State of Ohio
Environmental Protection Agency

Division of Surface Water

Biological and Water Quality Study of Yellow Creek and Selected Tributaries, 2005-2006

Columbiana, Carroll, and Jefferson Counties, Ohio

November 18, 2008

Ted Strickland, Governor
Chris Korleski, Director

Biological and Water Quality Study of Yellow Creek and Selected Tributaries 2005-2006

Columbiana, Carroll, and Jefferson Counties, OH

November 18, 2008

OEPA Technical Report EAS/2008-7-7

Prepared by

State of Ohio Environmental Protection Agency
Division of Surface Water
Lazarus Government Center
50 West Town Street, Columbus OH 43215
Mail to:
P.O. Box 1049, Columbus OH 43216-1049

Southeast District Office
2195 Front Street
Logan, Ohio 43138

TABLE OF CONTENTS

TABLES

FIGURES

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.

___ 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.

___ 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.

___ 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.

___ 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.

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.

These documents and this report may be obtained by writing to:

Ohio EPA, Division of Surface Water
Monitoring and Assessment Section
4675 Homer Ohio Lane
Groveport, Ohio 43125
(614) 836-8777

ACKNOWLEDGMENTS

The following Ohio EPA staff is acknowledged for their contribution to this report:

Chemical Water Quality – Robert Davic, Joann Montgomery
Sediment Quality – Robert Davic, Joann Montgomery
Physical Habitat – Brian Alsdorf
Biological Assessment – Brian Alsdorf, Jack Freda
Data Management - Dennis Mishne, Mary Ann Silagy
TSD coordination – Jack Freda
Reviewers - Jeff DeShon and Marc Smith

This evaluation and report were possible only with the assistance of the study team, many full and part time field staff, and the chemistry analyses provided by the Ohio EPA Division of Environmental Services. Property owners who permitted access for sampling are also gratefully acknowledged for their cooperation.

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:

Ohio EPA, Division of Surface Water
Ecological Assessment Unit
4675 Homer Ohio Lane
Groveport, Ohio 43125
(614) 836-8784

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 250-300 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

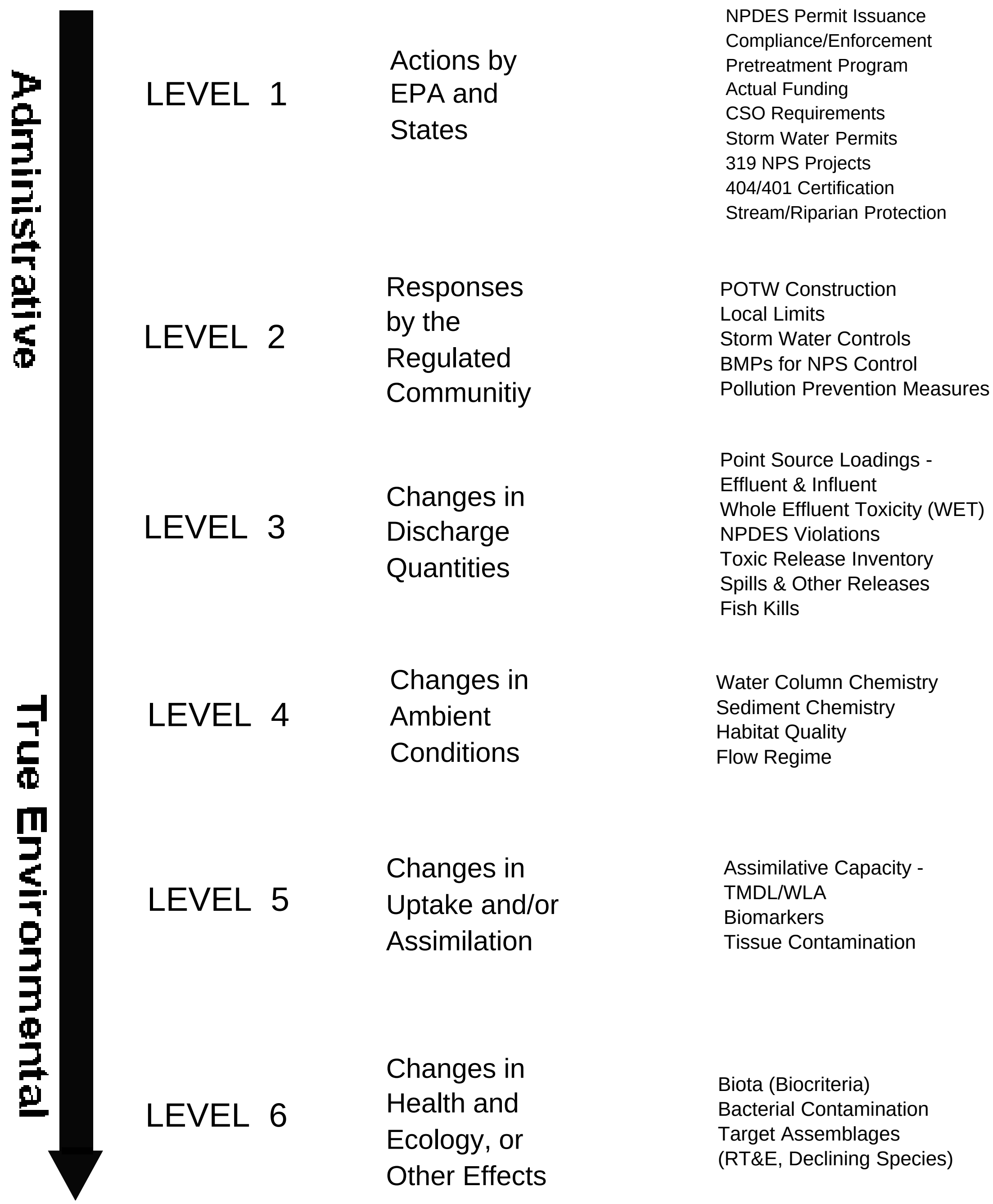


Figure 1. Hierarchy of administrative and environmental indicators which can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by the U.S. EPA.

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.

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) *Coldwater Habitat (CWH)* - this use is intended for waters which support assemblages of coldwater 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) or for partial body contact such as wading (SCR). 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 re-aeration 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).

Acid Mine Drainage (ph., metals, total dissolved solids)

(from Chapter 4 "*Effects Of Mine Drainage On Aquatic Life, Water Uses, And Man-Made Structures"* by Jane Earle and Thomas Callaghan *in* Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania, West Virginia Surface Mine Drainage Task Force Symposium, April 4 & 5, 2000, Morgantown, WV.

http://wvmdtaskforce.com/proceedings/00/PBrady.PDF

Mine drainage is a complex of elements that interact to cause a variety of effects on aquatic life that are difficult to separate into individual components. Toxicity is dependent on discharge volume, pH, total acidity, and concentration of dissolved metals. pH is the most critical component, since the lower the pH, the more severe the potential effects of mine drainage on aquatic life. The overall effect of mine drainage is also dependent on the flow (dilution rate), pH, and alkalinity or buffering capacity of the receiving stream. The higher the concentration of bicarbonate and carbonate ions in the receiving stream, the higher the buffering capacity and the greater the protection of aquatic life from adverse effects of acid mine drainage (Kimmel, 1983). Alkaline mine drainage with low concentrations of metals may have little discernible effect on receiving streams. Acid mine drainage with elevated metals concentrations discharging into headwater streams or lightly buffered streams can have a devastating effect on the aquatic life. Secondary effects such as increased carbon dioxide tensions, oxygen reduction by the oxidation of metals, increased osmotic pressure from high concentrations of mineral salts, and synergistic effects of metal ions also contribute to toxicity (Parsons, 1957). In addition to chemical effects of mine drainage, physical effects such as increased turbidity from soil erosion, accumulation of coal fines, and smothering of the stream substrate from precipitated metal compounds may also occur (Parsons, 1968; Warner, 1971).

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 percent particle size distribution (sand $\geq$60 μ, silt 5-59 μ, clay $\leq$4 μ), percent solids, and percent organic carbon. Most locations sampled had an abundance of sediment, and no difficulties were experienced in locating ample volumes of sediment for analysis. Chemical attributes included metals, volatile and semi-volatile organic compounds, pesticides, and poly-chlorinated biphenyls (PCBs).

Biological and Water Quality Study
of Yellow Creek and
Selected Tributaries
2005-2006

Columbiana, Carroll, and Jefferson Counties, OH

State of Ohio Environmental Protection Agency
Division of Surface Water
Lazarus Government Center
122 South Front St., Columbus OH 43215

INTRODUCTION

Ambient biological, water column chemical and sediment sampling was conducted in the Yellow Creek, Little Yellow Creek, and local Ohio River drainages from June through October 2005. A limited amount of supplemental, macroinvertebrate sampling was also conducted in 2006. The watersheds are located in eastern Ohio in portions of Columbiana, Carroll, and Jefferson counties near the Ohio, Pennsylvania and West Virginia borders. The Yellow Creek mainstem is formed by the confluence of Elk Fork and Elk Lick upstream from the Village of Amsterdam and flows east through a mostly forested landscape for approximately 33 miles. The creek enters the Ohio River just south of Wellsville, near Ohio River River Mile (RM) 931. Little Yellow Creek, located just north of the Yellow Creek basin is approximately 12 miles in length and flows between Highlandtown Lake and the Ohio River. Sampling was also conducted in a series of small, direct Ohio River tributaries located between East Liverpool and Yellow Creek. A list of all Yellow Creek mainstem and tributary sites evaluated in this study are found in Table 1.

Sampling was conducted 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. Subwatersheds within the study area included upper Yellow Creek, lower Yellow Creek, and Ohio River Tributaries (including Little Yellow Creek) in the East Liverpool and Wellsville areas. To the extent possible, tributary streams with at least 2 mi^2 of drainage were sampled.

Specific objectives of this evaluation were to:

1) Monitor and assess the chemical, physical and biological integrity of the streams within the 2005 Yellow Creek study area;

2) Characterize the consequences of various land uses on water quality within the Yellow Creek watershed;

3) Evaluate the influence of the Salineville wastewater treatment plant (WWTP) and unsewered communities in Amsterdam, Bergholz, Irondale, and Hammondsville;

4) Evaluate the potential impacts from past and present mining activity, 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]).

Table 1. Sampling locations in the Yellow Creek study area in 2005 and 2006. (C – conventional water chemistry, S – sediment, D – Datasonde® continuous monitors, Bac-T – bacteria (included at Chem. sites), M – benthic macro-invertebrates, F – fish, Flow – stream flow measurement). Precise river mile (RM) locations for each sample type may have varied slightly.

WAU Stream / RM	Sample	Latitude	Longitude	D.A.[a] Mi2	Location	USGS Topo. Map
WAU 05030101 180						
Elk Fork						
1.6	C,F,M	40.4628	80.9657	3.3	Senlac Road (T-606)	Amsterdam
Elk Lick						
1.7	C,F,M	40.4419	80.9467	2.9	Queens Road (T-394)	Amsterdam
Yellow Creek						
30.0	C,F,M	40.47307	80.92389	14	SR 164, ust. Goose Run	Amsterdam
27.6	C,F,M,S	40.4819	80.9167	26	CR 75A (Ref. site)	Amsterdam
25.1	Bac-T only	40.5150	80.8881	--	SR 164 dst. Elkhorn Cr.	Bergholz
24.3	F,M	40.52403	80.88639	66	SR 164 ust. Upper N. Fk.	Bergholz
24.2	C	40.52504	80.88406	85	SR 164 dst. Upper. N. Fk.	Bergholz
17.9	C,F,M	40.5181	80.8317	94	Ust. Ralston Run @ CR 54	Salineville
11.8	C,F,M	40.5154	80.7575	119	Ust. Long Run @ CR 53	Salineville
Yellow Cr. Trib @ RM 30.22						
0.1	C,F,M (05/06)	40.472	80.9299	2.3	Bear Rd (CR 28)	Amsterdam
Goose Creek						
1.9	C,F,M	40.4497	80.9086	2.5	T-267	Amsterdam
0.3	C,F,M	40.4692	80.9228	5.8	Ridgewood Drive	Amsterdam
Cox Creek						

WAU Stream / RM	Sample	Latitude	Longitude	D.A.[a] Mi2	Location	USGS Topo. Map
0.1	C,F,M	40.4825	80.9169	2.8	SR 164	Amsterdam
Wolf Run						
1.5	C,F,M	40.4791	80.8909	3.3	Wolf Run Rd.	Amsterdam
1.3	M (2006)	40.4812	80.8905	3.7	Ust. T-275	Amsterdam
Elkhorn Creek						
7.9	C,F,M	40.4899	80.9921	2.1	Plane Rd.	Amsterdam
6.8	C,F,M,S	40.5019	80.9803	7.7	SR 43 (Ref. Site)	Bergholz
0.2	C,F,M,S	40.5106	80.8972	33.5	Ust. SR 164 (Ref. Site)	Bergholz
Gault Run						
0.2	C,F,M	40.4932	80.995	3.4	Apollo Rd. (CR 12)	Amsterdam
Frog Run						
0.1	F,M (2006)	40.5414	80.9884	1.96	At mouth	Bergholz
Trail Run						
0.3	C,F,M,S	40.5318	80.9885	3.3	Bay Rd. (Ref. Site)	Bergholz
Center Fork						
1.9	C,F,M	40.5322	80.984	6.7	Apollo Road at Ball Park	Bergholz
0.1	C,F,M,S	40.5158	80.9611	12.5	Carry Rd. (Ref. Site)	Bergholz
Strawcamp Run						
2.2	F	40.5519	80.9515	2.9	Off Cinder Rd.	Bergholz
1.2	C, M			4.2	Chase Rd.	Bergholz
0.1	C,F,M,S	40.5284	80.9366	5.1	Bay Rd. (Ref. Site)	Bergholz
Upper North Fork						
5.7	C,F,M	40.578	80.9421	3.6	Avon Rd. (CR 21)	Bergholz
0.3	C,F,M	40.5286	80.8853	18.8	SR 524	Bergholz
Hazel Run						
0.6	M (2006)	40.57785	80.93313	2.7	Adj. Avon Rd.	Bergholz
0.1	C,F,M	40.5738	80.9346	3.1	SR 524 at mouth	Bergholz
Carroll Run						
0.1	C,F,M	40.5596	80.9019	2.2	Orchard Rd. (T-314)	Bergholz
Hump Run						
0.1	C,F,M	40.5373	80.8972	7	SR 524	Bergholz
Ralston Run						
0.3	C,F,M	40.52006	80.83737	5.6	CR 53 dst. Matthews Run	Salineville
Long Run						
4.3	C,F,M	40.4973	80.826	4.1	CR 54	Richmond
2.7	C, M	40.5003	80.7963	6.3	T-284 ust. Hidebrand Run	Salineville
0.1	C,F,M	40.5127	80.7579	10.4	CR 218	Salineville
Hildebrand Run						
0.1	F	40.497653	80.794861	1.7	T-284	Richmond
WAU 05030101 190						
Yellow Creek						
5.7	C,F,M,S	40.5361	80.7214	147	Camp Logan USGS gage	Wellsville
3.4	M	40.55109	80.70496	165	Ust. North Fork Yellow Cr.	Wellsville
3.3	F,M (2006)	40.5513	80.7022	224	Dst. North Fork Yellow Cr.	Wellsville
2.5	C	40.553486	80.691411	224	SR 213	Wellsville
Town Fork						

<u>WAU</u> Stream / RM	Sample	Latitude	Longitude	D.A.[a] Mi2	Location	USGS Topo. Map
10.4	C,F,M	40.4649	80.8231	3.9	T-262 ust. Jefferson Lake	Richmond
Lake Sample	C - Top/Bottom (3x)			--	Jefferson Lake	Richmond
8.2	C,F,M	40.4583	80.7908	7.9	Dst. Jeff. Lake nr. ball field	Richmond
8.01	D	--	--	7.9	Dst. Jeff. Lake nr. ball field	Richmond
5.2	C,F,M	40.4649	80.7471	16.1	Shane Road (CR 56)	Knoxville
0.1	C,F,M	40.51739	80.73115	26	CR 53	Wellsville
Keyhole Run						
0.1	C,F,M	40.4967	80.7447	2.8	Austin Lake campground	Knoxville
Brush Creek						
9.7	C,M	40.5755	80.8556	3.7	SR 164 dst. Sterling Mine S.	Salineville
8.8	F	40.568817	80.847308	4.3	Dst. Sterling Mine South	Salineville
6.1	C, M	40.5586	80.8048	7.4	T-290 dst. Sterling Mine N.	Salineville
6.0	F	40.559047	80.800181	7.4	T-290 dst. Sterling Mine N.	Salineville
0.1	C,F,M	40.54967	80.71839	15.3	Pine Grove Rd. (CR 72)	Wellsville
Dennis Run						
0.1	C,F,M	40.5517	80.7372	2.3	T-61 at mouth	Wellsville
Riley Run						
4.8	C,F,M	40.634	80.8935	2.8	CR 13, April Rd.	Kensington
1.8	C,F,M	40.6231	80.8376	15.2	SR 39 (Columbiana Co.)	Salineville
Riley Run Trib. @ RM 3.75						
0.3	C,F,M, D	40.6211	80.8826	3.6	Avon Rd.	Bergholz
0.01	C	40.6248	80.8805	3.7	Dst. Strip mine runoff	Bergholz
Nancy Run						
2.2	F,M	40.6482	80.8471	3.4	Dobson Rd. ust. trib.	Gavers
1.0	C,F,M,S	40.6356	80.8361	7.7	Foundry Mill Rd. (Ref. Site)	Gavers
Roses Run						
0.1	C,F,M	40.6457	80.8425	1.96	Foundry Mill Rd., at mouth	Gavers
North Fork Yellow Creek						
10.4	C,F,M,D	40.6215	80.8221	26.5	Dst. Nancy & Riley Runs	Salineville
10.32	Effluent	40.6212	80.8189	–	Salineville WWTP	Salineville
10.1	C,F,M,D	40.6242	80.8161	26	Hati Rd.	Salineville
6.2	C,F,M,S,D	40.6019	80.7709	38	Adj. Salineville Rd (Ref. Site)	Salineville
2.2	C,F,M,D	40.5732	80.7267	56	Creek St., ust. Irondale	Wellsville
1.9	C, Flow	40.5692	80.7256	--	East Ave (Sentinel Site)	Wellsville
0.8	C,F,M,S,D	40.5628	80.7092	58	Main St. ust. SR. 213	Wellsville
North Fork Yellow Cr. Trib. @ RM 9.65						
0.4	C,F,M	40.6244	80.8115	3.0	Jackoblonski Rd.	Salineville
North Fork . Yellow Cr. Trib. @ RM 8.96						
0.1	C,M	40.6149	80.8054	2.7	Near PC RR bridge	Salineville
North Fork Yellow Cr. Trib.@ RM 6.08						
0.1	C,F,M,S	40.6018	80.769	4.0	Hazel Run Rd. (Ref. Site)	Salineville
Salt Run						
0.8	M (2006),D	40.57413	80.74206	<3.6	Ust . Irondale	Wellsville
0.4	F	40.57201	80.73296	3.6	Ust . Irondale	Wellsville
0.3	D	--	--	3.9	Ust . Irondale	Wellsville
0.1	C,M	40.5731	80.7271	3.9	Jackson St. dst. Irondale	Wellsville
Randolf Run						

WAU Stream / RM	Sample	Latitude	Longitude	D.A.[a] Mi2	Location	USGS Topo. Map
0.2	C,F,M	40.5952	80.7407	2.2	CR 776, at mouth	Wellsville
Salisbury Run						
0.6	M, D	40.5992	80.7337	2.4	Bolivar Rd., ust. acid seep	Wellsville
0.1	C,F,M	40.5922	80.7367	2.4	CR 776, at mouth	Wellsville
Hollow Rock Run						
3.0	C,F,M	40.52274	80.6737	3.6	Ust. Carter Run	Wellsville
2.2	F,M	40.5333	80.6753	6.8	Ust. Tarburner Run	Wellsville
0.7	C			--	Hollow Rock Rd.	
Tarburner Run						
0.1	C,F,M	40.5419	80.6785	1.94	Hollow Rock Rd.	Wellsville
WAU 05030101 100						
Little Yellow Creek						
11.1	C,F,M	40.6506	80.7758	2.8	Clarks Mill Rd.	Gavers
Lake sample	C Top/Bottom (3x), Bac-T			--	Highlandtown Lake	Gavers
6.7	C,F,M, D	40.6331	80.7269	8.2	McCormick Run Rd.	West Point
3.3	C,F,M, D	40.6194	80.6714	17.1	Forbes Rd., dst. reservoir	Wellsville
1.1	C, Flow	40.6210	80.6538	22.1	Hibbits-Mill Rd. (Sent. Site)	Wellsville
Alder Lick Run						
0.1	C,F,M, D	40.6297	80.7085	3	Fife Coal Rd.	West Point
Bailey Run						
1.95	D	40.6481	80.701	--	Ust. Osborne Rd.	West Point
1.4	C	40.6481	80.701	--	Osbourne Rd.	West Point
0.7	F,M	40.63214	80.69561	2.5	Dan Smith Rd.	West Point
Carpenter Run						
1.2	C,F,M	40.6449	80.5879	3.3	Between road and freeway	E.Liverpool N
Jethro Run						
0.1	C,F,M (05/06)	40.6261	80.5938	2.7	Dst. SR 7/39	E.Liverpool N
McQueen Run						
0.2	C,F,M	40.5995	80.6645	2.1	Ust. SR 7	Wellsville
Wells Run						
0.2	C,F,M	40.6761	80.6377	2.2	Ust. SR 7	Wellsville
0.05	D	--	--	2.2	Dst. SR 7	Wellsville

[a] D.A. = Drainage Area

STUDY AREA DESCRIPTION

Yellow Creek is located in Carroll, Columbiana, and Jefferson Counties in eastern Ohio, draining 239 square miles with an average fall of 18 feet per mile. The creek enters the Ohio River at about river mile 931, approximately one half mile downstream from Wellsville. The highest point in the watershed is 1,300 feet above sea level and the mouth is at 654 feet.

The Little Yellow Creek watershed is located immediately north of Yellow Creek, entering the Ohio River at about river mile 934, just upstream from Wellsville. The creek drains 22.2 square miles with an average fall of 60 feet per mile. Physical descriptions of both the Yellow Creek and Little Yellow Creek mainstems and major tributaries are found in Table 2.

Table 2. Yellow Creek and Ohio River Tributary basins (including Little Yellow Creek) and major tributary characteristics.

Stream Name	Flows Into	Length (miles)	Avg. Fall (ft/mile)	Drains (sq.m.)
Yellow Creek	Ohio River	34.0	17.8	239.0
Rocky Run	Yellow Creek	3.6	138.2	2.9
Hollow Rock Run	Yellow Creek	6.4	85.5	9.8
North Fork Yellow Cr.	Yellow Creek	17.9	31.4	59.5
Brush Creek	Yellow Creek	11.0	41.2	15.3
Lowery Run	Yellow Creek	1.2	463.0	0.9
Town Fork	Yellow Creek	12.4	43.7	26.0
Long Run	Yellow Creek	8.0	68.0	10.7
Roach Run	Yellow Creek	2.2	205.0	1.7
Ralston Run	Yellow Creek	4.3	92.6	5.6
Upper North Fork Yellow Cr.	Yellow Creek	8.4	42.1	19.1
Elkhorn Creek	Yellow Creek	8.9	37.5	33.5
Wolf Creek (*aka* Wolf Run)	Yellow Creek	4.5	86.2	5.1
Cox Creek	Yellow Creek	3.0	103.0	2.9
Goose Creek	Yellow Creek	3.8	94.7	5.9
Elk Fork	Yellow Creek	3.4	72.9	4.6
Elk Lick	Yellow Creek	3.6	72.3	6.0
Little Yellow Creek	Ohio River	11.3	59.6	22.2
Alder Lick Run	Little Yellow Cr.	3.6	73.9	3.0
McQueen Run	Ohio River	2.6	192.5	2.2
Wells Run	Ohio River	3.0	167.1	2.1
California Hollow (*aka* Carpenter Run)	Ohio River	3.7	121.0	3.8

Ohio Department of Natural Resources, GAZETTEER OF OHIO STREAMS Second Edition August 2001, WATER INVENTORY REPORT 29.

Major communities and population centers in the study area are Amsterdam (568), Bergholz (769), Irondale (418) and Salineville (1,397). Of these, only Salineville is served by a central sewer system (http://factfinder.census.gov/home/saff/main.html). The watershed is entirely within the coal bearing, Western Allegheny Plateau ecoregion, characterized by steep hills with narrow valleys and ridges. Land use in 2001 was predominated by forest (72%) and grasslands, (14%). Much of the grassland is used for grazing beef and dairy cattle. More detailed 2001 land use is presented in Table 3 and Figure 2.

Table 3. Land use in the Yellow Creek basin study area listed by percentage.

Land Use	Headwaters to Town Fork 05030101 180	Town Fork To mouth 05030101 190	Ohio River Tribs. 05030101 100 240	Little Yellow Cr. 05030101 100 260
Open Water	0.2	0.5	1.0	1.6
Developed, Open Space	5.6	6.2	28.1	8.1
Developed, Low Intensity	0.2	0.4	10.5	0.7
Developed, Med.Intensity	0.1	0.1	5.2	0.1
Developed, High Intensity	0.0	0.0	2.2	0.0
Barren Land	0.0	0.0	0.0	0.0
Deciduous Forest	70.8	72.0	43.9	61.1
Evergreen Forest	1.6	0.8	0.5	1.6
Mixed Forest	0.0	0.0	0.0	0.0
Shrub/Scrub	0.1	0.0	0.1	0.0
Grassland/Herbaceous	1.8	2.0	1.6	1.8
Pasture/Hay	12.7	12.7	5.9	19.1
Cultivated Crops	6.9	5.2	0.9	5.9
Woody Wetlands	0.0	0.0	0.0	0.1
Emergent Herbaceous Wetlands	0.0	0.0	0.0	0.0

Multi-Resolution Land Characteristics Consortium, National Land Cover Dataset 2001, http://www.mrlc.gov/mrlc2k nlcd.asp

Coal has been extracted from the watershed by underground and surface mining methods. Surface mining has occurred rather recently and most of these mines have been reclaimed to the point that they create little acid mine drainage. The abandoned deep underground mining history is presented in Figure 3 (Hughes and Bowman, 2007). Abandoned underground coal mines frequently discharge acid mine drainage, a toxic solution of sulfuric acid, sulfates and metals, predominantly iron, manganese and aluminum. This solution is formed when high sulfur coal, water and oxygen combine. Sulfuric acid is formed which leaches metals from the adjacent geologic material. Because of the presence of buffering limestone in the region, negative impacts from acid mine drainage are generally localized to the immediate receiving tributaries. The locations of abandoned underground mines are presented in Figure 4 (Hughes and Bowman, 2007).

Soil series found in the Yellow Creek watershed are Gilpin, Upshur, Lowell and Guernsey. These are described by the Natural Resources Conservation Service below.

http://soils.usda.gov/technical/classification/osd/index.html

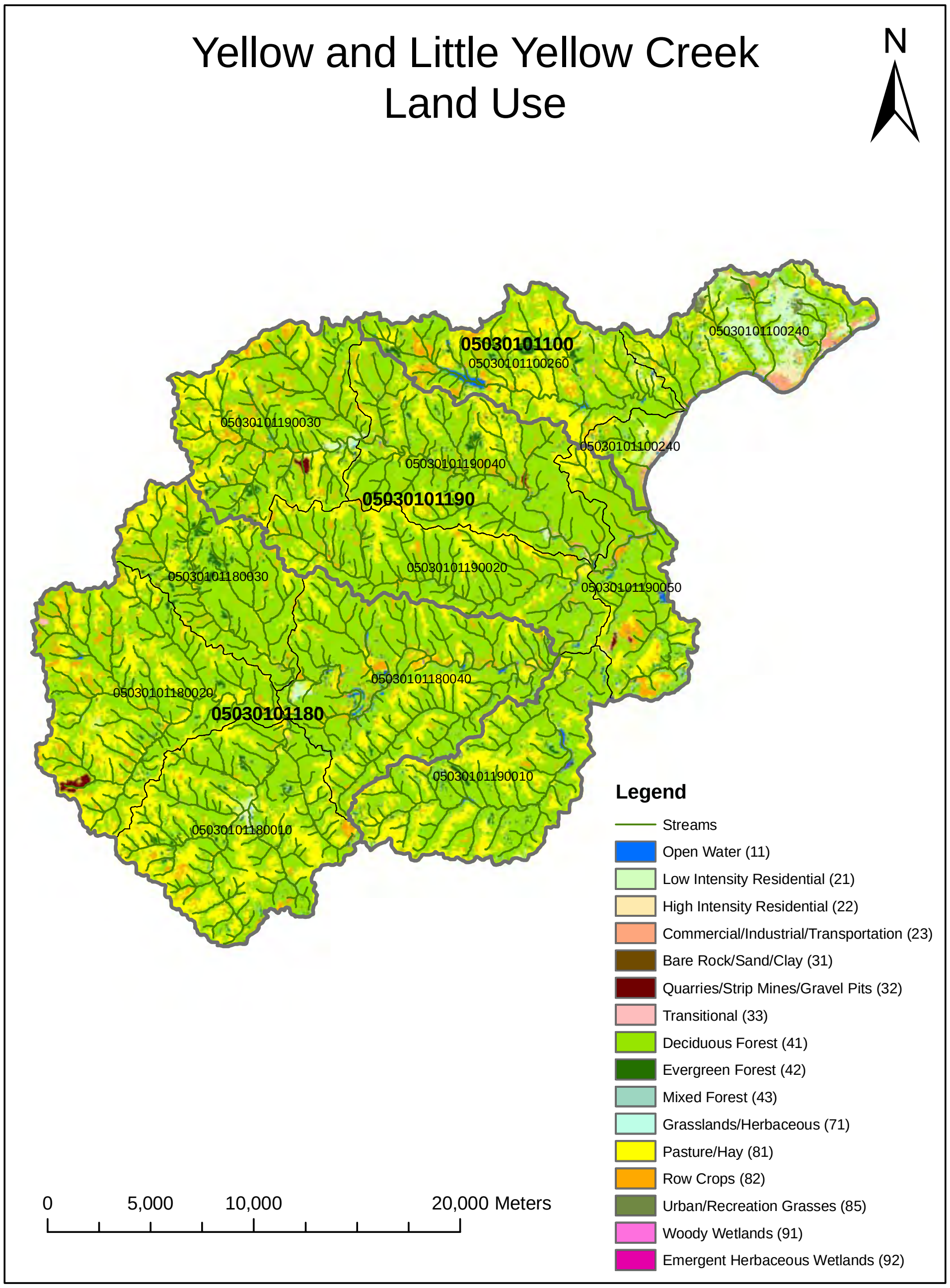
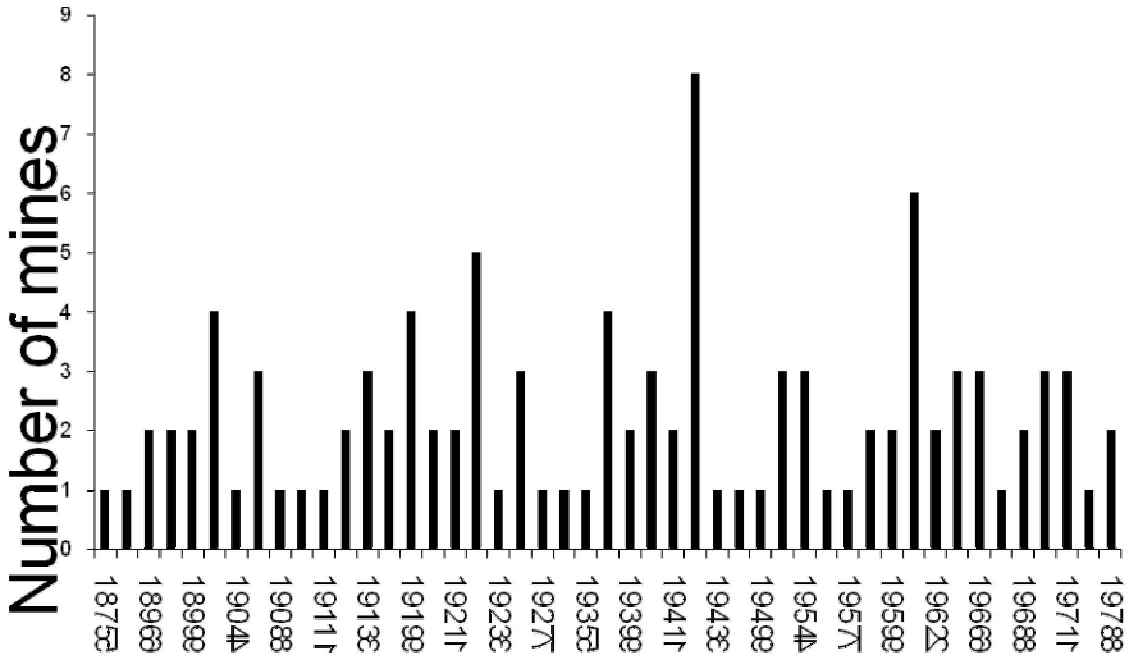


Figure 2. Land use characteristics in the Yellow Creek and the Little Yellow Creek/Ohio River tributaries study area, 2005.

Figure 3. A history of underground mine abandonment in the Yellow Creek Watershed, 1875-1978.



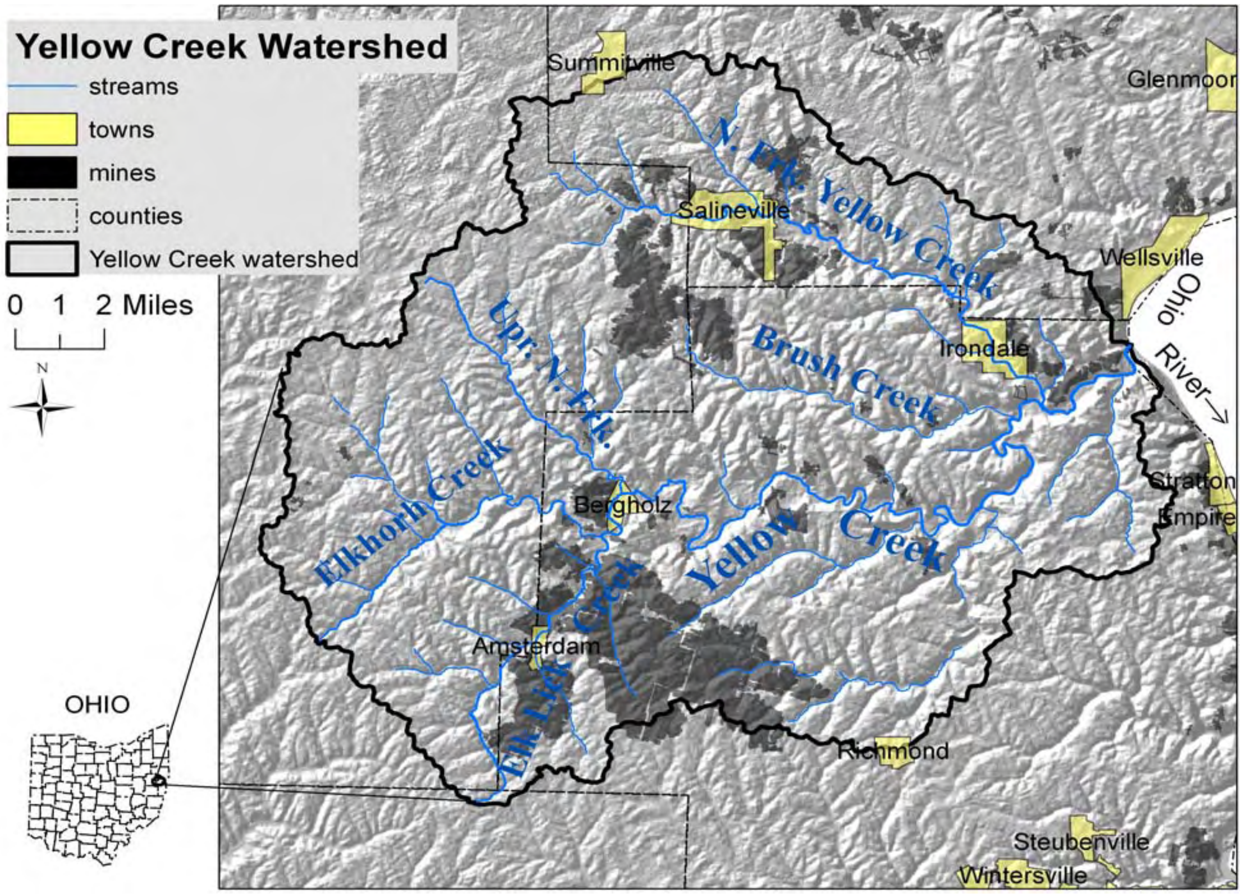
The Gilpin series consists of moderately deep, well drained soils formed in residuum of nearly horizontal interbedded shale, siltstone, and some sandstone of the Allegheny Plateau. They are on gently sloping to steep, convex, dissected uplands. Slope ranges from 0 to 70 percent and permeability is moderate.

The Upshur series consists of deep and very deep, well drained, slowly permeable soils formed in residuum derived from clay shale and in places interbedded with thin layers of siltstone. Upshur soils are on ridgetops, benches, and hillsides. Slope ranges from 0 to 70 percent.

The Lowell series consists of deep and very deep, well drained soils formed in residuum of limestone interbedded with thin layers of shale on upland ridgetops and sideslopes. Slopes range from 2 to 65 percent and permeability is moderately slow.

The Guernsey series consists of deep, moderately well drained soils formed in colluvium and residuum from interbedded siltstone, shale, and limestone. These upland soils have moderately slow or slow permeability and slopes ranging from 2 to 70 percent.

Figure 4. A map of abandoned underground mines in Yellow Creek Watershed.



SUMMARY

Biological sampling using fish and macroinvertebrates was conducted at 77 sites from 44 streams in the Yellow Creek and Little Yellow Creek basins in 2005. The watersheds are located in northeastern Ohio and drain to the Ohio River south of East Liverpool (Figure 5). Associated chemical, sediment, bacteriological and Datasonde® continuous monitor sampling was also conducted in the basin to support the biological evaluations. Watershed sizes at the sampling sites ranged from 1.7 mi^2 to 224 mi^2.

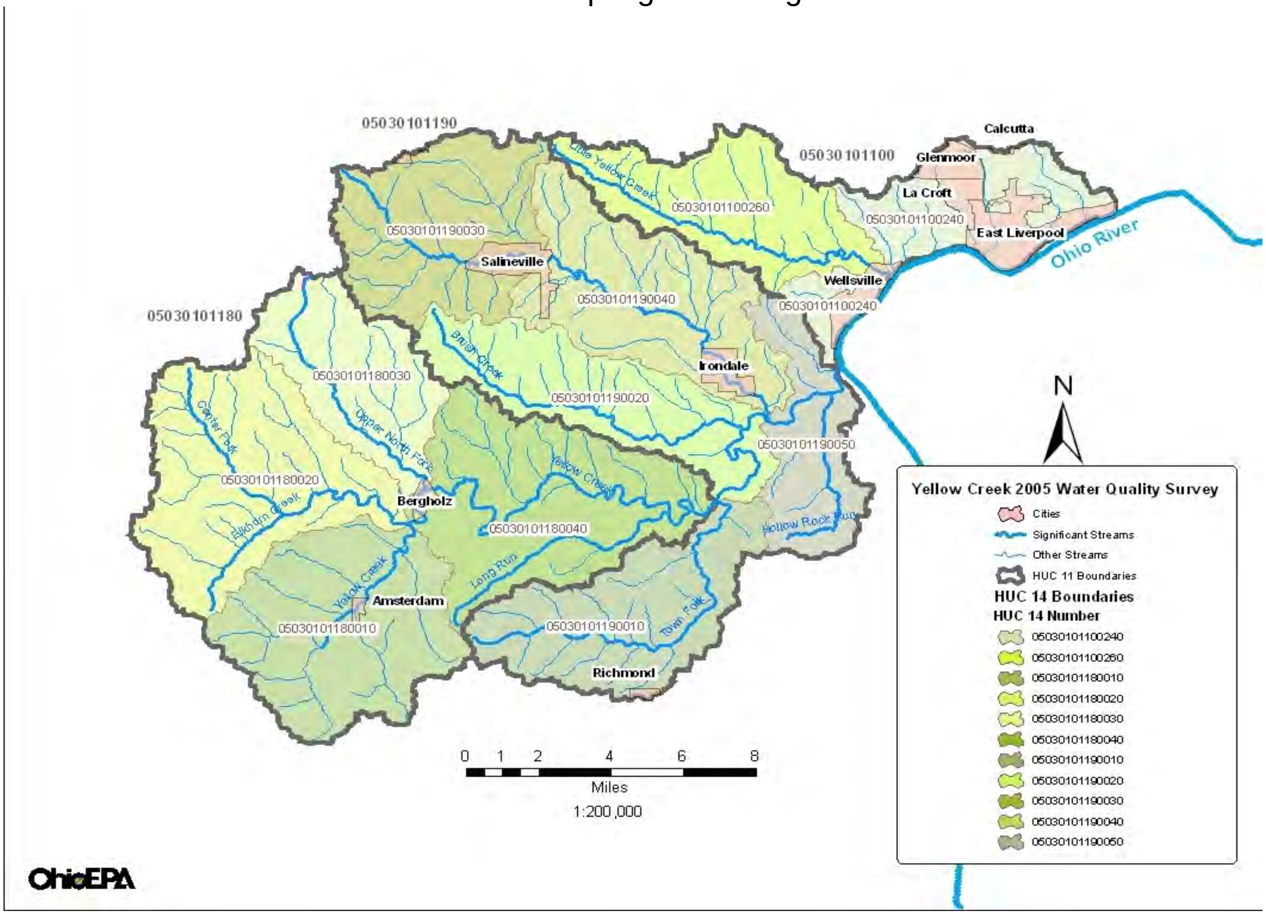


Figure 5. Watershed Assessment Units (WAUs) in the Yellow Creek and Ohio River Tribs. study area. Upper Yellow Creek, Lower Yellow Creek and Ohio River Tributaries (including Little Yellow Creek) study areas are identified by 11 digit Hydrologic Unit Code (HUC).

Major findings and conclusions of the survey include:

- The Yellow Creek watershed is largely forested, high gradient, and quite remote with low population densities and a lack of heavy industry. Stream channels throughout the basin are largely intact and lack significant alteration from channelization, straightening or impoundment. In addition, even the smallest streams sampled (1.7 sq. mi. minimum watershed size) were largely perennial with sustained flow augmented by cool, groundwater intrusion. These factors result in remarkable stream assimilative capacity and tend to blunt the influence of local pollutant stressors.

- Biological sampling results tended to reflect these positive basin-wide attributes as community health routinely fell in the very good and exceptional ranges (Figure 6). In the Yellow Creek basin, a majority of sites (65%) reached levels of performance associated with Exceptional Warmwater Habitat (EWH) potential, Coldwater Habitat (CWH) potential, or both. In contrast, only 8 of 68 sites (12%) failed to meet minimum WWH criteria. The level of biological performance in the Yellow Creek basin (> 90% attainment) ranks among the highest in the state. A basin map summarizing biological community health across the basin is portrayed in Figure 7.

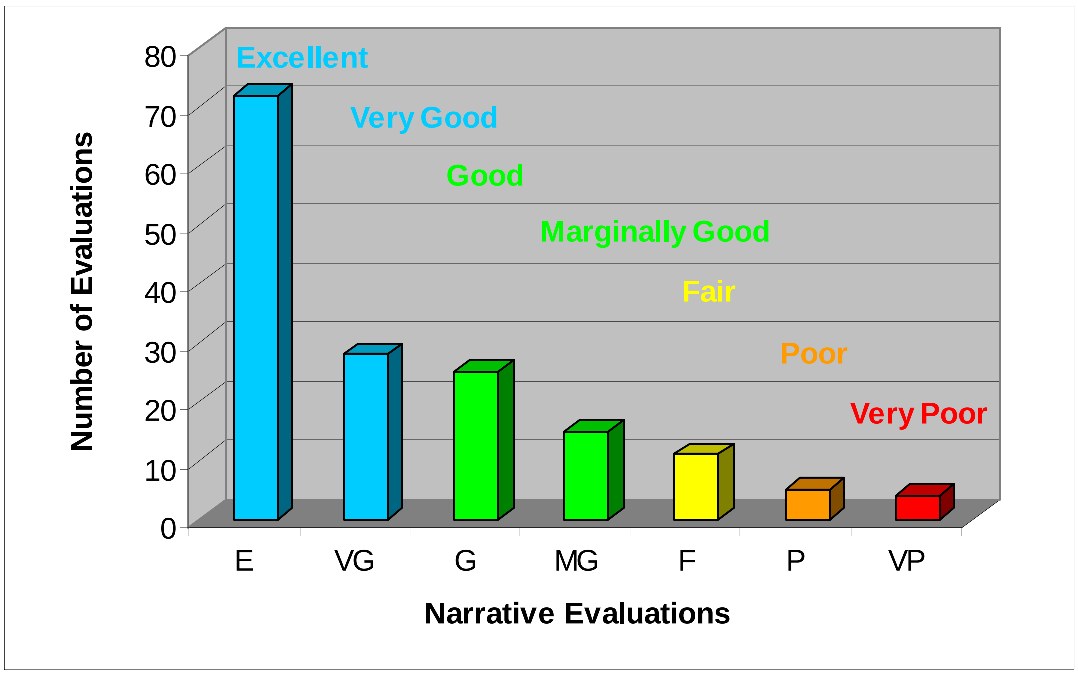


Figure 6. Narrative evaluations associated with fish and macroinvertebrate sampling sites in the Yellow Creek and Little Yellow Creek basin surveys (WAUs 100, 180, 190), 2005-2006. Evaluations were based on IBI, MIwb and ICI scores, and qualitative, natural substrate samples.

- Overall, 71% of sites (55) in the study area had biological communities fully meeting their designated or recommended aquatic life use while only 21% (16 sites) were impaired. As a result of data limitations, attainment status at the remaining 8% (6 sites) was not determined.

- 50% of impaired sites were located in Watershed Assessment Unit (WAU) 100, the small, 45 square mile drainage that lies directly along the more densely populated Ohio River corridor and includes Little Yellow Creek. In contrast to the Yellow Creek basin, only one of nine sites (11%) in the watershed met the appropriate aquatic life use designation. Samples reflected more severe and widespread impairments associated with impoundment, urban runoff, highway construction and mining.

