species that release toxic chemicals, could be a nonchemical stressor to help explain the depressed macroinvertebrate community.

Tributary to West Branch Mahoning River RM 0.01
Biological sampling at RM 2.10 indicated non-attainment for both fish and macroinvertebrates. Excessive stream bed siltation was noted during the biological survey. This tributary receives the discharge from the Ohio Army National Guard WWTP. The chemical data indicated stress from low dissolved oxygen in summer months (DO minimum of 3.38 mg/l). Ammonia and nutrients were not elevated. It is recommended that a survey be conducted of the upstream watershed to identify why oxygen levels are depressed in this stream. This survey should include a WLA model of the National Guard WWTP for dissolved oxygen.

A sediment sample for heavy metals was collected on 07/20/2006 as part of a cooperative survey between Ohio EPA Division of Emergency and Remedial Response (DERR) and Division of Surface Water (DSW). The purpose of this survey was to assess the chemical quality of ten streams draining from the Ravenna Training and Logistics Site (aka Ravenna Army Ammunition Plant), to provide data for the upper Mahoning River survey, and DERR regulatory responsibilities. The data for this special survey are presented in Appendix D. The results indicate that no heavy metals were found in the samples from the RM 0.01 Tributary that exceed DERR sediment reference concentrations for ecological risk assessment.

Tributary to West Branch Mahoning River RM 4.85
No biological sampling was conducted on this stream. A grab water sample and sediment sample for heavy metals was collected on 07/20/2006 as part of a cooperative survey between Ohio EPA Division of Emergency and Remedial Response (DERR) and Division of Surface Water (DSW). The purpose of this survey was to assess the chemical quality of ten streams draining from the Ravenna Training and Logistics Site (aka Ravenna Army Ammunition Plant), to provide data for the upper Mahoning River survey, and DERR regulatory responsibilities. The data for this special survey are presented in Appendix D. The results indicate that no heavy metals were found in the samples from the RM 4.85 tributary of the West Branch Mahoning River that exceed either stream water quality criteria or DERR sediment reference concentrations for ecological risk assessment.

Tributary to West Branch Mahoning River RM 8.28
Biological sampling showed partial attainment due to a depressed fish community, largely explained by poor habitat diversity (QHEI = 42.5). No significant problems were noted with chemical water quality, although fecal coliform bacteria were elevated suggesting runoff from home sewage treatment systems. The presence of marginally good macroinvertebrates and lack of

chemical stressors suggested that depressed habitat was the most significant reason for the depressed fish community.

Tributary to West Branch Mahoning River RM 9.63
No biological sampling was conducted on this stream. A grab water sample and sediment sample for heavy metals was collected on 07/20/2006 as part of a cooperative survey between Ohio EPA Division of Emergency and Remedial Response (DERR) and Division of Surface Water (DSW). The purpose of this survey was to assess the chemical quality of ten streams draining from the Ravenna Training and Logistics Site (aka Ravenna Army Ammunition Plant), to provide data for the upper Mahoning River survey, and DERR regulatory responsibilities. The data for this special survey are presented in Appendix D. The results indicate that no heavy metals were found in the samples from the RM 9.63 tributary of the West Branch Mahoning River that exceed either stream water quality criteria or DERR sediment reference concentrations for ecological risk assessment.

Tributary to RM 9.63 Tributary West Branch Mahoning River RM 0.74
Biological sampling indicated an exceptional macroinvertebrate community (ICI = 46) with fish depressed largely due to poor habitat diversity (QHEI = 40.5). No significant problems were noted with chemical water quality, although fecal coliform bacteria were elevated suggesting runoff from home sewage treatment systems. The presence of exceptional macroinvertebrates, and lack of chemical stressors, suggests that depressed habitat is the most significant reason for the depressed fish community.

A grab water sample and sediment sample for heavy metals was collected on 07/20/2006 as part of a cooperative survey between Ohio EPA Division of Emergency and Remedial Response (DERR) and Division of Surface Water (DSW). The purpose of this survey was to assess the chemical quality of ten streams draining from the Ravenna Training and Logistics Site (aka Ravenna Army Ammunition Plant), to provide data for the upper Mahoning River survey, and DERR regulatory responsibilities. The data for this special survey are presented in Appendix D. The results indicate that no heavy metals were found in the samples from the RM 0.74 tributary to the RM 9.63 tributary of the West Branch Mahoning River that exceed either stream water quality criteria or DERR sediment reference concentrations for ecological risk assessment.

Physical Habitat
The habitat of four Mahoning River mainstem locations and 20 tributary sites were evaluated with the QHEI. The average QHEI score for the mainstem sites was 65.3 (range of 41.5 – 80.5), while the tributary scores had an average QHEI score of 61.9 (range of 34.5-78.5). Flow regime alteration from the upstream and downstream dams scattered along the mainstem was the overriding force affecting the quality of habitat available to aquatic organisms. Several tributaries

were also affected by the dams, though direct alterations to stream channels and vegetative cover were the cause of several lower QHEI scores.

Mahoning River

Four sites were sampled along the Mahoning River from downstream from Newton Falls dam (RM 56.5) to downstream from Berlin Lake (RM 70.7). The two upper sites (RMs 70.7 and 62.68) had diverse substrates and a variety of instream cover, but the hydrologic regime of each was strongly influenced by upstream dams (Figure 36). Although the habitat was sufficient (QHEI=78.5 at RM 70.7 and QHEI=80.5 at RM 62.7), the severely altered hydrologic regime limited the ability of the area to support WWH fish communities.

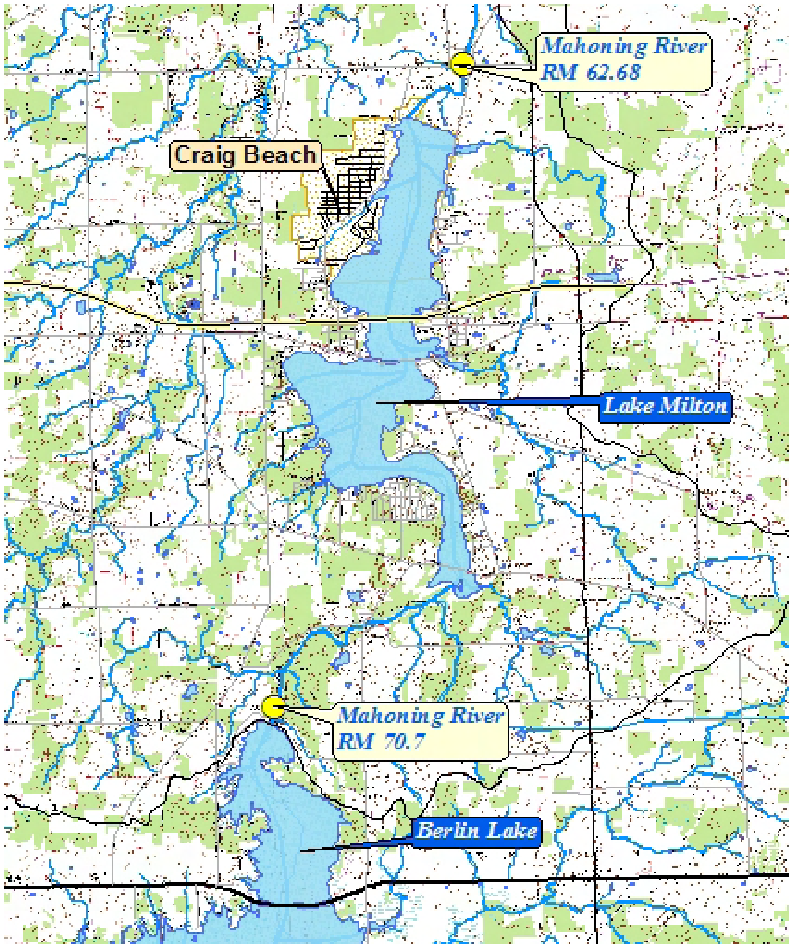


Figure 36. Proximity of Mahoning River sampling locations to Berlin Lake and Lake Milton.

Further downstream, the backwaters of the Newton Falls dam (RM 58.1) created an impounded reach that acted as a sink for silt, limiting the amount of interstitial spaces available for aquatic life. The site had two high influence MWH attributes, limiting its ability to support WWH communities (Figure 37). The sampling location downstream from the Newton Falls dam (RM 56.5) was greatly influenced by all of the upstream dams. In addition, it also had two high influence MWH attributes that limited its ability to support WWH communities.

West Branch Mahoning River

The West Branch Mahoning River was sampled in six locations from Cooley Road (RM 27.9) to County Road 114A (RM 0.4). The three sites upstream from Kirwan Reservoir had QHEI scores between 64.5 and 82.0, indicating good quality habitat able to support WWH communities. The site just below Kirwan

Reservoir (RM 11.39) received a QHEI score of 76.0, which would seem to indicate its ability to support WWH communities. However, the altered flow regime created by the dam releases inhibited the ability of the stream to support WWH communities in this area. Within the town of Newton Falls, the site near 6th Street Park (RM 3.15) was located within the backwaters of a dam further downstream. Situated in the backwaters, the area acted as a sink for silt and had little diversity in flow patterns. These factors affected the ability of the stream to support WWH communities as the site received a QHEI of only 34.5. The most downstream site (RM 0.4) had extensive amounts of instream cover balanced with diverse stream flow patterns which provided diverse habitat for aquatic fauna. The site received a QHEI of 78.5 indicating its ability to support WWH communities.

Tributaries

Several of the remaining streams sampled within the West Branch Mahoning River basin had habitat suitable to support WWH communities. Barrel Run, Harmon Brook, Silver Creek, Hinkley Creek and the tributary to West Branch Mahoning River (RM 0.01) all had QHEI scores ranging from 60.5 to 77.0 with an average QHEI of 67.0 (Figure 37 and Figure 38). Hinkley Creek (QHEI of 60.5) had three high influence MWH attributes, but the stream appeared to have recovered from much of the historical anthropogenic influences. The upstream site on Barrel Run (RM 5.3) was the only other site within this group which received a MWH attribute. The lack of sinuosity within this reach of Barrel Run was compounded by the presence of a small dam which influenced the flow regime. In general, the streams with QHEI scores >60 should be able to support WWH communities.

The most downstream site on Kale Creek (RM 3.7) received a QHEI score of 65.0, indicating it could potentially support WWH communities. However, the three remaining sites on Kale Creek received QHEI scores between 51.0 and 54.0 (average of 52.0) indicating the stream overall is less likely able to support WWH communities. In addition, the tributary to Kale Creek at RM 5.29 received a QHEI score of 56.5, indicating that it was less likely to support WWH communities. All of the sites sampled within this group except for Kale Creek RM 3.7 had more moderate influence MWH attributes than WWH attributes. This indicates that anthropogenic influences have compromised the integrity of the habitats available for aquatic life. While these streams may still support WWH communities, it is less likely due to the decreased habitat quality.

The two remaining streams sampled within the West Branch Mahoning River basin received QHEI scores of 40.5 (tributary to a tributary of West Branch Mahoning River RM 9.63/0.74) and 42.5 (tributary to West Branch Mahoning River RM 8.28) landing them within the poor range of habitat scores (Figure 38). Eroding banks were noted along the first stream and silt had backed up behind the bridge, limiting the habitat available to aquatic organisms. The other stream, a tributary to West Branch Mahoning River RM 8.28, was dramatically influenced by dam releases on the West Branch Mahoning River. According to a land owner who had grown up along the stream, prior to the dam being built the stream had teamed with turtles, frogs, fish and other aquatic organisms. He stated that prior to the dam, the stream had a swift current, though now it was primarily a backwaters area for the West Branch Mahoning River. The landowner also stated that road work about 10 years earlier had realigned the stream; cutting off its sinuosity and leaving in place a straightened channel. The highly modified conditions present within both streams indicated they were not likely able to support WWH communities.

HUC 05030103030 QHEI Attributes

Key QHEI Components

WWH Attributes

Site / River Mile	QHEI	Gradient (ft/mile)	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes
(18-001) Mahoning River, Year: 2006													
70.7	78.5	5.00	■	■		■		■	■		■	■	7
62.7	80.5	7.09	■	■		■		■	■	■	■		7
58.1	41.5	0.10						■			■		2
56.5	60.5	2.87		■				■	■	■	■		5
(18-048) Kale Creek, Year: 2006													
13.1	51.0	19.23	■				■	■			■		4
11.3	54.0	5.03	■	■			■	■			■		5
6.1	51.0	6.25	■					■			■		3
3.7	65.0	28.59		■				■		■	■	■	5
(18-050) West Branch Mahoning River, Year: 2006													
27.9	64.5	13.51	■	■		■		■		■		■	6
24.4	72.0	19.61	■	■		■	■	■	■		■	■	8
20.9	82.0	25.00	■	■		■	■	■	■		■	■	8
11.4	76.0	2.75	■				■	■	■	■	■	■	7
3.2	34.5	5.24						■			■		2
0.4	78.5	2.39	■				■	■	■	■	■	■	7
(18-054) Barrel Run, Year: 2006													
5.3	67.5	13.51	■	■			■	■		■	■		6
3.7	61.5	18.18	■	■			■	■			■		5
(18-055) Harmon Brook, Year: 2006													
0.5	77.0	27.78	■	■		■	■	■		■	■	■	8
(18-094) Trib. to Kale Creek (RM 5.29), Year: 2006													
1.1	56.5	10.87	■				■	■					3

MWH Attributes — High Influence

Site / River Mile	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes
(18-001) Mahoning River						
70.7						0
62.7						0
58.1	◆	◆				2
56.5	◆	◆				2
(18-048) Kale Creek						
13.1		◆				1
11.3						0
6.1		◆	◆			2
3.7						0
(18-050) West Branch Mahoning River						
27.9			◆		◆	2
24.4						0
20.9						0
11.4						0
3.2	◆	◆				2
0.4						0
(18-054) Barrel Run						
5.3			◆			1
3.7						0
(18-055) Harmon Brook						
0.5						0
(18-094) Trib. to Kale Creek (RM 5.29)						
1.1					◆	1

MWH Attributes — Moderate Influence

Site / River Mile	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(18-001) Mahoning River															
70.7					●	●				●	●		4	0.13	0.63
62.7						●					●		2	0.13	0.38
58.1		●			●	●			●	●		●	6	1.00	3.00
56.5		●			●	●				●		●	5	0.50	1.33
(18-048) Kale Creek															
13.1		●		●	●				●	●	●	●	7	0.40	1.80
11.3	●	●			●				●	●	●		6	0.17	1.17
6.1		●			●				●	●		●	5	0.75	2.00
3.7	●				●	●			●				4	0.17	0.83
(18-050) West Branch Mahoning River															
27.9					●				●				2	0.43	0.71
24.4		●								●			2	0.11	0.33
20.9										●	●		2	0.11	0.33
11.4					●	●							2	0.13	0.38
3.2		●			●	●			●	●		●	6	1.00	3.00
0.4					●								1	0.13	0.25
(18-054) Barrel Run															
5.3		●			●				●	●	●		5	0.29	1.00
3.7		●			●				●	●	●	●	6	0.17	1.17
(18-055) Harmon Brook															
0.5		●			●				●				3	0.11	0.44
(18-094) Trib. to Kale Creek (RM 5.29)															
1.1		●			●				●	●	●		5	0.50	1.75

03/19/2008 1

Figure 37. QHEI attributes for sites within the West Branch Mahoning River WAU, 2006.

HUC 05030103030 QHEI Attributes

Key QHEI Components

WWH Attributes

River Mile	QHEI	Gradient (ft/mile)	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes
(18-051) Silver Creek, Year: 2006													
3.5	67.0	19.61	■	■		■	■	■	■		■		7
1.8	68.0	2.08	■	■		■	■	■		■	■	■	8
(18-052) Hinkley Creek, Year: 2006													
0.7	60.5	21.05	■	■						■		■	4
(18-069) Trib. to W. Br. Mahoning R. (RM 0.01), Year: 2006													
2.1	67.5	15.87	■				■	■			■	■	5
(18-083) Trib to W. Br. Mahoning R (RM 9.63/0.74), Year: 2006													
0.6	40.5	15.38	■				■			■			3
(18-093) Trib. to W. Br. Mahoning R. (RM 8.28), Year: 2006													
0.3	42.5	7.30	■								■		2

MWH Attributes — High Influence

River Mile	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes
3.5 (18-051)						0
1.8 (18-051)						0
0.7 (18-052)			◆	◆	◆	3
2.1 (18-069)						0
0.6 (18-083)	◆		◆	◆	◆	4
0.3 (18-093)			◆	◆		2

MWH Attributes — Moderate Influence

River Mile	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
3.5 (18-051)		●			●					●	●		4	0.13	0.63
1.8 (18-051)									●				1	0.11	0.22
0.7 (18-052)		●			●				●				3	0.80	1.40
2.1 (18-069)		●			●				●	●			4	0.17	0.83
0.6 (18-083)				●	●				●			●	4	1.25	2.25
0.3 (18-093)	●	●		●	●				●	●		●	7	1.00	3.33

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Figure 37 continued. QHEI attributes for sites within the West Branch Mahoning River WAU, 2006.

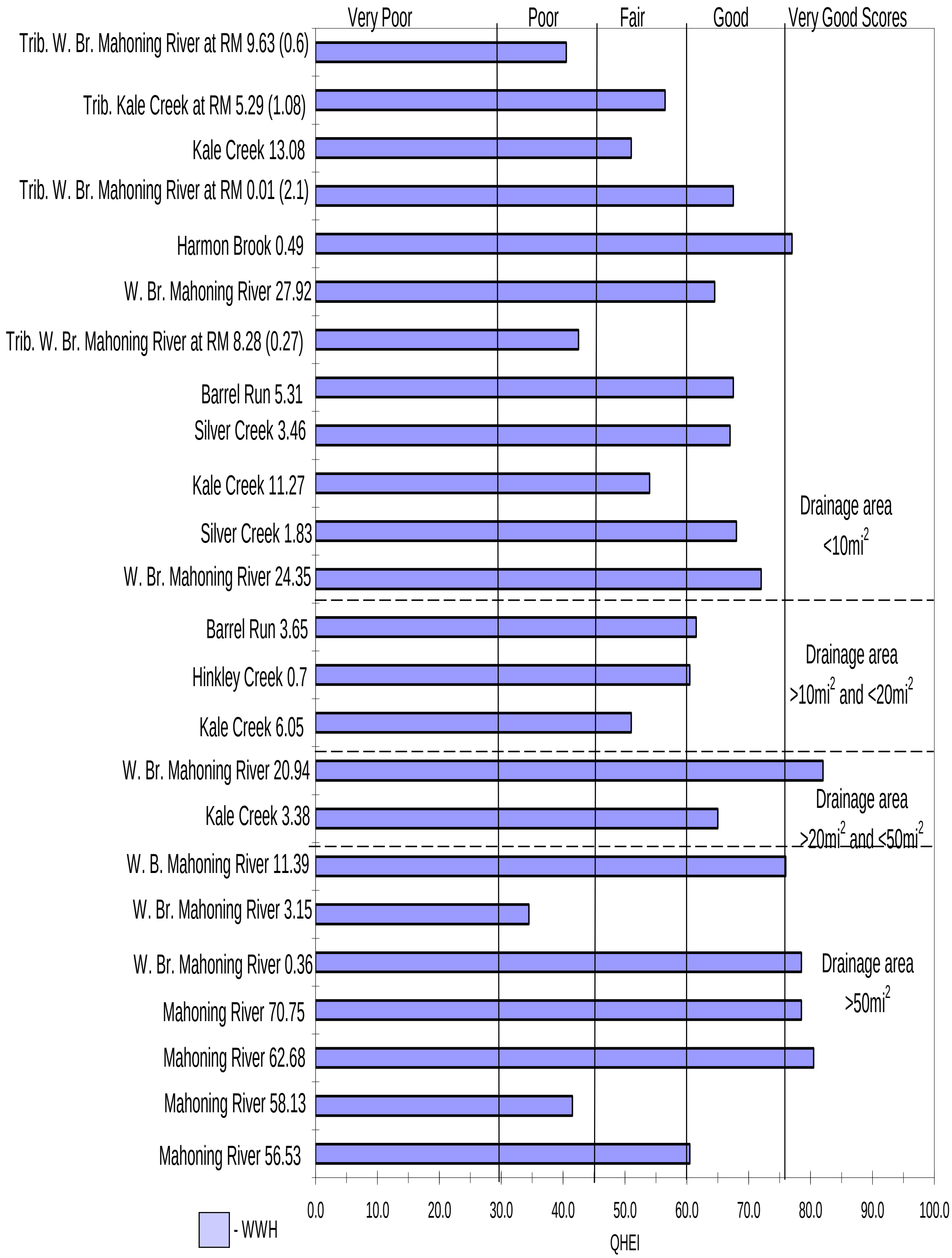

Figure 38. QHEI scores by drainage area for the West Branch Mahoning River basin (WAU 05030103030).

Biological Communities: Fish

The fish communities of West Branch Mahoning River basin (WAU 05030103030) were sampled in 24 locations. The fish community of most sites reflected the quality of habitat available (Figure 39). In areas where habitat conditions were good, fish communities generally met WWH expectations and where habitat conditions were poor, fish communities performed below WWH expectations. However, many fish communities within the basin were underperforming the habitat provided, which indicated that additional factors beyond habitat may be influencing the fish community.

The four sites along the Mahoning River mainstem, from RM 70.75 to RM 56.53, had an average IBI score of 34 (range of 28 to 45) and an average MIwb of 8.8 (range of 7.4 to 9.5). The twenty tributary sites had an average IBI score of 38.7 (range of 26 to 54). Only five of the tributary sites were >20mi^2, so the MIwb only applied to these five sites. The average MIwb was 7.8 and the individual sites ranged in value between 6.6 and 9.3. The wide span between minimum and maximum values for all sites within the basin reflected the range of habitat quality available to the aquatic community.

Mahoning River

The fish communities between RM 70.75 and RM 58.13 were significantly influenced by the altered flow regime of the upstream and downstream dams. The most upstream site (RM 70.75) received an IBI of 30, the site near Pritchard-Ohltown Road (RM 62.68) received an IBI of 28, and the site near Starr Road (RM 58.13) in the backwaters of the Newton Falls dam received an IBI of 33. All of these scores are below WWH expectations. The only site which met WWH biocriteria was downstream from the Newton Falls dam (RM 56.53) where the fish community received an IBI of 45. Insectivores comprised an average of 49% of the fish community downstream from Newton Falls dam, while insectivores comprised between 14% and 30% of the fish community at the three upstream locations. In addition, five sucker species were collected downstream from the Newton Falls dam, while at most 2 sucker species were collected at the three upstream locations. As discussed in the physical habitat section, the altered hydrologic regime has a significant negative influence on the fish community along the Mahoning River mainstem.

West Branch Mahoning River

Five of the six sites sampled on the West Branch Mahoning River received IBI scores between 44 and 49 (average IBI of 47). The fish community near 6th Street Park (RM 3.15) received an IBI of 29 and a MIwb of 6.6, which are both significantly below WWH expectations. The modified habitat conditions attributable to the downstream dam directly influenced the fish community within this area. The heavy silt, poor channel development and near stagnant flow patterns diminished the habitat available to the fish community.

Tributaries

The fish community of several streams met or exceeded WWH expectations. Harmon Brook received an IBI score of 54, which was the highest score within the West Branch Mahoning River basin. The high IBI score directly reflects the high quality habitat noted at the site (QHEI score of 77.0). Hinkley Creek received an IBI score of 48, as did the upstream site on Silver Creek (RM 3.46). The lower site on Silver Creek (RM1.83) received an IBI of 42, and the lower site on Barrel Run (RM 3.65) received an IBI of 44. The upper site on Barrel Run (RM 5.31) did not meet WWH expectations (IBI of 28) due to the presence of a small dam on the stream. All of the sites which met WWH expectations directly reflected the higher quality habitats available to the fish community.

Though the habitat of Kale Creek and its tributary at RM 5.29 had habitat which could potentially support WWH communities, the fish community in these areas did not meet WWH expectations (Figure 39). The four sites along Kale Creek received IBI scores between 26 and 32 (average IBI score of 30), while the tributary at RM 5.29 received an IBI score of 34. Tolerant fish comprised between 59% and 79% of the fish community of Kale Creek and they comprised 56% of the fish community in the tributary to Kale Creek at RM 5.29. Excess siltation appeared to be an issue at all of the sites, and the sources included agricultural activities, stream bank destabilization, and loss of riparian habitat. In addition, low dissolved oxygen influenced the fish community at two locations along Kale Creek (Table 19).

The remaining fish communities sampled within the West Branch Mahoning River basin did not meet WWH expectations. The fish communities of the tributary to a tributary of the West Branch Mahoning River at RM 9.63/0.74 (IBI of 33), and the tributary to West Branch Mahoning River at RM 8.28 (IBI of 32) had on average four species, none of which were pollution sensitive or headwater species. These two sites directly reflected the poor habitat conditions present in the streams. Meanwhile the fish community within the tributary to West Branch Mahoning River at RM .01 (IBI of 28) performed significantly below the habitat score of 67.5 indicating that influences beyond habitat were having a negative impact on the fish community. Additional reconnaissance to determine what may be affecting the fish community here is recommended.

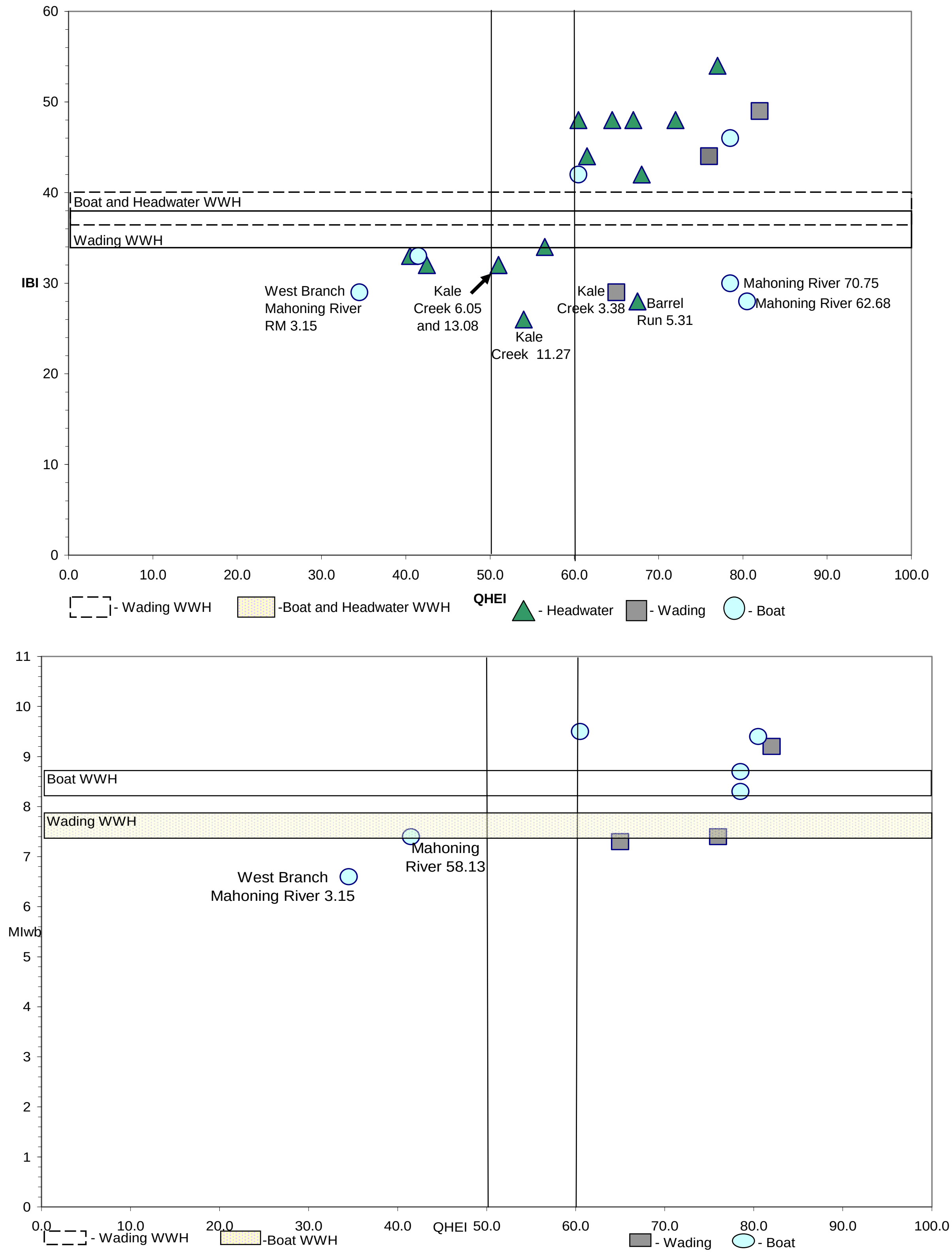

Figure 39. IBI and MIwb scores versus QHEI scores of the West Branch Mahoning River basin 05030103030. Sites that are labeled indicate community performance below habitat expectations. These sites are described further in the text.

Biological Communities: Macroinvertebrate

Twenty-five macroinvertebrate communities (Table 21) were sampled within the West Branch Mahoning River watershed in order to determine the integrity of water resources. There are two primary distinguishing characteristics to this watershed. First and foremost is the inclusion of the Upper Mahoning River's largest tributary, the West Branch, which drains just over 100 square miles. Most of the sites surveyed in this watershed were either direct or indirect tributaries to the West Branch. Secondly, this watershed is either influenced by or wholly includes three of the four largest reservoirs in the Upper Mahoning River watershed. This subwatershed begins with the Mahoning River immediately downstream from the Berlin Lake Dam, and includes all of Lake Milton. Michael J. Kirwan Reservoir impounds approximately 7 miles of the West Branch (Figure 31). In addition to these large lakes/reservoirs, a small dam in Newton Falls also impounds approximately two miles of the Mahoning River, and another impounds just over one mile of the West Branch, also in Newton Falls.

Out of the 25 sites sampled, 8 were below WWH expectations for the Erie Ontario Lake Plain ecoregion. More than half of these impairments were related to the dams or impoundments, mostly in the Newton Falls area on either the West Branch or the Mahoning River mainstem. In general, however, the overall performance of this watershed as expressed by those sites that attained WWH criteria was good, with 4 sites evaluated as exceptional, 2 as very good, 6 as good, and 5 as marginally good. Relatively undisturbed near and instream habitat accounted for most of the good to exceptional biotic integrity exhibited at those sites meeting the WWH biocriteria.

Mahoning River below Berlin Reservoir to above West Branch
HUC 12 - 05030103 03 06

The Mahoning River was sampled at four locations within this assessment unit. Two of the sites, RM 70.75 and RM 62.68, were directly influenced by dam releases from Berlin Lake and Lake Milton, respectively. In spite of low taxa richness and some evidence of enrichment, both sites were at least marginally meeting WWH criteria. Although biocriteria may have been met, there is cause for concern regarding the predominance of the zebra mussel, *Dreissena polymorpha*, in the Berlin Lake tailwaters. Large masses of this invasive bivalve were aggregated on the natural substrates, a phenomenon that was not observed when this reach was last sampled in 1994. The mollusk was also collected downstream from Lake Milton and into Newton Falls, though populations were not as dense. The incidence of zebra mussel populations has been correlated with declines in native mussel fauna and potential disruption of biological equilibrium. Currently, zebra mussels do not seem to imperil the Mahoning River in such a fashion; rather, flow regime changes due to dams and other impoundments are of more consequence to the river's biological integrity.

Table 21. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the West Branch Mahoning River watershed (WAU 05030103 03), June to September, 2006.

Stream RM[a]	Dr. Ar. (sq. mi.)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Ranges in Parentheses	ICI	Narrative Evaluation
HUC 12 - 05030103 03 06										
Mahoning River										
70.7	248	10	35	6/9	9/11	M/2833	0	Zebra mussels (F), bryozoa (F)	30	Marg Good
62.7	274	10	25	5/7	7/8	M/4698	0	Net-spinning caddisflies (F, MI)	34	Good
58.1	306	2	23	2	5	M-L	0	Sowbugs (MT)	--	Low Fair
56.5	307	--	23	4/5	6/9	M/1025	0	Scuds (MT), sowbugs (F), flatheaded mayflies (F)	26	Fair
HUC 12 - 05030103 03 01										
Kale Creek										
13.6	1.5	--	40	11	15	M-L	1	Craneflies (MI), Fingernail clams (F) beetles (F-MI)	--	Good
13.1	4.1	16	41	9	9	L	0	Midges (MT-MI)	--	Fair
11.2	9.1	--	41	10	7	M-L	0	Net-spinning caddisflies (F), sludge worms (T)	--	Fair
6.0	14.4	--	45	9	11	L	0	Net-spinning caddisflies (F), minnow mayflies (F-MI)	--	Marg. Good
4.0	21.4	13, 15	42	8/9	8/17	M-L/937	0	Net-spinning caddisflies (MI-F)	42	Very Good
Unnamed Tributary to Kale Creek @ RM 5.29										
1.1	3.4	--	39	13	11	L	0	Riffle beetles (MI-F), minnow mayflies (MI-F)	--	Good
HUC 12 - 05030103 03 02										
West Branch Mahoning River										
27.9	5.0	--	38	9	13	M	2	Riffle beetles (F-MI), Net-spinning caddisflies (F-MI)	--	Marg. Good
24.4	9.4	--	51	19	24	M	3	Net-spinning caddisflies (MI-F)	--	Exceptional
20.9	21.8	--	48	18/21	19/36	M	1	Minnow mayflies (F), brush-legged mayflies (MI), filter-feeding midges (*Rheotanytarsus sp.*) (MI)	52	Exceptional