- Biological impairments in the remainder of the study area (Yellow Creek basin) were generally small or localized and typically associated with mining, septic tank drainage, and impoundment. Recreational impairment from fecal coliform bacteria was more widespread and most often associated with on-site home septic systems concentrated in small villages and rural livestock operations.

- With one exception, all mainstem Yellow Creek and North Fork Yellow Creek sites supported biological communities meeting expectations for Warmwater Habitat (WWH) or EWH. The site that did not attain, Yellow Creek RM 3.3, was located immediately downstream from North Fork Yellow Creek. Mine drainage associated with a problematic abandoned shaft seep at the mouth of the North Fork, was the suspected source of impairment (Ohio EPA, 2003).

- A large stretch of the middle Yellow Creek mainstem, from Bergholz to Hammondsville (RMs 24.2-3.4), is recommended for an upgrade from WWH to EWH. In addition, two former Limited Resource Water (LRW) streams affected by mine drainage (Wolf Run and Salisbury Run) are now recommended for a CWH designation.

- A comparison of historical trends in upper Yellow Creek and Wolf Run since the early 1980s suggests significant recovery in chemical and biological conditions downstream from mining activity. While mining impacts remain severe in the headwaters of Wolf Run, the lower reaches have improved from nearly lifeless in 1983, to a marginally good to exceptional condition in 2005 and 2006. Substantial improvement, particularly in Yellow Creek fish communities, was also observed downstream from mining sources in the headwaters. These improvements appear largely a result of both Ohio Department of Natural Resources reclamation activity and natural recovery or attenuation (Hughes and Bowman 2007).

- Results of the 2005 survey, particularly the high level of biological performance in the Yellow Creek basin, were somewhat surprising. Both active and historic mining activity are widespread, but 2005 results found most mining influences were negligible or fairly localized and restricted to small drainages (*e.g.,* Salisbury Run, Wells Run, and Wolf Run). Bacteriological contamination was also common, particularly near population centers and livestock operations in the upper Yellow Creek basin. However, biological performance in these areas was routinely very good or exceptional and often reflective of cold groundwater influences.

Summary statistics related to aquatic life use of each assessment unit can be found in Tables 20-22. Raw chemical data are located in a separate document in Appendix 1. Raw bacteriological and sediment sampling results can be obtained by contacting the Ohio EPA Southeast District Office (see Appendix 2-4). Fish species collection and relative number information are provided in Appendix 5-6 while macroinvertebrate taxa identification and enumeration data from are provided in Appendix 7-8.

Aquatic Life Use Attainment Status

The 2005 Yellow Creek study area was divided into three Watershed Assessment Units (WAUs) aligned with the United States Geological Survey (USGS) 11 digit hydrologic units (see Figure 5). These were:

1) 05030101 180 - Yellow Creek (headwaters to upstream Town Fork) 118.7 sq. mi.

2) 05030101 190 - Yellow Creek (upstream Town Fork to mouth) 120.4 sq. mi.

3) 05030101 100 - Ohio River tributaries (downstream Little Beaver Creek to upstream Yellow Creek) 45.2 sq. mi. (includes Little Yellow Creek)

Fish and macroinvertebrate sampling was conducted at 77 locations from 44 different streams in the Yellow Creek study area ranging in drainage area size from 1.9 mi^2 to 224 mi^2. The large majority of sampling was conducted in 2005, but re-sampling or supplemental sampling was also conducted at a few macroinvertebrate locations in 2006. The Aquatic Life Use Attainment status for all sites can be found in Table 4 and a list of Causes and Sources of Impairment (listed by assessment unit) are found in Table 5.

Out of 77 sites evaluated, 72% (55 sites) had biological communities fully meeting their designated or recommended aquatic life use while only 21% (16 sites) were impaired. As a result of credible data limitations, the attainment status at 8% (6 sites) was considered unknown.

Overall, biological performance in the study area was quite high and assessments in 36 stream segments resulted in aquatic life use upgrades to Exceptional Warmwater Habitat (EWH), Coldwater Habitat (CWH), or both. Included were two former Limited Resource Water (LRW) streams affected by mine drainage (Wolf Run and Salisbury Run) that are now recommended for CWH. Currently, the headwaters of Wolf Run remain impacted by acid mine drainage. However, over the last 20 years, historic reclamation activity and natural attenuation has resulted in far-field recovery, sufficient to support good to exceptional quality communities in the lower reaches. In the North Fork Yellow Creek basin, Salisbury Run remains severely impacted by AMD near the mouth. However, the source of contamination is restricted to a discrete discharge point at RM 0.5; upstream from this point, the stream supported both pollution sensitive

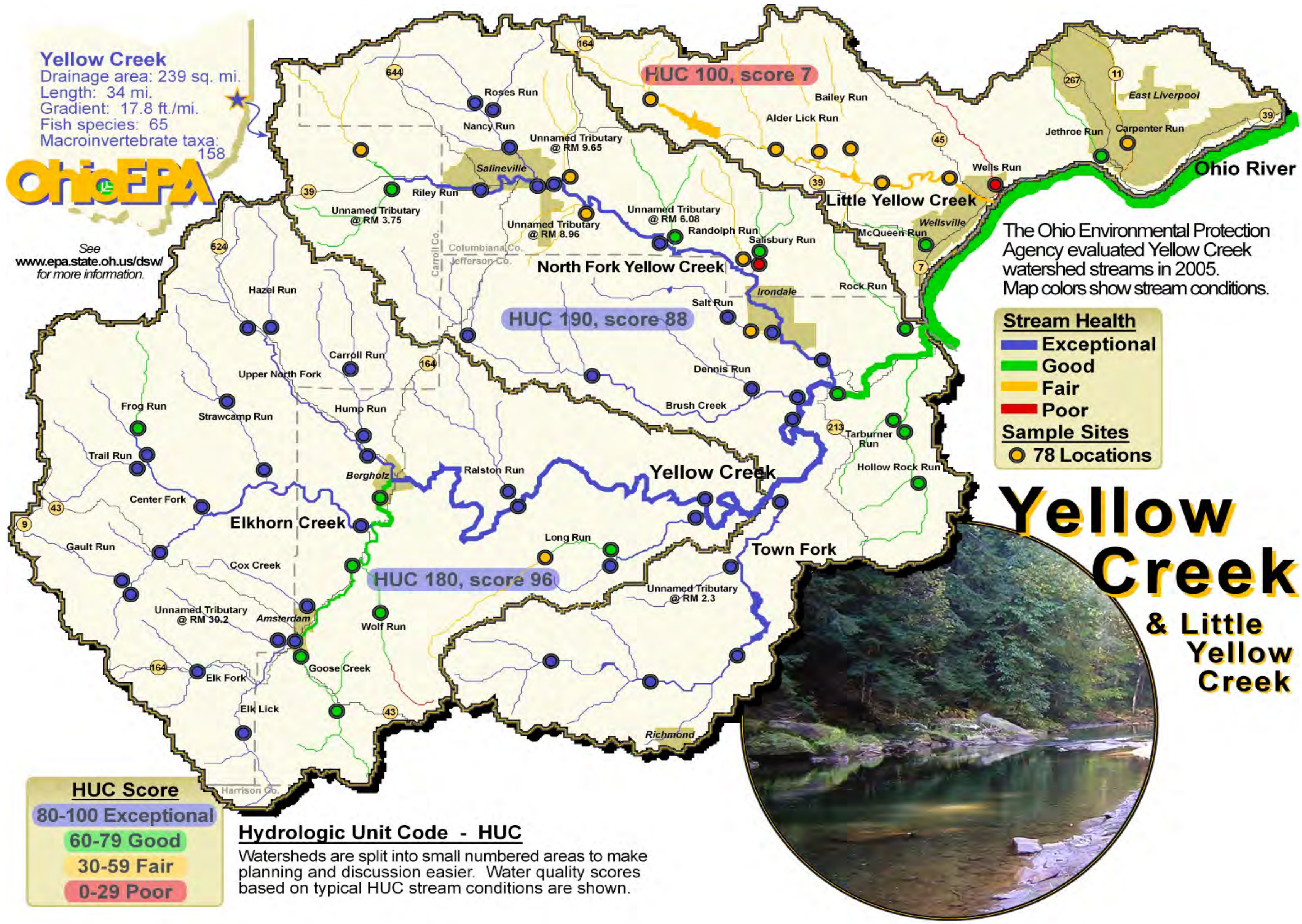


Figure 7. Biological community health (fish and macroinvertebrates) in streams sampled during the Yellow Creek watershed survey, 2005-2006.

and coldwater indicative populations. Center Fork, a tributary to Elkhorn Creek, was originally designated CWH. Based on the findings of this survey, stream potential is clearly exceptional, but coldwater populations were only marginally represented. A redesignation from CWH to EWH is recommended. Conversely, Frog Run did not meet it's designated, EWH use but supported coldwater populations adequate for a CWH recommendation (Frog Run was originally designated EWH in the 1978 water quality standards but the use was never field verified). Biological performance in the Yellow Creek mainstem, particularly among the fish, has improved to the extent that an upgrade from WWH to EWH is recommended for the 21 mile reach between Bergholz and Hammondsville (RMs 24.3-3.3).

Causes and Sources of Impairment

Out of sixteen impaired sampling sites in the study area, eight (50%) were concentrated in WAU 100, the small, 45 square mile Ohio River watershed that includes Little Yellow Creek (Table 4; Table 5). Many of the small, high gradient streams are clustered along the Ohio River corridor and tend to reflect impairment associated with urban runoff, highway construction (isolation or historic elimination of fish populations) and mining. In contrast, and excluding natural causes, only one site was biologically impaired in the upper Yellow Creek basin (WAU 180) and it was located immediately downstream from a septic tank discharge.

All mainstem Yellow Creek and North Fork Yellow Creek sites supported biological communities meeting expectations for warmwater habitat (WWH) or EWH with one exception. The site that did not attain, Yellow Creek RM 3.3, was located immediately downstream from North Fork Yellow Creek. Mine drainage, associated with a problematic abandoned shaft seep at the mouth of the North Fork, was the suspected source of impairment (Ohio EPA, 2003). Biological and physical habitat impacts in this complex reach were exacerbated by flooding and channel movement, habitat alteration (with associated bank destabilization and sedimentation), and excessive ATV traffic.

Of the remaining 15 impaired tributary sites, 9 were affected by flow alteration associated with impoundment, highway construction, mining or natural conditions, 3 were affected by mine drainage associated with coal mining, 1 was impaired by sewage from on-site septic tank systems (Cox Creek), 1 was impaired by siltation (upper Little Yellow Creek), and 1, upper Long Run, was impaired by natural, wetland conditions. Salt Run appeared impaired downstream from on-site septic systems in the Village of Irondale but attainment status was listed as unknown due to credible data limitations (no fish sample).

With biological impairment concentrated along the Ohio River in WAU 100, assessment unit scores for the Yellow Creek basin approached 100% attainment in both the upper and lower basins (96% and 88% attainment in WAUs 180 and 190, respectively; Tables 20-21). Basin wide, the levels of performance in Yellow Creek are among the highest found in the state. While coldwater communities were generally restricted to small drainages (<10sq. mi.), very good and exceptional quality communities were typical across all stream sizes (Table 4, Figure 6). Factors contributing to outstanding performance included intact stream habitats and adequate gradient, coupled with an almost pervasive groundwater recharge that tended to maintain cool, late summer flow in even the smallest drainages. These factors result in remarkable stream assimilative capacity across the landscape and tend to blunt the influence of local pollutant stressors. Conversely, the low population densities, forested landscapes, lack of intensive agriculture, and the general absence of highly acidic coal deposits contribute to the high instream performance.

Chemical Water Quality

Inorganic water chemistry grab samples and field measurements were collected at 74 sites within the study area at roughly two-week intervals (four to six times) from mid-July to late September. Samples were analyzed for a variety of parameters including nutrients and metals, and results are presented in Appendix 1, Table A-1. Results are presented in the individual chapters for each Watershed Assessment Unit (WAU).

The most significant Water Quality Standards violations were associated with abandoned strip and shaft mines related to coal extraction (Table 7, Table 9). Problem parameters included pH, iron, lead, dissolved solids, and conductivity. However, most impacts were localized and restricted to small drainages. The most pervasive WQS violations were for dissolved oxygen and most of these violations were found in small, rural tributaries involving slight departures from more stringent CWH and EWH daily minima. Low flow conditions during late summer sampling, possibly exacerbated by livestock or septic tank loadings, were the most likely reasons for the lower D.O. levels. However, in most instances, the excursions did not significantly influence biological performance as attainment levels in the Yellow Creek watershed were among the highest in the state.

Recreational Use Attainment Status

The safety of waters in the study area for recreational activities was assessed using fecal coliform bacteria as the indicator organism. The presence of these organisms indicates that water has been contaminated by feces from warm blooded animals. Elevated bacteria counts, reported in colony forming units (CFU)/100 ml, increase the risk of illness for people who come in contact with the water.

Recreation use status was determined for each of three watershed assessment units aligned with the 11 digit hydrologic unit. Results from the 2005 survey and a discussion of the test method are summarized in the *Ohio 2008 Integrated Water Quality Monitoring and Assessment Report:*

http://www.epa.state.oh.us/dsw/tmdl/2008IntReport/2008OhioIntegratedReport.html.

The recreation use is considered impaired if either the 75th percentile exceeds 1,000 or the 90th percentile exceeds 2,000.

Recreational use impairment from coliform bacteria was more widespread in the basin than biological impairment. Highest bacteria levels or "hot spots" were often associated with wastewater from on-site septic systems concentrated in the unsewered communities of Amsterdam, Irondale, and Hammondsville, or from clusters of homes on Cox Creek and Jethro Run near Amsterdam and East Liverpool, respectively. While not observed specifically, the Village of Bergholz on upper Yellow Creek may also be a source of bacteria. Like Amsterdam, located approximately five miles upstream, the two Villages lack a central sewage collection system and are mostly residential with a limited number of businesses and public buildings in the center of town. However, Bergholz may benefit from the larger receiving stream size and greater dilution in the more downstream reaches of Yellow Creek (*i.e.* a watershed size of approximately 70 mi^2 versus 20 mi^2 upstream).

High bacteria levels were also associated with the lone municipal point source discharge in the Village of Salineville. The Salineville WWTP has a history of poor performance and was under enforcement action by the Ohio EPA (February, 2007) to improve treatment at their facility. However, improvements were made in plant operations in 2006 and by April 2007, a plant inspection reported "great strides in returning the treatment plant to reliable and effective operation. The plant is operating satisfactorily." (Ohio EPA 2007, May 11 letter to Mayor of Salineville). There are currently no plans to sewer the other small villages.

Recreational impairment from agricultural sources was primarily associated with feedlots and the unrestricted livestock access to stream channels. These impacts were usually restricted to small drainages and most commonly found in the headwaters of upper Yellow Creek (WAU 180).

On the assessment unit or watershed level, both the upper Yellow Creek (WAU 180) and lower Yellow Creek (WAU 190) drainages were considered impaired, with highest levels of contamination in the upper basin (see Table 15). As stated above, on-site septic systems concentrated in small villages and rural livestock operations were the most common sources of elevated bacteria.

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. Fish consumption advisories specific to the Yellow Creek survey area are found at two locations, Highlandtown Lake in the Little Yellow Creek watershed and Jefferson Lake on Town Fork. Both advisories are for large-mouth bass due to mercury contamination and recommend limiting consumption to one meal per month for all sizes. Outside of these impoundments, no specific advisories are listed for free flowing streams in the Yellow Creek study area. For additional information, see the 2006 Fish Consumption Advisory report available at:

http://www.epa.state.oh.us/dsw/fishadvisory/index.html.

Spills

Only one pollutant spill was noted within the Yellow Creek study area during the sampling season. The event involved the release of diesel fuel or fuel oil to Jethro Run following a truck accident in late July 2005. Macroinvertebrate sampling conducted immediately following the spill revealed obvious sheens and poor quality communities. However, sampling a year later indicated recovery to at least a marginally good condition and no obvious indications of contamination. Records were checked from the Ohio EPA Division of Emergency and Remedial Response (DERR) emergency response hotline and no additional spills were on file involving the study area.

Table 4. Biological attainment table for the Yellow Creek and Ohio River Tributary Assessment Units, June to October, 2005 and August to September, 2006.

Upper Yellow Creek Basin WAU 05030101 180 (Headwaters to upstream Town Fork) Western Allegheny Plateau Ecoregion							
Stream-Code# River Mile Fish/Macro.	Attainment Status	IBI	MIwb	QHEI	ICI[a]	Location	DA
Elk Fork 06-939 *WWH (existing)* *CWH (recommended)*							
1.7/1.6	FULL	44	NA	65.5	E	Senlac Road (T-606)	2.9
Elk Lick 06-940 *WWH* (existing)* *CWH (recommended)*							
1.8/1.7	FULL	46	NA	63.0	E	Queens Road (T-394)	2.9
Yellow Creek 06-900 *WWH (existing)* *WWH - Hdwtrs. to Upper North Fork (retained)*							
30.1	FULL	48	NA	65.5	G	SR 164, Ust. Goose Cr.	14.4
27.6 (Mod. Ref)	FULL	46	10.2	73.0	46	Ust. Wolf Run	25
24.5/24.3	FULL	48	10.0	71.0	36	SR 164 ust Upper N. Fk.	66
Yellow Creek *WWH (existing)* *EWH -Upper N. Fork to N. Fork Yellow Creek (recommended)*							
18.5/18.0	FULL	51	10.3	89.0	44[ns]	CR 54 ust. Ralston Run	94
11.8	FULL	47[ns]	9.7	82.0	42[ns]	CR 53 ust. Long Run	119
5.5/5.7 (WAU 190)	FULL	56	10.8	89.0	56	Camp Logan/USGS gage	147
--/3.4 (WAU 190)	(FULL)	--	--	--	50	Ust. N. Fork Yellow Cr.	165
Yellow Creek *WWH (existing)* *WWH - North Fork Yellow Creek to mouth (retained)*							
3.3/3.3 (2006) (WAU 190)	PARTIAL	44	8.7	63.0	24*	Dst. N. Fork Yellow Cr.	224
Yellow Cr. Trib. @ RM 30.22 06-947 *Undesignated* *CWH (recommended)*							
0.1/0.1 (2006)	FULL	48	NA	52.0	G	Bear Rd (CR 28)	2.3
Goose Creek 06-938 *WWH (existing)* *CWH (recommended)*							
1.9	FULL	48	NA	63.0	MG[ns]	T-267	2.5
0.2/0.3	FULL	50	NA	73.5.0	MG[ns]	Ridgewood Dr., Amsterdam	5.8
Cox Creek 06-937 *WWH**							
0.1	PARTIAL	48	NA	81.0	F*	SR 164, at mouth	2.8
Wolf Run (Wolf Creek in WQS) 06-936 *LRW (existing)* *CWH (recommended)*							
1.5/1.3 (2006)	FULL	42[ns]	NA	69.0	E	Wolf Run Rd.	3.3
Elkhorn Creek 06-931 *EWH (existing)* *CWH/EWH Headwaters to Center Fork (recommended)*							
7.9	FULL	52	NA	76.0	E	Plane Rd.	2.1
6.8/6.7	FULL	54	NA	50.0	56	SR 43 Ref. Site	7.4
Elkhorn Creek *EWH (existing)* *Center Fork to mouth (recommended)*							
0.2	FULL	50	11	95.0	54	Ust. SR 164 Ref. Site	33.5

Stream-Code# River Mile Fish/Macro.	Attainment Status	IBI	MIwb	QHEI	ICI[a]	Location	DA
Gault Run 06-949 *Undesignated* *WWH (recommended)*							
0.3/0.4	FULL	52	NA	67.0	G	Apollo Rd. (CR 12)	3.4
Frog Run 06-935 *EWH (existing)* *CWH (recommended)*							
0.1	FULL	40[ns]	NA	56.5	E	At mouth	2.0
Trail Run 06-934 *CWH (existing)* *CWH/EWH (recommended)*							
0.3	FULL	50	NA	63.5	54	Bay Rd. Ref. Site	3.3
Center Fork 06-933 *CWH (existing)* *EWH (recommended)*							
-- /2.7	Unknown	--	--	--	E	Upstream Frog Run	4.3
1.9	FULL	50	NA	68.0	VG[ns]	Apollo Rd at Ball Park	6.7
0.2/0.1	FULL	54	NA	64.5	60	Carry Rd Ref. Site	12.5
Strawcamp Run 06-932 *EWH (existing)* *CWH/EWH Headwaters to Chase Rd.(recommended)*							
2.2/1.2	FULL	48[ns]	NA	91.0	E	Ust. Chase Rd.	4.2
Strawcamp Run 06-932 *EWH (existing)* *EWH Chase Rd to mouth.(recommended)*							
0.4/0.3	FULL	48[ns]	NA	55.0	VG[ns]	Bay Rd. Ref. Site	5.2
Upper North Fork 06-926 *WWH (existing)* *WWH Hdwaters to Hump Run (retained)*							
5.7/5.5	FULL	48	NA	53.5	VG	Avon Rd.	3.6
Upper North Fork *WWH (existing)* *CWH/EWH Hump Run to mouth (recommended)*							
0.3	FULL	58	NA	78.5	VG[ns]	SR 524	18.8
Hazel Run 06-930 *WWH (existing)* *CWH (recommended)*							
0.2/0.6(2006)	FULL	46	NA	73.0	E	SR 524 / ust. SR 524	3.1
Carroll Run 06-929 *WWH (existing)* *CWH (recommended)*							
0.1	FULL	48	NA	65.5	G	Orchard Rd.	2.2
Hump Run 06-927 *WWH (existing)* *CWH/EWH (recommended)*							
0.5/0.1	FULL	54	NA	78.0	E	SR 524	7.0
Ralston Run 06-924 *WWH (existing)* *CWH/EWH (recommended)*							
0.3	FULL	50	NA	71.5	E	CR 53 dst. Matthews Run	5.6
Long Run 06-909 *WWH (existing)* *WWH - Headwaters to Hildebrand Run (retained)*							
4.3	PARTIAL	42[ns]	NA	74.5	F*	Ust. CR 54 (wetlands)	4.1
2.7	Unknown	--	--	--	G	T-284 ust. Hildebrand Run	6.3
Long Run *WWH (existing)* *CWH/EWH - Hildebrand Run to mouth (recommended)*							
0.3/0.1	FULL	60	NA	92.5	E	CR 218	10.4
Hildebrand Run 06-918 *WWH (existing)*							
0.1	FULL	48	NA	66.5	--	T-284	1.7
Lower Yellow Creek Basin WAU 05030101 190 (Upstream Town Fork to mouth) Western Allegheny Plateau Ecoregion							

Stream-Code# River Mile Fish/Macro.	Attainment Status	IBI	MIwb	QHEI	ICI[a]	Location	DA
Yellow Creek *WWH (existing) EWH - Upper N. Fork to N. Fork Yellow Creek (recommended)*							
5.5/5.7	FULL	56	10.8	89.0	56	Camp Logan/USGS gage	147
-- /3.4	(FULL)[b]	--	--	--	52	Ust. N. Fork Yellow Cr.	175
Yellow Creek *WWH (existing) WWH - North Fork Yellow Creek to mouth (recommended)*							
3.3/3.3 (2006)	PARTIAL	44	8.7	63.0	24*	Dst. N. Fork Yellow Cr.	224
Town Fork 06-920 *WWH (existing) CWH - Headwaters to Jefferson Lake (recommended)*							
10.4	FULL	46	NA	60.0	VG	T-262 ust. Jeff. Lake	3.9
Town Fork *WWH (existing) EWH - Jefferson Lake to mouth (recommended)*							
8.0/8.1	PARTIAL	52	NA	77.0	MG*	Dst. Jefferson Lake	7.9
5.1/5.3	FULL	50	NA	79.0	E	Shane Road (CR 56)	16.1
0.2	FULL	46[ns]	10.2	76.0	52	CR 53 at mouth	26
Keyhole Run 06-948 *Undesignated CWH/EWH (recommended)*							
0.1	FULL	52	NA	72.0	E	Dst.T-248 and Austin Lake	2.8
Brush Creek 06-905 *WWH (existing) WWH: Headwaters to Rose Run (RM 6.32) (retained)*							
-- /9.7	Unknown	--	--	--	MG[ns]	SR 164 dst. Sterling Mine	2.3
8.8/ --	(FULL)[b]	44[ns]	NA	69.0	--	Dst. SR 164, adj. T-290	4.3
Brush Creek *WWH (existing) CWH/EWH Rose Run (RM 6.32) to mouth (recommended)*							
6.0/6.2	FULL	50	NA	89.5	E	Twp. Rd. 290	7.4
0.8/0.1	FULL	60	NA	81.0	E	Pine Grove Rd. (CR 72)	15.3
Dennis Run 06-906 *WWH (existing) CWH/EWH (recommended)*							
0.3/0.2	FULL	56	NA	74.0	E	T-61 at mouth	2.3
Riley Run 06-917 *WWH (existing) WWH (retained)*							
4.9	NON	42[ns]	NA	62.5	P*	CR 13 (April Rd.)	2.8
Riley Run *WWH (existing) CWH - UTrib. @ RM 3.75 to mouth (recommended)*							
1.8	FULL	56	NA	---	G	SR 39 (Columbiana Co.)	15.2
Riley Run Trib. @ RM 3.75 06-946 *Undesignated CWH (recommended)*							
0.3	FULL	44	NA	56.0	G	Avon Rd.	3.6
Nancy Run 06-915 *CWH (existing) CWH/EWH (recommended)*							
2.2	FULL	50	NA	71.5	E	Dobson Rd., ust. trib.	3.4
1.0/1.2	FULL	46[ns]	NA	65.0	E $^{\Delta}$	Foundry Mill Rd. Ref. Site	7.0
Roses Run 06-916 *WWH (existing) CWH/EWH (recommended)*							
0.1	FULL	48[ns]	NA	70.5	E	Foundry Mill Rd.	2.0
North Fork Yellow Creek 06-910 *WWH (existing) WWH (retained)*							
10.6/10.4	FULL	40	9.1	78.5	50	Dst. Nancy & Riley Run	26
10.1	FULL	44	9.3	67.5	48	Dst. Salineville WWTP at Hati Rd.	26
6.1/6.2	FULL	52	10.1	96.5	50	Adj. Salineville Rd. Ref Site	38

Stream-Code# River Mile Fish/Macro.	Attainment Status	IBI	MIwb	QHEI	ICI[a]	Location	DA
2.2	FULL	52	10.8	66.0	34	Ust. Irondale	56
0.5/0.7	FULL	46	10.6	78.0	G $^{\Delta}$	Ust. SR. 213	58
North Fork Yellow Cr. Trib. @ RM 9.65 06-945 *Undesignated CWH (recommended)*							
0.4	NON	22*	--	53.0	E	Jackoblonski Rd.	3.0
North Fork Yellow Cr. Trib. @ RM 8.96 06-944 *Undesignated CWH - Trib @ RM 0.18 to mouth (recommended)*							
-- /0.1	Unknown	--	--	--	F*	Ust. PC RR bridge	2.7
North Fork Yellow Cr. Trib.@ RM 6.08 06-941 *WWH (existing) WWH (retained)*							
0.2	PARTIAL	50	NA	79.0	F*	Hazel Run Rd. Ref. Site	4.0
Salt Run 06-912 *WWH (existing) CWH Hdwaters to Irondale (RM 0.3) (recommended)*							
0.4/0.8 (2006)	FULL	40^{ns}	NA	55.0	E	Upstream Irondale	3.6
Salt Run *WWH (existing)*							
-- /0.1	Unknown	--	--	--	F*	Dst. Irondale	3.9
Randolf Run 06-914 *LRW (existing) LRW (retained)*							
0.2	FULL	Dry	NA	--	F*	CR 776, at mouth	2.2
Salisbury Run 06-913 *LRW (existing) CWH (recommended)*							
0.6	Unknown	--	--	--	G	Upstream acid seep	2.2
0.2/0.1	NON	12*	NA	56.0	VP*	CR 776 dst. acid seep	2.3
Hollow Rock Run 06-902 *WWH (existing CWH (recommended)*							
3.0/3.0	FULL	42^{ns}	NA	65.0	G	Ust. Carter Run	3.6
2.2/2.0	FULL	44	NA	48.5	G	Ust Tarburner Run	6.4
Tarburner Run 06-903 Undesignated *CWH (recommended)*							
0.2/0.1	FULL	46	NA	69.0	G	Hollow Rock Rd	1.9
Ohio River Tributaries WAU 05030101 100 (Downstream Little Beaver Creek to upstream Yellow Creek) Western Allegheny Plateau Ecoregion							
Little Yellow Creek 06-079 *WWH (existing) WWH (retained)*							
11.1/11.3	PARTIAL	34*	NA	71.0	G	Clarks Mill Rd. (ust. lake)	2.8
6.7/6.6	NON	32*	NA	63.5	F*	McCormick Run Rd.	8.2
3.5/3.3	PARTIAL	38*	NA	61.0	G	Forbes Rd.	17.1
Alder Lick Run 06-080 *WWH (existing) WWH (retained)*							
0.2	PARTIAL	40^{ns}	NA	69.0	F*	Adj. Fife Coal Rd.	3.0
Bailey Run 06-095 *Undesignated CWH (recommended)*							
0.7	NON	24*	NA	83.5	MG^{ns}	Dan Smith Rd.	2.5
Carpenter Run (Ohio R trib.) 06-082 *WWH (existing) CWH (recommended)*							
1.6/2.2	NON	24*	NA	59.5	G	Between Dresden Ave. and SR 7/US 30	2.2

Stream-Code# River Mile Fish/Macro.	Attainment Status	IBI	MIwb	QHEI	ICI[a]	Location	DA
Jethro Run (Ohio R. trib.) 06-096 *Undesignated CWH (recommended)*							
0.1/0.1 (2006)	FULL	50	NA	57.5	MG[ns]	Dst. SR 7/39	2.7
McQueen Run (Ohio R. trib.) 06-078 *Undesignated CWH (recommended)*							
0.6	NON	12*	NA	59.5	G	Ust. SR 7	2.1
Wells Run (Ohio R. trib.) 06-081 *WWH (existing) CWH (recommended)*							
0.4/0.3	NON	12*	NA	54.0	P*	Ust. SR 7 (AMD @ RM 0.5)	2.2

Ecoregion Biocriteria: Western Allegheney Plateau

	IBI				MIwb					ICI			
Site Type	WWH	EWH	MWH	LRW	WWH	EWH	MWH Channel Mod.	MWH Mine affected	LRW	WWH	EWH	MWH	LRW
Headwaters	44	50	24	18						36	46	22	8
Wading	44	50	24	18	8.4	9.4	6.2	6.2	4.5	36	46	22	8
Boat	40	48	24	16	8.6	9.6	5.8	5.5	5.0	36	46	22	8

* Significant departure from ecoregional biocriteria; poor and very poor results are underlined.
ns Nonsignificant departure from ecoregional biocriteria for WWH or EWH (<4 IBI or ICI units; <0.5 MIwb units).
a A narrative evaluation is used in lieu of the ICI from sites with Qualitative data only (E=Excellent, VG=Very Good, G=Good, MG=Marginally Good, F=Fair; P=Poor, VP=Very Poor).
b Attainment status based on one organism group is parenthetically expressed.
∆ Narrative evaluation substituted for ICI score due to inadequate current velocity over artificial substrates
WWH = Warmwater Habitat
EWH = Exceptional Warmwater Habitat
CWH = Coldwater Habitat

Table 5. Causes and Sources of impact for impaired stream segments in the Yellow Creek and Little Yellow Creek (Ohio River Tributaries) study areas, June to October, 2005 and August to September, 2006.

Upper Yellow Creek Basin WAU 05030101 180 (Headwaters to upstream Town Fork)									
Stream River Mile Fish/Macro.	Attainment	IBI	MIwb	QHEI	ICI[a]	Location	DA	Cause	Source
Cox Creek (06-937) WWH* (existing)									
0.1	PARTIAL	48	NA	81.0	F*	SR 164	2.8	Org. Enrichment - H	Septic Tanks - H
Comments: Fair macroinvertebrates, elevated bacteria levels (as high as 43,000 on 10-4-05) and WQS exceedences for ammonia and copper were detected below a grey water discharge immediately upstream from the SR 164 sampling site. In contrast, fish collections upstream from the discharge reflected very good quality. A series of unsewered homes along T-275, adjacent to Cox Creek, appeared to be the source of contamination.									
Long Run (06-909) WWH* (existing) *WWH - Headwaters to Hildebrand Run (recommended)*									
4.3	PARTIAL	42ns	NA	74.5	F*	Ust. CR 54	4.1	Wetland - H	Natural - H
Comments: Partial attainment was considered primarily a result of natural wetland conditions and large beaver dam impoundment upstream from CR 54.									
Lower Yellow Creek Basin WAU 05030101 190 (Upstream Town Fork to mouth)									
Yellow Creek (06-900)WWH+ (existing) *WWH - North Fork Yellow Creek to mouth (recommended)*									
3.3/3.3 (2006)	PARTIAL	44	8.7	63.0	24*	Dst. North Fork Yellow Creek	224	Metals - H Habitat Alt. - M	Subsurface mining - H Off road vehicles, Streambank mod./ destabilization - M
Comments: The ICI declined sharply (from exceptional to fair) immediately downstream from the North Fork in 2006; fish experienced similar declines but met minimum WWH criteria in 2005. Declines in macroinvertebrates coincided with an increase in tolerant Oligochaetes (sludge worms) and extensive deposition of slimy silt or yellow boy. Sludge worms appeared entrained in the silty solids and may be associated with the iron-fixing bacteria growth (iron concentrations increased sharply [3-4x] downstream from the North Fork. The source of mine drainage was likely related to a problematic mine seep that discharged a large volume of mine drainage at North Fork RM 0.23 in 2002 (Ohio EPA 2003). However, at the time, the seep did not appear to impact the mainstem Yellow Creek biology downstream. Habitat quality in the reach was also reduced due to heavy ATV traffic in-stream and severe bank destabilization and bedload movement following habitat alteration by an upstream land owner and subsequent flooding in 2004.									
Town Fork WWH* (existing) *EWH - Jefferson Lake to mouth (recommended)*									
8.0/8.1	PARTIAL	52	NA	77.0	MG*	Dst. Jefferson Lake	7.9	Flow Alt. - H	Upstream Impoundment -H
Comments: Intermittent late summer flow conditions immediately downstream from Jefferson Lake were the primary cause of Partial attainment of the recommended EWH use. Outside of this localized impairment in the macroinvertebrates, biological communities were consistently in the exceptional range between Jefferson Lake and the mouth.									
Riley Run (06-917) WWH+ (existing) *WWH (recommended)*									
4.9	NON	42^{ns}	NA	62.5	P*	April Rd.	2.8	Flow Alt. - H Metals - M	Coal mining - H
Comments: Nearly intermittent flows, elevated mine drainage parameter (Mn, Sulfate) and poor macroinvertebrates downstream from pasture and strip mining areas suggest impacts associated with active or historic mining activity upstream.									
North Fork Yellow Cr. Trib. @ RM 9.65 (06-945) Undesignated *CWH (recommended)*									
0.4	NON	22*	--	53.0	E	Jackoblonski Rd	3.0	Flow Alt. - H	Natural - H Highway Const.-M
Comments: The primary cause of fish impairment was a rock ledge/culvert blocking upstream migrations of fish. Upstream from the ledge, pools were insufficient to support an acceptable WWH fish community (much of the stream was reduced to a roadside ditch adjacent to SR 39). However, the presence of 6 coldwater macroinvertebrates qualifies the stream for CWH.									
North Fork Yellow Cr. Trib.@ RM 6.08 (06-941) WWH+ (existing) *WWH (recommended)*									
0.1/0.2	PARTIAL	50	NA	79.0	F*	Hazel Run Rd.	4.0	Flow Alt. - H	Natural - H
Comments: Small, undisturbed watershed (Regional Reference site) with late summer, interstitial flows resulted in fair macroinvertebrates but no significant impact to fish. Low flow conditions were considered natural.									

Stream River Mile Fish/Macro.	Attainment	IBI	MIwb	QHEI	ICI[a]	Location	DA	Cause	Source
Salisbury Run (06-913) LRW+ (existing) *CWH (recommended)*									
0.2/0.1	NON	12*	NA	56.0	VP*	CR 776	2.3	pH/Metals - H	AMD - H
Comments: Salisbury Run at the mouth continues to be severely degraded by acid mine drainage. Mine drainage parameters were highly elevated throughout the sampling period (Fe, Al., Sulfate, etc.) and pH reached a minimum concentration of 3.71. The source of AMD was a discrete discharge or seep located at approximately RM 0.5. Macroinvertebrate sampling upstream from the discharge revealed a good quality, coldwater community (5 coldwater taxa), natural, intact stream habitat, and no visual indication of mine drainage.									
Ohio River Tributaries WAU 05030101 100 (Downstream Little Beaver Creek to upstream Yellow Creek)									
Little Yellow Creek (06-079) WWH* (existing) *WWH (recommended)*									
11.1/11.3	PARTIAL	34*	NA	71.0	G	Clarks Mill Rd.	2.8	Silt/Sediment - H Flow. Alt. - M	Ag. - H Impoundment - M
Comments: Stream located in the Highlandtown Wildlife Area, immediately upstream from Highlandtown Lake. The fair fish community appears to reflect an influence from historic but recovering Ag. Land use (old field/former pasture), a transitional Ag./Wetland habitat prior to the impoundment and limited potential for fish movement from downstream. DO violations were found at Clarks Mill Rd. (lentic habitat) but chemistry was collected downstream from the free-flowing biological sampling sites.									
6.7/6.6	NON	32*	NA	63.5	F*	McCormick Run Rd.	8.2	Flow Alt. - H Excess algae-M	Impoundment - H
Comments: Fair fish and macroinvertebrates were found downstream from Highlandtown Res. and upstream from Wellsville Res. Fish may be influenced by limited potential for fish movement and recovery due to upstream and downstream impoundments while macroinvertebrates appeared to reflect enrichment. Observations of excessive “organic fines” by fish crews and an unusual, “dark brown silt” obs. during macroinvertebrate sampling may be associated with dead algal mats or biomass from the upstream reservoir. An odor of manure from nearby farms was also noted.									
3.5/3.3	PARTIAL	38*	NA	61.0	G	Forbes Rd.	17.1	Flow Alt. - H	Impoundment - H
Comments: Like sites upstream, flow alteration associated with the limited flow from Wellsville Res. coupled with limited potential for fish movement and recovery between the reservoir and the impounded Ohio River were considered the most likely reasons for the fair quality fish. Outside of an increasing trend in sulfate, chemical results indicate no obvious water quality problems.									
Alder Lick Run (06-080) WWH* (existing) *WWH (recommended)*									
0.2	PARTIAL	40[ns]	NA	69.0	F*	Adj. Fife Coal Rd.	3.0	TDS - H	Coal Mining -H
Comments: Fair macroinvertebrates and Partial attainment appeared related to mining activity in the basin. Elevated mine parameters included TDS, Conductivity, and Sulfate. Among the macroinvertebrates, mayflies are particularly sensitive to high TDS and these taxa were absent from the sample.									
Bailey Run (06-095) Undesignated *CWH (recommended)*									
0.7	NON	24*	NA	83.5	MG[ns]	Dan Smith Rd.	2.5	Flow Alteration - H Metals - M Natural - M	Coal Mining -H Impoundment - M Natural - M
Comments: The poor fish community was considered primarily related to historic mining and small basin size, coupled with the physical isolation of the watershed by the Wellsville Reservoir, waterfalls, and wetland conditions in the headwaters. The fish community was composed of a few tolerant (99%) and pioneering species (91%) with only 5 total taxa present. Chemical sampling was conducted upstream from most historic mining activity but included highly elevated levels of Iron and Manganese and low D.O levels associated with wetland drainage.									
Carpenter Run (Ohio R trib.) (06-082) WWH* (existing) *CWH (recommended)*									
1.6/2.2	NON	24*	NA	59.5	G	Adj. US 39/SR 7	2.2	Flow Alt. - H Habitat. Alt. - M	Culvert/Highway Const. - H Urban Runoff - M
Comments: Like a number of other small, high gradient Ohio River tribs., the previous extirpation or degradation of the fish community (due to historic channel modification, relocation, or water quality degradation), and a lack of re-colonization potential (due to culverting and high stream gradient/energy) were likely causes of non-attainment (poor fish). Modification of the flow regime is also likely due to increased urban land usage in the Calcutta area.									
McQueen Run (Ohio R. trib.) (06-078) WWH* *CWH (recommended)*									
0.6	NON	12*	NA	59.5	G	Ust. SR 7	2.1	Flow Alt. - H	Culvert/Highway Const. - H
Comments: Good quality macroinvertebrates, the absence of fish, and lack of significant chemical problems indicate a small drainage/isolation issue. Many of these small, direct Ohio River tribs. are high-gradient and modified. The modified segment of McQueen Run upstream from SR 7 resembles a “toilet bowl” where the stream plunges into a deep, long culvert that runs under the highway. Combined with the high-energy of the stream, fish are unable to re-colonize the stream from the Ohio River side of the highway.									
Wells Run (Ohio R. trib.) (06-081) WWH* (existing) *CWH (recommended)*									

Stream River Mile Fish/Macro.	Attainment	IBI	MIwb	QHEI	ICI[a]	Location	DA	Cause	Source
0.2/0.3	NON	12*	NA	54.0	P*	Ust. SR 7	2.2	pH/Metals - H	AMD - H
Comments: Obvious AMD stream stained bright orange. Fe, Mn, and Al were quite elevated and Datasonde® continuous monitors recorded numerous low pH measurements (4.27 Avg.). The source of AMD was a large discharge of mine water near RM 0.5. The stream appeared clear and unimpacted upstream from the discharge but was not sampled. Although impaired, CWH is recommended based on the presence of 5 coldwater macroinvertebrates in very low numbers. These coldwater and sensitive taxa likely originate in the headwaters, upstream from the mine discharge.									
Ecoregion Biocriteria (see Table 4): Western Allegheny Plateau Ecoregion									
* Significant departure from ecoregional biocriteria; poor and very poor results are underlined.									
ns Nonsignificant departure from ecoregional biocriteria for WWH or EWH (<4 IBI or ICI units; <0.5 MIwb units).									
a A narrative evaluation is used in lieu of the ICI from sites with Qualitative data only (E=Excellent,VG=Very Good, G=Good, MG=Marginally Good, F=Fair; P=Poor, VP=Very Poor).									

RECOMMENDATIONS

Aquatic Life Uses Recommendations

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 Yellow Creek watershed resulted in the application of the WWH aquatic life use for Yellow Creek and the North Fork Yellow Creek. Sampling conducted in 2005 confirmed the WWH designations and a large section of Yellow Creek, from Bergholz to the North Fork Yellow Creek (RMs 24.2-3.4), was recommended as EWH.

Based on results of 2005 sampling, numerous aquatic life use designations changes are proposed in the Yellow Creek survey area. Current and recommended aquatic life, water supply and recreation uses are presented in Table 6. Justifications for the recommended aquatic life use designation changes are as follows:

<u>Coldwater Habitat (CWH) Designations</u>

Coldwater Habitat-Native Fauna stream sites with a drainage greater than about 1.0 mi2 were characterized by the presence a) $\geq$4 coldwater macroinvertebrate taxa or, b) populations of two species of cold water fish, and organisms from two taxa of primary cold water macroinvertebrates (3745-1-07 Beneficial use designations; currently under review). Most streams included both requisite coldwater fish and macroinvertebrates but fish were absent from some coldwater drainages due to natural causes.

<u>Coldwater Habitat Recommendations</u>

Upper Yellow Creek <u>(WAU 180)</u>	Lower Yellow Creek <u>(WAU 190)</u>	Little Yellow Cr. <u>(WAU 100)</u>
Elk Fork	Town Fork: (Hdwaters to Jefferson Lake)	Bailey Run
Elk Lick	Riley Run: (UTrib. @ RM 3.75 to mouth)	Jethro Run
Yellow Cr. Trib. @ RM 30.22	Riley Run Trib. @ RM 3.75	Wells Run
Goose Creek	Salisbury Run	McQueen Run
Wolf Run	Salt Run: [Hdwaters to Irondale (RM 0.3)]	Carpenter Run
Carroll Run	Tarburner Run	
Frog Run	Hollow Rock Run	
Hazel Run	N. Fk. Yellow Cr. Trib. @ RM 8.96 (UTrib. @ RM 0.18 to mouth)	

Additional comment or justification is included below where necessary.

Comments (CWH - WAU 180):

- The CWH designation for **Wolf Run*** was based on the presence of 5-12 coldwater macroinvertebrates collected in 2005 and 2006. Fish collections also included southern redbelly dace, a coldwater indicator. Wolf Run was originally designated LRW due to extensive mining activity and, as recently as 1983, fish and macroinvertebrates were virtually absent from the stream. The upper reaches of Wolf Run remain impacted by AMD (Hughes and Bowman 2007). However, the most recent Ohio EPA survey shows significant improvement in both organism groups in the lower 1-2 miles, primarily a result of ODNR reclamation activity and natural attenuation. Additional reduction of AMD in the headwaters should further biological recovery.

  *Wolf Run Is called Wolf "*Creek*" in the Ohio WQS and Ohio Department of Natural Resources (ODNR) Stream Gazetteer. However, the stream is called Wolf Run on USGS topographic maps and the unincorporated community of Wolf Run lies along the streams length. For these reasons, the name *Wolf Run* was considered most appropriate.

- **Frog Run** was originally designated EWH in the 1978 WQS but not field verified. Biological sampling results show performance is not up to exceptional levels, most likely due to wetland influences in the upper drainage and channel modification near the mouth. However, coldwater populations were found in sufficient number to merit a CWH designation. For these reasons, the CWH use is recommended but the EWH designation should be removed.

- **Carroll Run** biological sampling included 3 coldwater fish and 3 primary coldwater macroinvertebrate taxa, numbers adequate for a CWH designation.

- All **Elk Fork**, **Elk Lick**, **Yellow Creek Trib. @ RM 30.22** and **Goose Creek** collections included 2-3 coldwater fish and 4-6 coldwater macroinvertebrates, demonstrating levels of performance exceeding minimum CWH guidelines.