Stream RM[a]	Dr. Ar. (sq. mi.)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Ranges in Parentheses	ICI	Narrative Evaluation
Harmon Brook										
0.5	4.1	--	32	5	6	H-M	0	Blackflies (F), flatworms (F)	--	Low Fair
HUC 12 - 05030103 03 03										
Barrel Run										
5.3	5.1	--	34	8	14	M-L	2	Case-building (MI) and net-spinning (MI-F) caddisflies, blackflies (F)	--	Marg. Good
3.6	10.2	--	46	14	15	M	3	Net-spinning caddisflies (MI-F), minnow mayflies (F)	--	Good
HUC 12 - 05030103 03 04										
Hinkley Creek										
0.7	10.8	--	53	20	23	M	2	Case-building (MI-F) and net-spinning (MI-F) caddisflies, mayflies (flathead, brush-legged, minnow) (MI-F)	--	Exceptional
Silver Creek										
3.5	5.5	--	33	13	10	M	1	Net-spinning caddisflies (MI-F), snail-case caddisflies (MI)	--	Good
1.8	9.3	--	44	13	17	M	2	Net-spinning caddisflies (MI-F)	--	Good
HUC 12 - 05030103 03 05										
West Branch Mahoning River										
11.4	80.9	10	28	4/7	8/13	M/243	1	Zebra mussels (F)	22	Fair
3.3	101.0	2,8	32	2/4	3/5	H/484	0	Scuds (F-MT)	10	Poor
0.4	103.0	--	28	10/10	12/16	M/477	0	Net-spinning caddisflies (MI-F)	42	Very Good
Unnamed Tributary @ RM 0.74 to Unnamed Tributary to West Branch Mahoning River @ RM 9.63										
0.6	1.6	19	38	8/10	14/23	L/441	3	Square-gill mayflies (F), riffle beetles (MI-F)	46	Exceptional
Unnamed Tributary to West Branch Mahoning River @ RM 8.28										
0.2	5.1	--	41	10	8	M-L	0	Square-gill mayflies (F), scuds (F)	--	Marg. Good

Stream RM[a]	Dr. Ar. (sq. mi.)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Ranges in Parentheses	ICI	Narrative Evaluation
Unnamed Tributary to West Branch Mahoning River @ RM 0.01										
2.1	4.1	--	27	5	6	M-L	0	Net-spinning caddisflies (F)	--	Fair

RM: River Mile.
Dr. Ar.: Drainage Area
Data Codes: 8=Non-Detectable Current, 9=Intermittent or Near-Intermittent Conditions, 12=Suspected High Water Influence/Disturbance, 13=Suspected Disturbance by Vandalism, 15=Current >0.0 fps but <0.3 fps, 29=Primary Headwater Habitat Stream.
Ql.: Qualitative sample collected from the natural substrates.
Sensitive Taxa: Taxa listed on the Ohio EPA Macroinvertebrate Taxa List as MI (moderately intolerant) or I (intolerant).
Qt.: Quantitative sample collected on Hester-Dendy artificial substrates, density is expressed in organisms per square foot.
Qualitative sample relative density: L=Low, M=Moderate, H=High.
CW: Coolwater/Cold water.
Tolerance Categories: VT=Very Tolerant, T=Tolerant, MT=Moderately Tolerant, F=Facultative, MI=Moderately Intolerant, I=Intolerant

a – The RM indicated may differ slightly from the RM located in the Attainment Tables throughout this document. The RMs in this table are the Absolute Location Points (ALPs) which are the actual location where the data was collected. Each RM included in the Attainment Tables represents a Point of Record (POR) which is defined as a sampling station whereby ALPs representing the station may be linked.

The other two stations sampled in this subwatershed were located on the Mahoning River within Newton Falls. Both sites failed to meet WWH criteria. The community at RM 58.13 performed in the low fair range, which is expected given the sampling area is in impounded backwaters from a dam located at RM 56.55. Downstream from the dam, community performance remained within the fair range with an ICI of 26, despite the river's brief return to a free-flowing nature. This score is a precipitous drop from the very good ICI of 42 that was scored in 1994. Community response based on the artificial substrates in 2006 indicated potential toxicity, especially when compared with that of 1994. The 2006 community collected from the artificial substrates showed a substantial loss of mayfly and caddisfly taxa in both density and diversity, with a subsequent increase in tolerant organisms, particularly the toxicity-tolerant midges *Cricotopus bicinctus* and *Nanocladius distinctus* (Table 22). In 2006, Newton Falls was operating an outdated WWTP that did not treat for ammonia and experienced frequent wet-weather bypasses. These phenomena likely accounted for the impacts observed with the artificial substrate data in 2006. Newton Falls built a new WWTP that went online in September 2007 that now treats for ammonia and has expanded capacity from 0.5 MGD to 1.5 MGD. The upgrade also included a large equalization basin to capture high flows, thereby reducing or eliminating bypass events. Based on these improvements, RM 56.53 should be re-sampled to determine if the upgrade has improved macroinvertebrate community health.

Table 22. Macroinvertebrate attributes for communities collected at the Mahoning River, RM 56.53, in 1994 and 2006.

	1994	2006
ICI (Narrative evaluation)	42 (Very Good)	26 (Fair)
Total EPT taxa (natural + artificial substrates)	12	5
% EPT of total organisms on artificial substrates	44.3%	4.3%
Total taxa (natural + artificial substrates)	49	37
% *Cricotopus bicinctus* and *Nanocladius distinctus* (toxicity-tolerant midges) on artificial substrates	1.78%	7.7%
# individuals *Cricotopus bicinctus* and *Nanocladius distinctus* on artificial substrates	45	396

Kale Creek
HUC 12 - 05030103 03 02
Kale Creek traverses a primarily agricultural landscape, occasionally crossing wetland areas before draining into the Mahoning River at RM 59.6, just south of Newton Falls. Of the five sites sampled for macroinvertebrates on Kale Creek, three met WWH criteria: RM 13.57, RM 6.05 and RM 3.38. Of note is a large population of live freshwater mussels found at RM 6.05. Although there were no species of interest (rare, endangered, or threatened), given that mussel distribution in the Upper Mahoning River watershed is relatively sparse, the abundance of mussels in this reach was significant.

Two sites, RM 13.08 and RM 11.27, had fair macroinvertebrate assemblages that were not meeting WWH expectations. Both sites were affected by siltation; RM 11.27 was additionally affected by nutrient over-enrichment as evidenced by the presence of algal mats. RM 13.08 had unstable, eroding banks resulting in riffles embedded with fine silts, as substrates were mostly smaller gravel and sand. Streamside forested riparian, absent in this reach, would assist in restoring bank stability. The sources contributing to the siltation and nutrient enrichment at RM 11.27 are unclear, although failing septic systems in the area may be worthy of investigation.

A small unnamed tributary to Kale Creek at RM 5.29 was also sampled. The macroinvertebrate community sampled at RM 1.1 was indicative of good biotic integrity. Thirteen EPT taxa and eleven sensitive taxa were collected despite low flow conditions in this small stream.

West Branch Mahoning River (excluding Michael J. Kirwan Reservoir)
HUC 12 - 05030103 03 02 and HUC 12 - 05030103 03 05
The performance of the macroinvertebrate communities of the West Branch Mahoning River generally correlated well to near and instream habitat conditions. Where habitat quality was high, macroinvertebrate communities were of correspondingly high quality as well. This trend was particularly operative above Kirwan Reservoir, where positive habitat attributes combined with mostly unimpacted locales to create conditions conducive to exceptional macroinvertebrate assemblages (Figure 40). The community at RM 24.35 with 19 EPT and 24 sensitive qualitative taxa, was surpassed in quality only by the Mahoning River at RM 100.57. Rare, infrequently collected, or intolerant taxa collected in this segment included the midges *Demicryptochironomus sp*. and *Lipiniella sp*., the mayfly *Pseudocloeon frondale*, and the state threatened caddisfly *Psilotreta indecisa*.

Conversely, where habitat quality was low, community response fared poorly. Such was the case at RM 3.15, which was in an impounded section of stream in Newton Falls. A total of 19 tolerant taxa were collected on both natural and artificial substrates to account for the poor ICI of 10 scored here. The only anomaly with regard to habitat and performance was at RM 11.39, which was located immediately downstream from Kirwan Dam. Although habitat (as measured by QHEI) was high quality, the ICI was only in the fair range with a score of 22. Unlike other sites downstream from reservoir releases, the artificial substrates here were not densely populated with net-spinning caddisflies and filter-feeding midges of the tribe Tanytarsini. Instead, these two organism groups were depressed and aquatic worms were predominant. Ordinarily, such a response can indicate the release of anoxic bottom waters; however, Kirwan Dam usually does not release from the hypolimnion (Diane Ryszkiewkz, personal communication). A predominance of aquatic worms is often associated with organic enrichment, though a source of such contamination was not evident. It may be necessary, therefore, to resample at this station to further assess the impact observed in 2006. It is also of interest to note that the natural substrates were inundated with zebra mussels at this station, much like that observed in the Mahoning River below Berlin Dam.

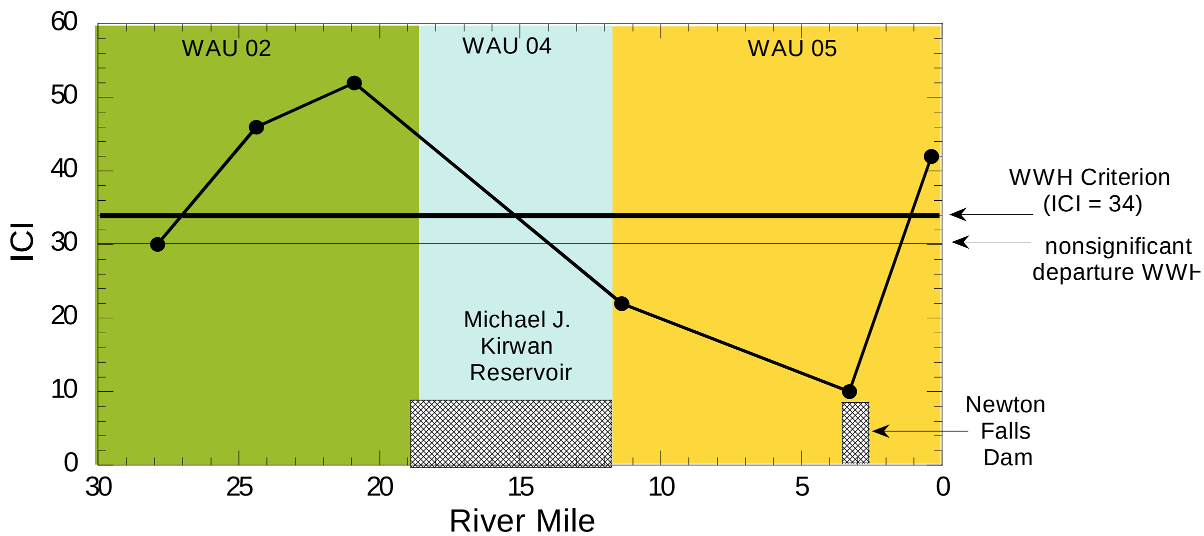

Figure 40. Longitudinal plot showing ICI scores for the West Branch Mahoning River, 2006. ICI scores are estimated in lieu of quantitative samples at RMs 27.92 and 24.35, where qualitative assessments were marginally good and exceptional, respectively.

West Branch Tributaries above Michael J. Kirwan Reservoir
HUC 12 - 05030103 03 02

One tributary to the West Branch above Kirwan Reservoir, Harmon Brook, was sampled during the 2006 survey. The sampling site at RM 0.49 on Harmon Brook was located downstream from a small pond featuring a spill-over dam. Large populations of facultative filter-feeding blackflies and net-spinning caddisflies were present in the riffles at this location. Duckweed and other macrophytes from the pond were present in this area of the stream, indicating that phytoplankton-rich surface water from the pond was likely contributing to eutrophication at this site. Additionally, an overabundance of flatworms, leeches, and aquatic worms was also signaling organic enrichment. The water at this site was extremely turbid with a foamy emulsion at its surface. Failing septic systems may have been an issue; however, the strong odor of manure in the sampling area indicated that livestock pasturage may also have been contributing to the impairment.

West Branch Tributaries draining into Michael J. Kirwan Reservoir
HUC 12 - 05030103 03 03 & HUC 12 - 05030103 03 04
Three direct tributaries draining into Kirwan Reservoir were sampled qualitatively for macroinvertebrates. Two of these streams, Barrel Run and Silver Creek, hosted communities that were in the good range and thus meeting their assigned WWH aquatic life use. The remaining stream, Hinkley Creek, was of exceptional quality and was the only stream in the entire survey with at least 20 EPT qualitative taxa. On average, there were 14 EPT taxa and 16 sensitive taxa among five sites sampled in these streams, further reflecting high levels of biotic integrity.

West Branch Tributaries below Michael J. Kirwan Reservoir
HUC 12 - 05030103 03 05
Macroinvertebrate response displayed an inverse relationship between habitat and community performance among the three West Branch tributaries sampled below Kirwan Reservoir. A tributary to an unnamed tributary to the West Branch at RM 9.63 produced an exceptional ICI of 46, indicating good water quality despite its channelized nature and extremely small drainage area (<2 mi^2). A marginally good community comprised the benthic fauna on an unnamed tributary at RM 8.28. This stream was influenced by backwater conditions resulting from reservoir releases from the Kirwan Dam. Both of these tributaries were within WWH criteria despite instream conditions favoring habitat-derived impairment. Conversely, the macroinvertebrate community sampled on an unnamed tributary at RM 0.01 did not meet its WWH aquatic life use, despite natural channel formation, riffle-run complexes, and intact riparian. The fair community collected at this site likely indicated a water quality issue. Given the proximity of SR 534, residential areas, and the Ravenna Training and Logistics Site (RTLS), nonpoint source runoff may be the source of impairment at the sampling site located at RM 2.10.

Trends
The 2006 survey accounted for the first complete assessment of the West Branch Mahoning River. Prior to 2006, only RM 0.4 had been sampled as part of the 1994 survey of the Mahoning River basin, scoring an ICI of 34. A repeat assessment of that station in 2006 showed an eight point improvement with an ICI of 42. A significant reduction in both tolerant and non-insect taxa, combined with an increase in pollution-sensitive tanytarsini midges accounted for this difference in scoring, indicating reduced pollutant loadings from Newton Falls.

The 2006 survey also accounted for the first comprehensive assessment of the tributaries to the West Branch. Previous sampling efforts were limited to two tributaries that were sampled in 2003 as part of an assessment of the Ravenna Training and Logistics Site (RTLS – formerly known as the Ravenna Arsenal). The first of these streams, Hinkley Creek, was sampled at four sites within the RTLS property in 2003. All of these sites scored within EWH criteria. In 2006, Hinkley Creek was sampled downstream from RTLS at RM 0.7. The exceptional community collected at this site was commensurate with the communities captured upstream in 2003.

The second stream, an unnamed tributary to the West Branch at RM 0.01, was qualitatively sampled at RM 2.1. The fair community collected here appears to be a decline from the good community collected at this location in 2003 (ICI=40). When qualitative (natural substrate) total, EPT, and sensitive taxa numbers are compared to those collected quantitatively (artificial substrate) as in Table 23, it is apparent that there may be issues regarding instream natural habitat. Indeed, the field investigators of both years noted riffles comprised of fine gravels that were embedded with silt, thus limiting colonization due to a lack of interstitial space. Fine substrates are more susceptible to the effects of siltation, whereas larger material (such as coarse cobbles or artificial substrates) exhibit greater resistance to embeddedness. Sources of siltation should be investigated in order to determine a proper course of mitigation for this stream.

Table 23. Total, EPT, and sensitive taxa collected from natural and artificial substrates in 2003 and 2006.

Year/Substrate Type	Total Taxa	EPT Taxa	Sensitive Taxa
2006 Natural	27	5	6
2003 Natural	13	4	0
2003 Artificial	37	8	19

Eagle Creek WAU

Eagle Creek and the Mahoning River downstream from Newton Falls to the Leavittsburg Dam comprise the largest drainage segments in the Eagle Creek WAU (Figure 41). Minimal development combined with a large percentage of forest land accounted for 60% of sampled sites fully meeting their assigned aquatic life use. Additionally, cold water-adapted communities were found on two small tributaries to Eagle Creek. Impaired biological communities, found on both the Mahoning River and on various tributaries, were mostly attributable to either natural sources or flow alterations.

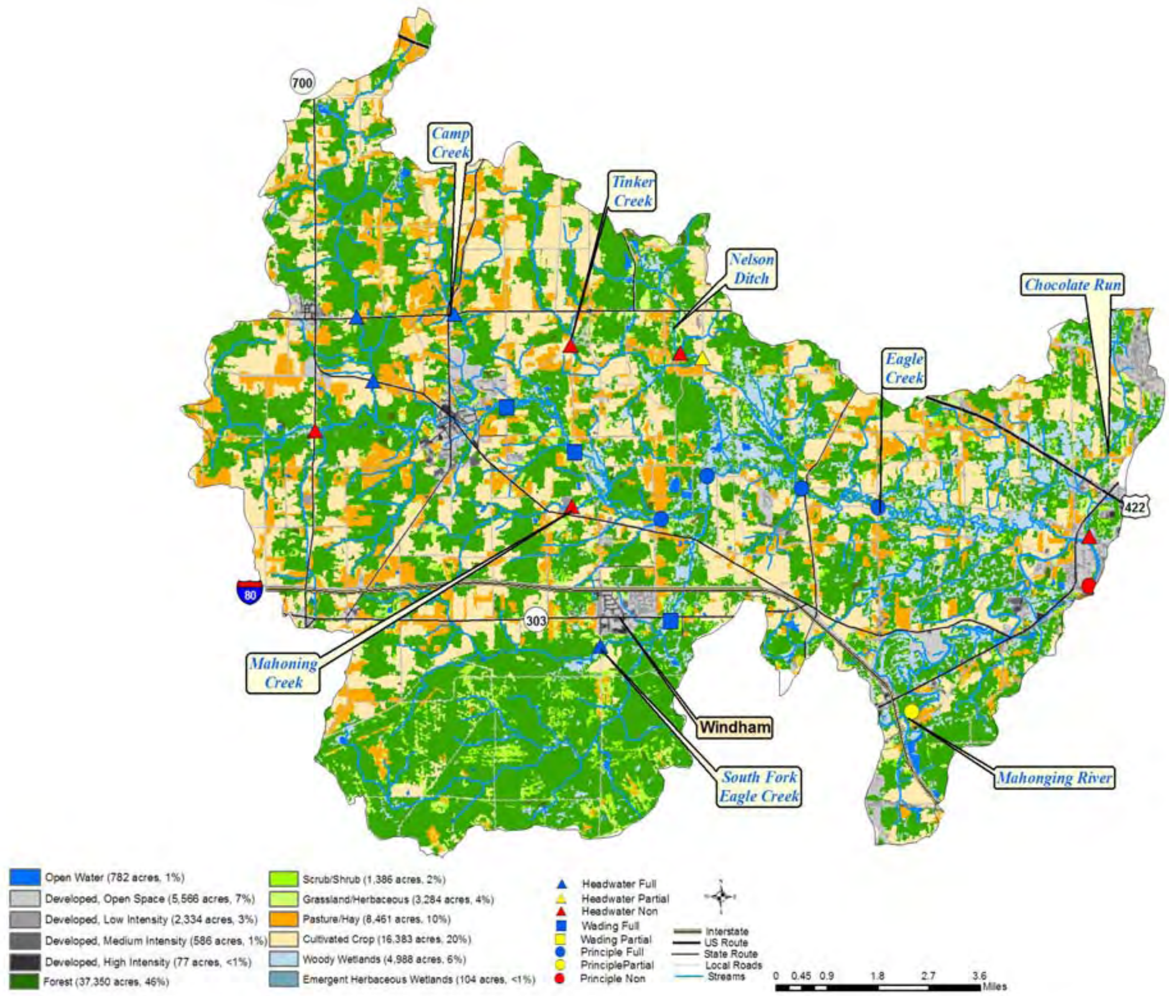

Figure 41. Land use and sampling locations by attainment status of Eagle Creek basin, 2006.

Table 24. Aquatic life use attainment status for stations sampled in the Eagle Creek Mahoning River WAU based on data collected June-October 2006. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community.

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
HUC 12 – 050301030401 Headwaters Eagle Creek							
Eagle Creek				*EOLP Ecoregion - WWH Existing*			
N02S02 (22.44) [H]	34*	N/A	F*	54.0	**NON**	Natural conditions (flow and habitat) Oil and grease?	Natural source (beaver dam) Source Unknown
Silver Creek (trib. to Eagle Creek)				*EOLP Ecoregion - CWH Existing*			
N02S04 (2.27) [H]	42	N/A	52	66.0	FULL		
N02S03 (0.79) [H]	41	N/A	54	64.0	FULL		
HUC 12 – 050301030402 South Fork Eagle Creek							
South Fork Eagle Creek				*EOLP Ecoregion - WWH Existing*			
N02K08 (3.86) [H]	44	N/A	46	66.5	FULL		
N02K06 (2.30) [W]	41	7.5	52	61.0	FULL		
HUC 12 – 050301030403 Camp Creek - Eagle Creek							
Eagle Creek				*EOLP Ecoregion - WWH Existing*			
N02P07 (17.61) [W]	51	9.6	46	81.5	FULL		
N02K10 (15.04) [W]	40	7.4	48	61.5	FULL		
300348 (12.10)	N/A	N/A	42	N/A	FULL		
Camp Creek					*EOLP Ecoregion - WWH Existing, CWH Recommended*		
N02K11 (3.16) [H]	44	N/A	E	74.0	FULL		

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
Mahoning Creek				*EOLP Ecoregion - WWH Recommended*			
N02K09 (0.70) [H]	18*	N/A	P*	54.0	**NON**	Siltation Nutrient/eutrophication biological indicators	Natural Source (Wetland Stream) Package plant (Downstream MHP WWTP)
HUC 12 – 050301030404 Tinkers Creek							
Tinker Creek				*EOLP Ecoregion - WWH Existing*			
N02K04 (5.45) [H]	24*	N/A	G	68.0	**NON**	Nutrient/eutrophication biological indicators	Agriculture
N02K02 (2.50) [H]	34*	N/A	G	68.5	PARTIAL	Nutrient/eutrophication biological indicators	Agriculture
Nelson Ditch				*EOLP Ecoregion - WWH Existing*			
300148 (0.30) [H]	34*	N/A	LF*	44.0	**NON**	Siltation Direct habitat alteration	Channelization
HUC 12 – 050301030405 Mouth Eagle Creek							
Eagle Creek				*EOLP Ecoregion - WWH Existing*			
N02K05 (10.10) [W]	46	7.5	*VG*	53.0	FULL		
N02Q01 (7.20)	N/A	N/A	38	N/A	FULL		
N02P08 (5.60) [B]	42	9.4	G	65.0	FULL		
HUC 12 – 050301030406 Chocolate Run – Mahoning River							
Mahoning River				*EOLP Ecoregion - WWH Existing, CWH Recommended*			
N02S11 (54.73) [B]	41	8.6[NS]	22*	58.5	PARTIAL	Flow regime alteration	Leavittsburg Dam backwater

Station (River Mile)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes	Sources
N03S64 (45.73) [B]	40	7.7*	20*	48.5	**NON**	Flow regime alteration	Leavittsburg dam pool
Chocolate Run				*EOLP Ecoregion - WWH Existing*			
N02K01 (0.11) [H]	32*	N/A	LF*	46.5	**NON**	Siltation Direct habitat alteration Nutrient/eutrophication biological indicators	Channelization

Ecoregion Biocriteria: Erie Ontario Lake Plain

	IBI			MIwb			ICI		
Site Type	**WWH**	**EWH**	**MWH**	**WWH**	**EWH**	**MWH**	**WWH**	**EWH**	**MWH**
Headwaters	40	50	24				34	46	22
Wading	38	50	24	7.9	9.4	6.2	34	46	22
Boat	40	48	24	8.7	9.6	6.6	34	46	22

H - Headwater electrofishing site.

W - Wading electrofishing site.

B - Boat electrofishing site.

a - MIwb is not applicable to headwater streams with drainage areas $\leq$ 20 mi^2.

b - A narrative evaluation of the qualitative sample based on attributes such as EPT taxa richness, number of sensitive taxa, and community composition was used when quantitative data was not available or considered unreliable. VP=Very Poor, P=Poor, LF=Low Fair, F=Fair, MG=Marginally Good, G=Good, VG=Very Good, E=Exceptional

c - Attainment status is given for both existing and proposed use designations.

ns - Nonsignificant departure from biocriteria ($\leq$4 IBI or ICI units, or $\leq$0.5 MIwb units).

* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

Point Source Dischargers

Village of Hiram WWTP 3PB00020 (Tributary to Silver Creek to Silver Creek to Eagle Creek)

The village of Hiram WWTP was last modified in 1994. Treatment processes include bar screen, communitor, flow equalization, extended aeration, clarifiers, and ultraviolet disinfection. The design flow is 0.200 mgd. The discharge is to an unnamed tributary of Silver Creek. Current monthly NPDES permit limits are cBOD5 (25 mg/l; 19 kg/day); TSS (30 mg/l; 22.7 kg/day); and summer ammonia-N (1.6 mg/l; 1.7 kg/day). The plant does not treat to remove phosphorus.

A compliance inspection report dated September 21, 2007 indicated that the plant was producing what appeared to be a satisfactory quality effluent. A review of effluent data submitted for the period April 2003 through August 2007 showed NPDES permit violations for pH (one in 2004) and copper (two in 2006) plus a number of reporting violations. Effluent flow and concentration of select parameters has remained relatively constant from 1995 to 2007(Figure 42). Full biological attainment was recorded in Silver Creek downstream from the WWTP discharge.

Village of Garrettsville WWTP 3PB00016 (Eagle Creek)

Treatment processes include bar screen, communitor, flow equalization, extended aeration, clarifiers, and ultraviolet disinfection. The design flow is 0.356 mgd. The discharge is to Eagle Creek. Current monthly NPDES permit limits are cBOD5 (25 mg/l; 33.7 kg/day); TSS (30 mg/l; 40.4 kg/day); and summer ammonia-N (8 mg/l; 10.8 kg/day). The plant does not treat to remove phosphorus. Effluent samples collected during the 2006 survey indicated that all parameters were within permit limits (Figure 43). Effluent total phosphorus ranged from 2.30-3.93 mg/l (n=4). Eagle Creek was found to be in full biological attainment both upstream and downstream from the WWTP discharge.

Portage County Western Reserve WWTP 3PG00121 (Camp Creek to Eagle Creek)

This plant is operated by the Portage County Engineers office. It was last modified in 2004. Treatment processes include trash trap, extended aeration, clarifier, slow sand filters and ultraviolet disinfection. The design flow is 0.0135 mgd. The discharge is to Camp Creek. Current monthly NPDES permit limits are summer cBOD5 (15 mg/l; 0.75 kg/day); TSS (12 mg/l; 0.6 kg/day); and summer ammonia-N (3.2 mg/l; 0.16 kg/day). The plant does not treat to remove phosphorus.

A compliance inspection report dated September 18, 2006 indicated that the plant was producing what appeared to be a satisfactory quality effluent. No effluent samples were collected during the 2006 survey. Camp Creek was found to be in full biological attainment downstream from the WWTP discharge. The WWTP effluent flow has been at or above the 0.0135 mgd design from 1999 to

2007 (Figure 44). The WWTP may be at its design capacity to accept additional wastewater flow with current levels of treatment.

PM Estates Mobile Home Park WWTP 3PX00004 (Mahoning Creek to Eagle Creek)
The plant is owned by Modern Management Solutions and serves a mobile home park. Treatment processes include trash trap, extended aeration, rapid sand filters, and ultraviolet disinfection. The design flow is 0.050 mgd. The discharge is to Mahoning Creek. Current monthly NPDES permit limits are summer cBOD5 (10 mg/l; 2.0 kg/day); TSS (12 mg/l; 2.3 kg/day); and summer ammonia-N (1.5 mg/l; 0.28 kg/day). The plant does not treat to remove phosphorus.

A compliance inspection report dated April 28, 2006 indicated that the plant was in operation. A single fecal coliform permit violation was noted for the period from October 2005 through March 2006. Effluent flow and concentration of select parameters has been relatively constant from 1996 to 2007 (Figure 45). No effluent samples were collected during the 2006 survey, although the water quality of Mahoning Creek was assessed downstream from the WWTP discharge. Biological communities in Mahoning Creek were in non-attainment downstream from the WWTP discharge, but no survey was conducted upstream from the discharge to determine background conditions.

Village of Windham WWTP 3PC00019 (Tributary to South Fork Eagle Creek to Eagle Creek)
Treatment processes include bar screen, comminutor, oxidation ditch, clarifiers, tertiary filters, flow equalization, and chlorine disinfection and dechlorination. The design flow is 0.450 mgd. The discharge is to an unnamed tributary of the South Fork Eagle Creek. Current monthly NPDES permit limits are summer cBOD5 (10 mg/l; 17 kg/day); TSS (12 mg/l; 20.4 kg/day); and summer ammonia-N (1.5 mg/l; 2.55 kg/day). The plant does not treat to remove phosphorus.

The WWTP has a long history of overflows and bypasses from the sewerage system (June 1997 to April 2004), which resulted in the Ohio EPA issuing Findings and Orders (December 18, 2006) to the village to correct plant overflow and bypass problems. The village completed a replacement of the main sanitary sewer as of 10/25/2006. A compliance inspection letter dated August 16, 2007 indicated that the facility was found to be in “general compliance with its NPDES permit”. A review of monthly operating report data from September 2003 to July 2007 noted a number of permit violations, four cBOD5 and one TSS in 2005. Effluent flow and concentration of select parameters has been relatively constant from 1996 to 2007 (Figure 46). Full biological attainment was found in the South Fork Eagle Creek during the 2006 survey downstream from the WWTP discharge.

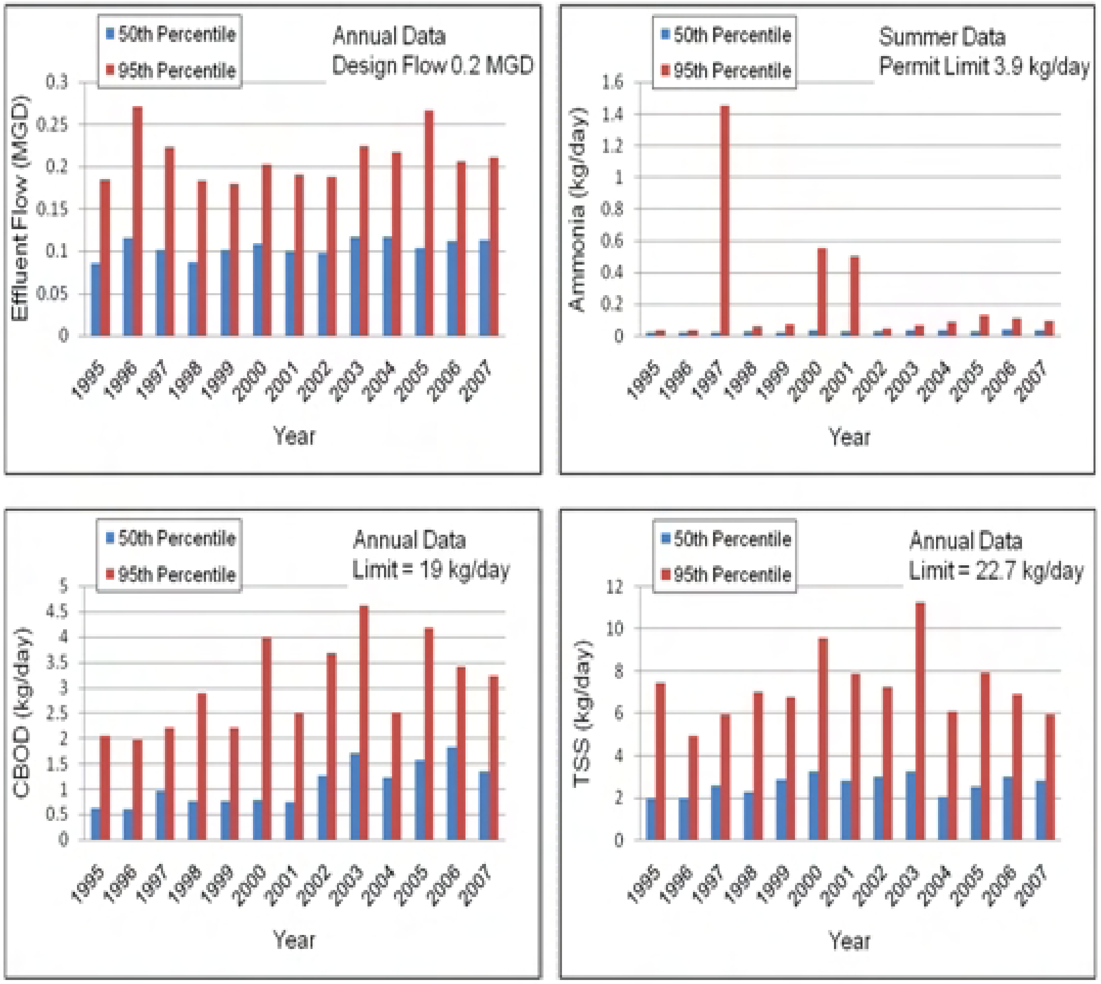

Figure 42. Annual flows, ammonia, carbonaceous biochemical oxygen demand (CBOD), and total suspended solids loadings for the Hiram WWTP treated effluent 1995-2007. NPDES Permit #3B00020.