Comments (CWH - WAU 190):

- The CWH designation for the **North Fork Yellow Cr. Trib. @ RM 9.65** was based on the presence of 6 coldwater macroinvertebrates at RM 0.4. Representative fish populations upstream from this location were precluded by a large rock ledge/culvert and the lack of deep pools further upstream.

- **North Fork Yellow Cr. Trib. @ RM 8.96** (UTrib. @ RM 0.18 to mouth). The channel was dry for most of its length but consistent flows were maintained in the lower reach, downstream from a very cold, spring fed tributary at RM 0.18. Fish were not sampled from this downstream reach but CWH is recommended based on the presence of 7 coldwater macroinvertebrates.

- **Salisbury Run** is currently designated LRW-Mine Affected and was severely impacted by acid mine drainage (AMD) near the mouth. However, good quality, coldwater macroinvertebrates were found immediately upstream from the AMD source at RM 0.6. The upstream reach was clear, natural and heavily wooded with coarse boulder and flagstone substrates. While fish were not sampled, they were observed in pools up to 24" depth. Coupled with the presence of salamanders, the collections suggest the presence of permanent pools and intact stream habitat. In the 1983 Ohio EPA survey, most or all fish sampling was conducted upstream from the acid seep. IBI scores (backpack method) were in the fair range but one pass nearly met WWH criteria (IBI=36). The fish community was composed of 3 headwater/coldwater populations including blacknose dace, creek chub, and the coldwater indicative mottled sculpin (41%). Based on these results, an upgrade from LRW to CWH is considered appropriate for the length of the stream.

- **Salt Run** [Headwaters to Irondale (RM 0.3)]. CWH is recommended upstream from the modified portion of the stream in Irondale based on the presence of 11 coldwater macroinvertebrates and a coldwater fish (mottled sculpin). Macroinvertebrates from the mouth of Salt Run in Irondale lost coldwater characteristics and appeared impacted by septic tank drainage, channelization, and riparian removal.

- **Hollow Rock Run**: CWH is recommended based on the presence of 4-7 coldwater macroinvertebrates and a large percentage of coldwater fish, (*i.e.*, mottled sculpin) at two sampling sites. Longnose dace, a rare Ohio fish species and coldwater indicator was also collected at one site.

- **Tarburner Run**: A tributary to Hollow Rock Run, CWH is also recommended for Tarburner Run based on the presence of 5 coldwater macroinvertebrates and a large percentage of coldwater fish, (*i.e.*, mottled sculpin). Longnose dace, a rare Ohio fish species and coldwater indicator was also collected.

Comments (CWH - WAU 100):

- CWH is recommended for **Bailey Run** based on the presence of 6 coldwater macroinvertebrates. A healthy, representative fish community was excluded from the stream due to several physical features including small drainage area (3 sq. mi.), disruption of the landscape by historic mining, physical isolation of the basin by Wellsville Reservoir, and a waterfall at RM 0.7 that poses a barrier to fish migration. Extensive wetland conditions in the headwaters were an additional factor that may limit the available pool of fish populations for re-colonization.

- **McQueen Run** supported a good quality, coldwater macroinvertebrate community (9 coldwater taxa) with no significant water quality problems. However, fish were entirely absent upstream from the SR 7/39 highway crossing.

Like similar direct Ohio River tributaries in the area, the condition of the fish was considered largely a function of hydrology or physical isolation. Many similar small, direct Ohio River tributaries are culverted under the SR 7/39 highway. In the case of McQueen Run, the upstream end of the culvert resembles a “toilet bowl” where the stream plunges into a long tunnel that runs under the highway. Fish populations that were absent or historically eliminated from the upstream segment would be unable to re-colonize from the Ohio River side. For these reasons, CWH was recommended based on the macroinvertebrate community only.

- Like a number of other small, high gradient tributaries to the Ohio River, non-attainment in **Carpenter Run** appeared related to historic extirpation or degradation of the fish community and a lack of re-colonization potential due to culverting, construction, and the high gradient/energy of the stream. Between Calcutta and East Liverpool, the stream channel lies in a narrow strip between the SR 7/US 30 highway to the west and Dresden Ave. to the east. Stream flow is routinely directed through a series of long culverts and large portions of the channel were likely relocated during construction of the limited access highway. The CWH designation is recommended based on the marginally good condition of the macroinvertebrates and presence of 7 coldwater varieties.

- **Wells Run** was severely impacted by acid mine drainage from an abandoned mine portal near RM 0.5. The stream was not sampled upstream from the discharge but appeared clear and unimpaired visually. A CWH designation is recommended based on the collection of 5 coldwater macroinvertebrates, albeit in very low densities, downstream from the mine portal. The coldwater taxa likely originated in the headwaters, upstream from the mine drainage discharge.

- CWH is recommended for **Jethro Run** based on the presence of 5 coldwater macroinvertebrates and longnose dace, a rare Ohio fish species and coldwater indicator. Unlike most other small, direct Ohio River tributaries sampled, the Jethro Run fish community was not structurally impaired (IBI=50). Fish were sampled downstream from SR 7 but the culvert under the highway had a low, flooded, flat apron that didn’t appear to be an impediment to fish movement.

<u>Exceptional Warmwater Habitat (EWH)/Coldwater Habitat (CWH) Designations</u>
The following streams met requirements for CWH and demonstrated exceptional biological performance and therefore, were recommended for a dual EWH/CWH aquatic life use. The streams are listed below by WAU unit.

Exceptional Warmwater Habitat (EWH)/Coldwater Habitat (CWH) Recommendations

Upper Yellow Creek (WAU 180)	Lower Yellow Creek (WAU 190)	Little Yellow Cr. (WAU 100)
Elkhorn Cr. [Hdwtrs. to Center Fork	Keyhole Run	None

(RM 5.35)]
Strawcamp Run (Hdwtrs. to Chase Rd. RM 1.2)
Trail Run
Hump Run
Ralston Run
Long Run [Hildebrand Run (RM 2.5) to mouth]
Upper North Fork [Hump Run (RM 1.43) to mouth]
Dennis Run
Roses Run
Nancy Run
Brush Creek [Rose Run (RM 6.32) to mouth]

Comments (EWH/CWH - WAU 180):

- **Elkhorn Creek** [Headwaters to Center Fork (RM 5.35)]. Elkhorn Creek is currently designated EWH. 2005 biological sampling confirmed the EWH use and also indicated CWH potential at 2 sites upstream from Center Fork at RMs 7.9 and 6.7. Center Fork was chosen as the downstream limit for CWH because it is a major tributary and reflected exceptional but only marginal coldwater conditions. Elkhorn Creek biological communities lost coldwater characteristics downstream from the confluence at the mouth.

- **Strawcamp Run** [Headwaters to Chase Rd. (RM 1.2)]. The stream is currently designated EWH but 2005 biological sampling results also indicate CWH potential in the upper reach based on the presence of 10 coldwater macroinvertebrates and 3 coldwater fish (RMs 2.2-1.2). Chase Road (RM 1.2) was chosen as the downstream limit for CWH because coldwater populations were lacking further downstream (see page 34).

- **Upper North Fork** [Hump Run (RM 1.43) to mouth]. The stream was originally designated WWH based on qualitative macroinvertebrate sampling in 1983 (no fish sample). Based on 2005 results near the mouth (RM 0.4) the stream demonstrated exceptional biological performance, CWH potential, and contained physical habitats adequate to support EWH (QHEI=78). Hump Run, another EWH/CWH designated tributary, was selected as the upstream limit for the designations. Upper North Fork communities upstream from Hump Run continued to reflect WWH conditions.

- **Long Run** [Hildebrand Run (RM 2.5) to mouth]. Biological performance at the mouth of Long Run was clearly exceptional and included coldwater fish and macroinvertebrate populations adequate for a CWH designation. Hildebrand Run was selected as the upstream limit for the dual use because it harbors good quality, coldwater fish populations and biological performance in Longs Run was limited by wetland conditions further upstream.

- **Ralston Run**: Fish and macroinvertebrates performance was exceptional near the mouth of Ralston Run and habitat quality (QHEI=71.5) approached levels considered capable of supporting EWH fish communities. Coldwater taxa were also present in numbers adequate for a CWH designation.

Comments (EWH/CWH - WAU 190):

- **Nancy Run** is currently designated EWH. Based on the presence of adequate populations of coldwater fish and macroinvertebrates, a CWH designation is also recommended. A similar, dual designation is proposed for Roses Run, a tributary to Nancy Run.

- After improving from a marginally good condition in the headwaters, biological performance throughout the lower 6.2 miles of **Brush Creek** was clearly exceptional. QHEI scores averaged 85.0 in the stretch, a strong indicator of EWH potential. The CWH designation is recommended based on an average 4.5 coldwater macroinvertebrates and 2 coldwater fish. Rose Run, a small named tributary immediately upstream from the RM 6.0/6.2 sampling site was an appropriate, upstream limit for the dual designation.

- **Dennis Run** supported coldwater populations and demonstrated exceptional biological performance at the mouth despite a reclaimed mine landscape and large beaver dam impoundment immediately upstream. Sustained cool stream flow from groundwater intrusion near the mouth and lack of heavy metal or pH contamination associated with mining contributed to the exceptional quality.

Exceptional Warmwater Habitat (EWH) Designations

The following streams demonstrated exceptional biological performance and are recommended for the EWH aquatic life use. The streams are listed below by WAU unit.

Exceptional Warmwater Habitat (EWH) Recommendations

Upper Yellow Creek (WAU 180)	Lower Yellow Creek (WAU 190)	Little Yellow Cr. (WAU 100)
Yellow Creek [Upper North Fork to North Fork Yellow Creek (RM 24.2-3.4)]	Yellow Creek [Upper North Fork to North Fork Yellow Creek (RM 24.2-3.4)]	None
Center Fork	Town Fork [Jefferson Lake (RM 8.36) to mouth]	
Elkhorn Creek [Center Fork (RM 5.35) to mouth]		
Strawcamp Run [Chase Rd. (RM 1.2) to mouth]		

Comments (EWH - WAU 180):

- **Yellow Creek** [Upper North Fork to North Fork Yellow Creek (RM 24.2-3.4)] Biological performance in this reach was exceptional for fish and very good to exceptional for macroinvertebrates. QHEI scores averaged 86.7, clearly exceeding levels considered adequate to support EWH communities (*i.e.,* $\geq$75). Macroinvertebrates tended to improve from a very good to an exceptional condition with increased distance downstream and may reflect lingering influences from mining and nutrient sources in the headwaters. A slight decline in both biological communities at RM 11.8 and observations of yellow boy deposits in pools suggested a localized influence, most likely related to AMD sources located immediately upstream between RMs 12.0 and 12.83.

- **Center Fork** was originally designated EWH in the 1978 WQS and re-designated CWH following the 1983 survey. However, using the most recent CWH performance guidelines, 1983 through 2005 sampling results show non or, at best, marginal coldwater attainment throughout most of the streams length. In contrast, EWH attainment was FULL for fish and macroinvertebrates during all surveys. QHEI scores averaged 68.8 (somewhat lower than is typically associated with EWH), but biological performance has consistently met the higher use.

- **Elkhorn Creek** [Center Fork (RM 5.35) to mouth]. Exceptional biological performance at the mouth of Elkhorn Creek confirmed the existing EWH designation. However, the coldwater biological characteristics that typified the headwaters were lost in the lower reach. Center Fork was chosen as the demarcation for the use because it was a major tributary reflecting exceptional, but not coldwater, conditions.

- **Strawcamp Run** [Chase Road (RM 1.2) to mouth]. Biological communities near the mouth of Strawcamp Run maintained marginally exceptional quality but lost significant numbers of coldwater forms compared to upstream (from 10 to 2 macroinvertebrates and 18.51% to 4.51% coldwater fish from the headwaters to the mouth). Declines may have been related to lower habitat quality as the stream was mostly pooled and the QHEI score dropped 36 points. The stream may also be losing flow to groundwater infiltration near the mouth but this could not be confirmed. For these reasons, extending the coldwater designation to the mouth should be deferred pending re-sampling at a later date. An investigation of land use characteristics, flow regime, and temperature should coincide with the sampling.

Comments (EWH -WAU 190)

- **Yellow Creek** (see comments above – EWH - WAU 180)

- **Town Fork** [Jefferson Lake (RM 8.36) to mouth): Biological communities lost coldwater characteristics downstream from Jefferson Lake but, with one exception, maintained exceptional quality downstream from the impoundment. Macroinvertebrates were negatively affected by de-watering immediately downstream from the dam during a late summer low-flow period but recovered quickly.

Warmwater Habitat (WWH) Designations

In general, warmwater habitat designated streams possess physical habitats adequate for support of warmwater communities (*i.e.,* QHEI $\geq$ 60) or demonstrate full attainment of the use in the fish and macroinvertebrates (*i.e*, good biological performance or better). Based on 2005 sampling, the following streams should receive or retain WWH designations; the streams are listed by WAU unit.

Warmwater Habitat (WWH) Recommendations

Upper Yellow Creek (WAU 180)	Lower Yellow Creek (WAU 190)	Little Yellow Cr. (WAU 100)
Yellow Creek (Hdwaters to Upper N. Fk.)	Yellow Creek (N. Fk. Yellow Cr to mouth)	Little Yellow Creek
Long Run [Hdwaters to Hildebrand Run (RM 2.5)]	North Fk. Yellow Creek Trib. @ RM 6.08	Alder Lick Run
Gault Run	North Fork Yellow Creek	
Upper North Fork (Hdwaters to Hump Run (RM 1.43)	Riley Run	

Comments: (WWH - WAU 180)

- **Yellow Creek** [Headwaters to Upper North Fork (RM 18.2)]: The existing WWH use should be retained for this reach of the upper mainstem. Biological attainment was in the good to very good range but rarely exceptional. Habitat quality (mean QHEI score = 70.0) was more associated with WWH attainment than EWH. Lingering influences from mining, livestock, and on-site septic systems in the headwaters may contribute to less than optimal biological performance.

- **Upper North Fork** [Headwaters to Hump Run (RM 1.43)]: The stream was originally designated WWH based on qualitative macroinvertebrate sampling in 1983 (no fish sample). Based on 2005 sampling, biological performance in the upper reach (upstream Hump Run) was very good but stream habitat was historically modified (QHEI=53.5) and communities lack the coldwater populations and clearly exceptional performance observed downstream (see page 32). Upper North Fork upstream from Hump Run should retain the existing WWH designation.

- **Long Run** [Headwaters to Hildebrand Run (RM 2.5)]: Partial attainment in the headwaters of Long Run was related to natural wetland conditions and not anthropomorphic modification. Habitat quality (QHEI=74.5) was clearly adequate to support WWH and the existing fish community marginally met WWH criteria. In the absence of "Wetland" or "Swamp Stream" aquatic life use designation, the existing WWH designation is considered appropriate. Additional biological sampling immediately upstream from Hildebrand Run at RM 2.7 was limited to macroinvertebrates only. Compared to upstream, habitat quality was natural with well developed riffle/pool development and firm, coarse substrates. The collection of four coldwater macroinvertebrate taxa suggested cooler stream temperatures with increased distance downstream. However, the WWH recommendation was retained due to the absence of fish data.

Comments: (WWH - WAU 190)

- **North Fork Yellow Creek**: Habitat quality throughout most of the North Fork Yellow Creek was at exceptional levels (Mean QHEI=77.3). However, biological performance was slightly below exceptional for fish in the upper reach (near Salineville) and macroinvertebrate performance fell well below exceptional levels in the lower reach, downstream from Salisbury Run and Irondale. Consequently, WWH attainment was full throughout the length of the stream (5 of 5 stations) but EWH attainment was fully met at only one site. Reduced loadings and remediation of point and nonpoint source discharges in the North Fork watershed may eventually result in the stream reaching its full potential. However, based on 2005 results, WWH is considered the most appropriate designation.

- **Yellow Creek** (North Fork Yellow Creek to mouth): Both biological performance and habitat quality declined from exceptional levels upstream, to partial WWH attainment downstream from the North Fork Yellow Creek. Declines in performance appeared the result of both physical habitat disruption and chemical impairment. Habitat quality was degraded by recent flooding, stream channel movement, bank destabilization, and riparian loss. Excessive ATV traffic throughout this stretch also contributed to degraded habitats. Macroinvertebrates appeared impacted by mine drainage as the stream bottom was covered with a slimy layer of flocculent solids or yellow boy. Mine drainage sources in the North Fork Yellow Creek, particularly a portal blowout near the mouth (Ohio EPA 2003) are suspected sources. These impairments, coupled with the Ohio River backwater that impounds the lower two to three miles of the mainstem, are the basis for retaining the WWH use.

Comments: (WWH - WAU 100)

- **Alder Lick Run**: Habitat quality (QHEI=69) was adequate for support of WWH communities and fish marginally attained WWH criteria. Partial attainment was the result of fair macroinvertebrate quality and was primarily related to abandoned mine land runoff and elevated levels of total dissolved solids. In the absence of pollution impacts, the stream could meet WWH standards (*i.e.,* good or better biological quality); cold water temperatures measured in 2005 and the presence of several coldwater populations suggest the ultimate stream potential may be CWH.

- **Little Yellow Creek**: This stream is currently designated WWH but the use has not been field verified. Habitat quality at three sites on Little Yellow Creek (mean QHEI=65.2) was adequate for support of WWH communities. Biological communities were in the fair to good range and have not achieved their full WWH potential for several reasons. Included is the physical alteration of flow and potential isolation of fish populations by two reservoirs along the streams length (Highlandtown and Wellsville Reservoirs) and the impounded Ohio River pool at its mouth. While these influences could inhibit or even preclude WWH attainment, additional factors such as recovery from land disturbance in the headwaters and organic enrichment may also influence the biology. In addition, dewatering of the stream below the Wellsville water supply reservoir should be abated with the introduction of a new water supply source (projected for 2009) and enhance flow conditions downstream. For these reasons, the current WWH designation is considered appropriate and verified. The stream should be monitored in the future to assess any changes in biological communities.

Limited Resource Water (LRW) Designations

The following stream is recommended to retain its existing LRW aquatic life use:

- **Randolph Run** [Lower Yellow Creek basin (WAU 190)]. This small stream was historically mined, less than 3 sq. mi. in size, and dried up for extended periods during the summer. Any fish that may have inhabited the evaluated reach would have been eliminated. Therefore, expectations of WWH potential was considered unrealistic and the existing use should be retained.

Undesignated

The following stream should retain an unverified, WWH aquatic life use:

- **Cox Creek**: [Upper Yellow Creek basin (WAU 180)]. Macroinvertebrates were impaired at the mouth of Cox Creek, immediately downstream from a series of home septic tank discharges. Fish community performance upstream from the discharge was very good and included three coldwater species. Habitat quality (QHEI=81) was also clearly adequate to support WWH. However, due to the localized impairment at the mouth, a specific use recommendation was deferred pending additional macroinvertebrate sampling upstream.

Table 6. Waterbody use designations for the Yellow Creek 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 (+) and a delta (Δ) indicates a new recommendation based on the findings of this report. Plus sign (+) designations shaded in gray are to be replaced by the new recommendations (Δ). Designations based on the 1978 and 1985 standards for which results of a biological field assessment are now available are displayed to the left of existing markers.

Water Body Segment		Use Designations												
		Aquatic Life							Water Supply			Recreation		
		SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR
Yellow Creek	- Headwater to Upper North Fk.		+							+	+		+	
	- Upper North Fk. to North Fk.		+	Δ						+	+		+	
	- North Fk. to mouth		+							+	+		+	
Hollow Rock Run			+				Δ			+	+		+	
Tarburner Run			*				Δ			*+	*+		*+	
North Fork Yellow Creek			+							+	+		+	
Salt Run	- Headwater to Irondale		*				Δ		+	*+	*+		*+	
	- Irondale to mouth (RM 0.3-0.0)		*							*+	*+		*+	
Salisbury Run							Δ	+		+	+		+	
Randolph Run								+		+	+		+	
Trib. to North Fk. (RM 6.1)			+							+	+		+	
Trib. to North Fk. (RM 8.96)														
	RM 0.18 Trib. to mouth						Δ			Δ	Δ		Δ	
Trib. to North Fk. (RM 9.65)							Δ			Δ	Δ		Δ	
Nancy Run				Δ			+			+	+		+	
Roses Run			*	Δ			Δ			*+	*+		*+	
Riley Run	- Headwater to UTrib. (3.75)		+						+	+	+		*+	
	- UTrib. (3.75) to mouth		+				Δ		+	+	+		*+	
Trib. to Riley Run (RM 3.75)							Δ			Δ	Δ		Δ	
Brush Creek	- Headwater to Rose Run (RM 6.32)		*							*	*		*	
	- Rose Run (RM 6.32) to mouth		*	Δ			Δ			*+	*+		*+	
Dennis Run			*	Δ			Δ			*+	*+		*+	
Town Fork	- Headwater to Jefferson Lake		*				Δ			*+	*+		*+	
	- Jefferson Lake to mouth		*	Δ						*+	*+		*+	
Keyhole Run				Δ			Δ			Δ	Δ		Δ	
Ralston Run			+	Δ			Δ			+	+		+	
Long Run	- Headwater to Hildebrand Run		*+							*+	*+		*+	
	- Hildebrand Run to mouth		*	Δ			Δ			*+	*+		*+	
Upper North Fork	- Headwater to Hump Run		+							+	+		+	

Water Body Segment	Use Designations												
	Aquatic Life							Water Supply				Recreation	
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR
- Hump Run to mouth		+	Δ			Δ			+	+		+	
Hump Run		*	Δ			Δ			*+	*+		*+	
Carroll Run		*				Δ			*+	*+		*+	
Hazel Run		*				Δ			*+	*+		*+	
Elkhorn Creek - Headwater to Center Fork			+			Δ			+	+		+	
- Center Fork to mouth			+						+	+		+	
Strawcamp Run - Headwater to Chase Rd.			+			Δ			+	+		+	
- Chase Rd to mouth			+						+	+		+	
Center Fork			Δ			+			+	+		+	
Trail Run			Δ			+			+	+		+	
Frog Run			*			Δ			*+	*+		*+	
Gault Run		Δ							Δ	Δ		Δ	
Wolf Run (Creek in WQS)						Δ	+		+	+		+	
Cox Creek		*							*+	*+		*+	
Goose Creek		*				Δ			*+	*+		*+	
Yellow Cr. Trib. @ RM 30.22						Δ			Δ	Δ		Δ	
Elk Fork		*				Δ			*+	*+		*+	
Elk Lick		*				Δ			*+	*+		*+	
McQueen Run		*				Δ			*+	*+		*+	
Little Yellow Creek`		*+						+	*+	*+		*+	
Bailey Run						Δ			Δ	Δ		Δ	
Alder Lick Run		*+							*+	*+		*+	
Wells Run		*				Δ			*+	*+		*+	
Jethro Run						Δ			Δ	Δ		Δ	
Carpenter Run		*				Δ			*+	*+		*+	

Other Recommendations and Future Monitoring Needs

- Improvements may be made to water quality throughout the study area by addressing the Causes and Sources of impairment located in each Assessment Unit discussion (Table 5). Most mine drainage sources of impairment identified in this report were also evaluated for remediation in: *Acid-Mine Drainage Abatement and Treatment (AMDAT) Report for the Yellow Creek Watershed, Ohio. Hughes, M.L. and Bowman, J.R. 2007*, written for Ohio DNR. Coupled with the Ohio EPA Yellow Creek TMDL (in review), these reports should be used to focus future reclamation efforts where they are most needed and practical.

- Harmful bacteria and viruses are a threat to safely participating in recreational activities such as fishing, wading, and canoeing in some areas of the Yellow Creek study area. Unfortunately, exceedences of bacteria water quality criteria are common, particularly in the headwaters of the basin and in close proximity to livestock (open access pasturage), small population centers (on-lot septic systems) and small WWTPs (Salineville). *[NOTE: Since the 2005 survey, improvements were made in plant operations at the Salineville WWTP. By April 2007, a plant inspection report found "great strides in returning the treatment plant to reliable and effective operation. The plant is operating satisfactorily." (Ohio EPA 2007, May 11 letter to Mayor of Salineville)]*

- Salineville has a drinking water intake located upstream from a low-head dam on Riley Run at RM 2.84. The impoundment is currently used (as of 2007) as a public drinking water source. However, Salineville will soon eliminate the Riley Run drinking water intake and connect to the new Buckeye Water District water supply system, projected to occur in 2009. When this action occurs, it is recommended the Riley Run low-head dam be removed. Dam removal would be predicted to have significant positive impact on the biology of Riley Run, eventually resulting in full attainment of the aquatic life use in the former dam pool. Removal should allow the upstream migration and restoration of high quality fish and macroinvertebrates communities now present downstream from the dam.

- Abandoned coal mines were a suspected source of the elevated AMD chemicals of concern in Riley Run at RM 4.80, Yellow Creek at RM 2.51, and Alder Lick Run at RM 0.1 where impaired biology was documented during the survey. However, the specific location where AMD inflow water is entering these streams has not been identified and should be a focus of future surveys. Yellow Creek RM 2.51 impairment is likely related to a problematic mine shaft portal at the mouth of the North Fork Yellow Creek (Ohio EPA 2002) but this should be field verified.

- Sampling locations with documented impact from AMD (chemical, biological, or both) as identified in Table 10 should be targeted for daily load (TMDL) modeling to determine what reductions in loadings from chemicals of concern will be needed to allow the streams to fully attain water quality standards in the future.

- Loss of coldwater conditions near the mouth of Strawcamp Run and marginal EWH performance are of concern since the tributary was among the highest quality streams in the study area. A slug of heavy metals detected at Chase Road during Aug. 15 chemical sampling and elevated bacteria levels from unidentified sources are additional concerns. Follow up sampling and reconnaissance in the lower reach should be conducted to locate potential pollution sources and discover specific reasons for lower biological quality near the mouth.

- Significant sediment organics contamination in the study area was found at one site in North Fork Yellow Creek at Hammondsville (RM 0.8) where a series of 16 polycyclic aromatic hydrocarbon (PAH) compounds were detected. The site was located immediately downstream from a large auto and scrap metal yard (A&S Salvage @ 502 CR 50A, Hammondsville OH.) located in a former clay works. Additional sediment sampling and an inspection of the property should be conducted in the future to confirm the specific source and extent of contamination.

- No completely common traits were apparent among Yellow Creek headwater streams which lacked one or more coldwater fish species aside from being warmer. Channel modification was found in streams with a mining heritage as well as the presence of increased fine sediment (sand or silt) in the bedload. In the broadest perspective, all Yellow Creek headwater streams should support coldwater fish assemblages and merit the corresponding CWH aquatic life use designation. Actions which effect stream temperature, such as planting or removing shade trees, will affect water quality.

- The Yellow Creek basin in 2005 was exceptional because habitat conditions (including woody debris, gravel bars and other natural stream channel features) were among the most unaltered anywhere in Ohio. The severe channel realignment and bank destabilization encountered in lower Yellow Creek following the physical alteration of the stream by an upstream landowner is a cautionary example of the unintended consequences of “stream improvement”. A recent survey of the Scioto Brush Creek watershed in southern Ohio found the sum total of similar “flood control projects” have eliminated critical headwater stream functions and resulted in the loss of the designated EWH use potential. Essentially, the same types of flood control projects have been occurring for a longer period in the Scioto Brush Creek basin but are beginning to increase in frequency in the Yellow Creek watershed. Yellow Creek streams will not maintain high water quality if such projects continue unabated.

METHODS

All physical, chemical, and biological field, laboratory, data processing, and data analysis methodologies and procedures adhere to those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurances Practices (Ohio Environmental Protection Agency 2006), Biological Criteria for the Protection of Aquatic Life, Volumes I-III (Ohio Environmental Protection Agency 1987a, 1987b, 1989b, 1989c), Manual of Laboratory Operating Procedures. Volumes I,II,III and IV, (Ohio Environmental Protection Agency 2002), The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application (Rankin 1989, 1995) for aquatic habitat assessment, and the Ohio EPA Sediment Sampling Guide and Methodologies (Ohio EPA 2001). Sampling locations are listed in Table 1.

Determining Use Attainment Status

Use attainment status describes 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 organism group reflects poor or very poor performance. An aquatic life use attainment table (Table 4) 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). 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. QHEI scores greater than 75 frequently typify habitat conditions with 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^oC) 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 WQS criteria, reference conditions, or published literature. Sediment evaluations were conducted using guidelines established in MacDonald *et al.* (2000) and Ohio Specific Reference Values (Ohio EPA 2003).

Recreational Use Assessment

Recreation use attainment was assessed by using fecal coliform and *E. coli* bacteria as test organisms. Their presence indicates that the water has been contaminated with feces from warm blooded animals. Counts are reported in colony forming units (CFU)/100 ml. To determine if criteria codified in OAC 3745-1-07 are met, a minimum of five samples must be collected within any 30-day period during the recreation season (May 1-October 15).

Rules for the PCR use state that the fecal coliform geometric mean shall not exceed 1000 and not more than 10% of the samples shall exceed 2000 and that the *Escherichia coli* geometric mean shall not exceed 126 and not more than 10% of the samples shall exceed 298.

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, and 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).

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).

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 SUMMARIES
(Yellow Creek Study Area: WAUs 100, 180, 190)

Chemical Sampling Results

Seventy-four sites were sampled for inorganic chemical parameters within the basin (Appendix 1 Table A-1). Most sites were sampled 4-6 times but additional samples were collected from Yellow Creek RM 5.7 to coincide with flow data available from the USGS gage at Hammondsville (Figure 9). Hazel Run, a small tributary to Upper North Fork in WAU 180, was only sampled once due to stream intermittence. Bacterial (fecal coliform and *Escherichia coli*) samples were also collected during the field season and the results are presented under *Status of Recreational Uses* on page 61. Datasonde® continuous monitors were deployed at 15 locations across the study area in late summer of 2005 and 2006 and are discussed under *Datasonde® Sampling* on page 51.

The discussion of sampling results was addressed by the eleven digit Watershed Assessment Unit or WAU (WAUs 180, 190, 100; see Figure 5). The North Fork Yellow Creek watershed in WAU 190 and Ohio River Tribs./Little Yellow Creek (WAU 100) were sampled by the Ohio EPA, Northeast District Office. Stations in the upper Yellow Creek basin (WAU 180) and remaining stations in the lower Yellow Creek basin (WAU 190) were sampled by the Southeast District Office. As a result, most sites were sampled in a slightly different time frame between Districts.

Water chemistry results that exceeded State of Ohio Water Quality Standards (WQS) for recommended aquatic life use designations are presented in Table 7. WQS violations for dissolved oxygen (D.O.) and elevated bacteria levels (see *Status of Recreational Uses* on page 61) were the most commonly encountered water quality problems.

Most D.O. violations were found in small, rural tributaries and involved slight departures from more stringent Coldwater Habitat (CWH) and Exceptional Warmwater Habitat (EWH) daily minima (Figure 8). Lower D.O. levels were likely associated with late summer low flows and may have been exacerbated by livestock and septic tank loadings. However, in most instances, the excursions did not significantly impact biological performance as attainment levels across the watershed were among the highest in the state.

Elevated fecal coliform levels were primarily associated with livestock and on-site septic systems on small tributaries or concentrations of septic tank discharges from small villages in larger drainages. High bacteria levels were also found below the Salineville WWTP on North Fork Yellow Creek, the only municipal WWTP in the study area.

Heavy metals concentrations were generally low or below detection limits throughout the study area. The few exceptions were most often encountered in streams influenced by acid mine drainage (see *Acid Mine Drainage Impairments* page 53).

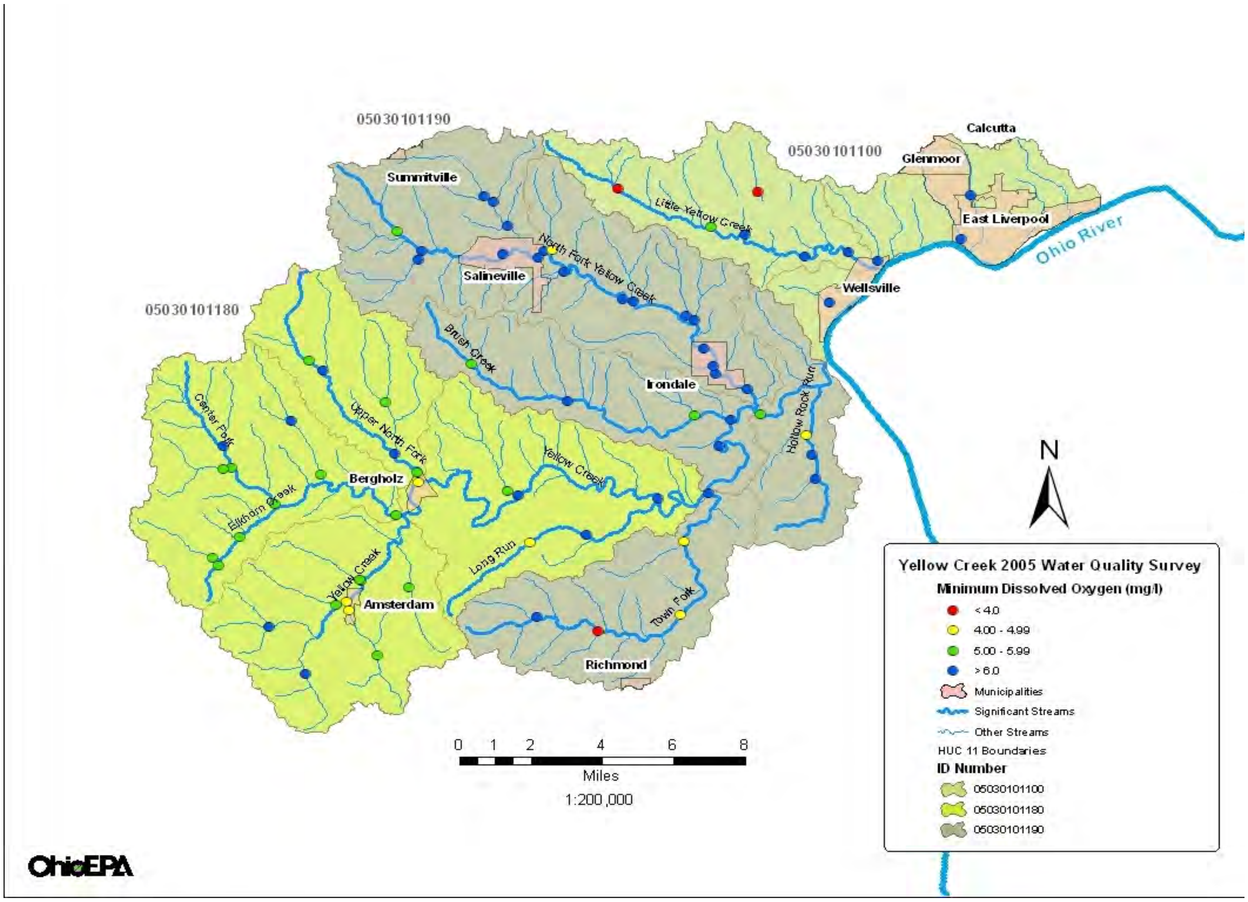


Figure 8. Ranges of minimum dissolved oxygen concentrations detected in the Yellow Creek and Little Yellow Creek basin study areas, 2005.

- Mercury and chromium values were all below detection levels.

- Nickel was only found above detection (*i.e.*, >40 ug/l) in Salisbury Run and Wells Run; both tributaries were severely impacted by acid mine drainage (AMD).

- Cadmium was at low but detectable levels in five streams scattered throughout the basin (*i.e.,* Wells Run, Salisbury Run, Wolf Run, Hollow Rock Run, and Elkhorn Creek) and most drained abandoned mine lands. However, even detectable concentrations were in line with background conditions for the WAP ecoregion (Ohio EPA, 1999).

- A WQS exceedence for copper was detected in Cox Creek near Amsterdam, immediately downstream from septic tank discharges near the mouth.

- Nine positive lead concentrations were found, ranging from just above detection (>2 ug/l) to 19.2 ug/l (a WQS violation) on Salisbury Run. Lead exceedences were also detected in Yellow Creek immediately upstream from Amsterdam and in Strawcamp Run but specific sources are unknown.

- Selenium was consistently below the 2.0 ug/l detection limit with only one positive, albeit, very low concentration at Hollow Rock Run RM 3.0 (4 ug/l). Selenium is associated with coal combustion from coal burning power plants and a fly ash disposal site, along with numerous abandoned strip mines, are located in the watershed.

Yellow Creek stream flows were measured from the USGS gaging station (RM 5.7) near Hammondsville (Figure 9). Flows were below the monthly averages through August and above average in September and October. Peak flows for the sampling period [400 cubic feet per second (cfs)] followed an isolated rain event in late August but typical summer flows were well below 100 cfs, and, at times, fell below 10 cfs. In contrast, September 2004 saw the highest average monthly flow (795 cfs) for the period of record (November 1940-September 1978). Channel relocation and severe bank erosion was observed in the mainstem near the confluence with the North Fork Yellow Creek (RM 3.4) following the high flow event.

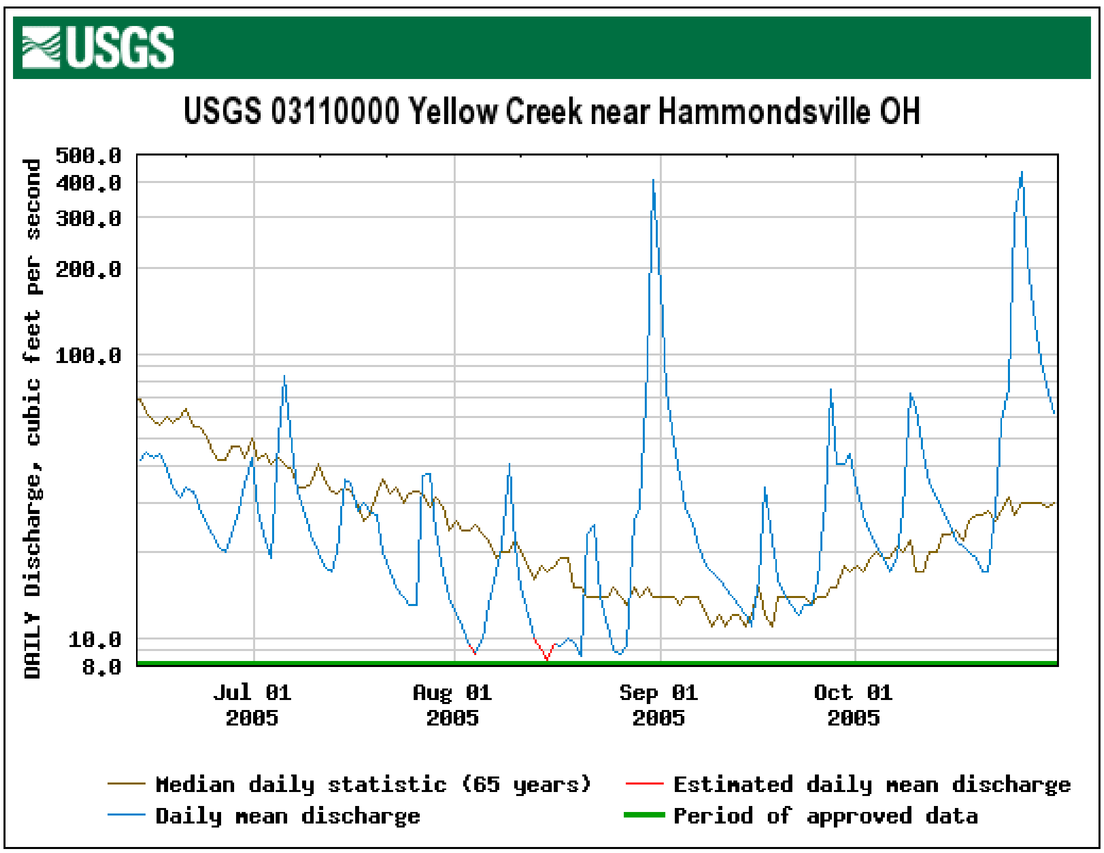


Figure 9. Daily mean flow discharges measured at the USGS Yellow Creek gage near Hammondsville (RM 5.7), June through October, 2005.

Upper Yellow Creek basin (WAU 180)
The most common water quality problems in the upper basin were associated with elevated bacteria levels (see *Status of Recreational Uses* on page 61) and departures from more stringent dissolved oxygen standards for the CWH and EWH aquatic life use designations (Table 7). Dissolved oxygen failed to meet required levels for the recommended use in nine of thirty sites on at least one occasion. Flow conditions were generally low during the sampling period, and may have contributed to lower DO levels. Organic wastes from livestock and septic tanks may have also been a factor since six of the eleven sites with D.O violations were also considered in non-attainment of the recreational use.

Other water quality standards (WQS) exceedences were noted for copper and ammonia in Cox Creek, iron and lead at the upper-most site on Strawcamp Run, and lead at the uppermost Yellow Creek site. In Cox Creek, septic tank discharges immediately upstream from the sampling site were the probable sources. The Strawcamp Run watershed is rural and heavily forested and there was no known source of metals that would account for the contamination. The upper reaches of Yellow Creek receive septic tank drainage and urban runoff from Amsterdam and nonpoint runoff from concentrated livestock operations in Elk Lick.

Lower Yellow Creek basin (WAU 190)
Excluding the North Fork Yellow Creek basin, chemical grab water samples were collected from fifteen sampling locations within the Lower Yellow Creek WAU, four to six times between July and October, 2005 (SEDO survey area). Excepting D.O., no chemical WQS exceedences were detected in this section of the watershed. Dissolved oxygen levels were noted to be lower than required in approximately one-third of the sites on at least one or more sampling events (Table 7).

In the North Fork basin, chemical grab water samples were collected from nineteen sampling locations on four occasions from June 23 to August 11, 2005 (NEDO survey area). Samples were collected from six major tributary streams and along the mainstem of the North Fork Yellow Creek. Chemical WQS exceedences in the basin were rare and limited almost entirely to pH and mine drainage related parameters at the mouth of Salisbury Run, a small tributary severely degraded by mine seepage.

Little Yellow Creek/Ohio River Tributaries (WAU 100)
Chemical grab water samples and bacteria samples were collected from ten locations within the WAU on six major tributary streams and the mainstem of Little Yellow Creek. Chemical samples were collected four times from June 14 to August 25, 2005. Seven additional samples were collected at Little Yellow Creek RM 1.1 (Hibbits-Mill Rd.) from June 14 to December 28, 2005 under different flow conditions. These “sentinel site” data were collected to support potential model development for the Total Maximum Daily Load (TMDL) process.

WQS exceedences in WAU 100 were limited to low dissolved oxygen levels in the Highlandtown Lake affected section of upper Little Yellow Creek and wetland influences in upper Bailey Run. Chemical impairment from AMD was noted in Wells Run (pH and iron), and Alder Lick Run (TDS).

Table 7. Chemical exceedences from the Yellow Creek study areas (WAUs 180, 190, 100) based on Ohio WQS criteria. Criteria include outside mixing zone minimum or maximum (OMZM) and average (OMZA) values. Units are mg/l for dissolved oxygen (DO); standard units (SU) for pH; and ug/l for metals. Use designations, in parentheses, are those recommended. Bacteria (fecal coliform and E.coli) numbers are provided in Table 14.

Stream name River Mile	Aquatic Life Use designation (recommended) Parameter (value)	
	Upper Yellow Creek basin WAU -180	
Yellow Creek	(WWH)	
30.0	Lead (14.8)*	
Yellow Creek Trib. @ RM 30.22 (CWH)		
0.1	D.O. (5.84) ◊◊◊	
Goose Creek	(CWH)	
1.9	D.O. (5.99) ◊◊◊	
0.3	D.O. (4.89) ◊◊◊	
Cox Creek	(WWH)	
0.1	Copper (33) ‡, Ammonia (9.69)*	
Wolf Run	(CWH)	
1.5	D.O. (5.64) ◊◊◊	
Elkhorn Creek (CWH-EWH)		
7.9	D.O. (5.99) ◊◊◊	(Note: meets EWH, not CWH)
6.8	D.O. (5.98) ◊◊◊	(Note: meets EWH, not CWH)
Trail Run	(CWH-EWH)	
0.3	D.O. (5.57) ◊◊◊	(Note: meets EWH, not CWH)
Strawcamp Run [CWH-EWH (Hdwaters to Chase Rd/RM 1.2); Water Supply Use: AWS]		
1.2	Lead (7.2)**, Iron (9520)▲	
Upper North Fork (CWH-EWH)		
0.3	D.O. (5.51) ◊◊◊	(Note: meets EWH, not CWH)
Carroll Run	(CWH)	
0.1	D.O. (5.98; 5.92) ◊◊◊	
	Lower Yellow Creek basin WAU -190	
Town Fork	(EWH)	
8.0	D.O. (3.24) ◊◊	

Table 7. (continued)

Stream name River Mile	Aquatic Life Use designation (recommended) Parameter (value)	
Town Fork (continued)		
5.2	D.O. (4.41) ◊◊	
Keyhole Run	(CWH-EWH)	
0.1	D.O. (5.23; 4.67) ◊◊◊	(Note: 5.23 meets EWH, not CWH)
Brush Creek	(CWH-EWH)	
6.1	D.O. (5.93) ◊◊◊ `	(Note: meets EWH, not CWH)
0.1	D.O. (5.28) ◊◊◊	(Note: meets EWH, not CWH)
Dennis Run	(CWH-EWH)	
0.1	D.O. (5.84) ◊◊◊	(Note: meets EWH, not CWH)
North Fork Yellow Creek Tributary @ RM 9.96 (CWH)		
0.4	D.O. (4.48; 4.85) ◊◊◊	
Randolph Run	(LRW)	
0.2	pH (6.33) ♦	
Salisbury Run	(CWH; Water Supply Use: AWS)	
0.1	pH (5.32; 3.71) ♦, Iron (21100; 16400; 43500; 40200) ▲, Zinc (524) ** Lead (19.2)*	
Tarburner Run	(CWH)	
0.1	D.O. (4.6) ◊◊◊	
	<u>Little Yellow Creek / Ohio River Tributaries WAU -100</u>	
Little Yellow Creek (WWH)		
11.1	D.O. (3.27; 2.33) ◊	
Bailey Run	(CWH, AWS)	
1.4	D.O. (2.41; 3.25; 3.4; 1.60) ◊◊◊	
Alder Lick Run	(WWH)	
0.1	TDS (1570; 2050)**	
Wells Run	(CWH; Water Supply Use: AWS)	
0.2	pH (4.6) ♦; pH (43 Datasonde® measurements: 4.04 min. - 5.11 max.) ♦ Iron (6810; 10,800; 13,000; 13,300)▲	

* Aquatic life outside mixing zone average (OMZA) (this is actually not a 30 day avg., but is based on a single value)
** Aquatic life outside mixing zone maximum (OMZM)
‡ Aquatic life inside mixing zone average (IMZA) (this in actually not a 30 day avg., but is based on a single value)
▲ Protection of agricultural uses (OMZA)
♦ Outside WQS criteria of pH=6.5-9.0
◊ Less than minimum WWH criteria for dissolved oxygen (OMZM not less than 4.0 mg/l)
◊◊ Less than minimum EWH criterion for dissolved oxygen (OMZM not less than 5.0 mg/l)
◊◊◊ Less than minimum CWH criterion for dissolved oxygen (OMZM not less than 6.0 mg/l)
CWH=Coldwater Habitat, EWH=Exceptional Warmwater Habitat, AWS- Agricultural Water Supply

Datasonde® Sampling

Continuous monitoring Datasonde® recorders were deployed from September 20-22, 2005 at four locations along the length of North Fork Yellow Creek, beginning downstream from the Salineville WWTP at RM 10.1, and extending downstream at RMs 6.2, 2.2 (downstream Salisbury Run), and 0.8 (downstream Irondale; Table 8). Eleven additional sites were evaluated in September 2006, in the North Fork Yellow Creek basin, (Salisbury Run, Salt Run, Trib. to Riley Run), Town Fork downstream Jefferson Lake, the Little Yellow Creek basin (Little Yellow Creek, Alder Lick Run, Bailey Run) and in Wells Run, a small direct Ohio River tributary impacted by acid mine drainage (Table 8). Hourly measurements were recorded for dissolved oxygen, pH, specific conductivity and water temperature over a 2-3 day sample period from September 6-8, 2006.

Evidence of severe effect from acid mine drainage was recorded at the Wells Run location; pH reached a minimum of 4.04 and an average of 4.33 over the 50 hour sample period; dissolved oxygen averaged 2.70 mg/l. Conductivity was elevated at the mouth of Alder Lick Run (average = 1,490 umhos/cm; 54 hour sample period), also an indication of historic mine activity in the watershed. These data are similar to measurements recorded from grab samples during the 2005 survey. Datasonde® measurements at the remaining sampling locations did not indicate violations of chemical WQS criteria.

Table 8. Datasonde® deployment locations in the Yellow Creek basin during 2005 and 2006. The table represents the minimum, maximum, and average values collected over varying time frames (10-45 hours). Units for values expressed in the table are as follows: dissolved oxygen (mg/l); pH (S.U.); temperature (°C); and conductivity (uS/cm).

Station	**Dissolved Oxygen**	**pH**	**Temperature**	**Conductivity**
Lower Yellow Creek basin (WAU190)				
North Fork Yellow Creek at RM 10.1 (9/20/05)				
Minimum	7.03	7.41	14.82	0.62
Maximum	10.96	7.91	20.42	0.68
Average	8.02	7.53	17.60	0.644
North Fork Yellow Creek adjacent T-879 @ RM 6.2 (9/20/05)				
Minimum	6.62	7.23	16.32	0.58
Maximum	9.54	7.61	21.10	0.61
Average	7.66	7.34	18.85	0.598
North Fork Yellow Creek at T-299 in Irondale @ RM 2.2 (9/20/05)				
Minimum	7.01	7.51	16.77	0.54
Maximum	9.00	7.89	23.37	0.55
Average	7.70	7.66	19.70	0.549
North Fork Yellow Creek at RM 0.8 dst. Irondale (9/20/05)				
Minimum	7.50	7.76	16.57	0.57

Station	Dissolved Oxygen	pH	Temperature	Conductivity
Maximum	11.00	8.46	23.44	0.58
Average	8.60	7.96	19.57	0.578
Unnamed trib. to Riley Run @ Avon Rd. @ RM 0.3 (9/6/06)				
Minimum	6.26	7.54	14.16	0.27
Maximum	8.76	8.22	19.98	0.30
Average	7.57	7.74	16.78	0.285
Salt Run just west of Irondale @ RM 0.4 (9/6/06)				
Minimum	8.07	7.36	14.33	0.17
Maximum	9.01	7.57	18.94	0.18
Average	8.58	7.44	16.14	0.178
Salt Run ust. Jackson Street @ RM 0.2 (9/6/06)				
Minimum	8.22	7.41	14.74	0.19
Maximum	9.09	7.57	17.14	0.21
Average	8.68	7.49	16.09	0.201
Salisbury Run at T-776, near the mouth @ RM 0.1 (9/6/06)				
Minimum	7.98	7.83	14.71	0.24
Maximum	8.17	7.86	16.90	0.24
Average	8.06	7.84	15.85	0.24
Town Fork dst. Jefferson Lake @ RM 8.1 (9/6/06)				
Minimum	7.85	7.94	20.23	0.61
Maximum	9.32	8.17	25.45	0.62
Average	8.57	8.05	22.18	0.611
Little Yellow Creek/Ohio River tribs (WAU100)				
Little Yellow Creek ust. McCormick Run Rd. @ RM 6.7 (9/6/06)				
Minimum	4.55	7.06	17.55	0.30
Maximum	8.84	7.41	21.84	0.32
Average	5.93	7.18	19.06	0.31
Bailey Run at Osbourne Rd. @ 1.45 (9/6/06)				
Minimum	5.42	6.68	16.26	0.29
Maximum	7.52	6.78	23.37	0.30
Average	6.38	6.72	18.92	0.292
Alder Lick Run adj. Fife Coal Rd, near mouth @ RM 0.1 (9/6/06)				
Minimum	8.09	7.96	15.27	1.40
Maximum	8.88	8.00	18.87	1.49
Average	8.48	7.98	17.01	1.454
Wells Run ust. SR 7 @ RM 0.05 (9/6/06)				
Minimum	Data rejected	4.04*	15.14	0.88
Maximum	Data rejected	4.66*	17.76	0.95
Average	Data rejected	4.27*	16.23	0.915
*Outside WQS criteria of 6.5-9.0				

Acid Mine Drainage Impairments

Water quality impacts associated with acid mine drainage (AMD) affected a number of streams within the Yellow Creek survey area. Acid mine drainage is the outflow or runoff of mostly acidic water from underground mines, surface mines, or mine wastes and is usually associated with abandoned mine lands (AML). If severe, AMD can have a devastating effect upon the aquatic life of a stream or river. Two types of impacts on water quality were used to help identify the presence of AMD for the survey:

(1) visual discoloration of stream sediments with the yellow-orange ferric-iron hydroxide known colloquially as "yellow boy" to such a magnitude that it violated Water Quality Standards (Section 3745-1-04 of OAC), where it is stated that waters of the state "*shall be free from materials entering the waters as a result of human activity producing color, odor or other conditions in such a degree as to create a nuisance*"; and

(2) stream locations showing less than full attainment of biological criteria (Partial or Non) that also had concentrations of AMD chemicals of concern (*i.e.*, pH, sulfate, iron, manganese, or conductivity) at levels reported to have moderate to severe negative impact on surface water quality, or where two or more AMD chemicals of concern were at levels reported to have minimal impact (Table 9).

Table 9. Associations between select mine drainage chemical parameters and the degree of impact on surface water quality. Source: U.S. Department of Agriculture, Soil Conservation Service, undated; *Assessment and treatment of areas in Ohio impacted by abandoned mines*.

	No Mining Impact *	Minimal Impact	Moderate Impact	Severe Impact
pH (s.u.)	6.5 – 9.0 #	5.5 – 6.4	4.5 – 5.4	< 4.5
Total Fe (mg/l)	< 1.0	1.1 – 5.0	5.1 – 10.0	> 10.0
Total Mn (mg/l)	< 0.05	0.06 – 2.0	2.1 – 4.0	> 4.0
Sulfate (mg/l)	< 250	251 – 600	601 – 960	> 961
Sp. Conductance (umhos/cm)	< 685	686 – 900	901 – 1200	>1200

* The document wording is: *No detectable mine drainage impact*.
\# Statewide water quality criteria never to be violated (OAC 3745-1-07-).

Those streams judged to be AMD impacted within the Yellow Creek study area due to visual discoloration of water and/or bottom sediments with yellow-boy were:

Salisbury Run at Township Rd. 776	(RM 0.10)
Wells Run upstream SR 7/39	(RM 0.20)
Wolf Run at Co. Rd. 75/Wolf Run Rd.	(RM 1.50)
Riley Run Trib. @ RM 3.75 at mouth	(RM 0.01)
North Fork Yellow Creek @ mouth	(RM 0.01)
Yellow Creek dst. North Fork Yellow Cr	(RM 3.30)

Other areas of the basin with obvious visual AMD discharges included a series of seeps to Yellow Creek between RMs 12.0 and 12.83 (Figure 10) and a large seep to the North Fork Yellow Creek near Irondale (Figure 11).

Two stream locations that showed less severe yellow-boy discoloration, but still created a visual nuisance, were Wolf Run at RM 1.5 and the mouth of the Riley Run Trib. @ RM 3.75. In Wolf Run, an Abandoned Mine Land (AML) reclamation project near RM 3.0 (*i.e.*, the Route 43 Washer) was conducted between 1982 and 1985 at an estimated cost of $1,035,432.90 (ODNR 2008a, Ohio EPA 1985). The reclamation was primarily to prevent erosion and sedimentation but AMD improvements would have been an unforeseen bonus. The lower reaches of Wolf Run and sections of upper Yellow Creek have undergone significant far-field improvement as a result of the reclamation, coupled with natural recovery. However, a culverted source of AMD continues to discharge from the project that may be from a deep mine piped through the work area (ODNR 2008b, Hughes and Bowman 2007). This is a residual problem that could be addressed in a future Yellow Creek reclamation project (ODNR 2008b).

Streams judged to be AMD impacted due to the association of impaired biological communities and elevated levels of AMD chemicals of concern are found in Table 10. Based on Ohio EPA sampling, Salisbury Run at RM 0.1 and Wells Run at RM 0.2 showed the most severe impact on biology and also had severe visual discoloration of bottom sediments with ferric iron hydroxide. Parts of upper Wolf Run also remain severely impacted by AMD (see below) but biological recovery was nearly complete at the Ohio EPA sampling site downstream.

The suspected source of the AMD at the Riley Run 3.75 Trib. is an abandoned mine. However, the mining influence was limited to the lower 0.2-0.3 river miles and did not affect biological communities upstream at RM 0.3. The AMD conditions in the lower reach of the Riley Run tributary appeared aggravated by low flow conditions and a diversion of flow. Macroinvertebrate field crew observations on July 26 found most flow was diverted through a culvert at RM 0.3 and into the small lake immediately north of Avon Road. The stream was clear upstream from the diversion but the stream bottom was stained bright orange in the downstream reach. A similar phenomenon was observed at the mouth of the North Fork Yellow Creek where the stream bottom was stained bright orange under late summer, interstitial low flow conditions. The site was located near an abandoned mine portal that discharged AMD to the mouth of the North Fork in the past (see below).

Abandoned coal mines are also a suspected source of biological impairment and elevated AMD chemicals of concern in Riley Run at RM 4.80, Yellow Creek at RM 3.3 (chemical sampling at RM 2.51), and Alder Lick Run at RM 0.1. In addition, marginal attainment of the recommended EWH use was observed at Yellow Creek RM 11.8, just downstream from the series of mine seeps between RMs 12.0 and 12.83 (Figure 10).

At Yellow Creek RM 3.3, impairment is likely related to a problematic mine shaft portal near the mouth of the North Fork Yellow Creek (Ohio EPA 2003, Hughes and Bowman 2007) but this should be field verified. Additional AMD sources in the North Fork Yellow Creek watershed included Salisbury Run (confluence RM 3.98) and a large mine drainage seep on the southern edge of Irondale near RM 1.8 (Figure 11).

It is recommended that sampling locations with documented impact from AMD (chemical, biological, or both) and identified in Table 10 should be targeted for daily load (TMDL) modeling to determine what reductions in chemical loadings are needed to fully attain water quality standards. Excepting Alder Lick Run and Wells Run (Little Yellow Creek/Ohio River Tribs. assessment unit), most of these AMD inflow sources are also identified in the Yellow Creek AMDAT Report and should be considered for future reclamation activity.

Figure 10. A mine seep discharging to Yellow Creek upstream from Long Run near RM 12.0.

Table 10. Streams in the Yellow Creek basin with documented biological impairment due to suspected acid mine drainage (AMD) chemicals of concern. Note: although not listed, severe AMD impacts remain in upper **Wolf Run** but biological impairment was not detected approximately 1.5 miles downstream.

Stream	River Mile	Location	pH (su)	Fe (µg/l)	Mn (µg/l)	SO4 (mg/l)	Spec. Cond. (µmhos/cm)	IBI	ICI	Attainment Status
Salisbury Run	0.10	T-776						12	VP	NON-CWH
geometric mean			*5.7*	<u>41817</u>	*1937*	*561*	<u>1215</u>			
median (50% percentile)			*6.2*	<u>41850</u>	*1970*	*567*	<u>1225</u>			
75% percentile			7.2	<u>42675</u>	**2150**	**607**	<u>1305</u>			
maximum			7.3	<u>43500</u>	**2330**	**648**	<u>1380</u>			
minimum			<u>3.7</u>	<u>16400</u>	*648*	*253*	565			
Wells Run	0.20	Ust. SR 7						12	P	NON-CWH
geometric mean			*6.2*	<u>10619</u>	*1538*	*326*	*732*			
median (50% percentile)			6.7	<u>11900</u>	*1630*	*339*	*745*			
75% percentile			6.9	<u>13075</u>	*1977*	*381*	*847*			
maximum			7.0	<u>13300</u>	**2660**	*490*	**1090**			
minimum			**4.6**	**6810**	*796*	199	476			
Alder Lick Run	0.10	Fife Coal Rd.						40	F	Part.-WWH
geometric mean			7.7	496	*449*	**826**	<u>1620</u>			
median (50% percentile)			7.1	496	*405*	**896**	<u>1695</u>			
75% percentile			7.8	613	*621*	<u>1011</u>	<u>1857</u>			
maximum			7.9	817	*943*	<u>1140</u>	<u>2180</u>			
minimum			7.5	304	*284*	*512*	**1100**			
Riley Run	4.80	April Rd.						42	P	NON-WWH
geometric mean			7.4	398	*803*	*366*	**949**			
median (50% percentile)			7.4	500	*1340*	*364*	**976**			
75% percentile			7.5	599	*1375*	*390*	**998**			
maximum			7.5	698	*1410*	*428*	**1020**			
minimum			7.3	181	*182*	132	450			
Yellow Creek	2.51	S.R. 213						44	24	Part.-WWH
geometric mean			7.8	*1677*	*143*	133	482			
median (50% percentile)			7.8	*1880*	*159*	146	541			
75% percentile			8.0	*2120*	*178*	154	557			
maximum			8.2	*2280*	*238*	162	573			
minimum			7.6	712	*81*	73	264			

AMD Impact Key:
= None
= Minimal (*green-italics*)
= Moderate (red-**bold**)
<u>#####</u> = Severe (red-<u>underline</u>)

Figure 11. Another mine seep discharging to the North Fork Yellow Creek near Irondale at approximately RM 1.8, 2005.

Sediment Quality

Sediments were analyzed from 11 regional reference sites throughout the Yellow Creek watershed and one long term monitoring site (*i.e*., sentinel site) near the mouth of Little Yellow Creek. 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. 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). Specific chemical parameters tested and results are available by contacting the Ohio EPA Southeast District Office (see Appendix 3 and 4).

Sample analysis indicated all sediment metals were within normal ranges for Ohio streams in the WAP ecoregion (Table 11). The concentration of chromium (53 mg/kg) at one site in Trail Run equaled but did not exceed the Sediment Reference Value. Since sediment metals sampling was largely restricted to regional reference sites, sediments were not evaluated at degraded sites and biological impairments were attributed to other factors. Still, sampling locations with obvious or severe chemical impacts (e.g., acid mine drainage streams) likely experienced significant metals contamination.

Most sediment organic compounds were below detection limits but those found above detection were at levels of concern (Table 12). The most significant contamination was in the North Fork Yellow Creek at Hammondsville (RM 0.8) where a series of 16 polycyclic aromatic hydrocarbon (PAH) compounds were detected. All the compounds were above the probable effect concentration (PEC), indicating levels likely to impact biological communities. PAHs are by-products of incomplete combustion of carbon-containing fuels, such as wood, coal, and diesel fuel. These compounds are also found in tar and build up on road surfaces in urban areas. In addition to potential urban runoff sources upstream, station RM 0.8 was located immediately downstream from a large auto and scrap metal yard (A&S Salvage @ 502 CR 50A, Hammondsville OH) located in a former clay works on river left. Additional sediment sampling and an inspection of the property should be conducted in the future to confirm the specific source and extent of contamination.

At remaining study area sites, two PAH compounds were detected in low concentrations from the North Fork Yellow Creek RM 6.2 (2-methylnaphthalene = 0.71 mg/kg) and the upper Yellow Creek mainstem near Bergholz at RM 27.6 (fluoranthene = 0.71 mg/kg). Both concentrations were above the threshold effect concentration (TEC) but well below the PEC. No other organic compounds were identified in the study area. A copy of the raw sediment organic data can be obtained by contacting Joann Montgomery at the Ohio EPA Southeast District Office: Joann.Montgomery@epa.state.oh.us.

Biologically, all sediment sites were in full attainment, with the exception of Little Yellow Creek RM 1.1 and the North Fork Yellow Creek Trib. @ RM 6.08. Late summer interstitial flow in the RM 6.08 Tributary was considered the primary factor in attainment rather than sediment quality. Partial attainment in Little Yellow Creek was attributed to flow alteration associated with impoundments and was also considered unrelated to sediment quality.

Fish and macroinvertebrates from the North Fork Yellow Creek at Hammondsville (RM 0.7) met WWH criteria but declined in quality compared to stations further upstream (Table 4). In addition to mine drainage and septic tank discharges upstream, declines may be related to the significant PAH contamination documented immediately upstream. No oil sheens were noted at RM 0.7, but field observations described unhealthy deposits of black muck or solids and extensive blue green algal mats in pools and margins. The former Regional Reference designation for this site has since been removed.

In summary, 2005 data indicates background sediment quality was rarely a significant or widespread stressor on biological quality in the Yellow Creek study area. Outside of obvious areas of impairment (e.g., acid mine drainage) and the PAH contamination discovered near Hammondsville, sediments do not appear to be an issue that warrants further studies.

Table 11. Metal concentrations (mg/kg) in sediment collected from regional reference sites and sentinel sites in the Yellow Creek 2005 study area. All values were below either the statewide (lead and mercury) or Western Allegheny Plateau (WAP) ecoregion sediment reference value (SRV). Values reported as “<” were below the quantification limit.

Stream	Sediment Concentration (mg/kg dry weight)								
RM	As	Cu	Cd	Cr	Fe	Pb	Ni	Zn	Hg
SRV	19	33	0.80	53	51,000	47	61	170	0.120
Upper Yellow Creek Basin (WAU180)									
Yellow Creek									
27.6	10.4	12.5	0.278	31	26,600	<23	27	86	0.036
5.7	11.6	10.2	0.290	31	31,500	<28	32	87.9	<0.032
Elkhorn Creek									
6.8	12.6	9.7	0.336	37	39,500	<28	33	98.1	0.045
0.2	8.6	7.1	0.186	24	21,900	<21	21	61.4	<0.027
Center Fork									
0.1	12.1	10.7	0.299	35	32,100	<32	<32	146	<0.0340
Trail Run									
0.3	16.7	14.9	0.290	53	39,900	<34	38	108	0.039
Strawcamp Run									
0.1	7.83	<6.2	0.186	22	25,100	<25	<25	59.9	<0.031
Lower Yellow Creek Basin (WAU190)									
North Fork Yellow Creek									
6.2	12.1	16.7	0.266	23	36,700	<19	33	99.8	0.039
0.8	11.1	23.7	0.444	31	33,200	29	34	126	0.073
Nancy Run									
1.0	11.4	15.3	0.224	29	36,900	<21	25	71.5	<0.021
Unnamed trib. to North Fork Yellow Creek at RM 6.08									
0.1	16.4	13.6	0.300	31	42,800	19	30	80	<0.027
Little Yellow Creek Basin (WAU100)									
Little Yellow Creek									
1.1	11.4	15.5	0.313	31	45,900	31	40	114	<0.022

Table 12. Organic chemical concentrations (mg/kg) in sediments from regional reference and sentinel sites in the Yellow Creek study area, 2005. Parameters analyzed included BNAs (base neutral acids), VOCs (volatile organic compounds), pesticides, and polychlorinated biphenyls (PCBs). All values were below detection limits (<DL) unless indicated.

Sample Site	*Yellow Cr. @ CR 75*	*Yellow Ck. @ gage*	*Elkhorn Cr. @ SR 43*	*Elkhorn Cr. Ust. SR 164*	*Strawcamp Run @ Bay Rd.*	*Center Fork @ Carry Rd.*	*Trail Run @ Bay Rd.*	*Little Yellow Creek*
River Mile Parameter[c]	27.6	5.7	6.8	0.8	0.1	0.1	0.3	1.1
BNA's	Fluoranthene (0.71)[a] all others <DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
VOC's	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
Pesticides	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
PCB's	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL

Sample Site	*North Fork Yellow Creek*	*North Fork Yellow Cr. @ Main St.*	*Nancy Run @ Foundry Mill Rd.*	*North Fork Y. Cr. Trib.@ RM 6.08*
River Mile Parameter[c]	RM 6.2	RM 0.8	RM 1.0	0.1
BNA's	2-Methylnaphthalene (0.71)[a] all others <DL	2-Methylnapthalene (2.06)[b] Naphthalene (5.03)[b] Phenanthrene (7.41)[b] Pyrene (5.21)[b] Acenaphthene (1.37)[b] Anthracene (1.74)[b] Benz[a]anthracene (2.94)[b] Benzo[a]pyrene (2.71)[b] Benzo[b]fluoranthene (2.36)[b] Benzo[g,h,i]perylene (1.46)[b] Benzo[k]fluoranthene (2.07)[b] Chrysene (2.72)[b] Dibenzofuran (1.51)[b] Fluoranthene (6.9)[b] Fluorene (1.54)[b] Indeno[1,2,3-cd]pyrene (1.88)[b] all others <DL	<DL	<DL
VOC's	<DL	<DL	<DL	<DL
Pesticides	<DL	<DL	<DL	<DL
PCB's	<DL	<DL	<DL	<DL

[a] Above TEC, but below PEC.
[b] Above PEC.
[c] Sample analysis employed Method No. 8270 (BNAs), 8260B (VOC's), and 8082A (Pesticides and PCB's).

Status of Recreational Uses

Water quality criteria for determining whether rivers and streams are suitable for recreational uses are established in the Ohio Water Quality Standards (Table 7-13 in OAC 3745-1-07) 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 of human and animal wastes, or may enter water bodies along with runoff from soils where these wastes have been deposited. There is currently no simple way to differentiate between human and animal sources of fecal bacteria in surface waters.

Pathogenic (disease causing) organisms are typically present in the environment in such small amounts that it is impractical to monitor them directly. Although some strains of *E. coli* can be toxic, causing serious illness, fecal coliform bacteria, including *E. coli*, by themselves are usually not pathogenic. Fecal coliform and *E. coli* bacteria groups are instead 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 recreational-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.

In flowing water habitats there is a strong positive association between numbers of *E. coli* and fecal coliform that are present in the same sample of water. Milligan (1987, Lake and Reservoir Management, Vol III, pp 163-171) reported a statistically significant correlation coefficient between fecal coliform and *E. coli* from samples collected in Bear Creek, Florida (r = 0.91, N=327, p <0.01). The pooled data for this Yellow Creek, Ohio survey give similar results (r = 0.73, N=255, p <0.01). Thus, a high level of one bacteria indicator group in a stream indicates the other indicator group will also be elevated.

Designations of recreational uses for water bodies in the Yellow Creek study area are listed in OAC Rule 3745-1-13, Table 13-1. All listed water bodies in the Yellow Creek basin 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)]. These designations were assigned based either on data available from the original 1978 Water Quality Standards, or the results of a subsequent field assessment. No waters within the Yellow Creek basin are designated for Secondary Contact Recreation (SCR), even those headwater streams with drainage areas less than 20 mi^2. Secondary Contact Recreation (SCR) means

"…waters that, during the recreation season, are suitable for partial body contact recreation such as…wading with minimal threat to public health…"

The bacteria data collected for the 2005 Yellow Creek survey were evaluated against the PCR criteria, including those streams undesignated in OAC 3745-1-13. The rationale for this approach is that, in all cases, the drainage areas of the undesignated streams were similar to the drainage areas of headwater streams currently protected for PCR, and thus should offer the same potential for full-body contact. Even 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 13. Bacteriological results from environmental samples are reported as colony forming units (cfu) per 100 ml of water.

Table 13. Primary Contact Recreational Use Water Quality Criteria applicable to the Yellow Creek 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.

Primary Contact
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 Yellow Creek survey, all data collected during the recreational season (May 1 through October 15) 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 (either full or non-attainment of the language in OAC 3745-1-07, Table 7-13). The wording in OAC 3745-1-07, Table 7-13 indicates that, if either of the two indicator groups (fecal coliform or *E. coli*) is in attainment of both of its criteria numbers, then the water body is in full attainment of the PCR use with minimal threat to human health from full-body contact. Consequently, when both fecal coliform and *E. coli* data are available from a sample, both sets of data should be used to determine attainment status of the recreational use because one group may exceed tabled criteria while the other does not.

In the event that either fecal coliform or *E. coli* was below the geometric mean and 90^{th} percentile criteria, but the other indicator group exceeded either criterion, a FULL-Attainment-Target status was assigned (see Table 14). Although these situations fully attain the PCR use, they were targeted for future sampling because at least one indicator groups did not fully meet all applicable criteria.

Where five samples are collected within a thirty-day period these data can be applied directly to the applicable PRC criteria. However, because fewer than five bacteria samples were collected at the majority of sampling locations during the Yellow Creek survey, all samples collected at each location during the recreation season were pooled for statistical analysis. Two statistics were calculated from these pooled data, the geometric mean and the 90th percentile. The calculated 90th percentile value was evaluated against the “not to exceed” 10% criteria in OAC 3745-1-07, Table 7-13 for each indicator group.

The colony forming units (cfu) per 100 ml of water for fecal coliform and *E. coli* bacteria collected at each sample location during the Yellow Creek Survey are located in Appendix 2. A summary of fecal coliform bacteria counts (geometric mean) in the study area is displayed in Figure 12. Evaluation of attainment status, and identification of suspected sources, where elevated levels of bacteria were recorded, is given in Table 14. The discussion below is summarized by watershed assessment unit (WAU).

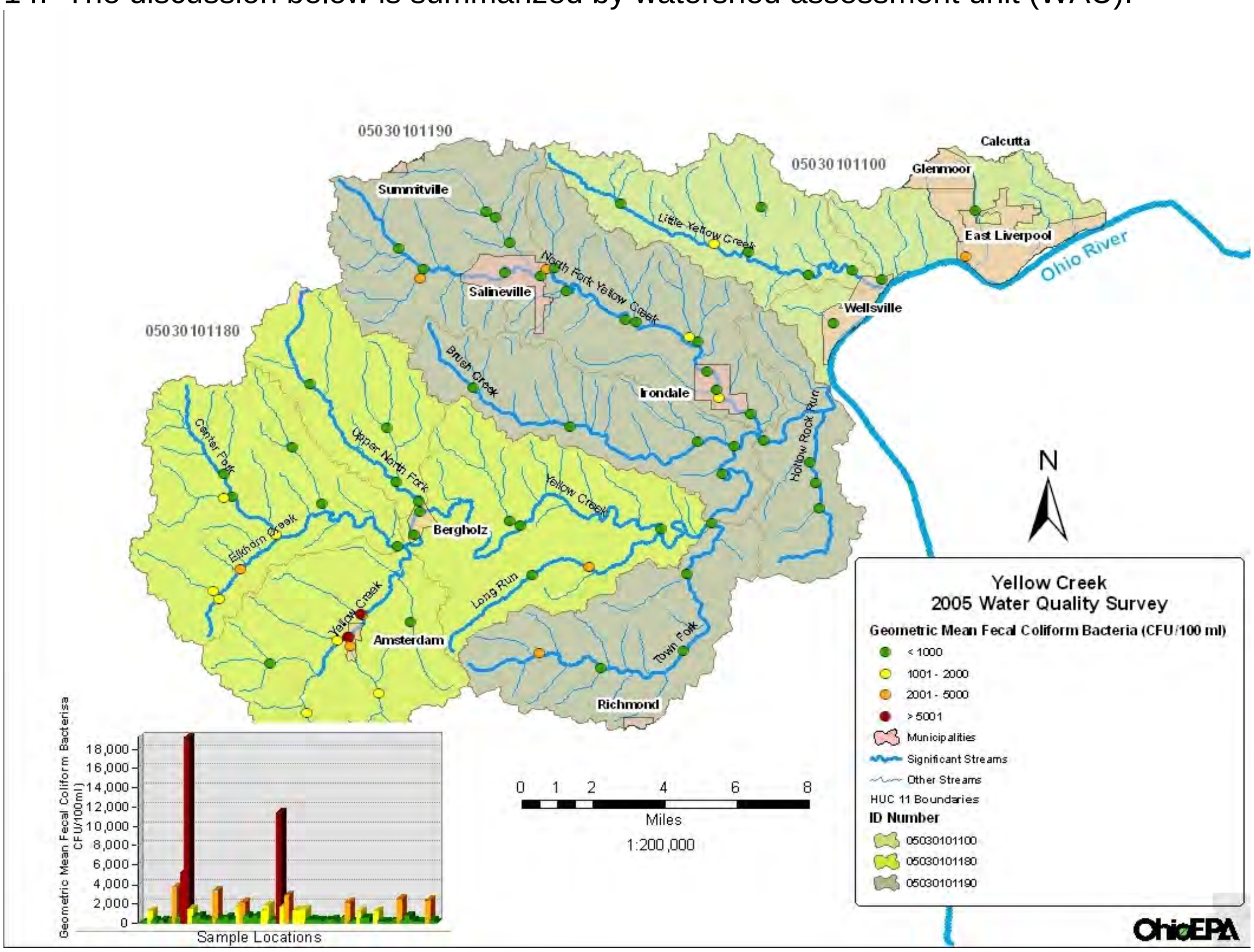


Figure 12. Summary of fecal coliform bacteria counts (geometric mean) in the Yellow Creek and Ohio River Tribs./Little Yellow Creek study area, 2005.

Recreation use status was also determined for each of three watershed assessment units aligned with the 11 digit hydrologic unit (Table 15). Results from the 2005 survey and a discussion of the test method are summarized in the *Ohio 2008 Integrated Water Quality Monitoring and Assessment Report*. Data that were pooled for statistical analysis included samples from the survey collected during the May 1-October 15 recreation season and other data sources available over the last five years. The recreation use was considered impaired if either the 75th percentile exceeded 1,000 or the 90th percentile exceeded 2,000. Both the upper Yellow Creek (WAU 180) and lower Yellow Creek (WAU 190) assessment units were considered impaired at the watershed scale, with highest levels of contamination in the upper basin. Septic tank drainage and livestock were considered the primary sources of contamination.

Table 14. Bacteriological sampling results from the Yellow Creek and Little Yellow Creek/Ohio River Tributaries study area, 2005.

Stream Name	**RM**	**Location**	**# Samples**	**GeoMean**		**90th %**		**Attainment**	**Potential**
			FecalColi /E coli	**Fecal Coli**	***E. coil***	**Fecal Coli**	***E. coli***	**Status (Bac-T)**	**Sources**
Upper Yellow Creek basin, Headwaters to upstream Town Fork WAU 05030101-180									
Yellow Creek	30.00	Ust. Goose Cr.	6/6	**5191**	**1430**	**18500**	**2900**	**NON**	HM, L, UR
	29.84	Liberty St., Amsterdam	6/6	**19205**	**2326**	**57000**	**9500**	**NON**	HM, UR
	27.60	CR 75(A)	6/6	**1495**	**728**	**6550**	**3400**	**NON**	HM, UR
	25.10	SR 164, dst Elkhorn Cr.	5/5	564	**320**	1996	**1604**	FULL-Target	
	24.20	SR 164, ust Up. N. Fk.	5/5	777	**341**	1660	**576**	FULL-Target	
	17.90	CR 54, ust Ralston Run	5/5	343	**227**	**3396**	**1708**	**NON**	Unk.
	11.80	CR 53, ust Long Run	6/6	195	82	840	**385**	FULL-Target	
Long Run	4.30	CR 54	3/3	348	**222**	518	**382**	FULL-Target	
	2.70	T-284	2/2	**3344**	**2149**	**23443**	**19821**	**NON**	L
Ralston Run	0.30	CR 53	4/4	417	**329**	**4657**	**2859**	**NON**	L
Upper North Fork	5.70	Avon Rd at T-21	3/3	421	**174**	1580	**798**	FULL-Target	
	0.30	Lane at SR 524	3/3	563	**289**	1666	**608**	FULL-Target	
Hump Run	0.10	SR 524	3/3	224	68	800	**640**	FULL-Target	
Carroll Run	0.10	Orchard Rd	2/2	234	66	727	**397**	FULL-Target	
Elkhorn Creek	7.90	Plane Rd	2/2	**1775**	**718**	**2040**	**1123**	**NON**	Unk., L
	6.80	SR 43	3/3	**2098**	**1019**	**2180**	**2188**	**NON**	L, Ag
	0.20	SR 164	4/4	798	**505**	**2184**	**1787**	**NON**	L, Ag
Strawcamp Run	1.20	Chase Rd.	3/3	435	**249**	1204	**920**	FULL-Target	
	0.30	Bay Rd	3/3	799	**328**	**2340**	**1776**	**NON**	HI, Unk.
Center Fork	1.90	Apollo Rd at ballpark	2/2	476	78	783	**550**	FULL-Target	
	0.10	Carry Rd	3/3	**1222**	**327**	**2320**	**786**	**NON**	Unk.
Trail Run	0.30	Bay Rd	3/3	**1871**	**936**	**2340**	**3200**	**NON**	Campground
Frog Run	0.10	At mouth	1/1	240	**150**	240	150	FULL-Target	
Wolf Run	1.50	Wolf Run Rd	3/3	326	102	640	150	FULL	L
Cox Creek	0.10	SR 164	4/4	**11411**	**2995**	**39400**	**11140**	**NON**	HM
Goose Creek	1.90	CR 267	2/2	**1744**	**1062**	**3588**	**2119**	**NON**	HI, Unk.
	0.10	Ridgewood St	2/2	**2891**	**649**	**3640**	**756**	**NON**	HM, UR

Stream Name	RM	Location	# Samples	GeoMean		90th %		Attainment	Potential
			FecalColi /E coli	Fecal Coli	*E. coil*	Fecal Coli	*E. coli*	Status (Bac-T)	Sources
Elk Fork	1.60	Senlac Rd	3/3	281	**194**	514	**332**	FULL-Target	
Elk Lick	1.70	Queens Rd.	3/3	**1312**	**449**	**2020**	**706**	**NON**	Ag, HI
Yellow Cr Trib @ RM 30.22	0.10	Bear Rd (CR 28)	3/3	**1382**	**445**	**5680**	**2950**	**NON**	HM
Gault Run	0.20	Apollo Rd (CR 12)	3/3	**1305**	**389**	**2120**	**694**	**NON**	L

Lower Yellow Creek basin, Town Fork to Ohio River WAU 05030101-190

Stream Name	RM	Location	# Samples	GeoMean Fecal Coli	GeoMean *E. coil*	90th % Fecal Coli	90th % *E. coli*	Attainment Status (Bac-T)	Potential Sources
Yellow Creek	5.70	Camp Logan USGS Gage	14/13	206	**150**	889	**736**	FULL-Target	
	2.51	SR 213	6/6	341	**173**	970	**560**	FULL-Target	
Hollow Rock Run	3.00	Ust Carter Run	3/3	209	92	708	**340**	FULL-Target	
	2.20	Hollow Rock Rd	6/6	214	108	660	**385**	FULL-Target	
Tarburner Run	0.10	Hollow Rock Rd	3/3	178	54	440	**422**	FULL-Target	
Brush Creek	9.50	SR 164, dst South Mine	1/1	260	50	260	50	FULL	
	6.10	T-290, Dst North Mine	2/2	357	**150**	833	**678**	FULL-Target	
	0.10	CR 72	5/5	181	49	398	158	FULL	
Dennis Run	0.10	T- 61	2/2	35	20	109	37	FULL	
North Fk. Yellow Creek	10.35	Ust Salineville WWTP	3/3	617	**668**	1260	**1378**	FULL-Target	
	10.10	Dst WWTP (Haiti Rd)	3/3	**2147**	**1752**	**4040**	**2240**	**NON**	WWTP
	6.20	Adj. Salineville Rd	3/3	74	39	100	67	FULL	
	2.19	Creek St	3/3	222	**149**	532	190	FULL-Target	
	1.90	Dst Irondale	8/7	**1208**	**1573**	**3520**	**3860**	**NON**	HM
	0.80	Main St	3/3	457	**168**	640	250	FULL-Target	
Riley Run	4.80	April Rd	3/3	179	**284**	610	**586**	FULL-Target	
	1.80	SR 39	3/3	355	**240**	400	240	FULL-Target	
Riley Run Trib. @ RM 3.75	0.30	Avon Rd	3/3	**2324**	**2184**	**2540**	**2960**	**NON**	L
	0.01	At mouth	3/3	273	**142**	618	**380**	FULL-Target	
Nancy Run	2.20	Dobson Rd	3/3	140	**145**	416	**304**	FULL-Target	
	1.00	Foundry Mill Rd	3/3	127	107	160	146	FULL	
Roses Run	0.10	Foundry Mill Rd	3/3	53	70	110	91	FULL	
NF Yellow Trib @ RM 9.96	0.40	Jackoblonski Rd	3/3	40	56	506	**627**	FULL-Target	
NF Yellow Trib @ RM 8.96	0.10	Adj. Salineville Rd	5/5	119	**132**	300	**396**	FULL-Target	
NF Yellow Trib @ RM 6.08	0.10	Hazel Run Rd	3/3	150	**168**	368	**358**	FULL-Target	
Randolf Run	0.20	CR 776	2/2	**1265**	**1670**	**3640**	**2793**	**NON**	Unk
Salisbury Run	0.10	CR 776	3/3	7	13	20	82	FULL	
Salt Run	0.01	At mouth	3/3	434	**955**	**2760**	**1860**	**NON**	HM
Town Fork	10.40	Ust Jeff. Lake, T-262	3/3	**2452**	**564**	**5920**	**2452**	**NON**	L
	8.00	At ballpark, dst Lake	4/4	252	**204**	1577	**766**	FULL-Target	
	5.20	Shane Rd.	3/3	726	**188**	**3390**	**538**	**NON**	HI, Ag
	0.10	CR 53	5/5	210	120	1528	**630**	FULL-Target	
Keyhole Run	0.10	T-248, dst Austin Lake	2/2	51	32	235	91	FULL	

Ohio River Tribs. /Little Yellow Creek East Liverpool to Yellow Creek WAU 05030101-100

Stream Name	RM	Location	# Samples	GeoMean Fecal Coli	GeoMean *E. coil*	90th % Fecal Coli	90th % *E. coli*	Attainment Status (Bac-T)	Potential Sources
McQueen Run	0.20	Upst. SR 7	3/3	42	55	59	57	FULL	
Little Yellow	11.10	Clarks Mill Rd	3/3	271	**266**	480	**562**	FULL-Target	

Stream Name	RM	Location	# Samples	GeoMean		90th %		Attainment	Potential
			FecalColi /E coli	Fecal Coli	*E. coil*	Fecal Coli	*E. coli*	Status (Bac-T)	Sources
Creek	6.70	McCormick Run Rd	2/2	**1277**	**903**	**3108**	**2194**	**NON**	HI, Ag
	3.30	Forbes Rd	2/2	235	111	549	186	FULL	
	1.10	Hibbits-Mill Rd	6/6	59	52	120	122	FULL	
Alder Lick Run	0.10	Adj. Fife Coal Rd	2/2	190	44	198	62	FULL	
Wells Run	0.20	Ust. SR 7/39	2/2	41	26	48	59	FULL	
Carpenter Run	1.20	Adj. US RT 30	2/2	480	**417**	923	**629**	FULL-Target	
Jethro Run	0.30	Ust. SR 7/39	2/2	**3660**	**1549**	**6230**	**2260**	**NON**	HM, UR
Bailey Run	1.95	Osbourne Rd	2/2	671	**597**	1380	**824**	FULL-Target	

Ag = Agriculture related
H = Homes, isolated
HM =Homes, multiple
UR = Urban runoff
WWTP = Wastewater Treatment Plant discharge
L = Livestock
Unk. =Unknown source

Table 15. Recreational use attainment status by watershed assessment unit.

			Fecal Colifom #cfu/100mL)		Attainment Status
WAU	Location	N	75th %tile	90th %tile	
100	Little Yellow Cr./Ohio River Tribs.	26	495	1750	FULL
180	Upper Yellow Cr. basin	106	2400*****	7050******	**NON**
190	Lower Yellow Cr. basin	132	685	2090******	**NON**

- 75th percentile exceeds 1,000 cfu/100mL) *****
- 90th percentile exceeds 2,000 cfu/100mL) ******

Upper Yellow Creek basin (WAU 180)
During the 2005 survey, a total of 106 bacteria samples were collected from 31 locations on 18 streams within the upper Yellow Creek assessment unit. Eighteen of the 31 sample locations (58%) were in non-attainment of the PCR recreational use. Those 18 sampling locations were associated with 12 different streams (Table 14) and are summarized below. In addition, WAU 180 was also considered impaired for recreation on the watershed level (Table 15). Septic tank drainage and livestock were the primary contamination sources.

Upper Yellow Creek mainstem (Recreation Use)
The unsewered communities of Amsterdam and Bergholz are located in the upper reaches of the Yellow Creek mainstem. Bacteria samples collected at three sites in upper Yellow Creek, from upstream Goose Creek (RM 30.00) to upstream Bergholz (RM 27.60), showed non-attainment of recreation use. Ohio EPA personnel observed some storm sewers in Amsterdam that continuously discharged raw sewage on most sampling runs, even during dry weather. While not observed specifically, it is believed that this is the case in Bergholz, as well, due to the similarities of the two villages and

lack of a central sewage collection system. Both communities are mostly residential with a limited number of businesses and public buildings in the immediate center of town. However, compared to Amsterdam, Bergholz may benefit from the larger receiving stream size and greater dilution in the more downstream reaches of Yellow Creek (*i.e.* a watershed size of approximately 70 mi^2 versus 20 mi^2 upstream). Once outside of Bergholz, heading east, the area becomes very rural with scattered homes and farms located along Yellow Creek. Both current and historic mining activities are apparent in some locations. Non-attainment of the recreation use at CR 54 (RM 17.9) persisted well downstream from Bergholz but a specific source of contamination was unknown.

Upper Yellow Creek Basin Tributaries (Recreation Use)

The following tributaries in the upper Yellow Creek basin (WAU 180) were classified in non-attainment of the recreational use based on site specific bacteriological sampling.

Elk Lick	Gault Run	Long Run (RM 2.7)	Elkhorn Creek (RMs 7.9, 6.8, 0.3)
Ralston Run	Cox Creek	Goose Creek (RMs 1.9, 0.3)	Trib. to Yellow Creek (RM 30.22)
Center Fork	Trail Run	Strawcamp Run (RM 0.3)	

With few exceptions, the most elevated bacteria levels coincided with field observations of obvious contamination sources. Unrestricted cattle access, feedlots, or herds of livestock were observed in close proximity to affected sites on Long Run, Ralston Run, Elkhorn Creek, Elk Lick and Gault Run and manure spreading was observed adjacent to Elkhorn Creek RM 6.8. In Elk Lick, severe hillside erosion and cattle were observed along the ridge top immediately adjacent to the sampling site.

Streams with elevated bacteria near multiple on-site septic systems included the Yellow Creek Trib. @ RM 30.22 and Goose Creek in Amsterdam, and Cox Creek, just north of Amsterdam. Continuous gray water discharges were routinely observed near the mouth of Goose Creek while the RM 30.22 Trib. drains a small neighborhood of unsewered homes near the mouth. Small lot sizes may limit the type of sewage treatment that serves homes within the Village. In Cox Creek, a grey water discharge was observed following the survey from a series of homes along the south side of T-275. The discharge flowed under T-275 and entered Cox Creek immediately upstream from the SR 164 sampling site. In August 2005, extremely elevated bacteria levels and WQS exceedences for ammonia and copper were detected at the same location (Table 7).

The source of contamination to Goose Creek RM 1.9 (upstream from Amsterdam) is unknown but septic tank drainage is suspected. In Trail Run, a private campground near the Bay Road sampling site may be a source of elevated bacteria. The specific contamination source in Center Fork is unknown.

Full attainment of the PCR use was recorded at sampling locations for Upper North Fork, Hump Run, Carroll Run, Frog Run, Wolf Run and Elk Fork. Twelve of the 31 (39%) locations in the assessment unit were in full attainment but should be targeted for future sampling at a greater frequency because at least one of the two indicator groups (fecal coliform or *E. coli*) exceeded aspects of their PCR criteria (Table 14).

Lower Yellow Creek basin (WAU 190)
Bacteria samples were collected from 33 sample locations on 18 streams within the WAU during this survey. Seven of the 33 sample locations (21%) were in non-attainment of the PCR recreational use. The 7 locations were associated with 5 different streams.

North Fork Yellow Creek	Salt Run	Randolf Run
Town Fork	Riley Run Trib. at RM 3.75	

In the North Fork Yellow Creek, non-attainment of recreational use was recorded immediately downstream from the Salineville WWTP (RM 10.1), and at RM 1.90 immediately downstream from Salt Run and the unsewered Village of Irondale. Salineville was previously under Director's Findings and Orders to improve treatment. Irondale is unsewered and lies at the mouth of Salt Run with direct septic tank discharges to the receiving stream. Elevated bacteria levels in upper Town Fork (RM 10.4), upstream from Jefferson Lake, and the Riley Run Trib. @ RM 3.75 were related to unrestricted cattle access. Bacteria sources in lower Town Run (RM 5.4) and Randolph Run are unknown but may be related to isolated on-site septic systems (Town Run) or wild animals coupled with very low flow (Randolf Run).