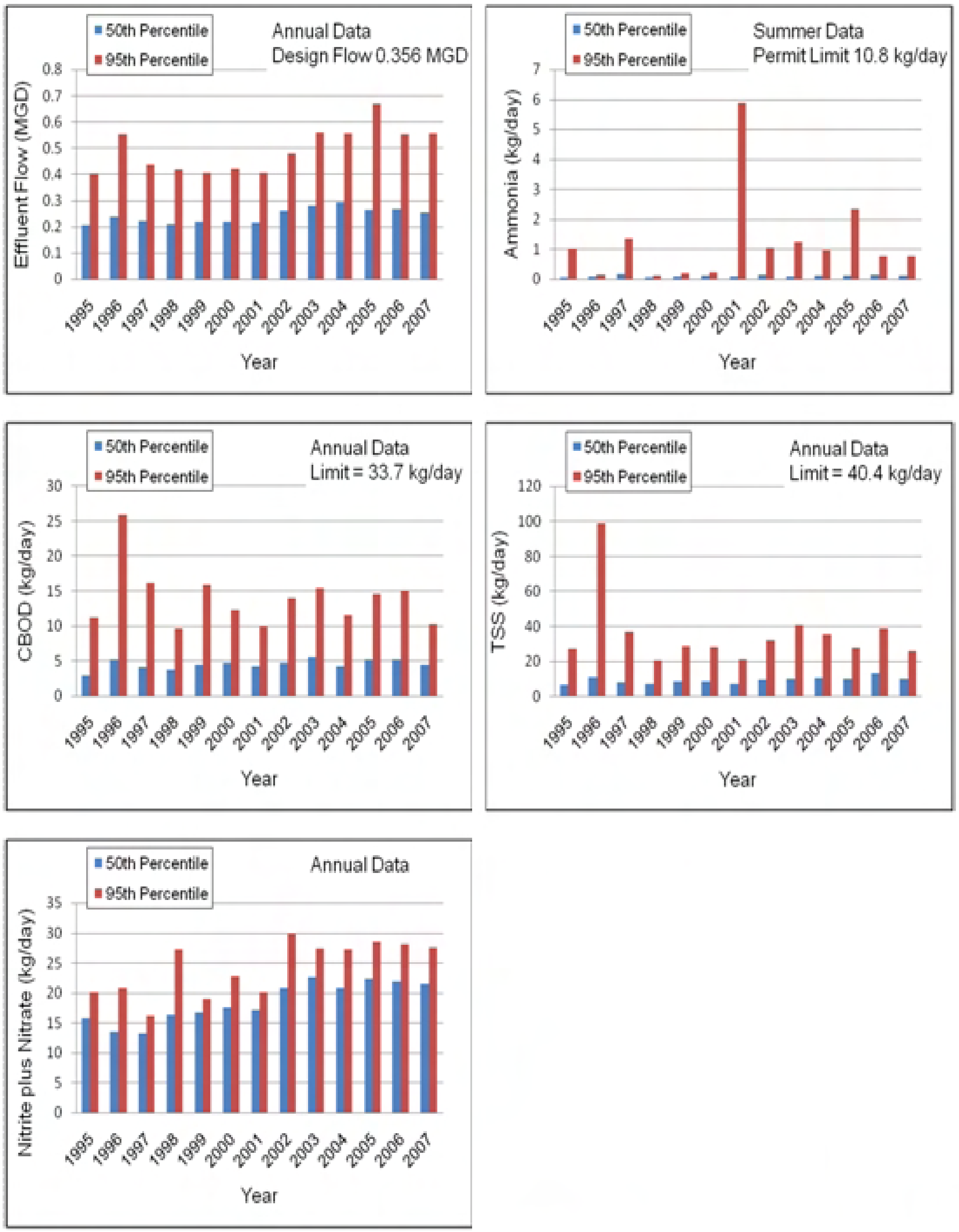

Figure 43. Annual flows, ammonia, carbonaceous biochemical oxygen demand (CBOD), total suspended solids, and nitrite plus nitrate loadings of the Garrettsville WWTP treated effluent 1995-2007. NPDES Permit #3PB00016.

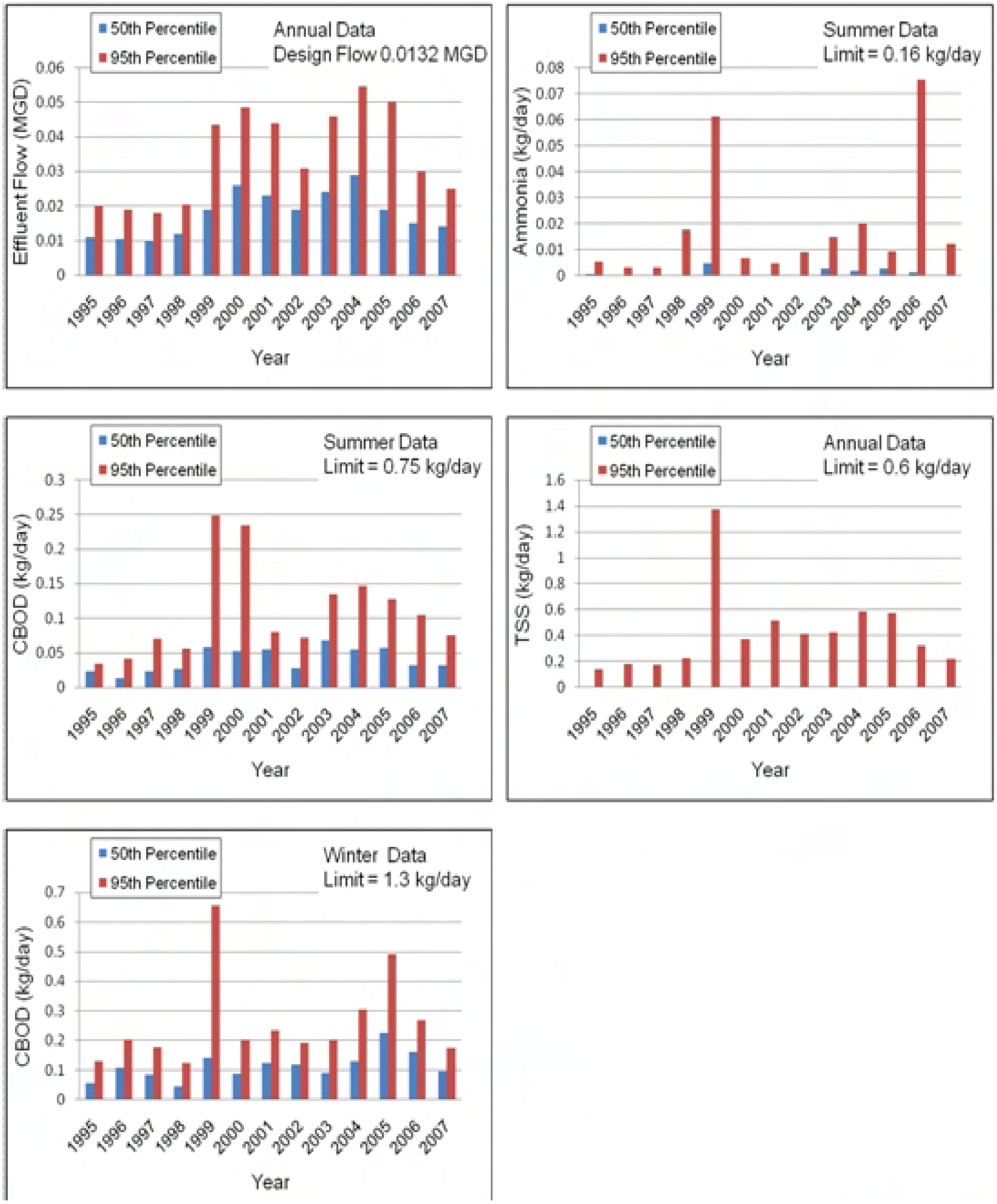

Figure 44. Annual flows, ammonia, carbonaceous biochemical oxygen demand (CBOD), and total suspended solids loading for the Portage Co. Western Reserve WWTP treated effluent 1995-200.7. NPDES Permit #3PG00121.

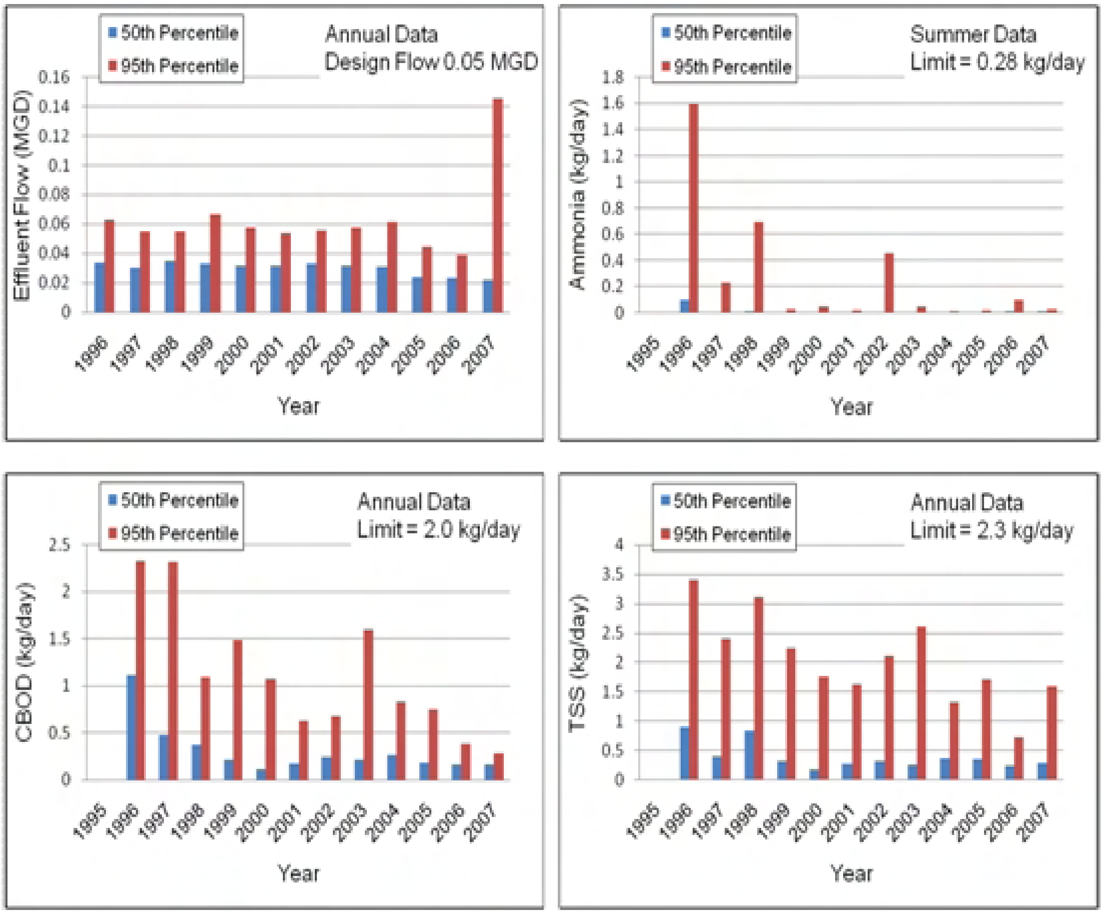

Figure 45. Annual flows, ammonia, carbonaceous biochemical oxygen demand (CBOD), and total suspended solids loadings for the PM Estates MHP WWTP treated effluent 1995-2007. NPDES Permit #3PX0004.

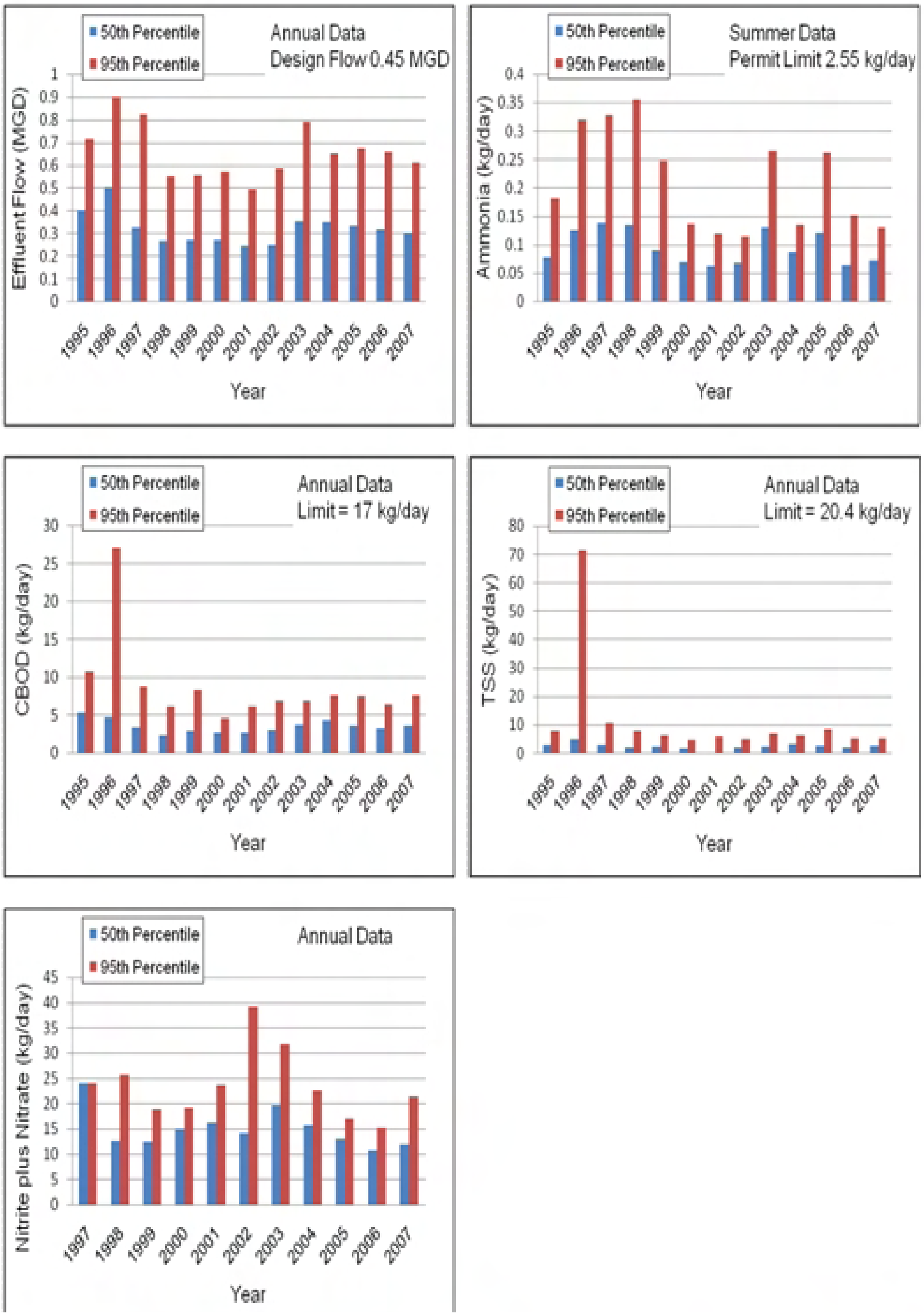

Figure 46. Annual flows, ammonia, carbonaceous biochemical oxygen demand (CBOD), total suspended solids, and nitrite plus nitrate loadings for the Windham WWTP treated effluent 1995-2007. NPDES Permit #3P00019

Recreation Use

This WAU covers the drainage downstream from the confluence of the mainstem Mahoning River and the West Branch Mahoning River, including Eagle Creek, to the Leavitt Rd. dam at RM 45.70. Elevated maximum bacteria counts were observed at the RM 54.73 station downstream from Newton Falls and full attainment of PCR was recorded at RM 45.73 at the Leavitt Rd. canoe livery boat launch.

Four of fourteen (28.6%) tributary sites within this WAU showed non-attainment of PCR criteria, however, the WAU as a whole was in full attainment of the PCR use (Appendix Table 4). The data suggest that bacteria problems are not as widespread in this WAU as the other three WAUs sampled. The highest average bacteria counts in this WAU were recorded at Tinker Creek at Nicholson Rd. (RM 2.50), but specific sources are unknown. Other problem areas on tributary streams were Silver Creek at RM 2.27 and Mahoning Creek downstream from the PM Estates MHP.

Full attainment was recorded at four of five sampling locations on Eagle Creek from RMs 22.44 to 10.10, with non-attainment at the most downstream sampling location (RM 5.60) at the USGS gage. However, a much larger sample size was available for the RM 5.60 station, and violations of PCR criteria were for a single maximum fecal coliform value above 2000/100 ml out of 10 sample events. Thus the data indicate that the bacteria quality at RM 5.60 for Eagle Creek, on average, does not differ significantly from upstream conditions at RM 17.61.

In September 2004 the US EPA approved a TMDL for fecal coliform bacteria for the Mahoning River 05030103-040 Assessment Unit (AU). The TMDL assessment was for the basin area downstream from the West Branch Mahoning River to upstream from Duck Creek, but it excluded data collected on the Mahoning River mainstem downstream from Eagle Creek. The 2004 US EPA TMDL report concluded that this WAU was in non-attainment of the primary contact recreation use and recommended a variety of bacteria load reduction activities. This determination was based on data limited to four sample locations within the WAU. The results of the 2006 bacteria survey indicated that this WAU is now in full attainment of PCR use. Therefore, this WAU was removed from the TMDL 303(d) list of watersheds impaired for primary contact recreation (PCR) in the 2008 Integrated Report.

The recommended removal of this WAU from the TMDL 303(d) list of impaired waters was not so much based on well documented reduction in bacteria levels, but was largely a result of an increase in the number of samples sites available for analysis in 2006 (n= 16 sample locations) than was used in the 2004 assessment (n = 4 sample locations). The four sample locations used in the US EPA TMDL to evaluate bacteria quality were geographically limited to upstream and downstream from the Garrettsville and Windham WWTPs from data collected between 1995 and 2002. The increased number and widespread distribution of sample locations throughout the WAU in the 2006 survey thus provided a more accurate assessment of bacteria quality.