Full attainment of PCR use was recorded for Yellow Creek mainstem, Hollow Rock Run, Tarburner Run, Brush Creek, Dennis Run, Salisbury Run, Nancy Run, Roses Run, Riley Run, Keyhole Run, and three tributaries to the North Fork Yellow Creek at RMs 6.08, 8.96, and 9.96. Eighteen of the 33 sample locations (54%) in the assessment unit were in full attainment but should be targeted for future sampling at a greater frequency because at least one of the two indicator groups (fecal coliform or *E. coli*) exceeded applicable PCR criteria.

Little Yellow Creek/Ohio River Tributaries (WAU 100)
Bacteria samples were collected from ten sample locations on seven streams within the WAU during this survey. All samples were collected on the same day, thus eliminating rainfall as a causal factor when comparing bacteria levels from one sample location to another.

Two of the ten sample locations (20%) were in non-attainment of the PCR designated use; Jethro Run downstream from US 7 (RM 0.1) and Little Yellow Creek at McCormick Run Road (RM 6.70). In Jethro Run, suspected sources of bacteria include failing home septic systems and urban runoff. At Little Yellow Creek RM 6.70, failing home sewage systems and livestock runoff from the area between the Highlandtown Lake dam and McCormick Run Road are potential bacteria sources. A strong airborne odor of animal manure was detected at the station. Because of the small sample size (n=2) at these sites, future sampling should be conducted at greater frequency and at additional locations upstream, to isolate specific sources of bacteria.

Full attainment of the PCR use was recorded in McQueen Run, Alder Lick Run, Wells Run, Carpenter Run, and Bailey Run. Three of the ten sampling locations (30%) in the assessment unit were in full attainment but are targeted for future sampling at a greater frequency because at least one of the two indicator groups (fecal coliform or *E. coli*) exceeded applicable PCR criteria (Table 14).

Physical Habitat Quality for Aquatic Life

Mean QHEI values from rivers or river segments equal to or greater than 60.0 generally indicate a level of macrohabitat quality sufficient to support an assemblage of aquatic organisms fully consistent with the WWH aquatic life use designation. Average reach values at greater than 75.0 are generally considered adequate to support fully exceptional (EWH) communities (Rankin 1989 and Rankin 1995). Values between 55 and 45 indicate limiting components of physical habitat are present and may exert a negative influence upon ambient biological performance. However, due to the potential for compensatory stream features (e.g., strong ground water influence) or other watershed variables, QHEI scores within this range do not necessarily preclude WWH or even EWH assemblages. Values below 45 indicate a higher probability of habitat derived aquatic life use impairment. Longitudinal performance of the QHEI and a matrix of macrohabitat features, by stations, are presented in Table 17.

In 2005 stream habitat conditions were evaluated at 68 fish sampling sites in the Yellow and Little Yellow Creek watersheds. Good habitat conditions (QHEI $\bar{x}$ = 69.6) were typical and generally improved with increasing drainage area (Table 16).

Table 16. Summary of QHEI scores for the Yellow Creek study area, 2005.

Mi^2	Sites	QHEI $\bar{x}$	QHEI Range	Fair Sites (QHEI < 60)
< 5 mi^2	36	66.1	52 - 91	12
5 - 20 mi^2	20	70.3	48.5 - 92.5	3
20 - 50 mi^2	5	81.6	67.5 - 96.5	--
> 50 mi^2	7	76.9	63 - 89	--

Habitat conditions were similar between the three study area WAUs (Figure 13). Good conditions were common among nine streams sampled in the Little Yellow Creek WAU (QHEI $\bar{x}$ = 64.3) where the largest location drained 17 mi^2. The Upper Yellow Creek WAU included five sites which drained more than 20 mi^2 (QHEI $\bar{x}$ = 82). Excluding these locations, a good average QHEI score of 66.8 (n=27) was consistent with the good average headwater QHEI score in the Lower Yellow Creek WAU (QHEI $\bar{x}$ = 70.2, n=20). The larger drainage sites in both the Upper and Lower Yellow Creek WAU (QHEI $\bar{x}$ = 76.6, n=7) displayed very good habitat quality.

The Yellow Creek mainstem was evaluated at six wading locations from RM 27.6 downstream to the confluence with Ohio River backwater. Very good habitat conditions (QHEI $\bar{x}$ = 77.8) in this reach were sufficient to support EWH aquatic life use designation.

Overall, habitat conditions were conducive to good biological assemblages throughout the Yellow Creek study area in 2005. Although there were a few locations where fair habitat conditions were documented, these smaller drainage sites were unlikely to exert significant basinwide effects. Addressing the deficiencies evidenced at these locations would thus be best accomplished on a site specific basis.

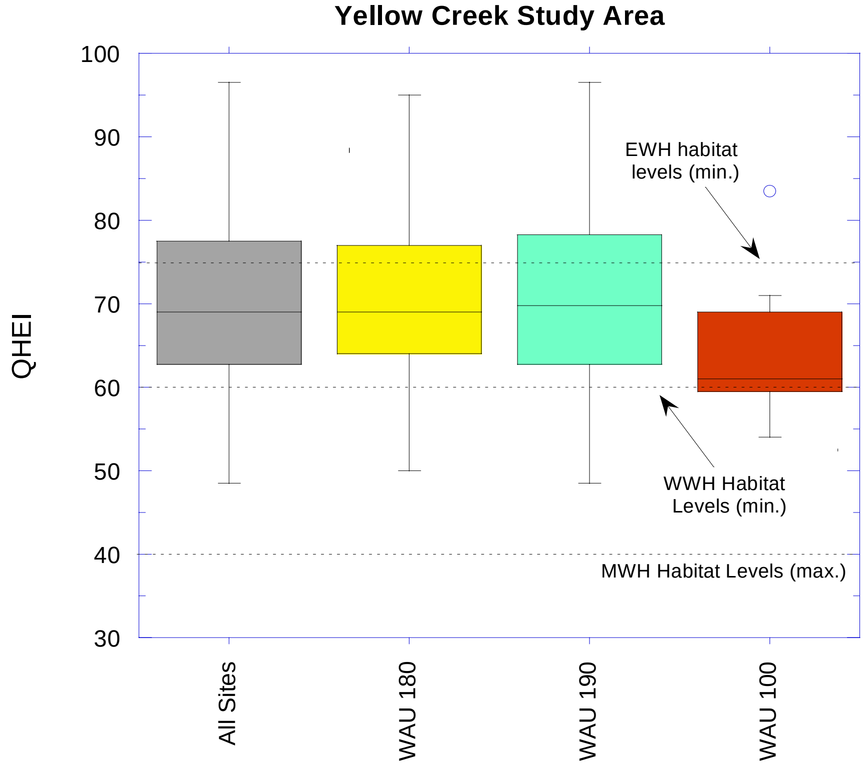


Figure 13. Box and whisker plots of QHEI scores for all sites and by watershed assessment unit (WAU) in the upper Yellow Creek (WAU 180), Lower Yellow Creek (WAU 190) and Ohio River Tribs./Little Yellow Creek (WAU 100) watersheds, 2005.

In particular, the lowest QHEI score in the study area was determined at one of three locations assessed in the Hollow Rock Run subbasin. While good QHEI scores were determined upstream from Carter Run (RM 3.0, QHEI=65) and on Tarburner Run near the Hollow Rock Run confluence (RM 0.2, adjacent to T-303, QHEI=69), fair conditions were documented downstream from these sites at RM 2.2 (QHEI=48.5).

The average QHEI score of 60.8 (good range) and full aquatic life use attainment at each location suggested that any habitat impairment was likely of limited influence. However, that should not preclude efforts to enhance habitat throughout the subbasin and specifically along the County Road.

In 2005, Ohio EPA discovered that previously unreported populations of longnose dace inhabited the Hollow Rock and Jethro Run subbasins. These fish prefer cold, high gradient, swift flowing streams and are only present in two areas of Ohio (Chagrin basin and Ohio River tributaries between Columbiana and Belmont Counties). Apparently, the species is somewhat tolerant because it was present in habitat modified reaches where the stream was improved to facilitate road drainage. The possibility that further improvements might aid survival of this unusual species is worth consideration.

Livestock encroachment in-stream and within the riparian corridor was evident at several study area locations. In most instances, better surrounding habitat conditions buoyed aquatic community performance through the degraded reaches. For example, most of the sample sites in the Elkhorn Creek subbasin were located within or adjacent to grazing pastures. Despite this condition, full aquatic life use attainment and mostly exceptional biological performance was extant in the subbasin and fair QHEI scores were recorded at just two of the eight sample sites.

Storm water runoff associated with historical mining operations likely influenced aquatic community performance at eight study area sites. Stream substrates were smothered by orange floc in Wells and Salisbury Runs. Fair QHEI scores (54, 56 respectively) and an absence of fish at both sample locations marked these two locations as the most impaired sites in the study area. Mine drainage related habitat effects were less noticeable at the other locations where good or better QHEI scores were tabulated.

Barriers to fish movement likely influenced fish community performance in an unnamed tributary to the North Fork Yellow Creek at RM 9.65 and in McQueen Run. A natural rock ledge was present in the unnamed tributary downstream from the sample site. McQueen run enters a long culvert before joining the Ohio River. Both streams are utilized to drain State highways. The fair QHEI scores at both sites (53, 59.6 respectively) reflected a lack of flow, no riffle function and modified habitat attributes.

Little Yellow Creek is impounded by the Highlandtown and Wellsville Reservoirs. In addition to preventing fish passage, these barriers limit downstream flow and facilitate water loss through evaporation. Furthermore, reservoir algal growth affected downstream nutrient cycles, oxygen demand and other assimilative factors. Despite good QHEI scores ($\bar{x} = 65.2$) at three Little Yellow Creek sample sites, the reservoir produced limitations were deemed likely to reduce the effectiveness of these habitats.

Lastly, the amount of water at some of the smaller stream sample locations precluded better habitat function. Although sample sites were stratified by drainage area and some natural variation was expected, there were some locations which were effectively desiccated by late summer, 2005. Two unnamed tributaries to the North Fork Yellow Creek at RMs 8.96 and 6.08 were reduced to several small pools and Randolf Run became completely dry. Obviously, the absence of water or near absence of water is a detrimental condition for aquatic communities adapted to flowing stream habitat. The possibility that historical mining operations might have contributed to some flow alteration was considered but no compelling information was referenced.

Table 17. QHEI habitat matrix for the Yellow Creek and Ohio River Tribs./Little Yellow Creek study area, 2005.

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
(06-078) McQueen Run																																		
Year: 2005																																		
0.6	59.5	166.7	■	■	■		■	■		■	■		7				◆		1					●				●			●	3	0.25	0.63
(06-079) Little Yellow Creek																																		
Year: 2005																																		
11.1	71.0	22.47	■	■		■	■	■		■	■		7						0		●			●				●	●		●	5	0.13	0.75
6.7	63.5	17.86	■	■		■	■	■		■	■	■	8				◆		1									●				1	0.22	0.33
3.5	61.0	57.14	■	■		■	■			■	■	■	7				◆		1									●				1	0.25	0.38
(06-080) Alder Lick Run																																		
Year: 2005																																		
0.2	69.0	111.1	■			■	■	■	■	■	■	■	8				◆		1													0	0.22	0.22
(06-081) Wells Run																																		
Year: 2005																																		
0.4	54.0	142.9	■	■			■						3				◆	◆	2		●			●				●	●	●		5	0.75	2.00
(06-082) California Hollow (Carpenter Run)																																		
Year: 2005																																		
1.6	59.5	86.96	■	■	■		■		■	■	■	■	8				◆		1					●								1	0.22	0.33
(06-095) Bailey Run																																		
Year: 2005																																		
0.7	83.5	173.9	■			■	■	■	■	■	■	■	8						0		●											1	0.11	0.22
(06-096) Jethro Run																																		
Year: 2005																																		
0.1	57.5	190.5		■			■			■	■	■	5				◆		1	●				●				●				3	0.33	0.83
(06-900) Yellow Creek																																		
Year: 2005																																		
30.1	65.5	16.67	■	■			■	■			■		5			◆			1		●			●				●	●	●		5	0.33	1.17
27.6	73.0	9.17	■	■		■	■	■			■	■	7						0		●							●	●			3	0.13	0.50
24.5	71.0	11.98	■	■		■		■			■		5				◆		1		●				●			●	●	●		5	0.33	1.17
18.5	89.0	5.22	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10
11.8	82.0	7.17	■	■		■	■	■	■	■	■	■	9						0		●								●			2	0.10	0.30
5.5	89.0	10.93	■	■		■	■	■	■		■	■	8						0										●			1	0.11	0.22
3.3	63.0	2.74	■	■		■	■				■		5				◆		1		●							●	●		●	4	0.33	1.00
(06-902) Hollow Rock Run																																		
Year: 2005																																		
3.0	65.0	83.33	■	■		■	■	■	■	■	■	■	9				◆		1		●								●			2	0.20	0.40

03/17/2008 1

Key
QHEI
Components

			WWH Attributes											MWH Attributes High Influence						Moderate Influence														
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
(06-902) Hollow Rock Run																																		
Year: 2005																																		
2.2	48.5	57.14		■					■	■		■	4	◆		◆	◆	◆	4		●			●		●			●			4	1.00	1.80
(06-903) Tarburner Run																																		
Year: 2005																																		
0.2	69.0	153.9	■	■	■	■	■	■	■	■		■	9				◆	◆	2													0	0.30	0.30
(06-905) Brush Creek																																		
Year: 2005																																		
8.8	69.0	48.78	■	■		■	■	■			■	■	7			◆			1		●							●	●	●		4	0.25	0.75
6.0	88.5	36.36	■	■	■	■	■	■	■	■	■	■	10						0													0	0.09	0.09
0.8	81.0	39.22	■	■	■	■	■	■	■	■	■	■	10						0					●								1	0.09	0.18
(06-906) Dennis Run																																		
Year: 2005																																		
0.3	74.0	125.0	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10
(06-909) Long Run																																		
Year: 2005																																		
4.3	74.5	32.26	■	■		■	■	■			■	■	7						0		●							●	●	●		4	0.13	0.63
0.3	92.5	36.36	■	■	■	■	■	■	■	■	■	■	10						0													0	0.09	0.09
(06-910) North Fork Yellow Creek																																		
Year: 2005																																		
10.6	78.5	12.50	■	■		■	■	■	■		■		7						0		●								●	●		3	0.13	0.50
10.1	67.5	25.00	■	■		■	■	■	■		■	■	8						0		●			●					●			3	0.11	0.44
6.1	95.5	16.39	■	■	■	■	■	■	■	■	■	■	10						0													0	0.09	0.09
2.2	66.0	17.86	■	■		■	■	■	■		■		7						0										●	●		2	0.13	0.38
0.5	78.0	18.52	■	■		■	■	■	■		■	■	8						0		●								●			2	0.11	0.33
(06-912) Salt Run																																		
Year: 2005																																		
0.4	55.0	76.92	■	■			■	■	■		■		6				◆		1					●		●			●	●		4	0.29	0.86
(06-913) Salisbury Run																																		
Year: 2005																																		
0.2	56.0	57.14	■	■		■	■	■			■		6				◆		1		●			●				●	●	●		5	0.29	1.00
(06-915) Nancy Run																																		
Year: 2005																																		
2.2	71.5	90.91	■	■		■	■	■		■	■	■	8				◆		1		●							●				2	0.22	0.44
1.0	65.0	42.55	■	■		■	■	■		■	■	■	8				◆		1		●							●	●			3	0.22	0.56

Key
QHEI
Components

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes											MWH Attributes																				
														High Influence						Moderate Influence														
			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
(06-916) Roses Run																																		
Year: 2005																																		
0.1	70.5	76.92	■	■		■	■	■		■	■	■	8						0		●							●				2	0.11	0.33
(06-917) Riley Run																																		
Year: 2005																																		
4.9	62.5	90.91	■	■		■	■	■			■	■	7				◆		1		●							●	●	●		4	0.25	0.75
(06-918) Hildebrand Run																																		
Year: 2005																																		
0.1	66.5	74.07	■	■	■	■	■	■		■	■	■	9				◆		1									●				1	0.20	0.30
(06-920) Town Fork																																		
Year: 2005																																		
10.4	60.0	50.00	■	■		■	■	■	■		■		7				◆		1		●								●	●		3	0.25	0.63
8.0	77.0	18.69	■	■		■	■	■		■	■	■	8						0									●				1	0.11	0.22
5.1	79.0	19.15	■	■	■	■	■	■	■	■	■	■	10						0													0	0.09	0.09
0.2	76.0	25.64	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10
(06-924) Ralston Run																																		
Year: 2005																																		
0.3	71.5	30.77	■	■		■	■	■			■	■	7						0		●							●	●	●		4	0.13	0.63
(06-926) Upper North Fork																																		
Year: 2005																																		
5.7	53.5	23.81		■			■	■			■	■	5			◆	◆		2	●				●				●			●	4	0.50	1.17
0.3	78.5	19.42	■	■	■	■	■	■		■	■	■	9						0									●				1	0.10	0.20
(06-927) Hump Run																																		
Year: 2005																																		
0.5	78.0	35.09	■	■	■	■		■		■	■	■	8			◆			1									●				1	0.22	0.33
(06-929) Carroll Run																																		
Year: 2005																																		
0.1	65.5	58.82	■	■	■	■	■	■		■		■	8					◆	1									●				1	0.22	0.33
(06-930) Hazel Run																																		
Year: 2005																																		
0.2	73.0	27.40	■	■			■	■			■		5						0		●		●	●				●	●		●	6	0.17	1.17
(06-931) Elkhorn Creek																																		
Year: 2005																																		
7.9	76.0	31.75	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10
6.8	50.0	38.46	■	■			■		■		■		5				◆		1		●			●					●	●		4	0.33	1.00

03/17/2008 3

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														
(06-931) Elkhorn Creek																																		
Year: 2005																																		
0.2	94.0	11.56	■	■	■	■	■	■	■	■	■	■	10						0													0	0.09	0.09
(06-932) Strawcamp Run																																		
Year: 2005																																		
2.2	90.0	40.00	■	■		■	■	■	■	■	■	■	9						0		●											1	0.10	0.20
0.4	55.0	45.45	■	■		■	■			■	■	■	7				◆		1									●	●	●		3	0.25	0.63
(06-933) Center Fork																																		
Year: 2005																																		
1.9	68.0	14.08	■	■	■		■			■		■	6				◆	◆	2					●				●				2	0.43	0.71
0.2	64.5	21.28	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10
(06-934) Trail Run																																		
Year: 2005																																		
0.3	63.5	45.45	■	■		■	■	■	■	■	■	■	9				◆		1		●								●			2	0.20	0.40
(06-935) Frog Run																																		
Year: 2005																																		
0.1	56.5	52.63	■	■			■	■		■		■	6				◆	◆	2		●			●				●	●	●		5	0.43	1.14
(06-936) Wolf Run																																		
Year: 2005																																		
1.5	69.0	33.90	■	■		■	■	■	■	■	■	■	9				◆		1													0	0.20	0.20
(06-937) Cox Creek																																		
Year: 2005																																		
0.1	81.0	41.67	■	■	■	■	■	■	■	■	■	■	10						0													0	0.09	0.09
(06-938) Goose Creek																																		
Year: 2005																																		
1.9	63.0	55.56	■	■		■	■	■			■		6						0		●			●				●	●	●		5	0.14	0.86
0.2	73.5	28.99	■	■		■	■	■	■		■	■	8						0		●								●	●		3	0.11	0.44
(06-939) Elk Fork																																		
Year: 2005																																		
1.7	65.5	60.61	■	■		■	■	■			■		6						0		●							●	●	●		4	0.14	0.71
(06-940) Elk Lick																																		
Year: 2005																																		
1.8	63.0	35.71	■	■		■	■	■			■		6						0		●							●	●	●		4	0.14	0.71
(06-941) Trib. to N. Fk. Yellow Creek (RM 6.08)																																		
Year: 2005																																		
0.2	79.0	83.33	■	■	■	■	■	■		■	■	■	9						0									●				1	0.10	0.20

03/17/2008 4

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**
(06-945) Trib. to N. Fk. Yellow Creek (RM 9.65)													
Year: 2005													
0.4	53.0	37.04	■	■						■	■		4
(06-946) Trib. to Riley Run (RM 3.75)													
Year: 2005													
0.3	56.0	45.45	■	■		■	■	■			■		6
(06-947) Trib. to Yellow Creek (RM 30.22)													
Year: 2005													
0.1	52.0	51.28	■	■			■					■	4
(06-948) Keyhole Run													
Year: 2005													
0.1	72.0	71.43	■	■	■	■	■	■		■	■	■	9
(06-949) Gault Run													
Year: 2005													
0.3	67.0	22.47	■	■		■	■	■	■	■	■		8

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**
(06-945) 0.4			◆	◆		2
(06-946) 0.3				◆		1
(06-947) 0.1			◆	◆	◆	3
(06-948) 0.1				◆		1
(06-949) 0.3						0

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**
(06-945) 0.4					●				●			●	3	0.60	1.20
(06-946) 0.3		●			●				●	●	●		5	0.29	1.00
(06-947) 0.1		●			●				●	●			4	0.80	1.60
(06-948) 0.1									●				1	0.20	0.30
(06-949) 0.3										●	●		2	0.11	0.33

Biological Sampling Results

Fish Community Assessment

Fish community performance was evaluated at 69 sampling sites in the Yellow and Little Yellow Creek watersheds in 2005 (Table 18). IBI and MIwb scores are presented in Appendix 5 and relative numbers and species collected per location are presented in Appendix 6. Among the three study area hydrologic units, streams in the Little Yellow Creek WAU were most affected by anthropogenic influences (*i.e.*, 7 of 9 fish communities impaired). In contrast, only two small streams in the Yellow Creek WAUs (2 of 60 sites) exhibited sub par conditions. Otherwise, fish community index scores from the Yellow Creek watershed were amongst the highest values recorded in Ohio.

Coldwater Fish Communities

Redside dace, mottled sculpin, and southern redbelly dace thrive in colder water. Their presence along with sympatric macroinvertebrate taxa are often prerequisites to the CWH aquatic life use designation. In Ohio, the proximity and frequency of springs and groundwater seeps is generally fundamental to maintaining cool water temperatures in warmer months. Among 47 Yellow Creek headwater sampling locations (<20 mi^2), redside dace were present at 32 (68%), mottled sculpin were at 41 (87%) and redbelly dace were at 21 (45%). Groundwater was obviously an important factor in the overall basin water quality.

Ohio is on the edge of the longnose dace range. This generally northern species also inhabits western and eastern mountain streams but is rare in Ohio. During the 2005 survey, previously undiscovered populations of longnose dace were recorded in the Hollow Rock Run subbasin and in Jethro Run, a direct Ohio River tributary. Both of these streams were noticeably colder than other study area streams. Coincidently, redside dace were not collected in these streams. Together, longnose and redside dace inhabited 77% of the Yellow Creek headwater streams. Only two Yellow Creek headwater streams were devoid of coldwater fish (Salisbury Run and unnamed tributary to the North Fork Yellow Creek at RM 9.65) and two others were dry.

No completely common traits were apparent among Yellow Creek headwater streams which lacked one or more coldwater fish species aside from being warmer. Channel modification was found in streams with a mining heritage as well as the presence of increased fine sediment (sand or silt) in the bedload. In the broadest perspective, all Yellow Creek headwater streams should support coldwater fish assemblages and merit the corresponding CWH aquatic life use designation. Actions which affect stream temperature, such as planting or removing shade trees, will affect water quality.

Yellow Creek Watershed

Yellow Creek, North Fork Yellow Creek and the downstream reaches of Elkhorn Creek and Town Fork were the only study area streams with drainage areas greater than 20 mi^2. These wadeable streams were sampled at 13 locations (18 samples) producing a very good average IBI score (48.2) and an exceptional average MIwb score (10.0).

Each assemblage was typically comprised of 25 to 30 species including pollution sensitive fish such as variegate darters, river chubs, stonecat madtoms and rosyface shiners. Likewise, the numerical abundance of fish at these sites was outstanding (5400 individuals in a 150 meter reach on Elkhorn Creek RM 0.2).

Fish community quality in most Yellow Creek headwater streams (drainage area < 20 mi^2) was also very good (IBI $\bar{X}$ =47.4, n=47). There were only two locations, both in the North Fork Yellow Creek basin (WAU 190), where fish communities failed to achieve the biocriterion. The first was Salisbury Run, which was obviously impacted by acid mine drainage at RM 0.2 (IBI = 12). The stream was devoid of fish and smothered by a bright orange precipitate. The impact originated from a mine drainage discharge near RM 0.5 as normal conditions were documented immediately upstream (macroinvertebrate sampling) in 2006. The second impaired stream was an unnamed tributary to the North Fork Yellow Creek at RM 9.65 (RM 0.4, IBI = 22). Only three fish species were present and the stream primarily functioned as a drainage channel for the adjacent State Route 164. Water was restricted to a few small pools and a natural rock ledge downstream from the sample site prevented upstream fish migration.

Aside from these two locations, all other Yellow Creek headwater streams supported fish communities which were considered at least marginally good. Locations on Brush Creek and Long Run near the respective confluences with Yellow Creek both achieved "perfect" IBI scores (60). Among all 65 Yellow Creek basin fish samples, 49 achieved the EWH biocriteria (75%). Nine of the 60 Yellow Creek basin locations were inhabited by at least 30 or more fish species (Yellow Creek RM 18.5 had 39 species). Twelve additional locations included at least 20 fish species. More than ten species were collected at 29 other locations. In total, 100,244 individual fish from 59 species were sampled in the Yellow Creek basin. An average of 1,500 individual fish and 19 species were collected from each site.

In comparison to fish community performance across entire watersheds, water quality in the Yellow Creek basin is unrivaled in Ohio. Habitat conditions were also among the best in Ohio (QHEI $\bar{X}$ = 70.4, n=59). However, there were places where the fish community did not perform as well as expected. In addition to Salisbury Run, there were other sites which also displayed indications of mining related impairment.

Salt (RM 0.4, IBI = 40), Riley (RM 4.9, IBI = 42) and Wolf Runs (RM 1.5, IBI = 42) and Yellow Creek (RM 3.3, IBI = 44) all lacked darter diversity, pollution sensitive species, and achieved only marginally good IBI scores. While habitat conditions at these sites were adequate, subtle signs of previous mining or industrial activities were evident. Past mining activity in Wolf Run was reflected by iron stained sediments and a milky haze in the water column, possibly a metal precipitate. [Note: Despite improvements in the lower reaches of Wolf Run, the headwaters remain impacted by acid mine drainage (Hughes and Bowman 2007)]. Large stretches of the upper Riley Run watershed appeared reclaimed, flows were reduced and areas of iron seepage were observed along margins. The Salt Run site was not below any known mining sources but coal fines were observed and the site was immediately downstream from a large, historic tin and steel manufacturing site that operated near the turn of the previous century. Yellow Creek RM 3.3 was downstream from both a problematic mine drainage seep and an area of significant channel modification and relocation (see below). It was also likely that other factors (*e.g.,* flow or habitat alteration, sedimentation) may have contributed to the lackluster performance at these sites.

Effects of Localized Habitat Alteration Projects: Yellow Creek near the North Fork Yellow Creek Confluence

The most downstream site on Yellow Creek (RM 3.3) was within a highly dynamic reach. Located downstream from the North Fork and upstream from the Ohio River backwater, the stream had cut across a meander bend within the previous year. This portion of Yellow Creek varied in length having essentially lost about one half mile of channel during the cutoff process. Comparison of satellite imagery and topographic maps suggested this reach has been in flux for several years.

It was reported that a landowner had altered the North Fork near the mouth to prevent high Yellow Creek flows from disturbing a swimming area that he had created. Yellow Creek in this area was actively scouring the opposite right bank. It appeared that the eroded material contributed to filling the cutoff meander channel. Furthermore, the desire to affect potential flood flows was considered to be a significant threat to future water quality across the entire basin.

Although the impetus to exert “an ounce of prevention” is laudable, common sense water control solutions which retain storm flows, facilitate infiltration and reduce current velocities are rare. At numerous bridge crossings and at some less obvious places, instances of the use of heavy equipment within stream corridors were frequently encountered during the 2005 sampling effort.

The intent of these projects was to remove potential stream flow impediments and to expedite flow downstream. The “success” of these often uncoordinated or unsanctioned projects was particularly apparent at RM 3.3 where the ability of Yellow Creek to contain normal flood flows was completely overwhelmed. The upstream solutions had created downstream problems. Although these projects may alleviate local flooding, they also contribute to water quality degradation.

The Yellow Creek basin in 2005 was exceptional because habitat conditions (including woody debris, gravel bars and other natural stream channel features) were among the least altered anywhere in Ohio. In 2006, Ohio EPA evaluated the Scioto Brush Creek basin in southern Ohio. Although widely perceived to be among Ohio’s most natural watersheds, many similar “flood control projects” have eliminated critical headwater stream functions from most Scioto Brush streams. An unintended consequence of these alterations was that few streams in the Scioto Brush Creek basin supported exceptional aquatic assemblages. There were almost no instances where the perception of outstanding water quality was validated by actual environmental conditions. The same types of flood control projects have been occurring for a longer period in the Scioto Brush Creek basin as were witnessed beginning to increase in frequency in the Yellow Creek watershed. Yellow Creek streams will not continue to maintain high water quality if such projects continue unabated.

In addition to the habitat alteration activity immediately upstream from the North Fork confluence, heavy ATV traffic was also evident in and adjacent to the channel just downstream. Failing banks, extensive ATV trails, and disrupted bar and stream substrates were observed in the downstream reach.

At the confluence of the North Fork with Yellow Creek an orange floc covered the substrates. This signature of acid mine drainage was most likely related to a mine seep that discharged a large volume of mine drainage at RM 0.23 in 2002 (Ohio EPA 2003). A difference in pH between the two streams could precipitate dissolved metals or other contaminates from solution. In this dynamic reach it was unclear if the mine drainage exerted any significant effect in 2005. However, follow-up macroinvertebrate sampling in 2006 was indicative of a mine drainage impact (see page 112).

<u>Habitat Alteration in Headwater Streams: The Frog Run Example</u>
Among small, unimpaired Yellow Creek basin streams (≤ 3 mi^2), Frog Run at RM 0.1 was virtually the only site not inhabited by redside dace (a few high quality headwater tributaries lacked redside dace but contained longnose dace, another coldwater species). Redside dace are intolerant of water pollution, require deep cold pools, and prefer headwater streams. Across Ohio, this species has declined in abundance. Although headwater streams are more numerous than larger streams, these small waterways are the most easily and most often modified waterways. Across Ohio, many larger rivers have demonstrated significant improvement from previous water quality impairments. Unfortunately, the improving trend has not been evident among headwaters. Often, detrimental site specific conditions maintained by unknowing individual landowners are sufficient to prevent natural recovery and better water quality.

Essentially, this is the same caution urged previously in regard to the most downstream Yellow Creek location. Physical modification, aggressive log jam removal, uninformed gravel bar relocation, etc. will degrade water quality. Frog Run was considered in 1978 to be a candidate EWH stream. Frog Run, in fact, might support an EWH assemblage upstream from the 2005 sampling site, but it is a small stream with limited assimilative capacity. This capacity was so overwhelmed by a short “improvement” project that a perceived EWH stream was unable to support a good WWH community.

It is important to keep this in perspective. While the absence of redside dace at a few headwater locations is discouraging, it is most compelling that their absence specifically indicates water quality in some Yellow Creek tributaries is degraded. In 2005, 13 of 18 two to three square mile Yellow Creek drainages were populated by redside dace and overall water quality in the basin was perhaps the best in Ohio. If residents of the Yellow Creek basin wish to protect this status, then informing each other about the relationship between stream habitat functions and water quality is a worthwhile endeavor.

Upper Yellow Creek basin (WAU 180)

Fish sampling from WAU 180 (Upper Yellow Creek watershed) was conducted in 20 streams at 31 stations, ranging in size from 1.7 to 119 square miles. All fish communities (100%) in the upper Yellow Creek watershed exceeded WWH criteria and the large majority (87%) was in the very good or exceptional ranges (see Figure 14). In addition to the high levels of performance, 83% of communities in the upper watershed suggested coldwater potential (*i.e.*, contained populations of one or more coldwater fish).

Lower Yellow Creek basin (WAU 190)

Fish sampling from WAU 190 (Lower Yellow Creek watershed) was conducted in 17 streams at 29 stations, ranging in size from 1.9 to 224 square miles. Two other streams, the North Fork Yellow Creek Tributary at RM 8.64 and Randolph Run, were not sampled because the stream channels were dry. The large majority of fish communities in the watershed were in the very good or exceptional ranges (69%) and virtually all (93%) exceeded WWH criteria (see Figure 15). In addition, 83% of communities sampled suggested coldwater potential.

Little Yellow Creek/Ohio River Tributaries (WAU 100)

Fish community performance was evaluated at 9 sampling sites in the Little Yellow Creek WAU in 2005. Seven of these sites had drainage areas of three square miles or less. Two tributaries and three mainstem Little Yellow Creek locations were sampled while the other four sites were on Ohio River tributaries.

In contrast to the Yellow Creek basin, fish were unimpaired at only 2 of 9 sampling sites (22%) with performance in the fair to very poor ranges (see Figure 16). Flow alteration and isolation of populations by impoundment (*e.g.*, Little Yellow Creek), road construction, and channel modification (*e.g.,* McQueen Run, Carpenter Run) were considered the primary causes of impairment. In comparison to Yellow Creek basin streams with similar drainage areas, Little Yellow Creek appeared to convey less water and reduced stream flow was evident. In Wells Run, fish communities were eliminated downstream from a large acid mine drainage portal discharge.

For additional information, see WATERSHED ASSESSMENT UNIT REPORTS and individual stream assessments for WAUs 180, 190, and 100 on pages 95-133.

Table 18. Fish community indices based on pulsed D.C. electrofishing samples collected by Ohio EPA within the Yellow Creek study area, 2005. All sites are located in the Western Allegheney Plateau (WAP) ecoregion. Attainment status is based on the recommended aquatic life use designation. All sites were sampled using headwater or wading methods.

River Mile	Drain. Area	Cumulative Species	Relative Number	Relative Weight	QHEI	MIWb	IBI	Narrative Evaluation[a]
Upper Yellow Creek basin (WAU 05030101 180)								
Elk Fork *Recommended Use (CWH)*								
1.7	2.9	12	7,020	--	65.5	NA[b]	44	Good
Elk Lick *Recommended Use (CWH)*								
1.8	2.9	11	2,265	--	63.0	NA	46	Very Good
Yellow Creek *Headwaters to Upper North Fork Recommended Use (WWH)*								
30.1	14.4	17	2,548	--	65.5	NA	48	Very Good
27.6	25	31	2,776	27.2	73.0	10.2	46	Exceptional-V.Good
24.5	66	32	3,088	30.4	71.0	10.0	48	Exceptional-V.Good
Yellow Creek *Upper North Fork to North Fork Yellow Creek Recommended Use (EWH)*								
18.5	94	39	3,752	26.3	89	10.3	51	Exceptional
11.8	106	33	2,765	10.6	82	9.7	47	Exceptional-V.Good
Yellow Creek Tributary @ RM 30.22 *Recommended Use (CWH)*								
0.1	2.3	15	2,253	--	52	NA	48	Very Good
Goose Creek *Recommended Use (CWH)*								
1.9	2.5	10	1,538	--	63.0	NA	48	Very Good
0.2	5.8	13	4,355	--	73.5	NA	50	Exceptional
Cox Creek (*WWH* existing)*								
0.1	2.8	25	5,783	--	81.0	NA	48	Very Good
Wolf Run *Recommended Use (CWH)*								
1.5	3.3	13	1,268	--	69.0	NA	42[ns]	Marginally Good
Elkhorn Creek *Headwaters to Center Fork Recommended Use (EWH/CWH)*								
7.9	2.1	13	2,665	--	76.0	NA	52	Exceptional
6.8	7.4	19	3,252	--	50.0	NA	54	Exceptional
Elkhorn Creek *Center Fork to mouth Recommended Use (EWH)*								
0.2	33.5	30	13,493	57.4	95.0	11.0	50	Exceptional
Gault Run *Headwaters to Center Fork Recommended Use (CWH)*								
0.3	3.4	16	3,885	--	67.0	NA	52	Exceptional
Frog Run *Recommended Use (CWH)*								
0.1	2.0	9	4,230	--	56.5	NA	40[ns]	Marginally Good
Trail Run *Recommended Use (EWH/CWH)*								
0.3	3.3	18	2,518	--	63.5	NA	50	Exceptional

River Mile	Drain. Area	Cumulative Species	Relative Number	Relative Weight	QHEI	MIWb	IBI	Narrative Evaluation[a]
Center Fork *Recommended Use (EWH)*								
1.9	6.7	17	1,658	--	68.0	NA	50	Exceptional
0.1	12.5	29	6,058	--	64.5	NA	54	Exceptional
Strawcamp Run *Headwaters to Chase Rd. Recommended Use (EWH/CWH)*								
2.2	2.9	18	2,540	--	91.0	NA	48	Very Good
Strawcamp Run *Chase Rd. to mouth Recommended Use (EWH)*								
0.4	5.0	21	5,485	--	55.0	NA	48	Very Good
Upper North Fork *Headwaters to Hump Run Recommended Use (WWH)*								
5.7	3.6	19	8,418	--	53.5	NA	48	Very Good
Upper North Fork *Hump Run to mouth Recommended Use (CWH/EWH)*								
0.4	18.8	24	5,983	--	78.5	NA	58	Exceptional
Hump Run *Recommended Use (CWH/EWH)*								
0.5	6.9	20	3,953	--	78.0	NA	54	Exceptional
Hazel Run *Recommended Use (CWH)*								
0.2	3.0	14	2,065	--	73.0	NA	46	Very Good
Carroll Run *Recommended Use (CWH)*								
0.1	2.2	8	4,015	--	66.5	NA	48	Very Good
Ralston Run *Recommended Use (CWH/EWH)*								
0.3	5.6	18	2,951	--	71.5	NA	50	Exceptional
Long Run *Headwaters. to CR 54 Recommended Use (WWH)*								
4.3	4.1	13	3,053	--	74.5	NA	42[ns]	Marginally Good
Long Run *Hildebrand Run to mouth Recommended Use (CWH/EWH)*								
0.3	10.4	28	1,665	--	92.5	NA	60	Exceptional
Hildebrand Run (*WWH* existing*)								
0.1	1.7	11	1,700	--	66.5	NA	48	Very Good
Lower Yellow Creek basin (WAU 05030101 190)								
Yellow Creek *Recommended Use (EWH)*								
5.5	147	37	1,931	35.1	89.0	10.8	56	Exceptional
Yellow Creek *Recommended Use (WWH)*								
3.3	224	33	896	24.5	63.0	8.7	44	Good
Town Fork *Hdwtrs. to Jefferson Lake Recommended Use (CWH)*								
10.4	3.9	13	6,126	--	60.0	NA	46	Very Good
Town Fork *Jefferson Lake to mouth Recommended Use (EWH)*								
8.0	7.9	19	1,832	--	77.0	NA	52	Exceptional
5.1	16.1	21	5,112	--	79.0	NA	50	Exceptional
0.2	26	24	6,166	22.7	76.0	10.2	46	Exceptional-V.Good
Keyhole Run *Recommended Use (CWH/EWH)*								
0.1	2.8	12	1,420	--	72.0	NA	52	Exceptional

River Mile	Drain. Area	Cumulative Species	Relative Number	Relative Weight	QHEI	MIWb	IBI	Narrative Evaluation[a]
Brush Creek *Recommended Use (WWH)*								
8.8	4.3	13	1,694	--	69.0	NA	44	Good
Brush Creek *Recommended Use (CWH/EWH)*								
6.0	7.4	16	2,748	--	89.5	NA	50	Exceptional
0.8	15.3	24	2,432	--	81.0	NA	60	Exceptional
Dennis Run *Recommended Use (CWH/EWH)*								
0.3	2.2	13	1,338	--	74.0	NA	56	Exceptional
Riley Run *Hdwtrs. to Trib. @ RM 3.75 Recommended Use (WWH)*								
4.9	2.8	8	2,258	--	62.5	NA	42ns	Marginally Good
Riley Run *Riley Run T rib. @ RM 3.75 to mouth Recommended Use (CWH)*								
1.8	15.2	20	4,219	--	--	NA	56	Exceptional
Riley Run Trib. @ RM 3.75 *Recommended Use (CWH)*								
0.3	3.6	12	2,643	--	56.0	NA	44	Good
Nancy Run *Recommended Use (CWH/EWH)*								
2.2	3.4	12	1,230	--	71.5	NA	50	Exceptional
1.0	7.5	12	2,488	--	65.0	NA	46	Very Good
Roses Run *Recommended Use (CWH/EWH)*								
0.1	2.0	9	1,840	--	70.5	NA	48	Very Good
North Fork Yellow Creek *Recommended Use (WWH)*								
10.6	26.4	19	6,718	9.5	78.5	9.1	40	V.Good-M. Good
10.1	26.4	25	6,576	25.3	67.5	9.3	44	V.Good-Good
6.1	38.0	25	4,140	32.9	96.5	10.1	52	Exceptional
2.2	56.0	30	4,022	33.4	66.0	10.8	52	Exceptional
0.5	58.0	30	9,683	30.3	78.0	10.6	46	Exceptional-VGood
N. Fk. Yellow Cr. Trib. @ RM 9.65 *Recommended Use (CWH)*								
0.4	3.0	3	1,003	--	53.0	NA	<u>22</u>*	Poor
N. Fk. Yellow Cr. Trib. @ RM 8.96 *Recommended Use (CWH)*								
0.4	2.7	Dry Channel, Not Sampled				NA	NA	NA
N. Fk Yellow Cr. Trib.@ RM 6.08 *Recommended Use (CWH)*								
0.2	4.0	14	2,225	--	79.0	NA	50	Exceptional
Salt Run *Hdwtrs. to Irondale Recommended Use (CWH)*								
0.4	3.6	6	1,603	--	55.0	NA	40[ns]	Marginally Good
Randolf Run *Recommended Use (LRW)*								
0.2	2.2	Dry Channel, Not Sampled				NA	NA	NA
Salisbury Run *Recommended Use (CWH)*								
0.2	2.3	0	0.0	--	56.0	NA	<u>12</u>*	Very Poor
Hollow Rock Run *Recommended Use (CWH)*								
3.0	3.6	6	1,102	--	65.0	NA	42[ns]	Marginally Good
2.2	6.3	7	1,878	--	48.5	NA	44	Good

River Mile	Drain. Area	Cumulative Species	Relative Number	Relative Weight	QHEI	MIWb	IBI	Narrative Evaluation[a]
Tarburner Run *Recommended Use (CWH)*								
0.2	1.9	6	1,020	--	69.0	NA	46	Very Good
Ohio River Tributaries/Little Yellow Creek basin (WAU 05030101 100)								
Little Yellow Creek *Recommended Use (WWH)*								
11.1	2.8	13	1,818	--	71.0	NA	34*	Fair
6.7	8.2	10	1,212	--	63.5	NA	32*	Fair
3.5	17.1	11	3,336	--	61.0	NA	38*	Fair
Alder Lick Run *Recommended Use (WWH)*								
0.2	3.0	5	1,175	--	69.0	NA	40[ns]	Marginally Good
Bailey Run *Recommended Use (CWH)*								
0.7	2.5	5	591	--	83.5	NA	<u>24</u>*	Poor
Carpenter Run (Ohio R trib.) *Recommended Use (CWH)*								
1.6	3.0	2	1,266	--	59.5	NA	<u>24</u>*	Poor
Jethro Run (Ohio R. trib.) *Recommended Use (CWH)*								
0.2	2.7	20	1,501	--	57.5	NA	50	Exceptional
McQueen Run (Ohio R. trib.) *Recommended Use (CWH)*								
0.6	2.1	0	0	--	59.5	NA	<u>12</u>*	Very Poor
Wells Run (Ohio R. trib.) *Recommended Use (CWH)*								
0.4	2.1	0	0	--	54.0	NA	<u>12</u>*	Very Poor

Ecoregion Biocriteria (see Table 4): Western Allegheney Plateau (WAP)

* Significant departure from ecoregional biocriteria; poor and very poor results are underlined.
ns Nonsignificant departure from ecoregional biocriteria for WWH or EWH (<4 IBI or ICI units; <0.5 MIwb units).
[a] Narrative evaluation is based on both MIwb and IBI scores, respectively.
[b] MIwb score applies to wading method sites (*i.e.,* > 20 sq. mi. drainage area) only.

Macroinvertebrate Community Assessment

Macroinvertebrate sampling from the Yellow Creek study area was conducted in 43 streams at 75 stations, ranging in watershed size from 2 to 224 square miles (Table 19). ICI metrics scores and raw data are presented in Appendix 7 and 8. In the Yellow Creek basin assessment units (WAUs 180 and 190), significant impacts to the macroinvertebrates were generally rare and localized. Community performance fell mostly in the very good to exceptional ranges (61% of sites) and nearly all collections (86%) exceeded WWH criteria (*i.e.*, macroinvertebrate performance was in the good range or better). Exceptional quality communities were characterized by high ICI scores (where applicable) and high species richness, particularly among pollution sensitive and EPT taxa (i.e., mayflies, caddisflies and stoneflies). Exceptional communities were often predominated by sensitive populations, community structure was balanced and diverse, and populations were not indicative of significant water quality stress.

In addition to the almost pervasive high quality conditions across watersheds, communities at 43 of the 75 survey sites (57%) indicated coldwater habitat potential. Coldwater conditions for the macroinvertebrates were defined as sites supporting a minimum 4 coldwater taxa or 2 primary coldwater taxa if adequate numbers of coldwater fish were also present (3745-1-07 Beneficial use designations; currently under review). Of the 43 sites with sufficient coldwater populations, 95% were from small drainages (<20 sq. mi.) and over two thirds were less than five square miles.

In contrast to the Yellow Creek watershed, performance in WAU 100 (Little Yellow Creek/Ohio River Tributaries) was much lower. None of the nine sites sampled reflected better than good quality. Mining, impoundment, spills, and urban runoff along the Ohio River corridor were the primary reasons for the marginal performance. However, outside of the Little Yellow Creek mainstem, most small tributaries in the watershed reflected coldwater potential.

Upper Yellow Creek basin (WAU 180)

Macroinvertebrate sampling from WAU 180 was conducted in 19 streams from 32 stations, ranging in watershed size from 2 to 119 square miles. Artificial substrates were collected from 8 regional reference sites and/or, from all sites with drainages exceeding 20 square miles.

With the exception of two locations, all sites in WAU 180 met or exceeded WWH criteria (*i.e.,* good quality) and 50% of sites reflected exceptional quality or coldwater potential (Table 19; Figure 14). Coldwater communities were most commonly found in small drainages of 2-6 square miles (81% of coldwater sites) with the largest drainage at the mouth of Long Run (10.4 sq. mi.). Exceptional performance was also encountered primarily in the smaller drainages (81% of sites <10 sq. mi.). In addition, over one third (34%) of sites reflected both exceptional quality and coldwater conditions. These were considered the highest quality streams in the watershed and included Elk Fork, Elk Lick, lower Wolf Run (2006 sampling), Elkhorn Creek (RMs 7.9-6.7), Frog Run, Trail Run, Center Fork (RM 2.7), Strawcamp Run (RM 1.2), Hump Run, Ralston Run, and the lower reaches of Long Run (RM 0.1). All were relatively small drainages (< 10.4 sq. mi.) with natural or, largely unmodified stream channels, and sustained late summer flows.

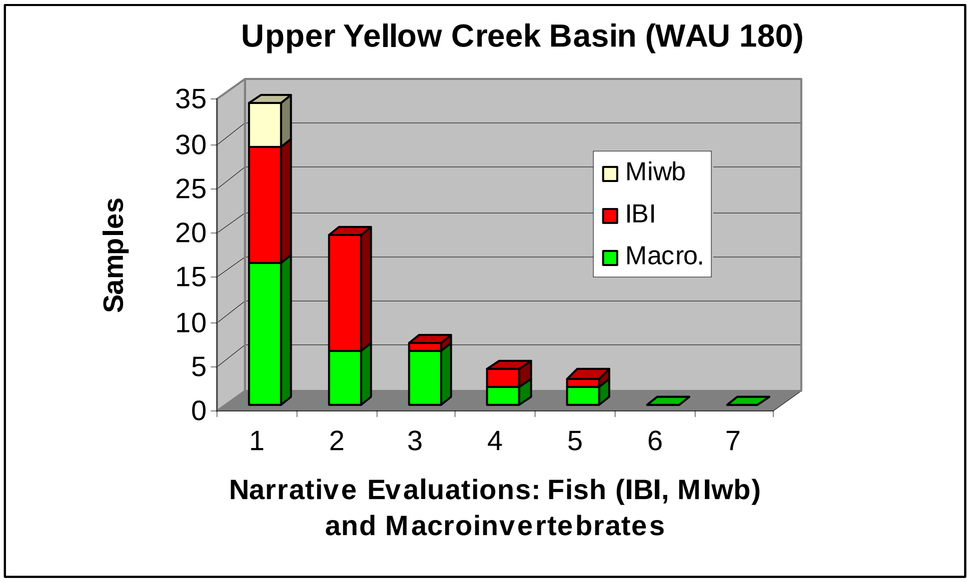


Figure 14. Narrative evaluations associated with fish (IBI and MIwb) and macroinvertebrate (ICI, Qual. Samples) site locations in the upper Yellow Creek basin (WAU 180), 2005-2006.

In the remainder of the upper watershed, very good to exceptional warmwater communities were collected at 3 of 5 sites in the Yellow Creek mainstem, in lower Elkhorn Creek (RM 0.2), Center Fork (RM 1.9-0.2), lower Strawcamp Run (RM 0.3), and Upper North Fork (RM 5.5). Warmwater streams with good qualtiy macroinvertebrates included Gault Run (RM 0.4) and Yellow Creek at RMs 30.1 and 24.3.

Macroinvertebrate performance fell below WWH standards at only two sites, 1) at the mouth of Cox Creek (RM 0.1) and 2) in the headwaters of Long Run (RM 4.3). Home septic tank drainage and natural, wetland conditions were the cause of impairment at the two sites, respectively.

Lower Yellow Creek basin (WAU 190)

Macroinvertebrate sampling from WAU 190 was conducted in 18 streams at 34 stations, ranging in size from 1.9 to 224 square miles (Table 19). Artificial substrates were collected from 10 regional reference sites or from monitoring sites with drainages exceeding 20 square miles. Narrative evaluations based on qualitative sampling collections were assigned to the remaining sites.

Macroinvertebrate collections from WAU 190 met or exceeded designated aquatic life criteria at 27 of 34 sites sampled (79%; Figure 15, Table 19). Like collections from

WAU 180, nearly half of the sites (16 sites; 47%) reflected exceptional quality and over half reflected coldwater conditions (18 sites; 53%). Like the upper Yellow Creek basin, coldwater communities were encountered in small drainages, averaging 6.2 mi^2 (range 1.9-26 mi^2). Nearly one third of sites in WAU 190 (10 of 34; 30%) reflected both exceptional quality and coldwater potential at the same locations. These streams were considered among the highest quality in the basin and included Keyhole Run, lower Brush Creek (RM 6.2, 0.1), Dennis Run, Nancy Run, Roses Run, North Fork Yellow Creek (RM 10.4), North Fork Yellow Creek Tributary at RM 9.65, and Salt Run upstream from Irondale (RM 0.8).

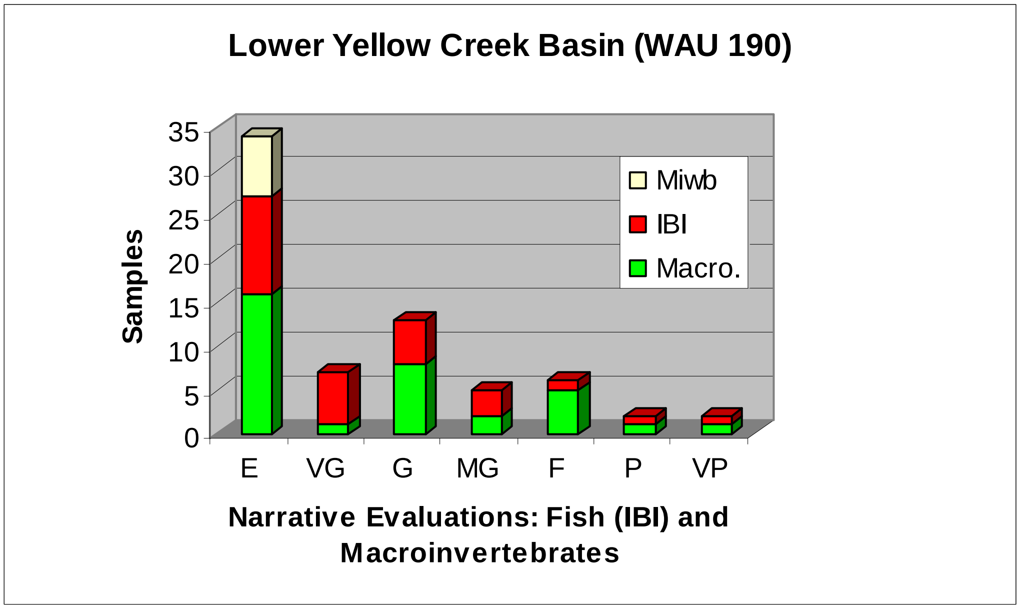


Figure 15. Narrative evaluations associated with fish and macroinvertebrate sampling in the lower Yellow Creek basin, 2005-2006.

Additional streams reflecting coldwater potential, but less than exceptional performance, included Town Fork (RM 10.4), Riley Run in Salineville (RM 1.8), Riley Run Trib. @ RM 3.75, North Fork Yellow Creek Trib. @ RM 8.96 (fair), Salisbury Run upstream from an AMD seep (RM 0.6), Hollow Rock Run, and Tarburner Run. The North Fork Trib. @ RM 8.96 was the only coldwater stream in WAU 190 with macroinvertebrate performance below the good range. Excessive siltation, possibly associated with mining, was a suspected source of impairment.

Macroinvertebrate performance fell below WWH standards (*i.e.,* fair) or recommended EWH standards at 7 sites in WAU 190. The WWH streams were Yellow Creek RM 3.3, Riley Run RM 4.9, North Fork Yellow Creek Trib. @ RM 8.96, North Fork Yellow Creek Trib.@ RM 6.08, Salisbury Run RM 0.1, and Salt Run RM 0.1. Town Fork is recommended EWH but reflected only marginally good quality in a de-watered reach at RM 8.1, immediately downstream from Jefferson Lake. Performance at one additional stream (Randolf Run) was fair but exceeded standards for the existing LRW aquatic life use designation.

Little Yellow Creek/Ohio River Tributaries (WAU 100)
Macroinvertebrate sampling from WAU 100 (Little Yellow Creek and direct Ohio River Tributaries; Little Beaver Creek to Yellow Creek) was conducted in 7 streams at 9 stations, ranging in size from 2.1 to 17.1 square miles. Because of the small stream size, sampling at all sites was limited to qualitative collections.

Macroinvertebrate collections from WAU 100 met or exceeded designated aquatic life criteria at 6 of 9 sites sampled (67%; Figure 16, Table 19). Unlike streams in the Yellow Creek basin, no macroinvertebrates from WAU 100 reflected better than good quality but over half (5 of 9 sites; 56%) reflected coldwater conditions. All coldwater sites were from very small drainages of less than 3 square miles.

Impairment to the macroinvertebrates was limited to Alder Lick Run, Wells Run, and Little Yellow Creek at RM 6.6. The Little Yellow Creek site appeared impaired by enrichment from decaying algae while the tributary sites were impacted by mine drainage. An additional tributary, Jethro Run was also impaired in 2005 as a result of a diesel fuel spill. However, resampling of the macroinvertebrates in 2006 found recovery was essentially complete and community health met minimum water quality standards.

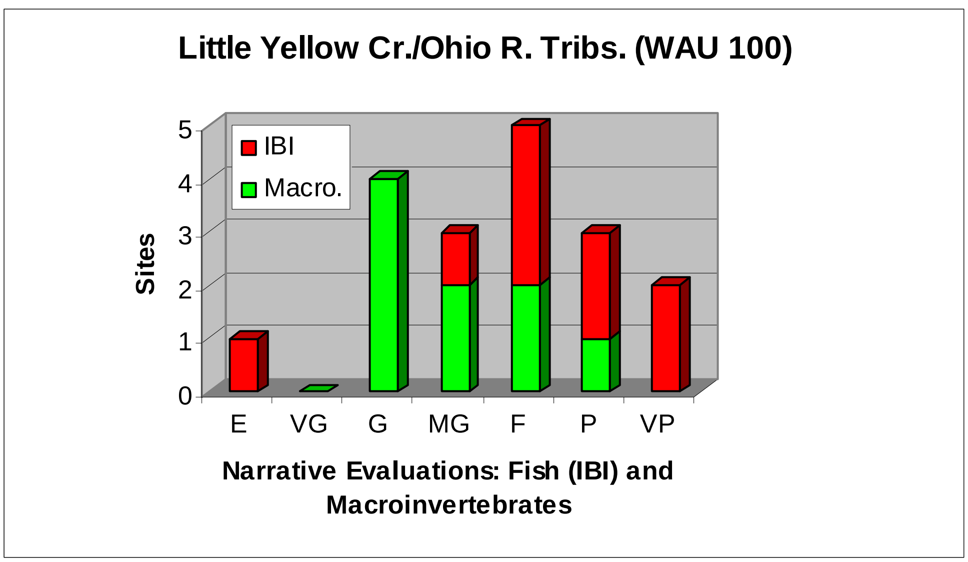


Figure 16. Narrative evaluations associated with fish (IBI) and macroinvertebrate (Qualitative) sampling in the Ohio River Tribs./Little Yellow Creek basin, (WAU 100) 2005-2006.

For additional information, see WATERSHED ASSESSMENT UNIT REPORTS and individual stream assessments for WAU 180, 190, and 100 on pages 95-133.

Table 19. Macroinvertebrate community characteristics in the Yellow Creek study area, 2005-2006.

Stream *Rec. Use* Riv. Mi.	DA	Quant. Taxa	Qual. Taxa	Qual. EPT	Sens. Taxa	Density #/Sq. Ft.	CW* Taxa	Predominant Populations [a] (Pollution Tolerance) [b]	ICI	Nar. Eval.
								Upper Yellow Creek basin (WAU 05030101 180)		
Elk Fork *CWH recommended*										
1.6	2.9	NA	50	13	27	Low	6	Mayflies (MI) Caddisflies (MI, F), Riffle beetles (MI)	--	Excep.
Elk Lick *CWH recommended*										
1.7	2.9	NA	51	17	23	Low	5	Baetid mayflies (MI, F), netspinner caddisflies (MI, F)	--	Excep.
Yellow Creek *Headwaters to Upper North Fork WWH*										
30.1	14.4	NA	37	14	11	Low	1	Netspinner caddisflies (MI, F)	--	Good
27.6	25	29	31	9	13	293	2	Netspinner (MI, F) and *Chimarra* [fingernet caddisfly (MI)]	46	Excep.
24.3	66	25	32	8	13	918	0	*Chimarra* [fingernet caddisfly (MI)]	36	Good
Yellow Creek *Upper North Fork to North Fork Yellow Creek EWH recommended*										
18.0	94	31	32	11	15	435	1	*Chimarra* [fingernet caddisfly (MI)]	44	V.Good
11.8	119	38	29	8	11	432	1	*Chimarra* [fingernet caddisfly (MI)]	42	V.Good
Yellow Creek Tributary @ RM 30.22 *CWH recommended*										
0.1 (2006)	2.3	NA	46	15	13	Low	5	Midges (MI, F), netspinner caddisflies (F)	--	Good
Goose Creek *CWH recommended*										
1.9	2.5	NA	27	7	11	Low	5	Netspinner caddisflies (MI, F), Diptera larvae (MI)	--	M.Good
0.3	5.8	NA	47	6	17	Low	5	Netspinner caddisflies (F), Midges (MI, F)	--	M.Good
Cox Creek *WWH* (use recommendation deferred)*										
0.1	2.8	NA	39	5	8	Low	1	Netspinner caddisflies (F)	--	Fair
Wolf Run *CWH recommended*										
1.3 (2006)	3.3	NA	47	18	22	Low	12	Netspinner caddisflies (MI, F), Diptera larvae (MI, F), *Leuctra* (cw stonefly (I)	--	Excep.
Elkhorn Creek *CWH/EWH recommended*										
7.9	2.1	NA	51	18	27	Low	8	Mayflies (MI), Diptera larvae (MI), Midges (MI, F)	--	Excep.
6.7	7.4	43	47	13	21	Mod.	6	Netspinner caddisflies (F), Midges (MI), Mites (F)	56	Excep.
0.2	33.5	38	38	14	17	Mod.	0	Netspinner (MI, F) and *Chimarra* [fingernet caddisfly (MI)] , Mayflies (MI, F)	54	Excep.
Gault Run *WWH recommended*										
0.4	3.4	NA	34	13	11	Low	1	Mayflies (MI, F)	--	Good
Frog Run *CWH recommended*										
0.1 (2006)	2	NA	58	22	25	Low	5	*Chimarra* [fingernet caddisfly (MI)], Mayflies (MI, F)	--	Excep.
Trail Run *CWH/EWH recommended*										
0.3	3.3	42	51	13	23	Mod.	8	Netspinner (MI, F) and *Chimarra* [fingernet caddisfly (MI)]	54	Excep.
Center Fork *EWH recommended*										
2.7	4.3	NA	51	16	25	Low	4	Riffle beetles (MI, F), *Chimarra* [fingernet caddisfly (MI)], Mayflies (MI, F)	--	Excep.

Stream *Rec. Use* Riv. Mi.	DA	Quant. Taxa	Qual. Taxa	Qual. EPT	Sens. Taxa	Density #/Sq. Ft.	CW* Taxa	Predominant Populations [a] (Pollution Tolerance) [b]	ICI	Nar. Eval.
1.9	6.7	NA	36	16	18	Mod.	1	Netspinner caddisflies (MI, F), Mayflies (MI, F), *Chimarra* [fingernet caddisfly (MI)]	--	V.Good
0.1	12.5	44	48	16	22	Mod.	3	Netspinner (MI, F) and *Chimarra* [fingernet caddisfly (MI)]	60	Excep.
Strawcamp Run *Headwaters to Chase Rd. CWH/EWH recommended*										
1.2	4.2	NA	70	24	38	Low	10	Baetid mayflies (MI. F), *Leuctra* (cw stonefly (I), Caddisflies (MI, F)	--	Excep.
Strawcamp Run *Chase Rd. to mouth EWH recommended*										
0.3	5.2	35	40	15	17*	Low	2*	*Chimarra* [caddisfly (MI)], *Optioservus*[riffle beetle (MI)]	--	VGood
Upper North Fork *Headwaters to Hump Run WWH recommended*										
5.5	3.6	NA	42	12	19	Low	1	Stenelmis [riffle beetle (F)], *Chimarra* [fingernet caddisfly (MI)]	--	V.Good
Upper North Fork *Hump Run to mouth CWH/EWH recommended*										
0.3	18.8	NA	45	13	21	Low	2	*Optioservus* [riffle beetle (MI)]	--	V.Good
Hazel Run *CWH recommended*										
0.6 (2006)	2	NA	46	17	25	Mod.	3	Baetid mayflies (MI. F), netspinner caddisflies (F)	--	Excep.
Carroll Run *CWH recommended*										
0.1	2.2	NA	48	9	16	Low	3	Midges (MI, F), Mayflies (MI), netspinner caddisflies (MI)	--	Good
Hump Run *CWH/EWH recommended*										
0.1	7	NA	44	14	28	Mod.	6	*Glossosoma* [cw caddisfly (MI)], *Leuctra* [cw stonefly (I)], netspinner caddisflies (MI)	--	Excep.
Ralston Run *CWH/EWH recommended*										
0.3	5.6	NA	43	18	20	High	3	Mayflies (MI, F), netspinner caddisflies (MI, F)	--	Excep.
Long Run *Headwaters. To Hildebrand Run WWH recommended*										
4.3	4.1	NA	46	7	7	Mod.	1	*Chimarra* [fingernet caddisfly (MI)], burrowing mayflies (MI), scuds (F), Damselflies (T)	--	Fair
2.7	6.3	NA	43	15	16	Mod.	4	Mayflies (MI), *Leuctra* [cw stonefly (I)], *Sialis* [alderfly (F)]	--	Good
Long Run *Hildebrand Run to mouth CWH/EWH recommended*										
0.1	10.4	NA	50	23	26	Mod.	4	Mayflies (MI), *Leuctra* [cw stonefly (I)]	--	Excep.
Lower Yellow Creek basin (WAU 05030101 190)										
Yellow Creek *EWH recommended*										
5.7	147	38	47	17	26	451	1	Mayflies (MI, F), *Chimarra* [fingernet caddisfly (MI)], Water Mites (F)	56	Excep.
3.4	175	39	28	11	12	1029	0	Mayflies (MI, F), Water Mites (F)	50	Excep.
Yellow Creek *WWH recommended*										
3.3 (2006)	224	32	37	11		1545	0	Water Mites (F), *Baetis* [mayfly (F)]	24	Fair
Town Fork *Hdwtrs. to Jefferson Lake CWH recommended*										
10.4	3.9	NA	50	14	23	Mod.	7	Mayflies, (MI, F), netspinner caddisflies (MI, F), Midges (MI, F)	--	V.Good
Town Fork *Jefferson Lake to mouth EWH recommended*										
8.1	7.9	NA	28	7	9	High	1	*Chimarra* [fingernet caddisfly (MI)], Midges (MI)	--	M.Good
5.3	16.1	NA	52	22	25	High	3	*Chimarra* [fingernet caddisfly (MI)], Mayflies (MI)	--	Excep.
0.2	26	32	26	13	21	Mod.	1	Caddisflies (MI, F), Mayflies (MI, F)	52	Exxep.
Keyhole Run *CWH/EWH recommended*										

Stream *Rec. Use* Riv. Mi.	DA	Quant. Taxa	Qual. Taxa	Qual. EPT	Sens. Taxa	Density #/Sq. Ft.	CW* Taxa	Predominant Populations [a] (Pollution Tolerance) [b]	ICI	Nar. Eval.
0.1	2.8	NA	41	14	23	Low	10	*Gammarus* [cw scud (F)], *Leuctra*[cw Stonefly (I)]	--	Exxep.
Brush Creek *WWH recommended*										
9.7	2.3	NA	38	10	13	Low	3	*Baetis* [mayfly (F)], *Optioservus* [riffle beetle (MI)]	--	M.Good
Brush Creek *CWH/EWH recommended*										
6.2	7.4	NA	43	18	26	Mod.	4	Mayflies (MI, F), netspinner caddisflies (MI)	--	Exxep
0.1	15.3	NA	50	20	26	High	5	Mayflies (MI, F), netspinner caddisflies (MI, F)	--	Exxep
Dennis Run *CWH/EWH recommended*										
0.2	2.3	NA	37	13	23	Mod.	10	Netspinner caddisflies (MI, F), *Hexatoma* [cranefly (MI)], *Isonychia* [brush-legged mayfly MI)]	--	Exxep
Riley Run *Hdwtrs. to T rib. @ RM 3.75 WWH recommended*										
4.9	2.8	NA	16	2	6	Low	0	*Atherix* [snipe fly (MI)], Red midges (T-MI)	--	Poor
Riley Run *Riley Run T rib. @ RM 3.75 to mouth CWH recommended*										
1.8	15.2	NA	41	13	20	Mod.	4	Caddisflies (MI, F), *McCaffertium vicarium* [mayfly (MI)]	--	Good
Riley Run Trib. @ RM 3.75 *CWH recommended*										
0.3	3.6	NA	48	11	19	Low	4	Netspinner caddisflies (F), Midges (MI, F)]	--	Good
Nancy Run *CWH/EWH recommended*										
2.2	3.4	NA	55	21	28	Low	3	*Ceratopsyche slossonae* [cw caddisfly (MI)], myflies (MI, F)	--	Excep.
1.2	7	40	53	19	26	Mod.	6	Coldwater caddisflies (MI)], *Leuctra* [cw stonefly (I)], Mayflies (MI)	46	Excep.
Roses Run *CWH/EWH recommended*										
0.1	2	NA	39	16	20	Mod.	7	*Doliphiloides* [cw caddisfly (MI)], *Leuctra* [cw stonefly (I)], Mayflies (MI)	--	Excep.
North Fork Yellow Creek *WWH*										
10.4	26	33	29	11	14	117	4	Caddisflies (MI, F), Mayflies (MI, F)	50	Excep.
10.1	26	34	39	12	15	728	2	*Rheotanytarsus* [filter-feeding midge (MI)], netspinner caddisflies (MI, F)	48	Excep.
6.2	38	39	34	14	15	128	1	Mayflies (MI, F)	50	Excep.
2.2	56	38	40	12	16	165	2	*Atherix* [snipe fly (MI)], *McCaffertium vicarium* [mayfly (MI)]	34	M.Good
0.7	58	37	25	12	12	214	0	*Baetis* [mayfly (F)], netspinner & fingernet caddisflies (MI, F)	--	Good
North Fork Yellow Cr. Trib. @ RM 9.65 *CWH recommended*										
0.4	3	NA	48	21	24	Mod.	6	Maylfies (MI), *Leuctra* [cw stonefly (I)], *Doliphiloides* [cw caddisfly (MI)]	--	Excep.
North Fork Yellow Cr. Trib. @ RM 8.96 *CWH recommended*										
0.2	2.7	NA	26	5	8	Low	7	Craneflies [coldwater (MI), (F)]	--	Fair
North Fork Yellow Cr. Trib.@ RM 6.08 *CWH recommended*										
0.2	4	NA	17	5	10	Low	2	Oligochaetes (T), Red Midges (MI)	--	Fair
Salt Run *Hdwtrs. to Irondale CWH recommended*										
0.8 (2006)	3.6	NA	57	19	36	Mod.	11	*Leuctra* [cw stonefly (I), other coldwater mayflies and caddisflies (MI)	--	Excep.
Salt Run *Irondale to mouth WWH recommended*										
0.1	3.9	NA	26	3	5	Mod.	0	*Physella* [lunged snail (T)], water mites (F)	--	Fair
Randolf Run *LRW*										

Stream *Rec. Use* Riv. Mi.	DA	Quant. Taxa	Qual. Taxa	Qual. EPT	Sens. Taxa	Density #/Sq. Ft.	CW* Taxa	Predominant Populations [a] (Pollution Tolerance) [b]	ICI	Nar. Eval.
0.2	2.2	NA	34	6	9	Low	2	*Chironomus* [red midges (T)]	--	Fair
Salisbury Run *CWH recommended*										
0.6	2.2	NA	22	11	13	Mod.	5	*Gammarus* [cw scud (F)], *Leuctra* [cw stonefly (I)]	--	Good
0.1	2.3	NA	1	0	0	None	0	None	--	V.Poor
Hollow Rock Run *CWH recommended*										
3.0	3.6	NA	33	10	11	Mod.	7	*Leuctra* [cw stonefly (I)], *Gammarus* [cw scud (F)]	--	Good
2.0	6.4	NA	25	8	9	Mod.	4	*Gammarus* [cw scud (F)], *Ceratopsyche slossonae*[cw caddisfly (MI)]	--	Good
Tarburner Run *CWH recommended*										
0.1	1.9	NA	19	7	9	High	5	*Gammarus* [cw scud (F)], *Leuctra* [cw stonefly (I)]	--	Good
<u>Ohio River Tribs./Little Yellow Creek basin</u> (WAU 05030101 100)										
Little Yellow Creek *WWH*										
11.3	2.8	NA	44	10	9	Low	1	Mayflies (F)	--	Good
6.6	8.2	NA	42	7	10	Low	1	Netspinner caddiflies (F), riffle beetles (MI), crayfish (F)	--	Fair
3.3	17.1	NA	44	1`7	16	Mod.	1	Netspinner caddiflies (MI, F), mayflies (MI,F)	--	Good
Alder Lick Run *CWH recommended*										
0.2	3	NA	13	5	5	Mod.	2	*Gammarus* [cw (F)], *Chimarra* [fingernet caddisfly (MI)]	--	Fair
Bailey Run *CWH recommended*										
0.7	2.5	NA	25	10	10	Low	6	Netspinner & fingernet caddisflies (MI, F)	--	M.Good
Carpenter Run (Ohio R trib.) *CWH recommended*										
2.2	2.2	NA	51	14	15	High	7	*Gammarus*[cw scud (F)], *Physella*[lunged snail (T)]	--	Good
Jethro Run (Ohio R. trib.) *CWH recommended*										
0.1	2.7	NA	27	6	8	High	5	*Gammarus* [cw (F)], *Baetis tricaudatus* [cw mayfly (MI)]	--	M.Good
McQueen Run (Ohio R. trib.) *CWH recommended*										
0.6	2.1	NA	27	13	15	Mod.	9	*Gammarus* [cw scud (F)], *Baetis tricaudatus* [cw mayfly (MI)], other mayflies (MI, F)	--	Good
Wells Run (Ohio R. trib.) *CWH recommended*										
0.3	2.2	NA	7	3	4	Vlow	5	None; a few *Gammarus* [cw scud (F)]	--	Poor

* CW = Coldwater

a Predominant Organisms listed are based largely on natural substrate (Qualitative) sampling field observations.

b Pollution Tolerance Ratings: I = Intorlerant, MI = Moderately Intolerant, F = Facultative, T = Tolerant, VT = Very Tolerant

STREAM SITE ASSESSMENTS (WAUs 180, 190, 100)

Upper Yellow Creek Watershed: Headwaters to Town Fork (WAU 05030101-180)

Table 20 Summary of Upper Yellow Creek study area watershed assessment unit scoring (WAU-180). The assessment unit score is an average grade of aquatic life use status. A maximum assessment unit score of 100 is possible if all monitored sites meet designated aquatic life uses. The method of calculation is presented in the 2008 Integrated Water Quality Monitoring and Assessment Report.

Upper Yellow Creek WAU (Hdwaters to Town Fork) (05030101 180)	Aquatic Life Attainment Status							Assessment Unit Score
	Total	Full		Partial		NON		
	31	#	%	#	%	#	%	
Sites ≤ 50mi² drainage area	28	26	92.9	2	7.1	0	0	96
Miles of assessed streams with > 50mi² and < 500mi² drainage area	17.1	3	100	0	0	0	0	

Comments

Large proportions of the assessment unit fully met the existing or recommended aquatic life use designations and a majority of sites (72%) reflected exceptional and/or coldwater potential. Despite fairly pervasive agricultural land usage along valley floors (cattle, pasture), elevated fecal coliform levels (particularly near unsewered communities), and land disturbance from past and present mining activity, most streams performed at high levels. Cool water temperatures, high groundwater recharge resulting in sustained summer flows, and intact stream habitat appeared to result in remarkable assimilative capacity and minimal impairments instream. Since 1983, biological and water quality conditions in upper Yellow Creek and Wolf Run have exhibited dramatic improvement, primarily a result of mine reclamation and natural attenuation of the disturbed landscape. Biological impairment in the upper Yellow Creek basin was limited to one tributary impacted by domestic sewage (Cox Creek) and the headwaters of Long Run, which were naturally limited by wetland conditions and beaver dam impoundment.

Two additional sites of less than 50mi² were sampled that did not meet credible data requirements to completely evaluate aquatic life status (lack of fish data). The sites supported exceptional (Center Fork RM 2.7) and good (Long Run RM 2.7) macroinvertebrate assemblages.

Introduction

The Yellow Creek headwaters (WAU 05030101-180) cover portions of eastern Carroll County and northern Jefferson County and drain a total of 118.7 mi². The watershed unit includes the upper 22.85 miles of the Yellow Creek mainstem from its source, formed by the confluence of Elk Fork and Elk Lick at RM 31.6, to just upstream Town Fork (RM 8.75). Other major tributaries sampled included the Elkhorn Creek basin, Wolf Run, Upper North Fork basin, Ralston Run, and Long Run. There are no permitted dischargers within the WAU. Amsterdam and Bergholz are the largest villages but lack a central sewage collection for treatment of sanitary wastes; both rely on individual systems for wastewater treatment and disposal. The remainder of the basin is rural with occasional small clusters of homes. Deciduous forest accounts for over 60 percent of the land use with pasture and hay comprising 15-30 percent. Row crop agriculture and mining comprise the remaining land use.

Fish, macroinvertebrates, water chemistry, bacteria levels, and stream habitat conditions were evaluated throughout the WAU. Causes and sources of impairment at sampling sites with biological impairment (i.e., partial or non-attainment) are summarized in Table 5. Most sites had six sets of chemical samples collected at two week intervals. Bacteria were tested to assess attainment of recreational use.

Biological Impairment

Biological performance fell below standards at only two locations in the upper Yellow Creek watershed (Table 5). The headwaters of Long Run (RM 4.2) were in the marginally good (fish) to fair ranges (macroinvertebrates) with impairment considered largely a function of the natural, wetland influences and beaver dam impoundment. The marginal performance was not indicative of significant water quality problems. In contrast, partial attainment in Cox Creek was related to the fair macroinvertebrate collections found immediately downstream from on-site home septic tank drainage. Significant WQS exceedences for ammonia and highly elevated coliform levels were also recorded. Fish sampled upstream from the discharge were unaffected and reflected very good quality.

Individual Stream Site Assessments

<u>Upper Yellow Creek mainstem (Headwaters to Town Fork)</u>

Chemical samples were collected from five mainstem sites, starting upstream from Goose Creek in Amsterdam (RM 30.0), and at various points downstream to RM 11.8. A WQS exceedence for lead (14.8 ug/l) and elevated iron concentrations (ranging from 1240 ug/l to 3970 ug/l) were found at the most upstream site. The source of lead is unknown but concentrations were below detection at both Elk Lick and Elk Fork stations approximately three miles upstream. Potential nonpoint sources between the sites include a large concentration of unrestricted cattle in lower Elk Lick and septic tank drainage from Amsterdam. An active septic tank discharge was observed just upstream from the RM 30.0 chemical site and a storm sewer discharged continuously immediately downstream, near the confluence with Goose Creek. The influence of the unsewered village was apparent in the bacteria results collected immediately below the discharge (RM 29.84) and for several miles further downstream (Table 14).

Iron also increased slightly at RM 11.8 during the August sampling dates, but declined to the levels seen early in the sampling runs by the end of field season. The RM 11.8

site was well downstream from mining activity near Bergholz but immediately downstream from a series of AMD sources including two small AMD tributaries at RM 12.0 (Figure 10) and 12.25 and mine drainage via Roach Run at RM 12.83.

Yellow Creek macroinvertebrates were sampled at five locations within WAU 180 from the headwaters, immediately upstream from Amsterdam and Goose Creek (RM 30.1), to CR 53, immediately upstream from Long Run (RM 11.2). Macroinvertebrate health ranged from good (ICI=36) to the lower exceptional range (ICI = 46) throughout the reach. While the macroinvertebrates marginally met EWH criteria at most sites, further improvements and clearly exceptional ICI scores were noted at additional downstream sites in WAU 190 (Table 19). The trend of gradual improvement with increased distance downstream is likely a reflection of increased distance downstream from point and nonpoint sources including mining operations (both active and abandoned), livestock operations, and septic tank discharges in the upper basin. In addition, deposits of yellow boy and a slight decline in the ICI score were noted at RM 11.0, immediately downstream from AMD discharges between RMs 12.83 and 12.0 (Figure 10). Communities at RM 11.8 may reflect a slight, isolated impact from these localized sources.

Yellow Creek fish communities were generally in the very good and exceptional ranges from Amsterdam to Bergholz (RMs 30.1-24.5) and exceptional range downstream from Bergholz and through the remainder of WAU 180 sites. Like the macroinvertebrates, a slight decline in the IBI score at RM 11.0 may indicate a localized mining influence.

Habitat quality was adequate for WWH attainment upstream between Amsterdam and Bergholz (mean QHEI=69.8). Further downstream, between Bergholz and Town Fork, physical habitat reflected EWH potential with a mean QHEI score of 85.5.

Elk Lick and Elk Fork

Elk Fork and Elk Lick are small rural drainages (4-6 sq.mi.) that originate south of Amsterdam in Carroll County and form the headwaters of Yellow Creek. Land use is primarily a mix of forest, pasture and cattle operations. Unrestricted cattle access is extensive in lower Elk Lick but most livestock were located downstream from the RM 1.7 sampling site. Fewer cattle were found in Elk Fork but hillside erosion and cattle herds were observed along the ridge top, immediately adjacent to the RM 1.6 sampling site. No WQS exceedences and no apparent water quality problems were detected in chemical samples from the two streams.

Both fecal coliform and *E. coli* levels were elevated in Elk Lick and the stream was considered in non-attainment of the recreational use. Septic tank drainage from residences immediately upstream was considered the most likely source of bacteria since cattle appeared limited to downstream reaches. Elk Fork bacteria were Full/Target, meaning levels of one parameter, fecal coli or *E. coli*, exceeded standards.

Biological communities were in the very good to exceptional ranges and reflected CWH potential ($\geq$4 coldwater macroinvertebrate taxa, 1-2 coldwater fish) in both streams.

Yellow Creek Trib. @ RM 30.22

This small (<3 sq.mi.), unnamed tributary in Carroll County enters Yellow Creek on the north side of Amsterdam at RM 30.22. The watershed is largely forested and undeveloped except for an unsewered residential area at the mouth. Water chemistry and biological sampling was conducted in the residential area at Bear Road (RM 0.1). During chemical sampling, one dissolved oxygen measurement fell below the minimum standard for the recommended, CWH use (*i.e.*, <6 mg/l) and BOD_5 levels were consistently above the detection limit of 2.0 mg/l, ranging from 2.2 to 8.0 mg/l. Bacteria levels were consistently elevated and the stream was considered in non-attainment of the recreational use. Septic tank drainage appeared the primary source of impairment. Lot sizes are small, limiting the type of sewage treatment that may be serving homes in this area.

Fish communities were largely unaffected by the septic tank discharges and residential development near the mouth. Historic channelization and riparian removal was common in the neighborhood and, based on QHEI score (52), habitat quality was marginal for support of WWH communities. However, the IBI score of 48 (very good range) demonstrated that habitat and water quality conditions were not particularly deleterious to performance. Fish collections included populations of two coldwater species, an indication of cool, sustained flows. Macroinvertebrates were sampled immediately downstream from a pond overflow near Bear Road in 2005 and community performance was marginal for both WWH and CWH attainment (fair to marginally good quality; one coldwater taxon). However, the stream was resampled in 2006 slightly further downstream and collections clearly indicated both good quality (15 EPT taxa) and coldwater potential (5 coldwater taxa). The 2005 sample near the pond was considered anomalous and not typical of normal stream conditions. The fact that coldwater conditions were documented near the mouth was considered strong evidence for extending the designation upstream since residences and stream modifications were absent from all but the most downstream reach.

Goose Creek

Goose Creek flows through Amsterdam from the south and enters Yellow Creek at RM 29.85. Older septic systems, which may be outdated, are characteristic of this area, and the stream carries raw or partially treated sewage through the Village. Discharging storm sewers were noted in dry weather during the 2005 sampling period. Bacteria levels were extremely high in Yellow Creek, just downstream from the confluence.

Chemistry and biology were sampled at two locations in the tributary. The upper site at RM 1.9 was rural and actively mined while the downstream site at RM 0.2 was located within Amsterdam. Based on the rankings of selected mine drainage parameters described in Table 9, mining in the headwaters was reflected by moderately elevated conductivity at the upper site, averaging about 1000 umhos/cm, and slightly elevated concentrations of sulfate, manganese and iron. Dissolved oxygen violations were encountered on one occasion at both RM 1.9 (< minimum CWH criterion) and RM 0.2 (< minimum EWH criterion). Both Goose Creek sites were in non-attainment of the recreational use with elevated levels of both fecal coliform bacteria and *E. coli*. Concentrated septic tank drainage in Amsterdam was an obvious source at the downstream site; scattered small homes and farms appeared the most likely sources in the upper watershed but further investigation is required.

Despite chemical and bacteriological impacts, Goose Creek fish communities appeared largely unaffected and reflected very good to exceptional quality (IBI = 48-50 at RMs 1.9 and 0.2, respectively). Collections also included a high percentage of coldwater fish with an average 28.3% mottled sculpin, redside dace and redbelly dace. Macroinvertebrate performance was lower than the fish (marginally good) but collections included 5 coldwater species at each location. Lower performance appeared related to mining upstream and septic tank drainage near the mouth. At the upstream site, a crusty, sulfite precipitate and fine silt deposition covered much of the stream bottom. Mayflies were nearly absent from the RM 1.9 and, as a group, are considered quite sensitive to high conductivity levels (Pond, *et. al.* 2006). Mining influences were not as visually apparent downstream in Amsterdam but community health was unimproved.

<u>Cox Creek</u>
Cox Creek is another small tributary that enters Yellow Creek at RM 29.06, just north of Amsterdam. The tributary is rural in nature, but flows through a hollow with several homes clustered along T-275, upstream from the SR 164 sampling site (RM 0.1). The homes are on septic systems and the collective effluents enter Cox Creek immediately upstream from the sample location (Ohio EPA 2007, field observation). One sampling run showed particularly high levels of ammonia (9.69 mg/l), copper (33 ug/l), total kjeldahl nitrogen (TKN) (11.2 mg/l), total phosphorus (2.3 mg/l), and BOD_5 (7.9 mg/l), which were not seen on previous or subsequent sampling events.

Biological results varied substantially between the fish (very good; 3 coldwater species) and macroinvertebrates (fair) but it is believed differences are related to sampling location. Fish were collected entirely upstream from the septic tank discharges while most macroinvertebrate sampling was conducted downstream. Macroinvertebrate collections were predominated by pollution tolerant varieties and suggested impacts from organic wastes.

<u>Wolf Run</u>
Wolf Run flows into Yellow Creek at RM 27.18, south of Bergholz. The RM 1.5 sampling location appeared to be mine drainage impacted with orange, iron-stained sediments, coal fines, and an opaque, white haze in the water column, possibly related to a metals precipitate. However, chemical parameters were not strongly characteristic of acid mine drainage; pH levels were consistently near 7.5 and, based on the rankings of selected mine drainage parameters described in Table 9, manganese, sulfate and

conductivity concentrations were only slightly elevated. Aluminum concentrations were also well within water quality standards but the mean concentration (736 ug/l) was the second highest in the survey. Only Wells Run, an AMD impacted tributary on the Ohio River, had a higher mean concentration (1,048 ug/l). The orange sediments observed at RM 1.5 were not apparent near the mouth, or during subsequent macroinvertebrate sampling conducted at RM 1.3 in 2006. Bacteriological sampling indicated full attainment of the recreational use.

Wolf Run was originally designated LRW due to the extensive abandoned mine lands (underground mining) and acid mine drainage impacts in the watershed. As recently as 1983, fish and macroinvertebrates were very poor and populations were virtually absent (see *Yellow Creek and Wolf Run Trend Assessment* on page 106). The most recent survey shows significant improvement in both organism groups.

Macroinvertebrates sampled at RM 1.5 in 2005 were of marginal quality (7 EPT taxa) but included 5 coldwater varieties. The site was located in open pasture and, as mentioned above, substrates were iron stained, an indication of mining sources upstream. A decision was made to resample in 2006 and a site was selected a short distance downstream (at RM 1.3) under more natural habitat conditions. Community performance was higher in 2006 as collections reflected exceptional quality (18 EPT and 22 sensitive taxa) and included 12 coldwater varieties.

Fish communities also improved from very poor in 1983 to marginally good in 2005; these conditions will likely improve with time, particularly if additional reclamation work is conducted upstream. Despite the physical indications of mine drainage, 13 fish species were present among 507 individuals, including pollution intolerant hogsuckers and southern redbelly dace (a coldwater indicator). The marginal quality and absence of additional coldwater fish species likely reflects residual mining influences and gradual, but incomplete, recovery. Addressing the continued, but now more localized AMD impacts from the “Route 43 Washer” site (RM 3.0) would likely speed recovery.

<u>Elkhorn Creek</u>

Elkhorn Creek enters Yellow Creek at RM 25.85, on the south side of Bergholz. The stream drains 33.5 square miles and is 8.9 miles in length. Three sites were sampled for chemistry and biology at RMs 7.9, 6.2, and 0.1. Except for slight excursions from the more stringent coldwater D.O. standard at RMs 7.9 and 6.2 and elevated bacteria levels (see below), no significant chemical water quality problems were detected. Iron and manganese were elevated on one sampling event at RM 7.9 and increased values of these same parameters were occasionally noted at the other two locations. None of the values exceeded water quality standards.

Bacteria sampling revealed non-attainment of the recreational use at all three sites. Extensive areas of unrestricted cattle and livestock access were observed between Plane Rd (RM 7.9) and SR 43 (RM 6.8) and manure application was observed in a field adjacent to RM 6.7. Unrestricted livestock access and a feedlot were also located in the lower reaches of Gault Run, an Elkhorn Creek tributary at RM 7.8. A few houses on septic systems are scattered along the stream's length but cattle appeared the most pervasive nonpoint source.

Despite potential nonpoint source impacts from livestock, biological performance was consistently exceptional throughout the length of Elkhorn Creek (Table 4). In addition, communities were indicative of coldwater potential in the upper reaches at RMs 7.9 and 6.8. An average of 7 coldwater macroinvertebrates and 2.5 coldwater fish, accounting for 19.5% of the communities, were found at the upstream sites. While exceptional quality was maintained at the mouth, coldwater macroinvertebrates were absent and coldwater fish populations (1.8%) were substantially reduced. A specific reason for the loss of coldwater characteristics is unknown.

Gault Run

Gault Run is a small tributary (3.4 sq. mi.) that discharges to upper Elkhorn Creek at RM 7.8. Chemical and biological sampling was conducted near the mouth at RMs 0.3-0.4. Land use in the lower reach was predominantly pastured with unrestricted livestock access, feedlots, and horse barns immediately adjacent to the stream. Despite the potential for water quality and stream habitat impacts, no chemical WQS violations were detected and biological communities were in the good (macroinvertebrate) to exceptional (fish) ranges. Bacteria levels were elevated and the stream was in non-attainment of the recreational use.

Strawcamp Run

Strawcamp Run discharges to Elkhorn Creek at RM 3.70. Two sites were sampled on this stream; one was at RM 1.2 (Chase Rd.) and a second near the mouth at RM 0.3. Dissolved oxygen was a minor issue at both locations while Chase Road had elevated levels of aluminum, arsenic, barium, lead, iron, manganese, and zinc on one sampling date (7/26/05). The source of this apparent slug of metals is unknown and further investigation may be warranted. Fish and macroinvertebrate communities appeared unaffected by the metals. The IBI score at both locations was 48 (very good), and macroinvertebrates were rated very good to exceptional. Although the average bacteria numbers were not elevated, a limited number of homes upstream from Bay Road may be the source of occasional spikes in bacteria recorded.

Biological sampling in the upper reaches of Strawcamp Run confirmed the existing EWH designation and reflected coldwater potential based on the presence of 10 coldwater macroinvertebrates and 3 coldwater fish. The 24 EPT taxa and 38 pollution sensitive taxa found at RM 1.2 were the highest in the Yellow Creek study area. Collections also included the caddisfly, *Psilotreta decisa*, a state threatened species.

Biological communities near the mouth of Strawcamp Run maintained marginally exceptional quality but lost significant numbers of coldwater forms compared to upstream (from 10 to 2 macroinvertebrates and 18.61% to 4.51% coldwater fish from headwaters to mouth). Declines may have been related to lower habitat quality as the stream was mostly pooled and the QHEI score dropped 36 points. The stream may also be losing flow to groundwater infiltration near the mouth but this could not be confirmed. Considering the high quality of Strawcamp Run and the puzzling chemical and biological results in the lower reach, investigations of flow, temperature, and land use characteristics should coincide with the biological sampling in the future. Field investigations to determine the source of metals at Case Rd. should also be conducted.

Center Fork

Center Fork, an Elkhorn Creek tributary, drains 12.5 sq. mi., and enters Elkhorn Creek at RM 5.35. Three stream sites were sampled at RMs 2.7 (macroinvertebrates only), 1.9 and 0.1. Chemical concentrations were consistent and all parameters were within water quality standards. Bacteria levels were low at Apollo Road (RM 1.9) but were elevated and in non-attainment near the mouth. The site near the mouth was a regional reference site with only a limited number of homes in the area, but these may be the source of elevated bacteria. Additional investigation of potential sources is required.