There has been a variety of steps taken by the Trumbull and Portage County Health Districts and SWCDs within the WAU to improve bacteria conditions since 2000. Within Portage County, the SWCD has implemented comprehensive nutrient management plans on 2463 acres, excluded livestock from 8045 feet of stream or wetland area, installed three manure waste storage facilities, and developed grazing plans and pasture management for 48 acres (communication with Jen White, Portage SWCD). From 2002-2005 the Portage County Health Department upgraded 25 failing home sewage treatment systems (HSTS) based on nuisance complaints and home sale inspections (communication with Kevin Watson and Tom Brannon). Within Trumbull County, about 42 acres have been put into conservation plans to address cattle compost/manure and to combat erosion. Educational programs reached 3519 individuals (communication with Amy Reeher, Trumbull SWCD). From 2000-2008 the Trumbull County Health Department replaced 27 failing off-lot discharging HSTS and upgraded 31 on-lot systems. In November 2002 a county regulation was implemented to prohibit installation of any new off lot discharging HSTS, and in July 2003 a regulation was passed to prohibit any HSTS within a 100 year floodplain and 50 foot from streams and lakes (communication with Sharron O'Donnell, Trumbull County Health Department).

Chemical Water Quality

Grab water samples were collected at sixteen sampling locations within this WAU to support the results of the biological surveys. These samples were collected from eight streams. This WAU is limited to the drainage from Eagle Creek, a major tributary of the upper Mahoning River mainstem. All chemical samples were collected on the same day within the study area, thus controlling for the effect of stream flow on the interpretation of data from each sample run. Additional chemical samples were collected from the Garrettsville, Hiram and Windham WWTP effluents (Table 7).

Biological sampling (for both fish and benthic macroinvertebrates) was conducted at fifteen locations within the WAU. Impaired biological communities were found at forty percent (6/15) of the biological sample locations. Of the four WAUs sampled for the Upper Mahoning River survey in 2006, this assessment had the highest percentage of locations showing full attainment of biological communities. Chemical data were compared against OAC 3745-1 water quality criteria and TMDL target nutrient values as medians (NO_2-NO_3 = 1.50 mg/l; TP = 0.08 mg/l for watersheds < 20 mi^2, 0.10 mg/l for watersheds > 20 < 200 mi^2) to help identify potential chemical stressors on biology.

Eagle Creek

Chemical samples were collected at five sampling locations along Eagle Creek, from RM 22.44 to RM 5.6. No chemical samples were collected at RMs 12.10

and 7.20 where additional biological sampling was conducted to assess the benthic macroinvertebrate community. The biological data indicated good-very good biological communities in Eagle Creek for all sample locations except the upper most location at RM 22.44 at St. Rt. 700, upstream from urban runoff from the village of Garrettsville.

Both fish and macroinvertebrate communities were depressed at RM 22.44. No problems were noted in the stream chemical data, although there was an elevated COD (chemical oxygen demand) value of 77 mg/l recorded on 7/26. Oil & grease contamination was noted in stream sediments during the biological survey. The presence of a beaver dam and concurrent modification to hydrology was another possible cause of the biological non-attainment.

Very good to exceptional biological communities were recorded at RM 17.61, which is downstream from the Garrettsville WWTP and storm water runoff from the village. Although the discharge from the Garrettsville WWTP significantly increased the concentrations of phosphorus and nitrates in Eagle Creek, any negative effect on biology was apparently mitigated by exceptional habitat quality and good riparian tree cover. Nutrients were slightly above TMDL targets at RM 17.61 (median TP = 0.120 mg/l; NO_2-NO_3 = 1.09 mg/l).

Given the high quality of the biology documented in Eagle Creek, and the fact that nutrients exceeded TMDL targets at RM 17.61, it is recommended that no future increase in nutrient loads be permitted from upstream discharges, including but not limited to the village of Garrettsville WWTP, the village of Hiram WWTP to Silver Creek, and the Portage County Western Reserve WWTP discharge to Camp Creek. None of these entities presently treat to remove phosphorus. Any future permitted increase in design flow should include the addition of phosphorus removal technologies to maintain current conditions. Added justification to limit additional nutrient loadings from the Hiram WWTP and Western Reserve WWTP is that Silver Creek and Camp Creek supported cool-cold water adapted biological communities during the 2006 survey and are designated or recommended CWH streams. Therefore, any future increase in design flow from these two entities will need to investigate the potential stress from thermal impact on biological communities.

One limitation of the 2006 survey was that no assessment was conducted on the lower 5.6 river miles of Eagle Creek. It is recommended that a survey be conducted in this segment of Eagle Creek to determine if the good biological and chemical conditions that were documented upstream continue to the mouth of Eagle Creek.

South Fork Eagle Creek

Full biological attainment was documented at RMs 3.86 and 2.30, which bracket the discharge from the village of Windham WWTP. No problems with chemical water quality were noted at the downstream RM 2.30 sampling location.

A grab water sample and sediment sample for heavy metals was collected on 07/20/2006 at both RMs 3.86 and 2.30 on the South Fork Eagle Creek as part of a cooperative survey between Ohio EPA Division of Emergency and Remedial Response (DERR) and Division of Surface Water (DSW). The purpose of this survey was to assess the chemical quality of ten streams draining from the Ravenna Training and Logistics Site (aka Ravenna Army Ammunition Plant), to provide data for the upper Mahoning River survey, and DERR regulatory responsibilities. The data for this special survey are presented in Appendix D. The results indicated that no heavy metals were found at either sample location that exceeded either stream water quality criteria or DERR sediment reference concentrations for ecological risk assessment.

Silver Creek

Silver Creek was the only stream in the upper Mahoning River study area with an existing Cold Water Habitat (CWH) designated use at the time of the 2006 survey. Full attainment of the CWH use was documented at RMs 2.27 and 0.79, which bracket the discharge from the village of Hiram WWTP. However, there was a significant increase in the concentration of phosphorus at the downstream location (median TP = 0.118 mg/l, n=4 at RM 0.79; median TP = 0.061 mg/l, n = 4 at RM 2.27), at a level that exceeded the TMDL target goal. The primary source of this phosphorus was the discharge from the Hiram WWTP, which is currently not designed to treat to remove phosphorus. Given the high quality nature of Silver Creek as a unique cold water habitat in the upper Mahoning River basin, and documentation that phosphorus exceeds the TMDL target in Silver Creek near the mouth, it is recommended that no future increase in phosphorus loading be permitted via NPDES permit in the Silver Creek watershed. In addition, any future increase in design flow from current NPDES regulated entities in the Silver Creek watershed will need to investigate potential stress from thermal impact on biological communities.

Camp Creek

The results of the 2006 biological assessment indicated that Camp Creek, currently a designated Warm Water Habitat stream, should be reclassified to a Cold Water Habitat designated use for protection of aquatic life. Summer stream water temperature ranged from 16.41 to 19.82 C^o, with average of 17.62 C^o (n=4), values that are well within the thermal range required for reproduction of cool-cold water adapted species. No problems were noted in the stream chemical data.

Mahoning Creek

Very poor biology was found near the mouth of Mahoning Creek. Poor habitat potential and wetland influences were identified as significant causes of the non-attainment. The PM Estates MHP discharges upstream from RM 0.7. Elevated levels of phosphorus (TP median = 0.523 mg/l) and nitrate-nitrite (median = 3.25

mg/l), well above TMDL target values, were recorded from Mahoning Creek downstream from the MHP discharge. It is recommended that a survey of Mahoning Creek be conducted upstream from the MHP to help partition the effects of poor habitat and natural wetland influence from the discharge of the WWTP.

Nelson Ditch
Biology was in non-attainment near the mouth at RM 0.30, largely a result of channelization and poor habitat conditions (QHEI = 44.0). Chemical samples collected upstream at RM 1.11 indicated potential stress on biology from low dissolved oxygen (4.75 mg/l minimum DO). Nutrients were not elevated on average above TMDL target values. Habitat modification appeared to be the most significant stressor on biology.

Tinker Creek
Impaired biology was documented at RMs 5.45 and 2.50, although the impact was limited to the fish community as the benthic macroinvertebrate community was judged to be in good condition at both sampling locations. The chemical data did not show a consistent trend that explained the depressed fish communities. Nitrate-nitrate was elevated above TMDL target value at RM 5.45 (median = 2.46 mg/l), but was low at RM 2.50 (median = 0.75 mg/l), while phosphorus was low at RM 5.45 (median = 0.045 mg/l) but elevated at RM 2.50 (TP median = 0.091 mg/l). Additional investigation will be required to identify specific stressors on fish communities in Tinker Creek.

Chocolate Run
Impaired biological communities, both fish and benthic macroinvertebrate communities, were found near the mouth at RM 0.11. Poor habitat quality due to channelization (QHEI = 46.5) was an important stressor on biology. The Pleasant Park MHP discharges to Chocolate Run and phosphorus was on average above the TMDL target RM 0.11 (TP median = 0.158, n=4), thus nutrient enrichment would be an additional stressor on biology. There also are areas in the watershed of Chocolate Run that have failing home sewage treatment systems that discharge into ditches. These failing HSTS areas have been referred to the Trumbull County Health Department for corrective actions.

Physical Habitat
The physical habitat of 19 locations within the Eagle Creek basin was evaluated with the QHEI. As Figure 47 shows, the majority of sites scored within the fair to good range. Nelson Ditch was the only site which scored in the poor range, and this was a direct result of habitat alterations. The only site to score within the very good range was Eagle Creek RM 17.61. Flow regime alteration to the habitat of the Mahoning River mainstem along with channelization and habitat alterations for agricultural activities in the tributaries were the primary physical habitat alterations noted.

Mahoning River

The Mahoning River had an average QHEI score of 53.5 (range of 48.5 to 58.5) at the two locations sampled. Downstream from the I-80 turnpike (RM 54.73) the physical habitat received a QHEI of 58.5, indicating the stream should be able to support WWH communities. Within the Leavittsburg dam pool (RM 45.73) the QHEI score dropped to 48.5. The lower score reflected the lack of diversified current and more monotypic habitat associated with dam pools.

Eagle Creek

The five sites along Eagle Creek had an average QHEI score of 63 (range between 53 and 81.5). The two lowest QHEI scores were a 54.0 near State Route 700 (RM 22.44) and a 53.0 along Silica Sand Road (RM 10.10). Each of these sites had more moderate influence MWH attributes than WWH attributes, indicating they may be less able to support WWH communities. The remaining sites on Eagle Creek appeared to have sufficient WWH attributes to support WWH communities (Figure 48).

Tributaries

The remaining ten sites sampled within the Eagle Creek basin had an average QHEI score of 61.3 (range of 44.0 to 74.0). Several of the streams received QHEI scores >60.0, indicating they should be able to support WWH communities. South Fork Eagle Creek, Camp Creek, Silver Creek, and Tinker Creek all had at least four WWH attributes in addition to QHEI scores >60.0. In addition to meeting WWH criterion, over 16% of the fish community of Camp Creek was comprised by CWH species including; mottled sculpin (9.6%), redside dace (7.2%), brook stickleback (0.6%), and central mudminnow (0.1%).

Several streams received QHEI scores <60.0, indicating less than ideal habitat. Mahoning Creek (QHEI of 54.0) should have had adequate habitat to support a WWH fish community, but the IBI score of 18 indicated that negative influences beyond habitat were affecting the ability of fish to prosper in the stream.

Nelson Ditch and Chocolate Run received QHEI scores of 44.0 and 46.5, respectively. Each of these streams had at least two high influence MWH attributes alluding to their poor to fair habitat quality. Direct habitat alterations within each stream increased siltation and left a straight channel devoid of proper channel development.

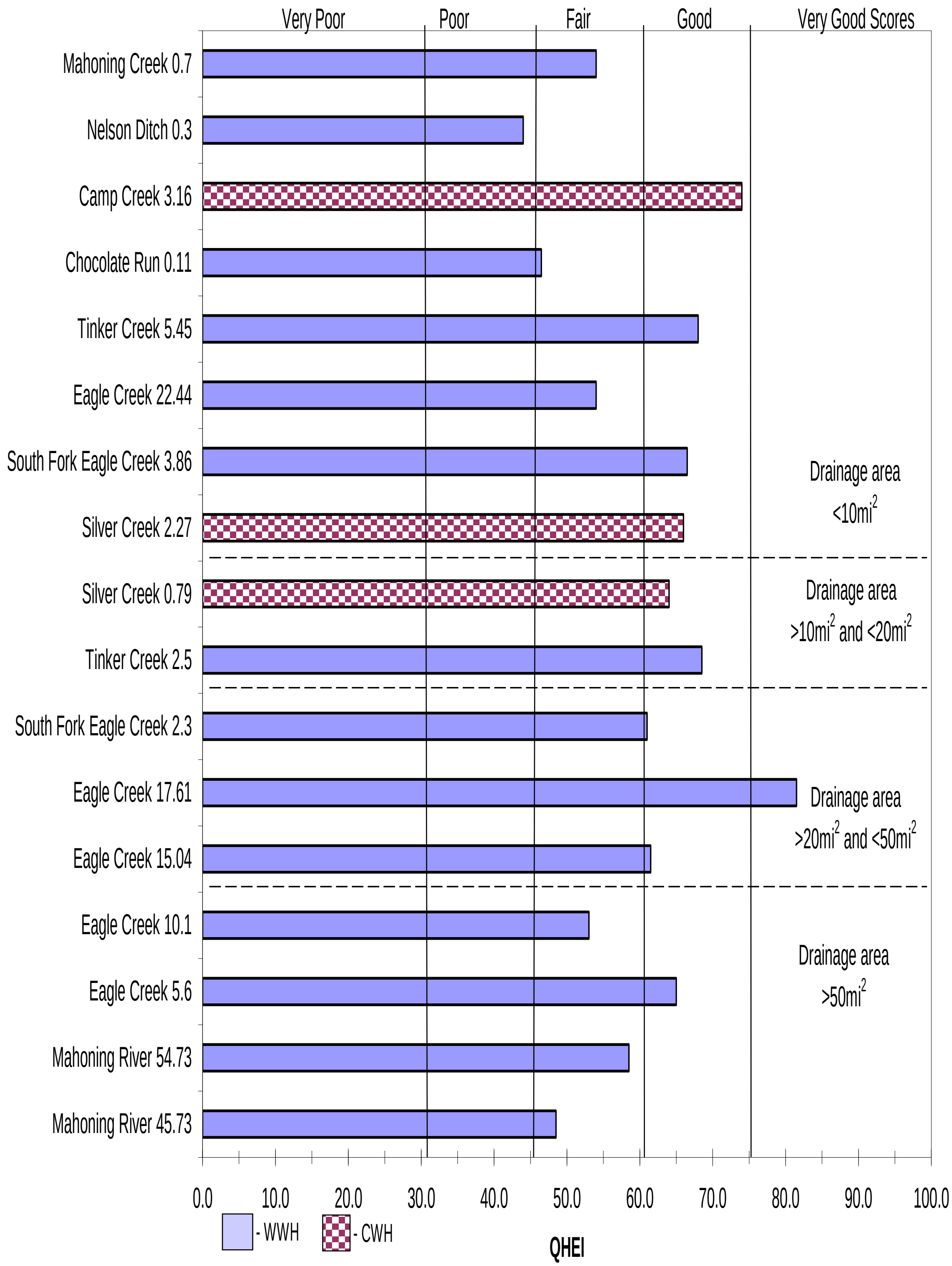

Figure 47. QHEI scores by drainage area for the Eagle Creek basin, WAU 05030103040.

HUC 05030103040 QHEI Attributes

Key QHEI Components

WWH Attributes

River Mile	QHEI	Gradient (ft/mile)	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes
(18-001) Mahoning River													
Year: 2006													
54.7	58.5	2.87	■	■				■	■		■		5
45.7	48.5	0.10		■				■			■		3
(18-040) Eagle Creek													
Year: 2006													
22.4	54.0	10.20	■				■	■			■		4
17.6	81.5	9.26	■	■		■		■	■	■	■	■	8
17.6	75.5	9.26	■	■		■	■		■	■	■	■	8
15.1	61.5	3.57	■				■	■		■	■		5
10.1	53.0	2.18	■					■			■		3
5.6	65.0	1.40	■	■			■	■			■	■	6
(18-043) South Fork Eagle Creek													
Year: 2006													
3.9	66.5	14.29	■				■	■			■	■	5
2.3	61.0	5.65	■			■		■			■	■	5
(18-045) Camp Creek													
Year: 2006													
3.2	74.0	22.22	■	■				■			■		4
(18-046) Silver Creek													
Year: 2006													
2.3	66.0	16.13	■				■	■			■	■	5
0.8	64.0	26.32		■		■		■	■		■		5
(18-092) Mahoning Creek													
Year: 2006													
0.7	54.0	14.93	■				■	■			■		4

MWH Attributes

River Mile	*High Influence*: Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	*Moderate Influence*: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(18-001) Mahoning River																					
Year: 2006																					
54.7		◆				1		●			●	●				●		●	5	0.33	1.17
45.7	◆	◆				2		●			●	●			●	●		●	6	0.75	2.25
(18-040) Eagle Creek																					
Year: 2006																					
22.4		◆				1		●			●				●	●		●	5	0.40	1.40
17.6						0		●				●				●	●		4	0.11	0.56
17.6				◆		1										●			1	0.22	0.33
15.1						0					●	●			●			●	4	0.17	0.83
10.1						0		●			●	●			●	●		●	6	0.25	1.75
5.6						0		●			●				●	●			4	0.14	0.71
(18-043) South Fork Eagle Creek																					
Year: 2006																					
3.9						0		●		●	●				●	●			5	0.17	1.00
2.3				◆		1		●		●	●	●			●	●			6	0.33	1.33
(18-045) Camp Creek																					
Year: 2006																					
3.2			◆			1					●				●	●	●		4	0.40	1.20
(18-046) Silver Creek																					
Year: 2006																					
2.3						0		●			●				●	●			4	0.17	0.83
0.8	◆		◆			2		●			●					●	●		4	0.50	1.17
(18-092) Mahoning Creek																					
Year: 2006																					
0.7		◆				1		●			●				●	●		●	5	0.40	1.40

04/02/2008 1

Figure 48. QHEI attributes for sites within Eagle Creek WAU, 2006.