Biological performance was almost consistently in the exceptional range while habitat quality was good (mean QHEI=66.3) but fell short of exceptional levels. Despite an existing, CWH designation, coldwater fish and macroinvertebrate populations were low in number and did not meet or, only marginally met, CWH benchmarks.

Trail Run

Trail Run is a small, coldwater designated tributary and regional reference site that discharges to Center Fork at RM 1.82. The stream drains 3.3 sq. mi. and was sampled near the mouth at RM 0.3. No chemical WQS exceedences were detected but concentrations of selected mine drainage parameters described in Table 9 (*i.e.*, iron, manganese sulfate, conductivity) were slightly elevated. Based on topographic maps, a few abandoned mine lands are located in the watershed about a half mile upstream. Bacteriological sampling indicated elevated levels of both fecal coliform and *E. coli*, resulting in non-attainment of the recreational use. The sampling site was near a campground. Facilities for sewage treatment were unknown (Carroll County) but the park may be the source of contamination. Weekday use didn't appear heavy but it was likely that it received more use on weekends.

Trail Run biological communities were in the exceptional range (IBI=50; ICI=54). In addition, the collection of eight coldwater macroinvertebrates and mottled sculpin, a coldwater fish, confirmed the existing CWH designation. Habitat quality was marginal for EWH attainment (QHEI=63.5) but did not preclude exceptional performance.

Frog Run

Frog Run is a small tributary to Center Fork at RM 2.60 and drains approximately two square miles. The stream was included in the original 1978 Ohio WQS rulemaking and apparently, based on inferences drawn from maps and other information, was one of a few Yellow Creek basin streams which received an unverified EWH aquatic life use designation. Biological and water quality sampling was conducted at the mouth but water chemistry was collected only twice due to limited access. No chemical WQS violations were detected. A single bacteria sample revealed low *E. coli* but elevated fecal coliform levels; recreational use attainment was considered Full but Targeted, meaning additional sampling should be conducted to confirm attainment status.

The headwaters of Frog Run were swampy with extensive algal growth. During the 2005 survey, access to Frog Run at the mouth was discovered via a farm lane adjacent to several hay fields. Apparently to improve farm operations, the reach of Frog Run immediate to the crossing culvert had been modified sometime within the previous five years. This reach was influenced by a critical lack of deeper pools and earned a fair QHEI score (56.5), a substantially lower score than is normally associated with EWH performance. The lack of pool depth directly precluded the presence of redside dace (and striped shiners).

The fish community in Frog Run included a disproportionate number of creek chubs (1056 / 1692, 62%). Consequently, several component scores within the IBI were negatively influenced. However, the absence of an otherwise frequently encountered minnow species (redside dace) had a more compelling influence on the marginally good IBI score. Both the creek chub abundance and lack of other minnows were due to the habitat specific conditions at the fish sampling location (for additional discussion, see Habitat Alteration in Headwater Streams: The Frog Run Example on page 81).

Macroinvertebrates from the mouth of Frog Run were quite diverse and included over 20 EPT and sensitive taxa (Table 19). Overall community performance was considered exceptional and the presence of five coldwater taxa suggested coldwater potential in the macroinvertebrates.

Upper North Fork

Two sites were sampled on the Upper North Fork at RMs 5.7 and 0.3. The stream drains 19.1 sq. mi. and enters Yellow Creek at RM 24.20, just north of Bergholz. Outside of a single elevated iron level (1870 ug/l) at RM 5.7, all chemical parameters were consistently below detection level or consistent with other sites within the basin.

Stream habitat at the upper site appeared historically modified and the QHEI score of 53.5 was marginal for WWH attainment. Despite the habitat limitations, fish and macroinvertebrate performance was very good (IBI=48) and clearly met the existing WWH designation. Collections included 2 coldwater fish species but only one coldwater macroinvertebrate.

Near the mouth at RM 0.3, macroinvertebrates continued to reflect very good quality and fish performance was clearly exceptional with a 10 point increase in the IBI score (IBI=58). Habitat quality (QHEI = 78.5) was also improved compared to upstream and fell in the range associated with an EWH designation. Coldwater taxa also increased downstream with 3 coldwater fish and 2 primary coldwater macroinvertebrates (the stonefly genus *Leuctra* and caddisfly genus *Glossosoma*) found at RM 0.3.

Hazel Run

A tributary to the Upper North Fork at RM 5.13, Hazel Run is 3.1 miles long. Sampling near the mouth at SR 524 was limited to a single collection on July 14 due to severe stream intermittence. Flow was reduced to stagnant pools and additional chemical samples were not collected following the July 14 collections. No exceedences of water quality standards or elevated concentrations were detected during limited sampling.

Fish were collected a few hundred yards upstream from the SR 524 bridge in 2005 and flow conditions appeared normal. The IBI score of 46 reflected very good quality with no indication of low flow stress. Fish collections also included large numbers of redside and redbelly dace, two coldwater indicators. Macroinvertebrates collected under nearly intermittent flow at SR 524 appeared fair. It was uncertain if the stream lost flow naturally or if modifications near the bridge affected the local hydrology so macroinvertebrates were re-sampled in 2006 upstream at RM 0.6. In this reach, the stream was natural and free flowing and macroinvertebrates were considered both exceptional (17 EPT taxa, 25 sensitive taxa) and indicative of coldwater potential (3 primary coldwater taxa). The localized, intermittent flow conditions encountered in 2005 were considered anomalous and the 2006 results were used to characterize macroinvertebrate performance.

Hump Run

A tributary to the Upper North Fork at RM 1.43, the stream drains seven square miles and was sampled near the mouth. No WQS exceedences were detected although, on one sampling event, iron, lead, manganese, and zinc were higher than results typically found at this site. Concentrations were low or below detection for the metals during the remaining sampling events.

Habitat quality (QHEI=78), fish community health (IBI=54) and macroinvertebrate performance in Hump Run were exceptional. Number of EPT taxa (14) was somewhat low for an exceptional evaluation but the collections included 28 sensitive varieties. In addition, six coldwater macroinvertebrates and three coldwater fish reflected CWH potential.

Ralston Run

A tributary to Yellow Creek, Ralston Run drains 5.64 square miles and enters the mainstem east of Bergholz at RM 17.87. Both chemical and biological samples were collected downstream from the confluence of Matthews Run at RM 0.3. Chemical concentrations were low and typical of parameters measured throughout the basin. Bacteriological sampling indicated non-attainment of the recreational use; the sampling site was immediately downstream from an open pasture with unrestricted cattle access the likely source of bacteria.

Fish and macroinvertebrates performance was exceptional in Ralston Run and habitat quality (QHEI=71.5) approached levels associated with EWH potential. In addition, the presence of 3 coldwater fish and 3 primary coldwater macroinvertebrates reflected CWH potential.

Long Run

Long Run drains a total of 10.4 square miles entering Yellow Creek about 10 miles east of Berhgolz at RM 11.60. Chemical and biological sampling sites were located at RMs 4.3, 2.7, and 0.1 but fish were not collected from RM 2.7 and water chemistry was not collected at the mouth due to access and time restrictions.

No WQS violations were detected in water chemistry results from the headwaters and RM 2.7 (samples were not collected from the mouth). However, station RM 2.7 was the only Long Run site in non-attainment of the recreational use with fecal coliform and *E. coli* counts (24,000 and 26,000 max.) among the highest recorded in the basin (following a moderate rainfall event). Several large, active livestock operations were observed on the adjacent hilltops immediately upstream from RM 2.7 and likely contribute to the elevated bacteria levels.

Long Run fish communities were assessed at two locations. Upstream sampling (RM 4.3) occurred immediately downstream from a beaver influenced wetland. This site was within an abandoned pasture where eroded false banks were still evident, silty gravel substrates were predominate, and riparian vegetation was limited. The marginally good performing fish community (IBI = 42) was represented by 13 species with 1221 individuals.

Bluntnose and fathead minnows (functionally similar species) comprised 33% of the mostly pollution tolerant (72%) population at RM 4.3. Mottled sculpin were absent. This coldwater dwelling fish was present in 57 of 65 (88%) of samples from the Yellow Creek basin. Mottled sculpin also represented 28% of the population at the downstream Long Run location (RM 0.3, IBI=60) and 11% at Hildebrand Run (RM 0.1, IBI = 48) a nearby Long Run tributary.

Although habitat conditions (QHEI = 74.5) were good at RM 4.3, the high proportions of detritivores and tolerant species coupled with the lack of a common cold water dependent fish implied the upstream wetland and the past pasture land use were exerting detectable effects. Apparently, Long Run was sufficiently impounded so that water temperatures were increased and high velocity flows were dampened. The wetland has prolonged the presence of cattle influenced substrates and contributed to the total organic load.

Fair macroinvertebrate performance at Long Run RM 4.3 was also attributed to wetland drainage and impoundment by beaver dams. Lower performance under wetland conditions is typical in the macroinvertebrates and often related to the comparatively low DO levels, depositional substrates, and lack of habitat diversity. These negative influences are considered naturally occurring and not indicative of significant pollution inputs.

Downstream at RM 2.7, stream habitat conditions were more natural with well developed riffle/pool development and coarse substrates. Macroinvertebrate communities reflected good quality and included 4 coldwater taxa. However, without associated fish sampling data from the site, the existing WWH designation was retained.

Further downstream and immediately prior to entering Yellow Creek (RM 0.1), biological performance was clearly exceptional (IBI=60; EPT=23) and reflected coldwater potential (4 coldwater macroinvertebrates, 2 coldwater fish) at the mouth. Habitat quality was also exceptional with a QHEI score of 92.5 out of a maximum 100.

Trend Assessment

<u>Yellow Creek and Wolf Run</u>
Biological and water quality conditions along the length of Yellow Creek have shown significant improvement compared to a previous survey in 1983, particularly in the upper reaches of the mainstem between Amsterdam and Bergholz (Figure 17 Figure 18). The improving trend is most pronounced immediately downstream from Wolf Run (RM 26.0), a historically degraded mine drainage tributary that is now recommended for an upgrade from Limited Resource Water (LRW) to coldwater habitat (CWH). Improvement downstream in Yellow Creek corresponds with improvements of similar magnitude in lower Wolf Run chemistry and biology. Improvements in Wolf Run appear the result of both historic reclamation activity in the upper watershed and, a gradual process of natural attenuation over the past 20-25 years (Hughes and Bowmen 2007). The potential for recovery from mine drainage impacts throughout most of the Yellow Creek watershed is enhanced by the alkaline soils and strong buffering capacity of the basin’s mixed limestone geology.

Mainstem fish communities between Amsterdam and Bergholz were in the fair to poor ranges in 1983 but reflected good to very good quality in 2005. In addition to improved index scores, 2005 collections from the reach included pollution sensitive species not found in 1983 such as black redhorse, silver shiner, mimic shiner, and variegate darter. Downstream from Bergholz, and extending downstream to the North Fork Yellow Creek, 2005 fish index scores showed additional improvement and routinely fell in the very good and exceptional ranges.

Water chemistry trends show significant reductions in concentrations of acid mine drainage related parameters such as iron, manganese, and aluminum (Figure 18). Following a rain event in August 1983, severe mine drainage effects were detected with pH concentrations as low as 4.4 at Yellow Creek RM 21.5. Iron and aluminum concentrations of 12,000 and 5,000 ug/l were found immediately downstream from the Wolf Run confluence, respectively. In contrast, iron and manganese concentrations from the mouth of Wolf Run have experienced declines of several orders of magnitude since 1983 (Figure 18).

Yellow Creek macroinvertebrates have also improved, albeit to a lesser degree then fish, and reflect good to very good quality between Amsterdam and Bergholz. Further downstream, communities improved to the very good and exceptional ranges in the approximate 20 mile reach from Bergholz to the North Fork Yellow Creek (Figure 17).

A severe decline in the macroinvertebrates immediately downstream from the North Fork Yellow Creek at RM 3.3 was the only instance of significant declining trend in the biology. Besides sedimentation and habitat disruption associated with nearby channel modifications, a problematic mine drainage overflow at the mouth of the North Fork was a suspected source of impairment.

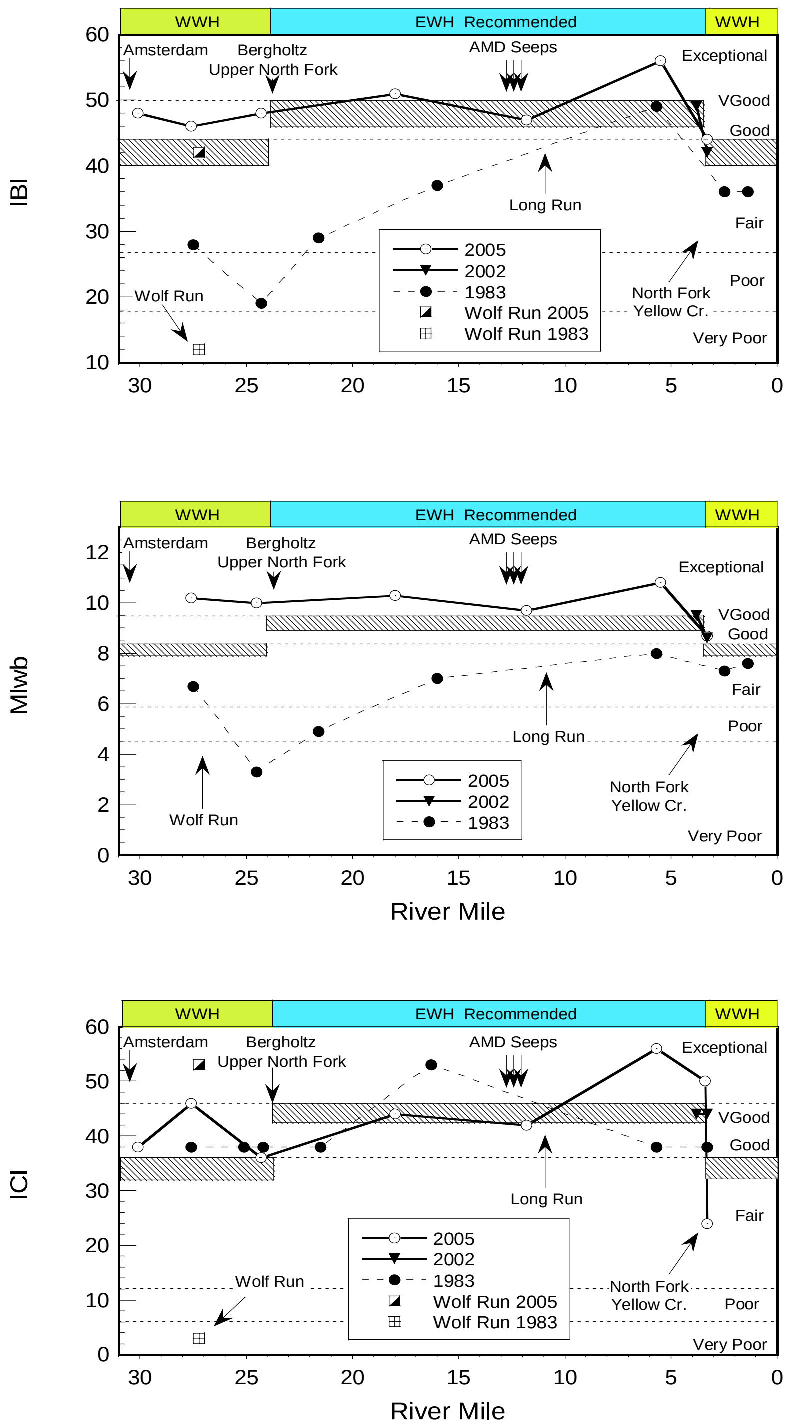


Figure 17 Historical trends in IBI, MIwb, and ICI scores from the Yellow Creek mainstem and Wolf Run in 1983 and 2005 (Note: macroinvertebrates from Wolf Run and Yellow Creek RM 3.3 were collected in 2006).

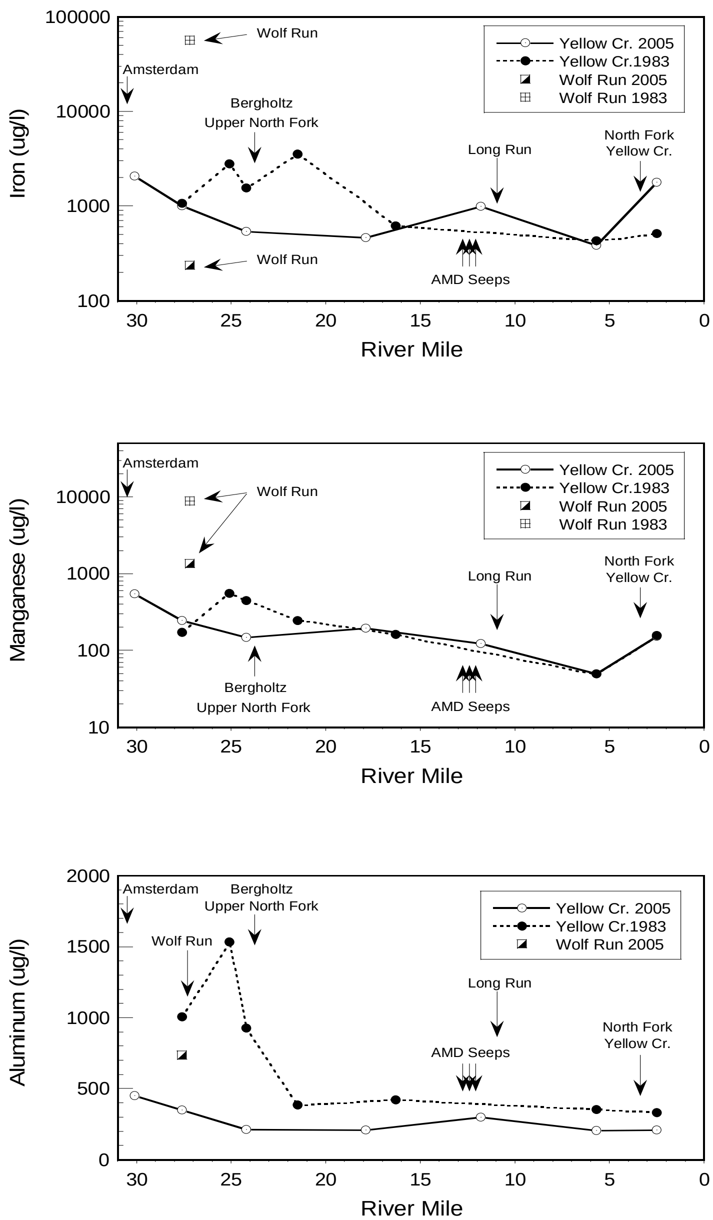


Figure 18 Historical trends in iron, manganese, and aluminum concentrations from Yellow Creek and Wolf Run in 1983 and 2005 (Note: aluminum was not analyzed from Wolf Run in 1983).

Lower Yellow Creek basin: Town Fork to mouth (WAU 05030101 -190)

Table 21. Summary of Lower Yellow Creek study area assessment unit scoring (WAU -190). The assessment unit score is an average grade of aquatic life use status. A maximum score of 100 is possible if all monitored sites meet designated aquatic life uses. The method of calculation is presented in the 2008 Integrated Water Quality Monitoring and Assessment Report.

Lower Yellow Creek WAU (Town Fork to mouth) (05030101 190)	Aquatic Life Attainment Status							Assessment Unit Score
	Total	Full		Partial		NON		
	31	#	%	#	%	#	%	
Sites ≤ 50mi^2 drainage area	28	23	82.0	2	7.1	3	10.7	88
Miles of assessed streams with > 50mi^2 and < 500mi^2 drainage area	10.3	9.7	94.2	0.6	5.8	0	0	
Comments Like the headwaters of Yellow Creek, large proportions of the assessment unit fully met the existing or recommended aquatic life use designations and a majority of sites (57%) reflected exceptional or coldwater potential. The landscape tended to be more wooded with higher relief and localized, but more pronounced impacts from past and present mining activity. Again, cool water temperatures, high groundwater recharge, sustained summer flows, and intact stream habitat appeared to increase assimilative capacity and limit significant impairment instream. Biological impairments were relegated to small, headwater drainages with the exception of an apparent mine drainage impact at Yellow Creek RM 3.3, immediately downstream from the North Fork Yellow Creek. A problematic mine seep at the mouth of the North Fork is a suspected source. An additional four sites of less than 50mi^2 were sampled that did not meet credible data requirements to completely evaluate aquatic life status. Two sites supported macroinvertebrate assemblages in the good and marginally good ranges and two sites had macroinvertebrate assemblages in the fair range.								

Introduction

The lower Yellow Creek basin includes the lower 8.75 miles of the mainstem from Town Fork to the mouth, the Town Fork, Brush Creek, Long Run, Hollow Rock Run, and North Fork Yellow Creek watersheds, and all associated tributaries (Figure 5). This WAU unit, located in the WAP ecoregion, flows mostly within Jefferson County, except the upper reaches of the North Fork Yellow Creek, which are within Columbiana County. Significant NPDES point source discharges in WAU 190 are limited to the Sterling Mine North Plant and South Plant in the headwaters of Brush Creek and the Salineville WWTP on the North Fork Yellow Creek. Sterling Mine discharges groundwater and surface runoff from two underground mines between RMs 9.8 and 7.6 while the

Salineville WWTP is located in the upper reaches of the North Fork at RM 10.41. Land use is mostly consistent with deciduous forest making up almost three-quarters of the watershed and pasture/hay fields and row crops making up the balance.

Fish, macroinvertebrates, water chemistry, bacteria levels, and stream habitat conditions were evaluated at 38 sampling locations throughout the WAU (Table 1). Causes and sources of impairment at sampling sites with biological impairment (*i.e.*, partial or non attainment) are summarized in Table 5. Most sites had six sets of chemical samples collected at two week intervals. Bacteria were tested to assess attainment of recreational use.

Biological Impairment

Biological impairment in the lower Yellow Creek watershed (WAU 190) was relatively rare or localized and, with the exception of Yellow Creek downstream from the North Fork confluence, was restricted to very small drainages (<5 sq. mi.). Causes of impairment were primarily related to mine drainage (Yellow Creek RM 3.3, Salisbury Run RM 0.2, Riley Run RM 4.9) or flow alteration and stream desiccation (Town Fork RM 8.1, Riley Run RM 4.9, North Fork Yellow Cr. Trib.@ RM 6.08) (Table 5). Macroinvertebrate performance was also fair at two additional sampling stations (Salt Run RM 0.1, Trib. to North Fork @ RM 8.96). However, because of credible data limitations (i.e., the lack of associated fish collections and habitat evaluation), aquatic life use attainment status was listed as Unknown. At the mouth of Salt Run, communities appeared degraded by organic enrichment associated with on-site septic systems in the Village of Irondale. In the RM 8.96 Trib., populations reflected coldwater conditions immediately downstream from a coldwater tributary at RM 0.18 but appeared impacted by fine silt deposition.

Individual Stream Assessments

<u>Yellow Creek Mainstem</u>
Chemical sampling was conducted at two Yellow Creek sites in WAU 190, at the USGS gage at RM 5.7 and downstream from the North Fork Yellow Creek at RM 2.5. Samples from the most downstream site were taken from the SR 213 bridge, nearest the confluence with the Ohio River. Flows were more sluggish at this location with the potential to be influenced by impounded flow from the Ohio River. However, this phenomenon was not observed, due to the low flows during the entire summer. No chemical WQS exceedences were detected in the reach but iron concentrations increased sharply (3-4x) at the most downstream site.

Mainstem biological communities were collected near the USGS gage at RM 5.7 and immediately downstream from the North Fork Yellow Creek confluence at RM 3.3. Because of the channel relocation following 2004 flooding, 2005 macroinverebrates were mistakenly sampled *upstream* from the North Fork at RM 3.4 so the stream was resampled in 2006 at the downstream site. Biological performance was clearly exceptional upstream from the North Fork, at RM 5.7 (IBI=56; ICI=56) and macroinvertebrates maintained exceptional quality downstream to RM 3.4.

At RM 3.3, the 2006 ICI score declined sharply immediately downstream from the North Fork Yellow Creek (from exceptional to fair); fish experienced similar declines but still met minimum WWH criteria. Declines in macroinvertebrates coincided with an increase in pollution tolerant oligochaetes (sludge worms) and extensive deposition of slimy silt or yellow boy on the substrates. Large numbers of sludge worms appeared entrained in the solids and may be associated with the iron-fixing bacterial growth (iron concentrations increased sharply downstream from the North Fork in 2005 chemical samples). Oligochaetes are also associated with organic enrichment and may reflect septic tank inputs from the Irondale and Hammondsville areas.

The primary source of mine drainage in lower Yellow Creek appeared to be an underground mine seep located near the mouth of the North Fork. The seep was discovered earlier by ODNR and evaluated by Ohio EPA in 2002 (ODNR AMD project). However, unlike the most recent 2006 results, biological impairment in 2002 was limited to the extreme lower reaches of the North Fork and did not appear to extend to the Yellow Creek mainstem. In addition to the seep at the mouth, other mine drainage sources in the lower North Fork include Salisbury Run (confluence RM 3.98) and a large mine seep observed immediately downstream from Irondale near RM 1.8 (see Figure 11). In addition to mining impacts, habitat quality at Yellow Creek RM 3.3 was also reduced due to heavy all terrain vehicle (ATV) traffic and severe bank destabilization and bedload movement related to habitat alteration by an upstream landowner and subsequent flooding in 2004.

<u>Town Fork</u>

Town Fork drains 26 square miles with an average fall of 43.7 feet per mile and enters Yellow Creek at RM 8.75. Two impoundments are located on the stream at RM 8.1 (Jefferson Lake) and RM 3.2 (Austin Lake). Jefferson Lake is a 17 acre state lake operated by the Ohio Department of Natural Resources while Austin Lake is privately owned and encompasses 66 acres at normal pool (Reference: Bill Cable, owner). Chemical and biological samples were collected in free-flowing sections of Town Fork at RM 10.4 (upstream Jefferson Lake), RM 8.0 (immediately downstream Jefferson Lake), RM 5.2, and RM 0.1 (downstream Austin Lake). Chemical sampling was also conducted within Jefferson Lake and is discussed on page 134.

Biological performance upstream from Jefferson Lake at RM 10.4 was very good and collections reflected coldwater potential (3 coldwater fish; 7 coldwater macroinvertebrates). The high quality conditions persisted despite potential impacts from unrestricted cattle access, the absence of a woody riparian border, and somewhat marginal habitat quality (QHEI=60).

Late summer, intermittent flow conditions were found immediately downstream from the Jefferson Lake outlet at RM 8.1 Fish maintained exceptional quality despite the low flows, but macroinvertebrates were only marginally good (7 EPT taxa, 9 pollution sensitive taxa), resulting in Partial attainment of the recommended EWH designation. During one chemical sampling event, the water had a very strong sulfur odor, typical of a bottom release from a lake. Many parameters, including BOD_5, COD, ammonia, aluminum, arsenic, iron, and manganese were elevated above "typical" concentrations observed during the other sampling runs. Outside of this localized area, biological communities were consistently in the exceptional range at additional sites between Jefferson Lake and the mouth. However, coldwater macroinvertebrate populations were low in number (1-3 coldwater taxa per site) and did not meet minimum benchmarks for a CWH designation.

Bacteriological sampling found two of the four sample locations in non-attainment of the PCR recreation use: 1) the upper most site at RM 10.4, located upstream from Jefferson Lake, and 2) RM 5.20 at Shane Road, downstream from the lake. Agricultural runoff from animal grazing was the likely source at RM10.4 as unrestricted cattle access and pastures were observed in the immediate vicinity of the sampling site. Isolated homes with failing sewage systems are potential sources of bacteria near Shane Road.

<u>Brush Creek</u>

Brush Creek drains 15.3 mi^2 with an average fall of 41.2 ft/mi. before entering Yellow Creek at RM 4.55. Sterling Mine operates two underground mines in the headwaters of the stream. The North and South mines discharge groundwater and stormwater runoff at 8 outfalls near RMs 9.8 and 7.6, and at RM 8.05, via Allman Run.

The Sterling South Mine (permit # OIL00136*DD) includes four final settling pond outfalls that discharge to Brush Creek near RM 9.8. These ponds remove sediment associated with groundwater from underground mines as well as stormwater runoff. Outfall 001 has the following limits (daily maximum/monthly average): pH: 6.5-9.0; TSS: 70/35 mg/l; Iron: 6000/3000 ug/l; Manganese: 4000/2000 ug/l; fecal coliform: 2000/1000 colonies/100 ml; chlorine residual: not to exceed 0.038 mg/l. pH limits (6.5-9.0) must be within the range stated within the permit, and may not to be lower than 6.5 or higher than 9.0 S.U. at any time. Flow rates from the outfall are monitored. The 002 and 003 outfalls have the same limits as the 001, except fecal coliform and chlorine residual are unmonitored. An internal outfall (601) monitors for visual parameters (color, odor, and turbidity) as well as containing the following limits: CBOD5 10/15 mg/l; TSS 12/18 mg/l; ammonia 2/3 mg/l. This outfall discharges through the sedimentation pond 001 outfall. Sterling Mine recently added another pond to allow additional retention time and serve as a back-up if a pond is out of service for cleaning.

The North Mine (permit # 0IL00135*DD) has four permitted outfalls from various settling ponds. The 001 discharges to Allman Run, a Brush Creek tributary at RM 8.05, while outfalls 002, 003, and 004 discharge to Brush Creek from a final settling pond between RMs 7.7 and 7.6. Monitoring and permit limits for all outfalls include: pH: 6.5-9.0; TSS 70/35 mg/l; Iron: 6000/3000 ug/l; Manganese: 4000/2000 ug/l; and flow (monitored). Loading limits are slightly different at each outfall, based on their projected flow rate. In both permits, alternative limits are available when flows exceed the 10-year, 24-hour precipitation event. In this case, pH is the only parameter required to be met while the other parameters are monitored.

Chemical and biological samples in Brush Creek were collected from four sites near RMs 9.7 (chem./macroinvertebrates), 8.8 (fish only), 6.1, and 0.1. Sampling at RM 9.5 was immediately downstream from the South Mine while RM 6.1 was downstream from all potential mine drainage impacts.

Chemical and macroinvertebrate samples from Brush Creek RM 9.7 (SR 164) were collected immediately downstream from the Sterling South 001-004 settling ponds. Chemical sampling found no exceedences of WWH criteria in Brush Creek. However, based on the mine drainage parameter rankings in Table 9, most iron, manganese, sulfate and conductivity concentrations were slightly or moderately elevated at the upstream site. Macroinvertebrate sampling at RM 9.7 found very low population densities and most substrates were covered with a moderate to heavy layer of silt. However, community health was evaluated as marginally good based on the presence of adequate numbers of both pollution sensitive (13) and EPT taxa (10). Due to credible data limitations (*i.e.*, lack of fish data), attainment status at RM 9.7 was listed as Unknown. As a result, the current, unverified WWH use designation should remain unchanged for this upper reach.

The most upstream fish sampling site at RM 8.8 was located between the South and North mine discharges in an area of active and historic mining activity. The fish site was also separated from the South Mine by a long stretch of dry, formerly modified channel downstream from the SR 164. Stream flow was restored by RM 8.8 where fish collections reflected marginally good quality (IBI = 44) and included two coldwater species (redside dace and mottled sculpin). Marginal quality in the fish was most likely associated with lingering mining influences and historic disturbance of the upstream channel and landscape.

Biological performance improved at two stations in the lower 6.2 miles of Brush Creek and reflected both exceptional quality and coldwater potential (Table 18 and Table 19). An average 4.5 coldwater macroinvertebrates and 2 coldwater fish were found at each location. QHEI scores averaged 85.0 in the downstream reach, another strong indicator of EWH potential. WQS violations in lower Brush Creek were limited to two D.O. measurements at RMs 6.0 and 0.8 that fell below the recommended, CWH criterion (< 6 mg/l). Iron and manganese concentrations declined substantially between RMs 9.5 and 6.1, an indication of lessening mine influences with increased distance downstream from the headwaters.

<u>Dennis Run</u>

A small tributary to Brush Creek, Dennis Run is only 1.5 miles in length and drains just over two square miles. The stream supported coldwater populations and demonstrated exceptional biological performance at the mouth, despite a reclaimed mine landscape and large beaver dam impoundment immediately upstream. Water quality conditions were also good with only one dissolved oxygen measurement falling below more stringent coldwater habitat criteria; there were also no indications of mine drainage in the chemical results. Sustained cool stream flow from groundwater intrusion and the lack of heavy metal or pH contamination associated with historic mining contributed to the exceptional in-stream performance.

<u>Hollow Rock Run</u>

Hollow Rock Run is a small (9.2 mi^2), high gradient (85.5 ft/mi) Yellow Creek tributary that enters the mainstem at RM 0.99. Chemical and biological samples were collected immediately upstream from Carter Run at RM 3.0 and further downstream at RMs 2.2 (biological) and 0.7 (chemical). No water quality exceedences were detected but water chemistry results revealed the influence of past mining practices. While pH levels were consistently neutral, conductivity, total dissolved solids, sulfate and strontium concentrations were all much higher in this stream than was typically seen throughout the remainder of this basin.

Biological community performance was in the good to marginally good ranges and did not appear significantly influenced by mining. Coldwater conditions were strongly reflected by the presence of 4-7 coldwater macroinvertebrates and a large percentage of coldwater fish, (*i.e.*, avg. 75% mottled sculpin) at the two sampling sites. Longnose dace, a rare Ohio fish species and coldwater indicator, was also collected at one site.

<u>Tarburner Run</u>

Tarburner Run, a small, 2 sq. mi. tributary to Hollow Rock Run also had elevated conductivity levels but most mine drainage parameters were within normal ranges. The headwaters of the stream flow through old mining areas, which may explain the elevated conductivity. WQS exceedences were limited to a single dissolved oxygen concentration that fell below more stringent CWH criterion. The stream maintained a strong base flow during the entire sampling season, in spite of this small drainage area.

Biological communities at the mouth of Tarburner Run were good quality and, like Hollow Rock Run, were strongly indicative of coldwater conditions. Macroinvertebrate communities were predominated by coldwater stoneflies and amphipods (five coldwater taxa total) and mottled sculpin accounted for over 80% of the fish community. Longnose dace, a rare Ohio fish species and coldwater indicator, was also collected.

<u>North Fork Yellow Creek</u>

The North Fork Yellow Creek is a direct tributary to Yellow Creek with a drainage area of 59.5 mi^2 (Ohio DNR, 2001) within Columbiana and Jefferson counties. Two tributary streams, Riley Run and Nancy Run, merge at RM 10.74 in Salineville to form the mainstem of the North Fork. The North Fork watershed is completely within the WAP ecoregion and has its confluence with Yellow Creek at RM 3.43 near Hammondsville in Jefferson County.

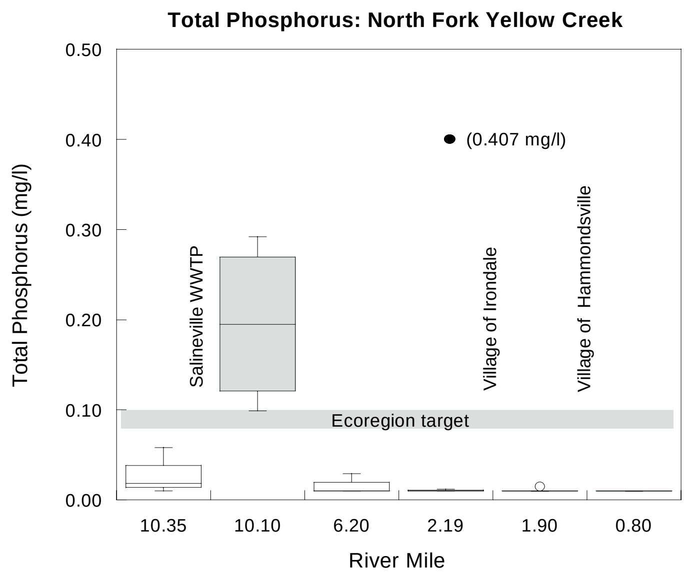
The Village of Salineville (Columbiana County) operates a WWTP that discharges to the North Fork Yellow Creek at RM 10.32. Two smaller communities, Hammondsville and the Village of Irondale, each with about 100 homes and commercial buildings, are not served by a central wastewater treatment facility. The Salineville WWTP, just downstream from the confluence of Riley Run and Nancy Run at RM 10.32, was constructed in 1980 in response to widespread bacteria problems documented within the Village. Treatment processes include comminutor, extended aeration, and clarification, with chlorination/dechlorination. Plant design flow is 0.200 mgd. NPDES permit limits (daily maximum/monthly average) for select parameters are D.O. (5.0 mg/l), cBOD5 (40/25 mg/l), TSS (45/30 mg/l), summer ammonia-N (3.7/2.5). The lack of sand filters in the treatment process helps to explain the thirty day average total suspended solids permit limit of 30 mg/l, a value much higher than is currently required for all new point source municipal wastewater treatment plants (12 mg/l TSS).

The Southern Local Schools operates a WWTP (permit #: 3PT00098, 0.020 mgd design flow) that discharges to an unnamed tributary (RM 6.08) of the North Fork Yellow Creek. The discharge is to an unnamed tributary (about 1.2 miles upstream) that enters the RM 6.08 tributary at RM 1.15. The WWTP was upgraded in 2002; treatment processes include extended aeration, sand filter, trash trap, chlorination/dechlorination, and EQ basin. A 2006 inspection noted that the facility was well maintained and in compliance with permit requirements.

Chemical and Bacteriological Sampling

Chemical and effluent samples were collected from six locations along the mainstem of the North Fork Yellow Creek, from RM 10.35, immediately upstream from the Salineville WWTP, to RM 0.8 near Hammondsville. No exceedences of chemical water quality criteria were recorded at any of the mainstem sites. As shown in Figure 19, total phosphorus and total nitrate concentrations increased significantly downstream from the Salineville WWTP. While this level of nutrient enrichment did not effect biological attainment status, fish community composition bracketing the WWTP suggested an enrichment influence and macroinvertebrate densities increased downstream from the discharge.

Grab water samples were collected from the Salineville WWTP discharge four times during the 2005 survey (6/23, 7/7, 7/21, 8/11). The range of values for select chemical parameters were all within permit limits during this time period: DO (effluent range 7.5-8.3 mg/l), NH3-N (0.1-1.4 mg/l), TSS (5-31 mg/l), BOD_5 (8-16 mg/l). Visual inspection of the stream during this time period did not reveal any solids, color, or odors in the North Fork Yellow Creek downstream from the discharge. These data compare well with the results of the 2005 biological sampling, which showed no significant difference in the fish and benthic macroinvertebrate communities upstream and downstream from the Salineville WWTP outfall.



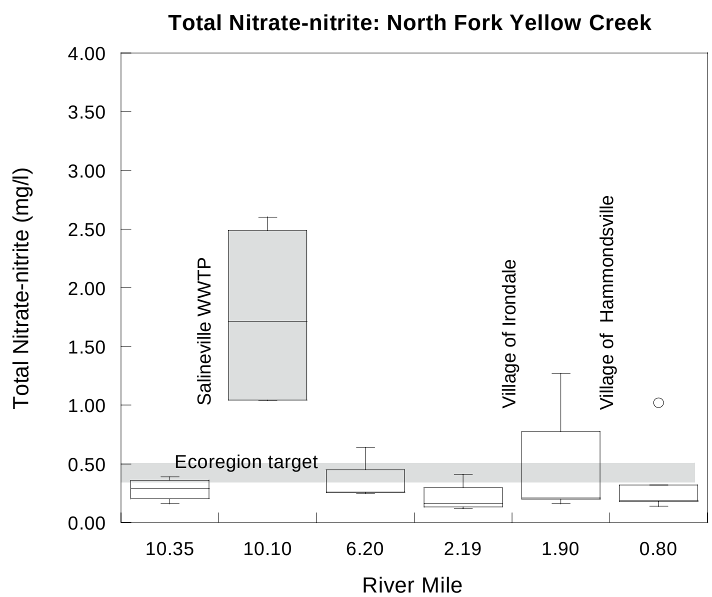


Figure 19. Concentrations of primary nutrients in North Fork Yellow Creek, 2005.

Non-attainment of the PCR recreational use was recorded at two North Fork sampling locations, at Haiti Road (RM 10.10) downstream from the Salineville WWTP, and at RM 1.90 downstream from Irondale. In Salineville, extremely elevated levels of fecal colform bacteria were recorded from three effluent samples taken in 2005 (7/21/2005-

35,000/100 ml; 8/2/2005-51,000/100 ml; 8/11/2005-5,400/100 ml.). The impact on the North Fork Yellow Creek was significant, resulting in non-attainment of the PCR use just downstream at RM 10.10 (Haiti Road). Full attainment of the recreation use was documented immediately upstream from the outfall on the same sample days (geometric mean fecal coliform upstream WWTP = 617/100 ml, downstream WWTP = 2147/100 ml, N=3). These data suggest that the Salineville WWTP was not providing proper chlorination to the effluent, perhaps for an extended period of time during the summer of 2005. A WWTP inspection conducted during this same period indicated operational problems and the discharge of poorly treated effluent. However, no monthly operating report data were submitted by the Village during this period (February 2004 to October 2006). Bringing the WWTP into compliance should eliminate non-attainment of the recreational use downstream. Note: The Salineville WWTP was under enforcement action by the Ohio EPA (February, 2007) due to inadequate plant operation and failure to report monthly operating data. However, improvements were made in plant operations in 2006 and by April 2007, a plant inspection reported “great strides in returning the treatment plant to reliable and effective operation. The plant is operating satisfactorily.” (Ohio EPA 2007, May 11 letter to Mayor of Salineville).

Irondale is not served by a central wastewater treatment facility. There are a few storm sewers that empty into the North Fork Yellow Creek and it is likely that these serve as a point of entry for bacteria into the stream from failing home and commercial sewage systems. It is recommended that the Jefferson County General Health District conduct an inventory of the sewage systems serving the Village to determine if they are a source of bacteria. The sampling location in Irondale was adjacent to a park where children would have access to stream water with elevated levels of fecal coliform and *E. coli* bacteria. Until such time that sampling shows normal levels of bacteria in the stream, it is recommended that signs be posted within the Village to advise citizens not to come in contact with stream water.

Sediment Sampling

Significant sediment organic chemical contamination was found in the North Fork Yellow Creek at Hammondsville (RM 0.8) where a series of 16 polycyclic aromatic hydrocarbon (PAH) compounds were detected (Table 12). All the compounds were above the probable effect concentration (PEC), indicating levels likely to impact biological communities. PAHs are by-products of incomplete combustion of carbon-containing fuels, such as wood, coal, and diesel fuel. These compounds are also found in tar and build up on road surfaces in urban areas. In addition to potential urban runoff sources upstream, station RM 0.8 was located immediately downstream from a large auto and scrap metal yard (A&S Salvage @ 502 CR 50A, Hammondsville OH.) located in a former clay works on river left. Additional sediment sampling and an inspection of the property should be conducted in the future to determine the specific source and extent of contamination. Sediment metals concentrations from the same location were not elevated above background levels (Table 11).

Biological Sampling

Biological sampling site locations matched the five water chemistry sites between Salineville and the mouth (Table 4). Habitat quality throughout most of the North Fork Yellow Creek was at exceptional levels (Mean QHEI=77.3). However, biological performance fell below exceptional for fish in the upper reaches (near Salineville) and macroinvertebrate performance fell well below exceptional levels in the lower reaches, downstream from Salisbury Run, Irondale, and a large scrap metal yard in Hammondsville (RM 0.8). Consequently, communities fully attained WWH throughout the length of the North Fork (all 5 stations) but only attained EWH at one (RM 6.2).

Marginal performance in the fish was found downstream from Salineville and the Salineville WWTP at RMs 10.6 and 10.1. The most upstream site (RM 10.6, IBI = 40) was downstream from Riley and Nancy Runs and from the Village of Salineville but upstream from the WWTP. Despite having the fourth highest abundance of fish among all Yellow Creek basin samples (3,359, n = 65), this community was only represented by an average number of species (19). It also included the second and third highest populations of stonerollers (1,812) and bluntnose minnows (453) in the basin, respectively.

Stoneroller minnows graze on algae. Their disproportionate abundance (54%) generally indicates excessive algal growth, often a symptom of nutrient enrichment. Bluntnose minnow feed on detritus. Numerically rich fish communities often include many bluntnose minnow. However, these fish are also associated with organic enrichment from poorly treated septage. The disproportionate abundance of bluntnose minnow at RM 10.6 (14%) suggested that a malfunction may have occurred in the central sewage collection system. Some local residences may not be correctly connected. There may also be another nutrient source.

Further downstream, acceptable but lower quality macroinvertebrate communities were found, beginning downstream from the mine runoff in Randolf Run and Salisbury Run and extending downstream from the unsewered communities of Irondale and Hammondsville. A large scrap metal yard, a potential sediment contamination source, was also located immediately upstream from the RM 0.8 site. At RM 2.2, a thin layer of yellow boy was deposited on substrates downstream from Salisbury Run while at RM 0.8, deposits of black solids and blue-green algae mats, an indication of nutrient enrichment, were observed. Reduced loadings and remediation of point and nonpoint source discharges in the North Fork watershed may eventually result in the stream reaching its full potential. However, based on 2005 results, the existing WWH designation was considered the most appropriate aquatic life use until those improvements occur until those improvements occur.

In addition to point and nonpoint sources in the North Fork Yellow Creek basin, an additional area of mine seepage near the mouth of the North Fork was also suspected of impacting macroinvertebrate communities in Yellow Creek, immediately downstream from the confluence. In 2002, a large volume of mine water discharged from an abandoned underground mine at RM 0.23 but, at that time, impacts appeared restricted to the mouth of the North Fork (Ohio EPA, 2003).

<u>Riley Run</u>

The U.S. Department of Agriculture has published ranges of chemical parameters associated with impacts on surface water quality from coal mining activities (Table 9). The chemical data from Riley Run at RM 4.9 indicate potential impact on biological communities from historic coal mining using the USDA assessment criteria Table 10). The elevated ranges of sulfates (132-428 mg/l), manganese (182–1410 mg/l) and specific conductivity (450-1,020 umhos/cm) indicate minimal to moderate impact on water quality from upstream mine drainage. Specific sources of either recent or historical mine activities that may be contributing to these elevated chemical parameters are unknown at this time.