HUC 05030103040 QHEI Attributes

Key QHEI Components

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	MWH Attributes, High Influence: Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	MWH Attributes, Moderate Influence: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(18-039) Chocolate Run																																			
Year: 2006																																			
0.1	46.5	9.78	■					■			■		3	◆		◆			2					●				●	●		●	4	0.75	1.75
(18-041) Tinker Creek																																			
Year: 2006																																			
5.4	68.0	35.71	■			■	■	■	■	■	■	■	8						0		●								●			2	0.11	0.33
2.5	68.5	7.81			■	■		■	■	■	■	■	7			◆	◆		2	●				●								2	0.38	0.63
(18-042) Nelson Ditch																																			
Year: 2006																																			
0.4	44.0	5.05		■				■			■		3	◆	◆	◆			3		●			●				●	●		●	5	1.00	2.25

04/02/2008 1

Figure 48 continued. QHEI attributes for sites within Eagle Creek basin.

Biological Communities: Fish

The fish community within the Eagle Creek basin was sampled at 17 locations. The majority of IBI scores indicated attainment of WWH community expectations (Table 24). The fish community of the two Mahoning River mainstem sites was influenced by the altered habitat and flow regime modifications of the Leavittsburg dam. Several tributaries did exhibit fish community scores below WWH criteria. This was found to occur primarily where habitat alterations had reduced habitat quality available to the aquatic community (Figure 49), or where nutrient eutrophication was occurring (Table 24).

Mahoning River

The fish community along the Mahoning River mainstem received IBI scores indicating WWH communities within the Leavittsburg dam backwater (RM 54.73, IBI score of 41) and dam pool (RM 45.73, IBI score of 40). However, MIwb scores dropped from an 8.6 downstream from I-80 (RM 54.73) to a 7.7 within the Leavittsburg dam pool (RM 45.73). The MIwb is sensitive to the total number and biomass of fish excluding tolerant species and to the uneven distribution of individuals and biomass within the community assemblage. This shift was not surprising as the dam pool did not provide a diversity of niches for aquatic life.

Eagle Creek

Four of the five locations sampled within Eagle Creek received IBI scores meeting WWH expectations. The site near State Route 700 (RM 22.44) received an IBI score of 34 (fair). The fish community was 57% percent pollution tolerant individuals, indicating that conditions were less than ideal for the fish community.

For the reach along State Route 700, fish community performance has declined over time. Previous sampling at this location in 1999 had similar results to the 2006 sampling, but sampling in 1981 had an average IBI score of 43. In 1981 a total of 17 species were collected and included central mudminnow (2.1%), redside dace (2.1%), mottled sculpin (3.6%), and brook stickleback (3.5%). These four species are known to be indicative of strong groundwater connections between the stream and aquifer. The redside dace is also considered a pollution sensitive species. Since 1981, redside dace, brook stickleback, and mottled sculpin have not been collected from this area. In addition, central mudminnow has comprised a very small percentage of the population, 0.31% in 1999 and 0.68% in 2006. The species lost were not replaced by other species. The total species count dropped to 14 in 1999 and 13 in 2006.

A review of land use changes from 1994 and 2001 indicate that there has been little change over time throughout the area near and upstream from Eagle Creek RM 22.5 (Table 25). QHEI scores have ranged between 52.5 and 54.0 at this station since 1981. While this indicated that habitat conditions have remained consistent over time, a closer look at the QHEI attributes shows that the substrates may have become more embedded over time (Figure 48). Increased substrate embeddedness limits the interstitial spaces available for aquatic life.

Species requiring the flow of oxygenated water through coarse substrates, such as the redside dace, may have low survival of offspring in such conditions. In addition, as the redside dace, mottled sculpin, and brook stickleback are insectivorous species, a drop in macroinvertebrate populations due to decreased quality habitat (lack of interstitial spaces) could hamper their survival rates as well.

Table 25. Upstream Eagle Creek RM 22.5 land use in 1994 and 2001.

LAND USE	2001 Acres	2001 Percent	1994 Acres	1994 Percent
Open Water	10.90	0.34	11.34	0.36
Developed, Open Space	99.63	3.13	N/A	N/A
Developed, Low Intensity	26.69	0.84	N/A	N/A
Low-Density Residential	N/A	N/A	0.67	0.02
Commercial/Industrial/Transportation	N/A	N/A	0.67	0.02
Deciduous Forest	1564.55	49.14	1644.39	51.65
Evergreen Forest	13.34	0.42	18.01	0.57
Mixed Forest	1.11	0.03	6.89	0.22
Grassland/Herbaceous	90.07	2.83	N/A	N/A
Pasture/Hay	510.17	16.02	909.37	28.56
Cultivated Crops	823.31	25.86	429.89	13.50
Woody Wetlands	42.48	1.33	131.66	4.13
Emergent Herbaceous Wetlands	1.33	0.04	30.69	0.96

While increased embeddedness may affect both macroinvertebrate and fish populations, the source of this stressor is not completely understood. Increased embeddedness is often the result of a change in land use (e.g., forest to residential homes or row crop agriculture) resulting in increased siltation which covers the stream substrates. Cultivated crops have increased from 13.5% in 1994 to 25.86% in 2001 and may be contributing to the sedimentation. Also, beavers have been noted within Eagle Creek and the surrounding area since 1981. The construction of dams by beavers can impound the streams and increase the sedimentation in the slow current of the pool. Water temperature may also increase in the resulting broad pool as the flow regime is altered. Such conditions would cause species such as redside dace and brook stickleback to seek more suitable habitat elsewhere.

Spills may have also contributed to the decline of the more sensitive species in the area. A review of spill information from the area between 1978 and 2007 indicates 14 spills which may have occurred in Eagle Creek or one of its tributaries. However, information for spills prior to 1994 (9 of the 14) do not have specific location information, which makes it difficult to determine if a spill could have affected the area in question. Brine was the most common source of the spills, though oil was also spilled.

The fish community has improved over time, comparing the 1981 results further downstream to the corresponding 2006 results. However, according to the 1982 report regarding the 1981 sampling, “Representative collections were obtained at RM 22.5 and 17.5 but gear efficiency decreased in the progressively deeper and wider pooled areas at RM 19.1, 14.7, and 10.1”. (Ohio EPA, 1982). Therefore, the only data which should be used for comparison from that year downstream from State Route 700 (RM 22.5) is the site downstream from the Garrettsville WWTP at RM 17.5. This site has dramatically improved from an IBI of 35 in 1981 to an IBI of 51 in 2006 (Figure 50). Improvements at the Garrettsville WWTP are likely responsible for the much improved fish community performance.

Tributaries

Several tributaries within the Eagle Creek basin met or exceeded WWH expectations in regards to the fish community. South Fork Eagle Creek, Silver Creek, Camp Creek and Eagle Creek all had IBI scores between 41 and 44 (average IBI score of 42), exceeding the WWH criterion of 40. In addition to meeting the WWH criterion, over 16% of the fish community of Camp Creek was comprised by CWH species; mottled sculpin (9.6%), redside dace (7.2%), brook stickleback (0.6%), and central mudminnow (0.1%).

From a historical perspective, South Fork Eagle Creek and Silver Creek have both been sampled previously. The fish community of Silver Creek has been sampled at least once a decade since 1981 and has consistently met WWH criteria (Figure 51). The fish community of the South Fork Eagle Creek was sampled extensively in 2003. The fish community sampled in 2006 at RM 3.9 scored similarly to the sites sampled in 2003. A detailed summary of the fish community of Silver Creek is available in the *Facility-Wide Biological and Water Quality Study 2003 Ravenna Army Ammunition Plant* available on the Ohio EPA website at: http://www.epa.state.oh.us/dsw/documents/FWSWAFinalReport_19apr06.pdf.

In addition to the streams which consistently met WWH expectations, several streams scored below WWH expectations. Sites along Tinker Creek, Nelson Ditch, and Chocolate Run all scored below WWH expectations with an average IBI score of 31 (range of values between 24 and 34). Mahoning Creek, which is a wetland stream sampled below a MHP WWTP, received the lowest IBI score in the basin, 18. These low fish community scores reflected the modified habitats present along each stream.

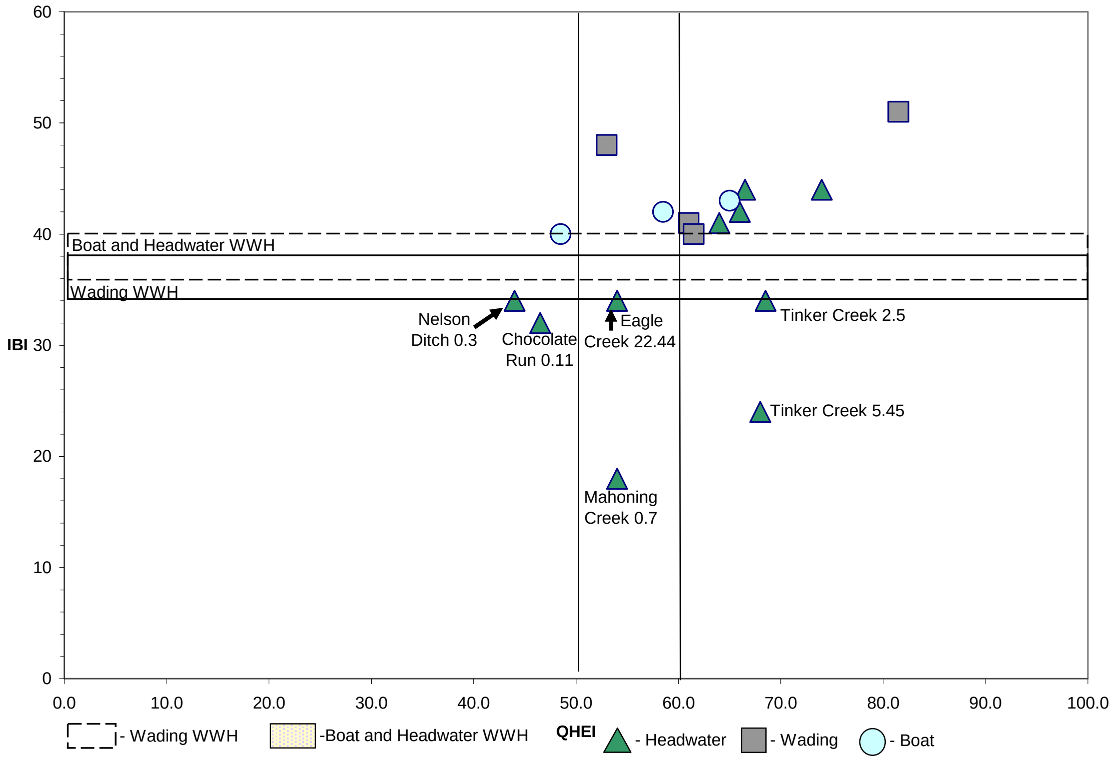

Figure 49. QHEI versus IBI and MIwb scores for the Eagle Creek basin, WAU 05030103040.

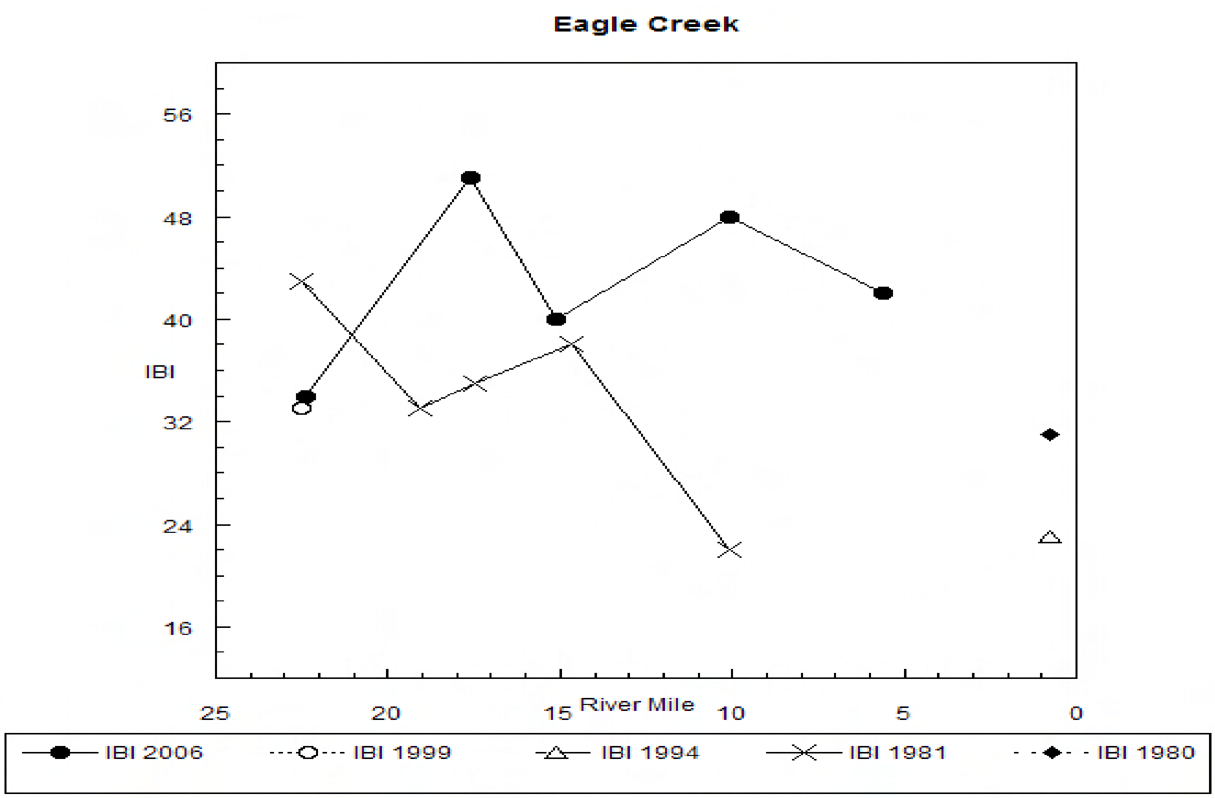

Figure 50. Historical fish sampling results for Eagle Creek, 1981-2006.

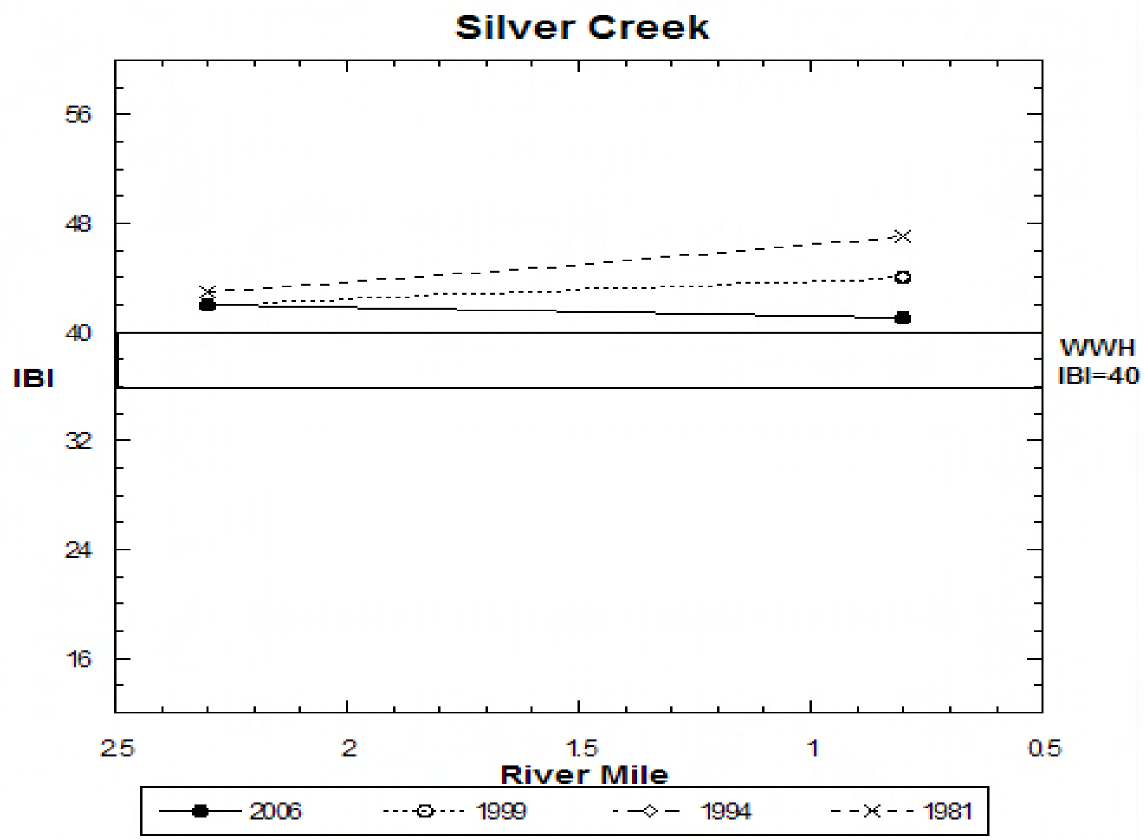

Figure 51. IBI scores over time for Silver Creek.

Biological Community: Macroinvertebrate

A total of nineteen sites were sampled for macroinvertebrates in the Eagle Creek Mahoning River watershed assessment unit (Table 26). By far, this assessment unit exhibited the highest level of biotic integrity of any other sampled in the survey. Thirteen sites were achieving ecoregional WWH expectations, nine of which were within EWH criteria. Eagle Creek and its associated tributaries comprised most of the sampling effort in this watershed; the Mahoning River downstream from Newton Falls to the Leavittsburg Dam constituted the remaining portion. The six sites that did not meet water quality goals were principally affected by poor quality habitat attributes including impoundments, channelization, and wetland conditions. *Baetisca sp.*, an infrequently collected mayfly that favors high quality streams with sandy substrates, was commonly found throughout Eagle Creek and the South Fork Eagle Creek. The Eagle Creek sampling effort also revealed two cold water communities on the tributaries of Camp Creek and Silver Creek.

Eagle Creek

HUC 12- 05030103 04 01, 05030103 04 03, and 05030103 04 05

Overall, Eagle Creek displayed a high level of macroinvertebrate community integrity, meeting its associated WWH criteria at every site except for the headwaters site at RM 22.44, where a fair community was collected. At this location, instream habitat consisted mostly of fine substrate material intermixed with clay, with only one true riffle. Most of the sampling reach was a slow glide with very deep pools, due to a beaver dam impoundment. This resulted in low overall abundance on the natural substrates, with few EPT and sensitive taxa. Once removed from the headwaters, Eagle Creek immediately improved with an exceptional community collected at RM 17.61, and continued to meet or exceed WWH criteria at every subsequent downstream sampling location. Figure 52 displays the longitudinal performance of the macroinvertebrate communities of Eagle Creek as indicated by the ICI (scores are estimated where ICIs are unavailable).

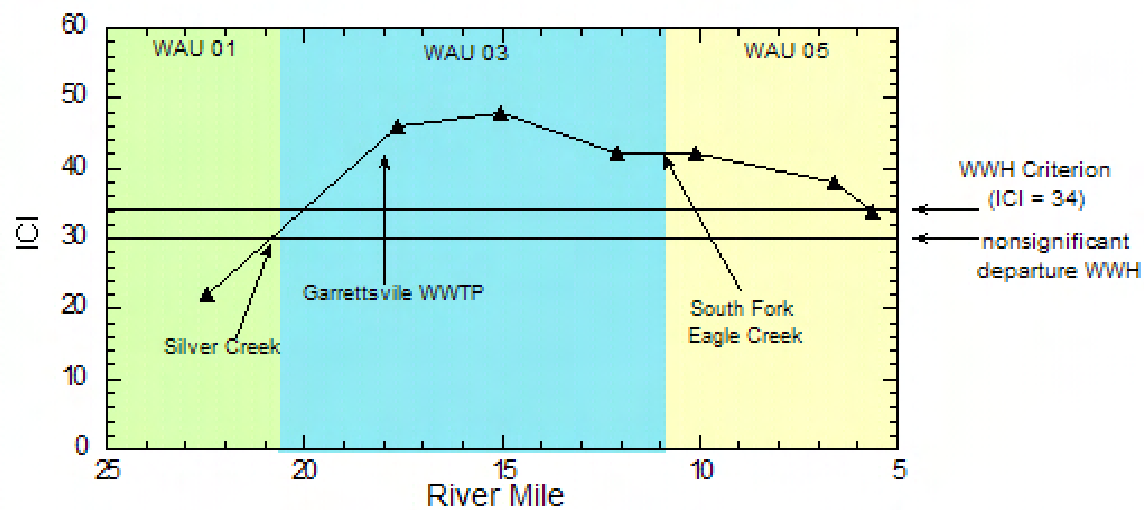

Figure 52. Longitudinal plot of ICI scores for Eagle Creek, 2006. ICIs are estimated for RMs 22.44, 10.10, and 5.60 in lieu of a quantitative sample.

Table 26. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Eagle Creek Mahoning River watershed (WAU 05030103 04), June to September, 2006.

Stream RM[a]	Dr. Ar. (sq. mi.)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Ranges in Parentheses	ICI	Narrative Evaluation
HUC 12 - 05030103 04 01										
Eagle Creek										
22.44	5.2	--	45	7	6	L	1	Midges (VT-MI)	--	Fair
Silver Creek										
2.27	8.8	19	48	15/15	19/32	M/707	2	Mayflies (F-I)	54	Exceptional
0.79	11.2	--	40	16/16	16/28	M/1674	4	Net-spinning caddisflies (F-MI), *Rheotanytarsus sp*. midges (MI)	52	Exceptional
HUC 12 - 05030103 04 02										
South Fork Eagle Creek										
3.86	7.5	4,15, 19	61	18/22	24/37	ML/1806	3	Net-spinning caddisflies (MI), *Rheotanytarsus sp*. midges (MI)	46	Exceptional
2.30	23.5	--	54	16/22	18/31	M/4876	1	Brush-legged mayflies (MI), minnow mayflies (F)	52	Exceptional
HUC 12 - 05030103 04 03										
Eagle Creek										
17.61	32.0	--	39	14/16	12/17	M/1587	0	Mayflies (F-I), *Rheotanytarsus sp*. midges (MI)	46	Exceptional
15.04	36.0	--	44	13/18	15/22	L/1060	0	Mayflies (F-MI), net-spinning caddisflies (F-MI)	48	Exceptional
12.10	49.0	--	45	13/15	16/27	M/403	0	Brush-legged mayflies (MI)	42	Very Good
Camp Creek										
3.16	4.2	--	61	17	23	M	7	Net-spinning caddisflies (MI-F)	--	Exceptional
Mahoning Creek										
0.70	3.7	--	33	3	3	M	0	Net-spinning caddisflies (F), sowbugs (MT), scuds (F)	--	Poor

Stream RM[a]	Dr. Ar. (sq. mi.)	Data Codes	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Ranges in Parentheses	ICI	Narrative Evaluation
HUC 12 - 05030103 04 04										
Tinker Creek										
5.45	4.4	--	46	12	16	M	3	Net-spinning caddisflies (MI-F)	--	Good
2.30	11.2	--	46	13	11	M	2	Blackflies (F), net-spinning caddisflies (MI-F)	--	Good
Nelson Ditch										
0.30	3.9	--	31	4	5	L	0	Midges (MT-MI), net-spinning caddisflies (F)	--	Low Fair
HUC 12 - 05030103 04 05										
Eagle Creek										
10.10	74.0	--	46	17	18	M	0	Net-spinning caddisflies (MI-F), minnow mayflies (F), riffle beetles (MI)	--	Very Good
6.6	95.0	6	40	14/16	16/21	HM/3080	0	*Rheotanytarsus sp.* midges	38	Good
5.6	97.6	--	40	10	15	M-L	0	Net-spinning caddisflies	--	Good
HUC 12 - 05030103 04 06										
Mahoning River										
54.73	418.0	--	20	4/9	3/13	L/197	0	Scuds (F-MT)	22	Fair
45.73	542.0	2,8	22	2/6	3/9	L/226	0	Scuds (F)	20	Fair
Chocolate Run										
0.11	4.4	--	22	3	4	H-M	0	Scuds (F-MT)	--	Low Fair

RM: River Mile.
Dr. Ar.: Drainage Area
Data Codes: 8=Non-Detectable Current, 9=Intermittent or Near-Intermittent Conditions, 12=Suspected High Water Influence/Disturbance, 13=Suspected Disturbance by Vandalism, 15=Current >0.0 fps but <0.3 fps, 29=Primary Headwater Habitat Stream.
Ql.: Qualitative sample collected from the natural substrates.
Sensitive Taxa: Taxa listed on the Ohio EPA Macroinvertebrate Taxa List as MI (moderately intolerant) or I (intolerant).
Qt.: Quantitative sample collected on Hester-Dendy artificial substrates, density is expressed in organisms per square foot.
Qualitative sample relative density: L=Low, M=Moderate, H=High.

CW: Coolwater/Cold water.
Tolerance Categories: VT=Very Tolerant, T=Tolerant, MT=Moderately Tolerant, F=Facultative, MI=Moderately Intolerant, I=Intolerant
a – The RM indicated may differ slightly from the RM located in the Attainment Tables throughout this document. The RMs in this table are the Absolute Location Points (ALPs) which are the actual location where the data was collected. Each RM included in the Attainment Tables represents a Point of Record (POR) which is defined as a sampling station whereby ALPs representing the station may be linked.

Eagle Creek Tributaries
HUC12 - 05030103 04 01-04

With little exception, the tributaries to Eagle Creek were of similar quality to its mainstem counterpart, with all but two of the nine stations sampled meeting the ecoregional WWH criteria. Of the seven exceptional communities collected in the entire Eagle Creek-Mahoning River watershed, five were located on the direct Eagle Creek tributaries of Silver Creek (HUC 12 - 05030103 04 01), South Fork Eagle Creek (HUC 12 - 05030103 04 02), and Camp Creek (HUC 12 - 05030103 04 03). The South Fork Eagle Creek displayed the highest level of biodiversity of any individual stream sampled in the Upper Mahoning River survey in 2006, both in terms of total (82) and qualitative (61) taxa richness.

Camp Creek should be assigned the CWH aquatic life use based upon the presence of seven indicator taxa within the collected fauna. Included among those taxa are the intolerant stonefly *Leuctra sp.*, the infrequently collected caddisfly *Lepidostoma sp.*, and the state threatened caddisfly *Ptilostomis indecisa*. Based upon the presence of these sensitive species, any near and instream changes that may disrupt the ecological balance of this stream should be carefully monitored.

The benthic fauna of Silver Creek RM 0.79 also included four cold water taxa in addition to its exceptional ICI score. Given the upstream presence of the Hiram WWTP and the removal of riparian vegetation in the sampling area, such a performance shows great assimilative capacity. Silver Creek is currently designated the CWH use based upon past performance of the fish community. Future evaluations of Silver Creek at RM 0.79 should also include the assessment of cold water macroinvertebrates.

The two sites that fell below ecoregional expectations were on Mahoning Creek (HUC 12 - 05030103 04 03) and Nelson Ditch (HUC 12 - 05030103 04 04). Nelson Ditch was sampled just upstream from its confluence with Tinker Creek and appeared to be recovering from prior channelization, as mostly young trees and shrubs populated the riparian corridor. However, the low gradient nature of the stream reduced the overall energy of the system, resulting in a sluggish stream with little turbulence and low dissolved oxygen. These conditions contributed to a sparse benthic community with few sensitive and EPT taxa. Wetland conditions and high phosphorus output from the PM Estates Mobile Home Park package plant combined to account for the poor macroinvertebrate community collected in Mahoning Creek.

Chocolate Run-Mahoning River
HUC 12 - 05030103 04 06

All macroinvertebrate communities collected in the Chocolate Run-Mahoning River subwatershed scored within the fair range. The two stations on the Mahoning River were clearly influenced by the presence of the Leavittsburg Dam, as the station at RM 54.73 was in the deep, slow backwaters created by the dam, while the station at RM 45.73 was located directly within the dam pool. The Leavittsburg Dam has frequently been cited as a source of flooding in surrounding neighborhoods, and its presence also accounts for nearly nine miles of sluggish backwater conditions in the Mahoning River. Consideration should be sought for removal of the dam in order to restore the river to a free-flowing nature, thus improving water quality and alleviating flooding issues.

The benthic community belied the high quality habitat encountered at RM 0.11 of Chocolate Run. In spite of forested riparian and riffle-run complexes comprised of mildly embedded coarse substrate material, only 22 total taxa were collected, of which only four were pollution-sensitive. The natural substrates were densely populated with scuds; flatworms, leeches, and aquatic worms were also in high abundance. Such benthic composition indicated both nutrient and organic enrichment. Water column chemistry samples revealed high levels of total phosphorus, which furthers the notion of enrichment issues. A mobile home park discharges effluent upstream from the sampling station, and failing septic systems have been documented in the area. Either of these sources could have accounted for the impairment observed in the macroinvertebrate community of Chocolate Run.

Trends

The presence of three wastewater treatment facilities and numerous regional reference sites yielded a considerable amount of historical data in the Eagle Creek watershed. Eagle Creek itself was sampled in 1981, 1994, and 1999, culminating in the sampling effort conducted in 2006. In lieu of ICI scores (unavailable for 1981), qualitative sensitive taxa are plotted longitudinally for all sampling events (Figure 53). Two patterns are evident in this plot. The first is a notable improvement downstream from the Garrettsville WWTP. RM 17.61 showed a precipitous drop in both EPT and sensitive taxa from its upstream counterpart during 1981 sampling. The same site displayed an increase in these taxa when sampled again 25 years later in 2006. Upgrades to the Garrettsville WWTP throughout the years have apparently translated into these improvements in the benthic community. The second phenomenon appears to be a decline in biotic integrity at the regional reference site at RM 22.44. Sensitive taxa numbers were lower in 2006 than in any other year sampled. Beaver activity has been documented at this site over the years; in 1981 the field investigator noted that the remnants of an old beaver dam actually formed one of the riffles that was sampled. In 2006, however, an intact dam created a slow glide habitat that allowed for the deposition of heavy silts, thus depressing the macroinvertebrate community.

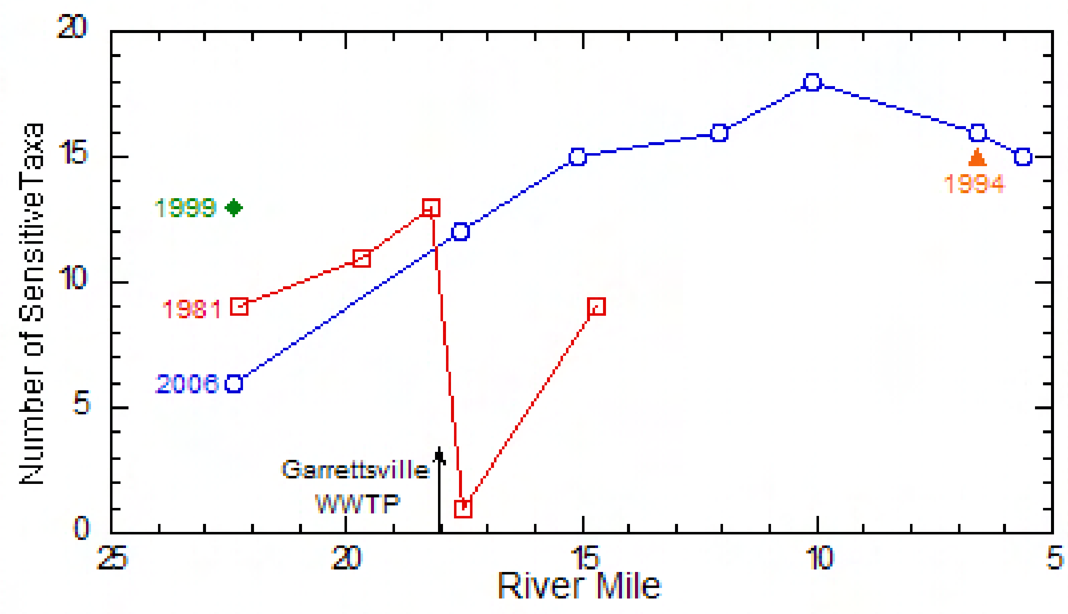

Figure 53. Longitudinal plots of qualitative sensitive taxa for Eagle Creek collected during the years 1981, 1994, 1999, and 2006.

In addition to Eagle Creek, Silver Creek and South Fork Eagle Creek have also been subjected to historical sampling. Records for Silver Creek extend back to 1981, while South Fork dates to only 1999. Silver Creek has demonstrated steady improvement in the biota over the 25 year sampling period, particularly at the station downstream from the Hiram WWTP (RM 0.79). This station has improved from marginally meeting WWH criteria in 1981, to scoring within EWH standards in both 2003 and 2006. In addition, four cold water taxa were collected from this reach in 2006. Currently, Silver Creek is designated CWH based upon previous assessment of the fish community. Future appraisals of this station should also include the assessment of cold water macroinvertebrates.

South Fork Eagle Creek also demonstrated CWH potential in 2003, when the stream was sampled extensively within the Ravenna Training and Logistics Site (RTLS). Three of the four communities collected included at least the requisite four cold water taxa to be considered for the CWH aquatic life use (RM 6.2=8, RM 5.5=7, and RM 2.7=4). As such, South Fork Eagle Creek from its headwaters to RM 2.7 should be recommended for the CWH aquatic life use. Sampling protocols in the 2006 survey resulted in the capture of only 1 cold water taxon outside of RTLS property. This reach should be resampled in the future to better appraise its CWH potential before recommending an aquatic life use change. Overall, sampling in 2003 and 2006 showed benthic communities that were within EWH criteria. One sampling event at RM 4.0 in 1999 garnered a depressed ICI of 32 due to the presence of a beaver dam.

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