The headwater sampling location on Riley Run (RM 4.9) was in non-attainment of the recommended WWH aquatic life use based on the poor performance of the macroinvertebrates. Flow conditions were nearly intermittent but, despite signs of mining heritage at the site, fish communities maintained a marginally good performance (IBI=42). Macroinvertebrate performance was poor based on very low population densities, very low taxa richness (16), and the presence of only 2 EPT taxa. In contrast, most other similar sized Yellow Creek tributaries supported very good or exceptional macroinvertebrate performance and often reflected CWH potential. Coupled with the apparently altered flow regime, chemical and biological results suggest impacts associated with mining activity in the watershed immediately upstream.

Salineville has a drinking water intake located upstream from a low-head dam on Riley Run at RM 2.84. An adjacent upground reservoir (Kirt's Hollow Reservoir) is also used as a source of public drinking water. The Salineville Source Water Assessment and Protection Plan (SWAP, 2003) indicates that water is diverted from the Riley Run intake only in the summer months when excessive growth of algae is present in Kirt's Hollow Reservoir. The water treatment plant production rate in 2003 was about 0.155 mgd.

Biological sampling at Riley Run RM 1.8, about a mile downstream from the water supply low-head dam, reflected coldwater potential (i.e., $\geq$4 coldwater macroinvertebrate taxa and $\geq$1 coldwater fish) and exceptional fish community performance (IBI = 56). While the immediate effect of the dam pool on biological communities was not evaluated, it is predicted to be significant and negative due to loss of critical riffle-run habitat diversity. Currently (as of 2007), the impoundment is used as a source of public drinking water. However, Salineville is scheduled to eliminate the Riley Run intake in 2009 and connect to the new Buckeye Water District water supply system. When this action occurs, removal of the low-head dam is recommended. Elimination of the dam should result in improved habitat quality in the former dam pool and allow the reestablishment of high quality fish and macroinvertebrate populations now present below the dam.

Riley Run Trib. @ RM 3.75

Chemical and biological sampling was conducted at RM 0.3 in the Riley Run Trib. with additional chemical sampling conducted at the mouth to evaluate suspected mine drainage impacts. No violations of chemical criteria were observed at RM 0.3, however, fecal coliform bacteria were elevated (range 2100-2600/100 ml) above the PCR. The sampling site was located immediately downstream from an open pasture with unrestricted cattle access, an obvious source of contamination.

Fish and macroinvertebrates reflected good quality at RM 0.3 and included coldwater populations in numbers sufficient for a CWH designation (*i.e.*, four coldwater macroinvertebrates and two coldwater fish accounting for nearly 35% of the community). Good biological performance and coldwater conditions were maintained despite significant potential for impacts from unrestricted cattle access immediately upstream and somewhat marginal habitat quality (QHEI=56). The results point to the positive influence of the cool, sustained groundwater flows that tended to ameliorate potential nonpoint source impacts.

Abandoned mine seepage near the mouth of the RM 3.75 tributary resulted in extreme ferric hydroxide discoloration of the stream bed sediment, but pH measurements were consistently greater than 7.0 S.U. and no chemical violations were recorded. The suspected source of AMD appeared to be an abandoned mine as shown on the Bergholz USGS topographic map. However, the mining influence was limited to the lower 0.2-0.3 river miles and did not affect biological communities upstream at RM 0.3. This problem may have been exacerbated by low flow conditions and flow diversion immediately upstream. Macroinvertebrate sampling crews in late July 2006 observed most of the stream volume was diverted through a pipe at RM 0.3 and into a small lake north of Avon Road. The lake overflow discharged to Riley Run, thus bypassing the affected downstream reach.

Nancy Run

Two locations were sampled on Nancy Run (RMs 2.2 and1.2). No violations of chemical criteria were recorded. Both stations met the level of biological integrity associated with a recommended dual Coldwater Habitat/Exceptional Warmwater Habitat aquatic life designated use, making Nancy Run one of the highest quality watersheds identified within the larger North Fork Yellow Creek basin. It is recommended that watershed protection plans be implemented to protect the very high quality biological communities that are present in Nancy Run and its tributaries.

Roses Run

This stream is a headwater tributary of Nancy Run with a drainage area of 1.96 mi^2. Based on the exceptional biological performance, the stream met a recommended dual Coldwater Habitat/Exceptional Warmwater aquatic life designated use. No violations of chemical criteria were observed although potential exists for impairment based on the extensive off-road vehicle traffic immediately upstream from Foundry Hill Road. Attempts were made to avoid the most disrupted habitats during biological sampling.

North Fork Yellow Creek Trib. @ RM 9.96
The small, 3 sq. mi. North Fork tributary was sampled at RM 0.4, immediately upstream from a large bedrock ledge/culvert that created a barrier to upstream fish migration. Chemical sampling showed two of three dissolved oxygen values below 5.0 mg/l (4.48 and 4.85 mg/l). The channel was dry about 0.1 miles upstream from this site in late summer; thus it is possible the location was close to a groundwater spring having naturally low dissolved oxygen. The cool water and consistent flow would help explain the presence of an exceptional macroinvertebrate community (21 EPT taxa) and six cold water adapted species. In contrast, fish communities were poor (IBI=22) indicating the ledge barrier, shallow pool depths, and lack of flow upstream resulted in physical habitat conditions inadequate to support a WWH community. This small stream might be best designated as a Class 3 Primary Headwater Habitat (PHWH) if determined that cold water obligate salamanders are present in the reach. The Ohio EPA "primary headwater habitat" (PHWH) stream field assessment guidance document is located at this agency internet link:

http://www.epa.state.oh.us/dsw/wqs/headwaters/index.html#Project%20Reports.

The results of this survey would provide information on the existing aquatic vertebrate community to supplement the existing data on macroinvertebrates

North Fork Yellow Creek Trib. @ RM 8.96
Grab water samples were collected near the mouth (downstream Salineville Road) where perennial flow was observed throughout the summer months. No violations of chemical criteria were recorded at this station. This tributary had the lowest water temperature of all streams sampled in the North Fork Yellow Creek watershed. Temperature ranged from 12.83-14.66 C^{o} during the June 23 to August 11 sample period. Spring flow was traced to an unnamed tributary at RM 0.18 that flows down the hillside adjacent to Malone Road. The cold and constant flow helps to explain the presence of seven coldwater macroinvertebrate taxa downstream at RM 0.1. Community composition reflected coldwater potential but community performance was considered fair as a result of fine silt deposition. Abandoned mine lands are common in the basin but the specific source of silt was unknown. Fish sampling was attempted but not conducted upstream from the spring because the stream channel was dry. It is recommended the riparian vegetative community be protected to ensure the continued coldwater nature of this tributary.

North Fork Yellow Creek Trib. @ RM 6.08
No violations of chemical criteria were recorded at this station. A regional biological reference site is located on the RM 6.08 tributary of North Fork Yellow Creek at Hazel Run Road (RM 0.1). Survey results indicate only partial attainment of aquatic life use at

this sampling location due to fair performance of the macroinvertebrates and exceptional quality fish (IBI = 50). The cause of the impairment on benthos is believed to be stress from observed isolated pools of water with interstitial flow conditions. The discharge from the Southern Local Schools WWTP discharge is not thought to be a cause of the impaired conditions since this entity is in full compliance of permit limits and there is little effluent flow in summer when school is not in session.

Salt Run

This tributary flows into the North Fork Yellow Creek just downstream from the Creek Street bridge in Irondale. Chemical and bacteriological sampling was limited to the mouth of Salt Run, where the channel has been turned into a roadside ditch. Evidence of organic and nutrient enrichment was observed with slightly elevated BOD, total phosphorus, and nitrate-nitrite. *E. coli* bacteria levels were also elevated (geometric mean = 955 #/100ml) with septic tank drainage from homes that lay directly along the modified channel the likely source. The macroinvertebrate sampling crew observed sewage solids and several active gray water discharges immediately upstream from the site. The stream is also directly accessible to residents in Irondale and there was evidence of wading and stream use by children.

Initial macroinvertebrate sampling was conducted at the mouth of Salt Run and was considered fair downstream from septic tank discharges and habitat modification in Irondale. The community was predominated by pollution tolerant lunged snails of the genus *Physella* and primarily reflected impacts from organic enrichment. The modified, open channel supported low numbers of EPT (3) and sensitive (5) taxa and only one coldwater variety.

Fish were collected at RM 0.4, upstream from the majority of residences in Irondale and the most severe habitat modifications. However, collections reflected only marginally good quality (IBI=40) and, unlike most similar sized streams in the survey, darter species were noticeably absent. Coal fines were observed in the channel and it was later discovered the site was immediately downstream from a large, historic tin and steel mill works that had operated in the Village at the turn of the previous century. The marginal performance in the fish may at least partially reflect a localized influence from the past industrial activity. However, despite these conditions, the coldwater indicative mottled sculpin accounted for over 35% of the community.

Because of uncertainty about the quality of the stream outside of Irondale, additional 2006 macroinvertebrate sampling was conducted upstream from the Village at RM 0.8. Community health was clearly exceptional and strongly indicative of coldwater conditions with 19 EPT taxa, 36 sensitive taxa, and 11 coldwater taxa collected. The numbers of sensitive and coldwater taxa were among the highest in the Yellow Creek study area. Future Salt Run surveys should include fish collections further upstream from Irondale to more accurately determine aquatic life use potential. CWH potential is obvious based on the macroinvertebrates but the additional sampling would determine if EWH was appropriate.

Randolf Run

This tributary enters the North Fork Yellow Creek at RM 4.28, 0.3 river miles upstream from Salisbury Run. There is historical mining activity in the watershed but no impact from mining was indicated from the chemical data. The most significant observation was that the stream flow was reduced to isolated pools near the mouth by July and completely disappeared by the end of the summer (August 11). The U.S.G.S. topographic map shows a large historical mining operation in the very headwaters of Randolf Run. It is unknown if normal stream drainage was diverted away from the Randolf Run watershed after this mine was closed, and if this is a reason for the intermittent flow conditions. It is also possible that Randolf Run is a naturally occurring intermittent headwater stream. Given the intermittent hydrology, it is recommended that the current Limited Resource Water aquatic life use be continued.

Fish were not sampled from Randolph Run due to the dry stream channel described above. Macroinvertebrates were collected earlier in the summer when a small amount of flow remained. A pervasive layer of fine, grayish silt covered most stream substrates. The community was considered fair but included 6 EPT taxa and 9 pollution sensitive varieties. Biological impairment appeared largely related to low flow or siltation, with no indication of impact from acid mine drainage.

Elevated bacteria levels were found in one of two samples on a day the stream hydrology was reduced to isolated pools. On a third occasion the stream was completely dry. There are no known sources of bacteria immediately upstream but contamination may have resulted from mammals and birds that congregated in the isolated pools.

Salisbury Run

This tributary enters the North Fork Yellow Creek at RM 3.98. The water chemistry at the mouth of Salisbury Run showed significant impact from historical coal mining activity. The stream was stained with a bright orange floc of ferric hydroxide, a violation of statewide water quality criteria in OAC section 3745-1-04(C), which states all waters of the state shall be “Free from materials entering the waters as a result of human activity producing color, odor, or other conditions in such a degree to create a nuisance”. A pH value of 3.71 S.U. was significantly lower than the minimum 6.5 water quality criterion. Applying the USDA values from Table 9, Salisbury Run showed severe predicted impact on aquatic life from pH, total iron, and specific conductance, with moderate impact from sulfates (Table 10).

Biological sampling revealed Salisbury Run continues to be severely degraded by acid mine drainage at the mouth. Fish were entirely absent from the impacted reach and macroinvertebrate collections were limited to a single individual. Impacts to the biology were so severe, the very poor collections were considered in non-attainment of even the existing, Limited Resource Water designation.

During the survey the source of AMD to Salisbury Run was found to be a discrete discharge point located at approximately RM 0.5. The U.S.G.S. Wellsville topographic map indicates that a historical coal extraction “strip mine” was present near this location. Macroinvertebrate sampling upstream from the discharge revealed a good quality, coldwater community (5 coldwater taxa), and natural, intact stream habitat with no visual indications of mine drainage. Fish were not sampled but numerous fish were observed in pools (up to 24” depth) along with salamanders, another indication of stable, intact headwater habitat. In addition, 1983 fish sampling was conducted upstream from most or all of the mine drainage influences. The 1983 collections revealed fair quality but one of the two sampling passes nearly met WWH criteria (IBI scores of 36 and 24, respectively). Collections were predominated by mottled sculpin and blacknose dace, two headwater species often associated with coldwater habitats. For these reasons, CWH is recommended for the length of Salisbury Run. The lower 0.5 river miles should be targeted for future reclamation, with the goal of restoring a high quality, coldwater adapted community. The current vertebrate fish and amphibian communities upstream from the mine drainage influence should also be evaluated.

Little Yellow Creek Basin/Ohio River Tributaries: Little Beaver Creek to Yellow Creek (WAU 05030101 – 100)

Table 22. Summary of Yellow Creek study area assessment unit scoring. The assessment unit score is an average grade of aquatic life use status. A maximum assessment unit score of 100 is possible if all monitored sites meet designated aquatic life uses. The method of calculation is presented in the 2008 Integrated Water Quality Monitoring and Assessment Report.

<table>
<tr><td rowspan="3">Ohio River Tribs WAU (Little Beaver Creek to Yellow Creek) (05030101 100)</td><td colspan="7">Aquatic Life Attainment Status</td><td rowspan="3">Assessment Unit Score</td></tr>
<tr><td>Total</td><td colspan="2">Full</td><td colspan="2">Partial</td><td colspan="2">NON</td></tr>
<tr><td>9</td><td>#</td><td>%</td><td>#</td><td>%</td><td>#</td><td>%</td></tr>
<tr><td>Sites ≤ 50mi^2 drainage area</td><td>9</td><td>1</td><td>11.1</td><td>3</td><td>33.3</td><td>5</td><td>55.6</td><td>11</td></tr>
<tr><td colspan="9">Comments
With the exception of Little Yellow Creek, most tributaries in the basin are small, cool and high gradient, discharging directly to the Ohio River. Urban populations, highway construction and industrial land usage are concentrated along this narrow Ohio River corridor and biological communities tended to reflect commensurate impacts associated with urban runoff, mine drainage, and disruption of fish colonization potential. Marginal performance in Little Yellow Creek was considered primarily a result of the physical disruption of the flow regime by a series of permanent impoundments and the Ohio River. As a result of these influences, few streams sampled in this small WAU were in full attainment of their designated aquatic life use (11%).</td></tr>
</table>

Introduction

The 45 sq. mile WAU includes the 11.3 mile length of Little Yellow Creek and two associated tributaries (Alder Lick Run and Bailey Run) and a series of small direct tributaries to the Ohio River between Little Beaver Creek near the Ohio/Pennsylvania border and Yellow Creek (*i.e.,* Carpenter Run, Jethro Run, Wells Run and McQueen Run.

Significant NPDES point source discharges in WAU 100 are limited to two small mobile home park WWTPs that discharge to unnamed tributaries in the Little Yellow Creek basin. Remaining municipal and industrial discharges concentrated along the Ohio River corridor discharge directly to the Ohio River.

Fish, macroinvertebrates, water chemistry, bacteria levels, and stream habitat conditions were evaluated at 11 sampling locations throughout the WAU (Table 1).

Causes and sources of impairment at the eight biological sampling sites in partial or non attainment are summarized in Table 5.

Individual Stream Assessments

Little Yellow Creek

Little Yellow Creek is a relatively small basin (total length 11.3 miles; drainage area 22.22 mi^2) that empties directly into the Ohio River near Wellsville, Ohio. The basin is located in Columbiana County, within the Western Allegheny Plateau (WAP) ecoregion. Land use is mostly agricultural and forest, with scattered areas of mostly historical and some active strip mining for coal.

Chemical samples were collected from four locations along the mainstem of Little Yellow Creek (from RM 11.1 to RM 1.1). Biological communites were sampled near the same locations but the most downstream site was located at RM 3.30.

No NPDES entities directly discharge to the mainstem of Little Yellow Creek but two minor entities discharge to tributaries. The Sunrise Mobile Home Park (3PV00094) discharges at RM 0.55 to an unnamed tributary that empties into Little Yellow Creek at RM 2.03. WWTP design flow is 0.010 mgd and treatment processes include extended aeration, sand filter, trash trap, and chlorination/ dechlorination. An October 26, 2006 inspection letter reported the facility was in significant non-compliance, with effluent violations for ammonia-N, TSS, and BOD. Potential impact to Little Yellow Creek biological communities was not evaluated as the most downstream sampling site (RM 3.3) was well upstream from the discharge. However, chemical and bacteria samples collected from Little Yellow Creek at Hibbits-Mill Road (RM 1.10) did not identify any chemical pollutants associated with the MHP discharge. A future survey near the mouth of the RM 2.03 tributary is recommended to determine biological and water quality conditions downstream from this entity.

The Skyview Acres WWTP (3PG00123) discharges at RM 1.07 to an unnamed tributary that enters Little Yellow Creek at RM 4.08, just downstream from Wellsville Reservoir. The WWTP is maintained by the office of the Columbiana County Engineer and has a design flow of 0.20 mgd. The facility was upgraded in mid 2004 to correct ongoing problems with the structural design of the aeration tank and permit violations for ammonia-N. New treatment processes include extended aeration, trash trap, flow equalization, and chlorination/dechlorination. Low levels of effluent ammonia-N have been reported since the upgrade.

Two reservoirs impound the Little Yellow Creek mainstem. The most downstream is the Wellsville Reservoir with a dam structure at RM 4.20 (25 acres surface area impoundment; dam constructed in 1926). During the 2005 survey this reservoir was used by the Buckeye Water District as a primary source of public drinking water. About 0.768 mgd of reservoir water was diverted to the Buckeye Water District-Wellsville plant for treatment (Source Water Assessment Plan (2003) for the Wellsville Reservoir).

Modified flow hydrology was identified as a potential cause of the non-attainment of biological communities recorded downstream from the reservoir.

A new water treatment plant is under construction (as of January 2007), and will pump raw water from the Ohio River. When the new plant becomes operational (projected for 2009), Wellsville Reservoir will no longer be a primary source of raw water. This action will result in an additional flow of 0.768 mgd to the lower four miles of Little Yellow Creek. Future biological surveys should be conducted to assess how the aquatic communities respond to the increased flow.

The upstream Highlandtown Lake (170 acres surface area, dam constructed in 1966) is maintained by the Ohio Department of Natural Resources for public boating and fishing. The dam structure is located at RM 8.10 on Little Yellow Creek. A water quality survey of Highlandtown Lake was conducted in 2005 at a single sampling location (L-1) near the dam and discussed on page 138.

Chemical Sampling

No exceedences of water quality criteria for laboratory analyzed chemical parameters were recorded at any of the four sampling locations along the Little Yellow Creek mainstem. Total phosphorus concentrations throughout the mainstem were within a range of values (TP range <0.01-0.025 mg/l, N=18) recorded at WAP ecoregion reference sites. For these reasons, chemical pollutants (excluding dissolved oxygen for the two upper most stations) are not considered to be significant stressors of biotic communities in Little Yellow Creek.

Low dissolved oxygen (min 2.33 mg/l) was recorded at the most upstream location (Clarks Mill Road, RM 11.1), just upstream from the Highlandtown Lake. The stream at this site was channelized, slow moving, and connected to a wetland complex located above the roadway culvert, all habitat stressors that could contribute to low oxygenated water during warm and low flow summer months. The severe DO violations found at Clarks Mill Rd. were measured downstream from the more free-flowing biological sampling sites, located further upstream.

The next sampling location was downstream from Highlandtown Lake dam at McCormick Run Road (RM 6.70). Dissolved oxygen levels were significantly higher than upstream but the range of concentrations (5.0-7.3 mg/l) was lower than expectations for the WAP ecoregion based on data collected from reference sites (range 7.0-8.4 mg/l as 50th and 75th percentiles). Datasonde® results from 2006 did not reveal any WQS violations either, but the average D.O. of 5.93 mg/l was the lowest in the 12 Datasonde® sampling sites in the Yellow Creek survey. Lower than average levels of dissolved oxygen may be a chronic stressor and help explain the inability of biological communities to fully attain WAP ecoregion aquatic life criteria at RM 6.70. Elevated levels of bacteria above PCR criteria were also recorded at this location.

The two sampling locations downstream from the Wellsville Reservoir dam (at RM 3.3 and RM 1.1) showed significantly higher levels of dissolved oxygen (DO mean = 8.50 - 8.89 mg/l, n=4) than was found upstream from the dam at RM 6.7 (DO mean = 6.7 mg/l, n=4), and upstream from Highlandtown Lake dam (DO mean = 4.01, n=4). The concentration of sulfate also was significantly higher at the two stations downstream from Wellsville Reservoir (range 166-224 mg/l), as compared to the two most upstream stations (range 15-60 mg/l), perhaps a result of drainage from historical coal mining.

Fish Sampling

Little Yellow Creek was impounded by a private lake, by the Highlandtown and Wellsville Reservoirs and by the Ohio River New Cumberland dam pool. Three sample sites were situated between these barriers and, at each location, the flow interruptions affected fish community performance. The number of darter species was limited, mottled sculpin were absent, the total number of fish was reduced and all locations were predominated by tolerant assemblages. Pollution sensitive redhorse sucker species, various minnows (e.g., sand shiner, rosyface shiner, silver shiner) and sport fish including smallmouth bass, rock bass, and crappie were also missing from all Little Yellow Creek sub-basin samples. In addition to flow alteration along the course of Little Yellow Creek, excessive, lingering siltation at the site upstream from Highlandtown Lake (RM 11.3) was also a potential source of impairment. The former agricultural land use is now part of the Highlandtown Wildlife Area. The stream sediment load will likely continue to abate and recover as the landscape transitions from former pasture land and old field, to a more natural state.

Reduced stream flow was evident throughout Little Yellow Creek and, in comparison to Yellow Creek basin streams with similar drainage areas, Little Yellow Creek appeared to convey less water. In general, the fish assemblages at Little Yellow Creek sites were more comparable to those from the smallest Yellow Creek drainages. Pioneer species (creek chub and bluntnose minnow) are adapted to recolonize desiccated stream reaches and were especially abundant at these sites. The proportion of generalist feeding species was high while insectivore and omnivore ratios were low.

Fish communities downstream from Wellsville Reservoir in particular, may have been negatively affected by diversion of 0.768 mgd of water from the Wellsville Reservoir for public drinking water. Under late summer, low flow conditions, the diversion of this amount of water could have a chronic impact on aquatic life downstream. The introduction of a new water supply source (projected for 2009) should relieve the dewatering of the stream below the current Wellsville water supply reservoir and enhance flow conditions downstream in the future.

Macroinvertebrate Sampling

Macroinvertebrate community health ranged from fair to good at the three sampling sites along Little Yellow Creek. Immediately upstream from Highlandtown Lake, macroinvertebrates tended to reflect the transitional lotic to lentic habitat conditions at RM 11.1. However, community health was considered good (10 EPT taxa) with no obvious indications of impairment. Communities declined to fair at RM 6.7, as evidenced by declines in EPT and sensitive mayfly taxa, coupled with an increase in predominance of facultative and tolerant varieties. The stream bottom at RM 6.7 was covered with a layer of flocculent, dark brown solids, most likely mats of decaying dead algae from Highlandtown Lake. Communities improved to a good condition downstream from Wellsville Reservoir at RM 3.3 and prior to discharging to the Ohio River.

<u>Alder Lick Run and Bailey Run</u>
Both Little Yellow Creek tributaries showed evidence of chemical stress. At the mouth of Alder Lick Run, total dissolved solids (TDS) were elevated, with 2 of 4 samples exceeding the average water quality criterion of 1,500 umhos/cm. However, the average of the four samples was 1,459 umhos/cm, just below the OMZA criterion. Elevated levels of TDS (typically >1000 umhos/cm) have been associated with toxic effects on certain species of benthic macroinvertebrates, especially mayfly taxa. Extremely hard water also was present in Alder Lick Run (range hardness 645-1490 mg/l), in addition to elevated sulfates (range 512-1140 mg/l) and manganese (284-943 mg/l). This type of chemical signature indicates impact from legacy coal mine drainage. Large areas of land very close to Alder Run were historically strip mined as shown on the U.S.G.S. topographic map for the area. Future surveillance will be required to identify any specific outbreaks of acid mine seepage that may be entering Alder Lick Run.

Biological communities in Alder Lick Run were in the fair (macroinvertebrate) to marginally good (fish) ranges resulting in partial attainment of the recommended WWH use. Physical habitat quality was good (QHEI=69) and more than adequate to support WWH communities. Impacts to the macroinvertebrates were considered largely the result of mine drainage, particularly high concentrations of total dissolved solids. Only thirteen total taxa were collected and mayflies were entirely absent, a typical response in streams with highly elevated TDS or conductance (Pond *et. al*. 2006). A thick crust of sulfite deposits was also observed on many substrates, another indication of a mining influence.

At the Bailey Run chemical sampling location (RM 1.95 at Osbourne Road), very low levels of dissolved oxygen were recorded (range 1.60-3.40 mg/l), likely due to drainage from an upstream beaver dam impoundment and wetland complex. However, because chemical samples were collected well upstream from the biological site at RM 0.7, no cause-effect association between water chemistry and biology could be made.

Biological sampling at RM 0.7 found significant non-attainment due to the poor fish community (IBI=24). The combined influences of wetlands, historical chemical pollution from mine runoff, altered hydrology due to strip mine reclamation ponds, a waterfall, and the Wellsville Reservoir (into which Bailey Run flows) may irretrievably limit the ability of the fish community to attain its designated warmwater habitat aquatic life use (*i.e.,* good quality or better). Macroinvertebrates reflected a marginally good condition and appeared less affected than fish by the physical disruption of the watershed. In addition, the presence of 6 coldwater taxa suggested CWH potential.

Carpenter Run

Carpenter Run is another highly modified Ohio River tributary with high gradient that functioned as storm drainage for the adjacent US 30 and hilltop suburban development. Between Calcutta and East Liverpool, the stream lies in a narrow strip between the SR 7/US 30 highway to the west and Dresden Ave. to the east. Stream flow is routinely directed through a series of culverts and large portions of the channel were likely relocated during construction of the adjacent, limited access highway. No problems with chemical water quality were observed at the RM 1.20 location.

This modified stream was home to two fish species (blacknose dace and creek chub) that were capable of surviving in the spring fed low base flow and in torrential storm flows. A poor IBI score (24) was consistent with the unmoderated flow extremes. The condition of the macroinvertebrates was marginal but a CWH designation is recommended based on the presence of 7 coldwater taxa. In addition to urban runoff, non-attainment in the biology appeared related to historic extirpation or degradation of the fish community and a lack of re-colonization potential due to culverting and road construction.

Jethro Run

Although full biological attainment was recorded in Jethro Run near the mouth (RM 0.3), elevated total phosphorus (TP range 0.045 – 0.234 mg/l) suggest impact from upstream home sewage systems. Bacteria numbers also were elevated above PCR criteria. It is recommended that the Columbiana County Health District conduct inspections of the homes adjacent to Jethro Run to determine the condition of wastewater treatment systems.

Among the four small Ohio River tributaries sampled in the Little Yellow Creek WAU for fish, Jethro Run was unique. This cold water stream was inhabited by an exceptional fish community (IBI=50). Although the sampling location was necessarily situated between the Ohio River backwater and a long under road tunnel and the species rich (20) assemblage included several species more common to larger waters (highest recorded numbers of gizzard shad and emerald shiner location in survey, freshwater drum, white bass, etc.), the community also included three darter, eight minnow and five pollution sensitive species. Longnose dace, a rare, potential coldwater indicator species was also present. It was intriguing to speculate about the upstream condition of Jethro Run because this small waterway flows within a steep largely inaccessible valley. Thus, despite the influx and possible score skewing effect of some atypical species, there was some probability that the essentially intact basin has retained good assimilative capacity.

Jethro Run macroinvertebrates were initially sampled on July 27, 2005, within days of a fuel oil or diesel spill from a truck accident on SR7. Heavy oil sheens and a strong odor of fuel were observed immediately downstream from the highway. Macroinvertebrates appeared in the fair to poor range with only 2 EPT taxa and no mayfly taxa present. The 2005 site was resampled in August 2006 and collections indicated substantial improvement. While only six EPT taxa were found, the community was predominated by large numbers of the coldwater mayfly, *Baetis tricaudatus,* and the coldwater amphipod, *Gammarus minus*; the taxa were entirely absent or present in low numbers the previous year. In all, 5 coldwater taxa were found, a strong indication of coldwater habitat potential. The 2006 community was considered marginally good and some lingering influences from the spill or from septic tank drainage upstream may have contributed to the marginal quality. However, the collections were fairly typical of other small, cool, Ohio River tributaries in the area so the community was considered in attainment. Fish communities were sampled about two months after the fuel spill in 2005 and indicated no significant influence.

McQueen Run

No problems with water chemistry were recorded in McQueen Run, a high gradient tributary that flows directly into the Ohio River. The upper watershed is heavily forested but much of the channel was historically modified adjacent to SR 39 and substrates were mostly loose sand. In addition, the stream plunges into a deep, long culvert immediately upstream from SR 7 that directs flow under the highway.

No fish were present upstream from the SR 7 culvert and the tunnel was considered a barrier to upstream fish movement. If McQueen Run became desiccated or if the fish assemblage was otherwise eliminated, little opportunity for recolonization seemed plausible. In contrast to the fish, macroinvertebrate communities maintained good quality and included 9 coldwater varieties upstream from SR 7. Low population densities did appear to reflect the high gradient and flashy conditions.

Wells Run

Wells Run at RM 0.2 was found to be significantly impacted by upstream mine drainage, with a minimal pH of 4.60 recorded in 1 of 4 samples, well below the minimum water quality criterion of 6.5. Manganese (range 796-2660 mg/l) and iron (range 6,810-13,300) also were extremely elevated, and stream acidity was above detection limit, all chemical signatures of current impact from mine drainage. The stream had an extensive orange colored iron floc covering the bottom sediment, in violation of statewide “free-from” narrative criteria (OAC section 3745-1-04), which states that surface waters should be free from …”substances that enter the waters as a result of human activity and that…settle to form putrescent or otherwise objectionable sludge deposits…” and from ...”materials…producing color, odor or other conditions in such a degree as to create a nuisance.”

An inspection of the upstream area found a mine portal discharging a large volume of orange colored water to the stream at approximately RM 0.5. Upstream from the mine, Wells Run flowed over a picturesque water fall where the stream was clear and natural. The upstream reach was not sampled but a cursory inspection by an Ohio EPA fish crew found abundant salamanders, an indication of permanent pools, intact stream habitat, and neutral pH.

No fish were found in Wells Run and macroinvertebrates were virtually absent downstream from the AMD discharge. Only 7 total macroinvertebate taxa were found but five were coldwater varieties, most likely from the unaffected reach upstream from the portal. A recommended CWH designation is based on the macroinvertebrate collections only. Future sampling should be conducted upstream from the mine portal to fully document chemical and biological conditions and the possible presence of fish or amphibians. It is also recommended the lower segment of Wells Run be targeted for a mine reclamation study to determine the most cost effective way to eliminate the acid mine discharge. Like McQueen Run, the Wells Run tunnel under SR 7 may also prevent upstream fish passage. However, the gradient of the reach immediately upstream from its entrance was not as steep.

PUBLIC LAKES AND RESERVOIRS

Jefferson Lake Evaluation

A water quality survey of Jefferson Lake was conducted in 2005 by the Ohio EPA, Division of Surface Water as part of the Yellow Creek Total Maximum Daily Load watershed survey. Jefferson Lake is located in Jefferson County, Salem Township. The lake is a 17 acre on-stream impoundment of Town Fork with a maximum depth of 3.6 meters. The dam was built in 1934 and the impoundment was filled in 1946.

The 4,788 acre Jefferson Lake watershed is located within the Western Allegheny Plateau ecoregion. The watershed is entirely rural with no communities, industries or point source discharges. Land cover is 67% deciduous forest, 16% pasture/hay land, 7% open space and 6% cultivated crops. However, as noted during chemical and biological sampling on Town Fork, pastures upstream from the lake tend to be concentrated in the lowlands immediately adjacent to the stream channel. Riparian removal and fecal coliform contamination associated with unrestricted cattle access was noted along the feeder stream at RM 10.4, approximately a mile upstream from the lake. More detailed land use data is found in Table 23. The highest point in the watershed is 1,280 feet above sea level and the spillway outlet and water level is 955 feet above sea level.

Table 23. Jefferson Lake watershed land use.

Open Water	16.9	0.30%
Developed, Open Space	351.8	7.30%
Developed, Low Intensity	17.1	0.36%
Barren Land (Rock/Sand/Clay)	12.7	0.03%
Deciduous Forest	3202.0	66.90%
Evergreen Forest	41.6	0.09%
Mixed Forest	1.1	0.00%
Grassland/Herbaceous	80.1	1.70%
Pasture/Hay	773.0	16.10%
Cultivated Crops	292.0	6.00%
Total	4788.4	98.77%

Multi-Resolution Land Characteristics Consortium, 2001

Jefferson Lake is managed by the Ohio Department of Natural Resources (ODNR), Divisions of Parks and Recreation and Wildlife. The lake has a normal warmwater assemblage of sport fish including largemouth bass, bluegill, redear sunfish, crappie, channel catfish, and bullhead catfish. No motorized boats are allowed on the lake.

Jefferson Lake: Sampling Methods

On 11 August depth and field parameter profiles were measured near the deepest location in the lake; parameters included temperature, dissolved oxygen, pH, and conductivity (Table 24) and Secchi depth (Table 27). Samples were collected at 0.5

meter below the surface and 0.5 meter above the bottom and analyzed for the parameters listed in Table 25. Water was collected at 0.9 and 1.8 meters for chlorophyll analysis with three aloquats of 200 ml. filtered separately from each depth. Bacteria samples were collected at the beach for analysis of *E. coli* and fecal coliform on 27, July and 16 August 2005.

Jefferson Lake: Results and Discussion

The aquatic life use designation for all public and private inland lakes within Ohio, except upground reservoirs at the time of this report production, is Exceptional Warmwater Habitat (EWH). Numerical water quality parameters for EWH apply to lakes but biological criteria do not. Currently, Ohio EPA has no methodology to determine attainment of aquatic life use in lakes. No exceedances of applicable WQS criteria were observed in the upper one half meter and three meter grab samples analyzed for inorganic constituents (Table 25). Dissolved oxygen was below the EWH criterion at one meter and below (Table 24).

The trophic condition of Jefferson Lake was evaluated by examining Secchi transparency, nitrogen, total phosphorus, and chlorophyll-*a*. The results of these measures were compared to USEPA reference values (Table 26) and used to calculate Carlson's Trophic State Index, TSI, (Carlson 1977).

The trophic state parameters listed above were compared to values from the USEPA document: Ambient Water Quality Criteria Recommendations, Information Supporting the Development of State and Tribal Nutrient Criteria, Lakes and Reservoirs in Nutrient Ecoregion XI. Jefferson Lake sampling results and associated reference values are found in Table 27.

Except for Nitrate-nitrite, all the trophic state parameters listed in Table 27 indicate a highly eutrophic lake.

The Secchi depth values, a measurement of sunlight penetration and dissolved oxygen reported in Table 27 indicate a eutrophic lake. The measured Secchi depth of 0.9 m. is less than one third of the USEPA 25th percentile Secchi reference value.

Nitrate-nitrite concentrations were below the detection limit of 0.1 mg/l. The detection limit is greater than the USEPA 25th percentile reference value of 0.025 mg/l but well below the maximum value (2.625 mg/l) reported for reference lakes.

All TKN and total nitrogen concentrations were above the USEPA 25th percentile reference value of 0.182 mg/l and 0.207 mg/l, respectively. However all concentrations were below the maximum values of 1.24mg/l. and 3.865 mg/l, respectively, reported for reference lakes.

Total phosphorus concentrations were greater than the USEPA 25th percentile reference value but less than the maximum reported for reference lakes within the ecoregion.

Chlorophyll a reported in Table 27 is the average of three duplicate sample analysis results. Both samples were well above the maximum reported for reference lakes.

TSI values, presented in Table 28, were calculated from total phosphorus, chlorophyll and Secchi disk data from the epilimnion. The total phosphorus results were below the 10.0 ug/l detection limit. Therefore a 5.0 ug/l value, which is half of the detection limit, was used for the total phosphorus TSI calculation. The resulting TSI values all indicate a eutrophic lake.

On 27 July *E. coli* was 40 colonies /100ml and fecal coliform 110/100ml. On 16 August *E. coli* was 720 colonies/100ml and fecal coliform 3600/100ml. The August results exceed the Bathing Water standards for *E. coli* content in that results exceeded 235 per 100 ml in more than ten per cent of the samples taken during any thirty-day period and fecal coliform content exceeded 400 per 100 ml in more than ten per cent of the samples taken during any thirty-day period.

Table 24. Jefferson Lake field parameter measurements, 2005.

Date	Depth (m.)	Temp. (C)	Dissolved Oxygen (mg/l)	pH (SU)	Conductivity (umhos)
11 August 2005	0.5	26.98	5.21	7.52	614
	1.0	25.50	3.84*	7.36	614
	1.5	25.36	3.69*	7.30	615
	2.0	25.25	2.25*	7.26	613
	2.5	24.49	0.26*	7.04	609
	3.0	23.46	0.16*	7.00	618
	3.5	22.57	0.17*	6.98	636
* DO concentrations in red are below EWH daily minimum criterion.					

Table 25. Jefferson Lake inorganic sample analysis results, 11 August 2005.

Depth	0.5 M.	3.0 M.
Date	11-Aug-05	11-Aug-05
Parameter		
Arsenic ug/L	3.3	4.5
Cadmium ug/L	0.30	0.34
Calcium mg/L	100	95
Chromium ug/L	30 K	30 K
Copper ug/L	10 K	10 K
Iron ug/L	112	144
Lead ug/L	2.0 K	2.0 K

Depth	0.5 M.	3.0 M.
Date	11-Aug-05	11-Aug-05
Parameter		
Magnesium mg/L	24	23
Manganese ug/L	498	4280
Mercury ug/L	0.20K	0.20K
Nickel ug/L	40 K	40 K
Potassium mg/L	3	3
Selenium ug/L	2.0 K	2.0 K
Sodium mg/L	11	10
Zinc ug/L	10K	10K
Hardness, Total mg/L	348	332
Alkalinity mg/L	134	133
BOD5 mg/L	2.0 K	2.0K
TOC mg/L	3.8	3.8
Conductivity umhos/cm	680	667
Nitrate+nitrite mg/L	0.10 K	0.10 K
Nitrite mg/L	0.020 K	0.020 K
Ammonia mg/L	0.155	0.444
TKN mg/L	0.48	0.64
pH s.u.	7.94	7.67
Total Phosphorus mg/L	0.015	0.041
Total Solids mg/L	474	474
Total Dissolved Solids mg/L	454	440
Total Suspended Solids mg/L	6	7
Sulfate mg/L	215	205
Aluminum ug/L	200 K	200 K
Barium ug/L	51	195
Strontium ug/L	339	320
Total Volatile Solids mg/L	62	58
	K= *detection limit*	

Table 26. Reference conditions for 70 level III ecoregion lakes and reservoirs.

Parameter	No. of Lakes N ++	Reported values		25th Percentiles based on all seasons data for the Decade
		Min	Max	P25* all seasons +
TKN (mg/L)	64	0.025	1.24	0.182
NO2 + NO3 (mg/L)	63	0.01	2.625	0.025
TN (mg/L) - calculated	NA	0.035	3.865	0.207
TP (*u*g/L)	64	3.25	230	9.75
Secchi (meters)	29	0.453	4.435	2.795
Chlorophyll *a* (*u*g/L) - F	8	2.05	10.5	2.425

From: USEPA, 2000

Table 27. Trophic state parameters analysis results; 2005.

Date	Depth (m.)	Chl-a (ug/l)	Secchi (m.)	NO2-NO3 (mg/l)	TKN (Kjeldahl-N) (mg/l)	T-N (mg/l) (NO2-NO3+TKN)	T Phos. (mg/l)	N/P Ratio
11 August	0.5	14.6 (0.9 M.)	0.90	0.01(K)	0.48	0.53	0.015	35.3
	3.0	13.3 (1.8M.)		0.01(K)	0.64	0.69	0.041	16.8
25th %tiles (from Table 26)	---	*2.425*	*2.795*	*0.025*	*0.182*	*0.207*	*0.00975*	---

Table 28. Trophic State Index

Date	Chl-a TSI 9.81 ln (CHL ug/L) + 30.6	Secchi TSI 60 - 14.41 ln(SD meters)	Total Phosphorus TSI 14.42 ln(TP ug/L) + 4.15
11 August surface	56.9	61.5	43.2

Highlandtown Lake

Highlandtown Lake is a 170 acre impoundment of Little Yellow Creek in Columbiana County. The lake is part of the Highlandtown Wildlife Area managed by the Ohio Department of Natural Resources. The lake dam was completed in 1966. The lake has a capacity of 1,230 acre-feet of water with an upstream drainage area of about 6.0 mi^2. Boating (electric motors), fishing, and hiking are the primary recreational activities. Game fish in demand include largemouth bass, channel catfish, yellow perch, and crappies (Ohio DNR communication).

A previous survey of Highlandtown Lake was conducted by Ohio EPA in 1978 near the dam. The data are available in the Ohio EPA 1982 305(b) report and the 1985 USGS Open-File Report 84-249 titled “Chemical and biological quality of selected lakes in Ohio 1978 and 1979”. Highlandtown Lake was found to be slightly eutrophic in 1978, with a final Carlson Trophic State Index TSI = 57.5 (see Table 29).

Highlandtown Lake: Sample Methods

Grab water samples were collected in 2005 on three dates (6/13; 07/13; 9/14) at a location about 0.3 km from the lake dam (Ohio EPA lake station L-1; Lat: 40.6399, Long: 80.7555). All chemical, physical, and field and laboratory methods and procedures followed those specified in the Ohio EPA Surveillance Methods and Quality Assurance Practices Manual (Ohio EPA, 2006 revised). Field measurements for pH, temperature, dissolved oxygen, and conductivity were collected through the water column at fixed intervals. Duplicate samples for chlorophyll-a analysis were collected at the 0.5 meter depth and filtered through Whatman GF/C 1.2 micron glass microfiber filters. Chlorophyll concentration was determined using a Turner Model fluorometer modified for chlorophyll-a analysis. Secchi disk depth was measured using a standard 20 cm diameter black and white disk. Plankton samples were collected using a 11.5 cm diameter, 63 micron, Wisconsin plankton net. Duplicate plankton samples were collected from vertical tows to twice the measured Secchi disk depth. Zooplankton samples were fixed in 5% formalin and preserved in 75% ethyl alcohol. Phytoplankton samples were preserved in Lugols iodine solution. At the time of this report the plankton samples have not been analyzed.

Highlandtown Lake: Results and Discussion

Results from the 2005 survey show a significant reduction in the trophic state of Highlandtown Lake compared to 1978 (Table 29). A drop of 12.5 TSI points resulted in a mesotrophic classification. The amount of chlorophyll-a present in the lake also dropped significantly between 1978 and 2005. The reason for the reduction in algal biomass is unknown, but it does not appear to be related to a decrease in the amount of total phosphorus. A decrease in the biomass of algae could result from an increase in feeding activities of zooplankton that graze on algae; however, this hypothesis cannot be tested because zooplankton was not sampled in 1978.

Table 29. Trophic state data for Highlandtown Lake from samples collected by Ohio EPA in 1978 and 2005. Samples collected near the dam in 1978 and 0.3 km upstream from the dam in 2005.

Lake	Site	Date (m/d/y)	Chl-a (ug/l)	TSI (chl)	SD (M)	TSI (SD)	TP (ug/l)	TSI (TP)	Final* TSI	Trophic ** State
Highlandtown Lake	at dam	5-15-78	47.0	68	1.47	54	20	47		
(1978 survey)	at dam	8-21-78	43.7	68	1.09	59	10	37	57.5	Eutrophic
Highlandtown Lake	L-1	6-13-05	3.67	43	1.92	51	10	37		
(2005 survey)	L-1	7-13-05	6.73	49	1.41	55	<10	37		
	L-1	9-14-05	6.46	49	1.42	55	21	48	45.0	Mesotrophic

* Final TSI calculated as the average of TSI for summer chlorophyll-a (July,Aug,Sept)+ spring TP (Apr., May, Jun).
** Trophic state terminology from Ohio EPA 1996 305(b) Report, Vol III., “Ohio’s Public Lakes, Ponds, and Reservoirs”.
Samples collected from 0.5 m depth.

A sample of the bottom water, 0.5 meters from the sediment, revealed the presence of a number of pesticides at low concentrations (Table 30). However, of the twelve pesticides tested that have water quality criteria, none were at concentrations that exceeded criteria values.

Field measurements taken at one meter intervals through the water column revealed that a thermocline developed by the mid-June sample, but was weakly present by mid-September (Table 31). Very low levels of dissolved oxygen were recorded from June to September below a 4.0 m depth. These data indicate that aquatic life would be stressed in bottom waters during the summer months when a thermocline has established. The concentration of total phosphorus was relatively low in both surface (TP range < 10–21 ug/l) and bottom (<10–14 ug/l) waters; thus, internal loading of nutrients to the water from the sediment when the bottom waters attain an anoxic condition does not appear to be a problem. The concentration of priority heavy metals such as lead, copper, zinc, nickel, cadmium were either below detection limits or at background levels.

A fecal coliform bacteria sample was collected at the boat ramp on June 13, 2005. The measured value of 160 counts/100 ml is well below the PCR criterion of 1000 counts/100 ml. The lake showed very soft water, with a water hardness ranging from 46 to 48 mg/l during the survey. The heavy metals copper, lead, nickel, and chromium were below detection limits in all samples collected in both surface and bottom waters.

In summary, the results of the 2005 survey indicate that Highlandtown Lake has significantly less biomass of planktonic algae as measured by chlorophyll-a than was present in 1978. The reason for this decrease in trophic state is unknown but does not appear to be related to change in watershed loading of total phosphorus. Relatively low levels of total phosphorus were present in the lake water in summer months in both 1978 and 2005. It is possible that zooplankton grazing may be responsible for the shift in trophic state. Higher level of zooplankton grazing in 2005 would be predicted to decrease total algal biomass. One method to induce higher numbers of zooplankton is by biomanipulation of game fish populations. Increased predation by top predator fish species can result in decreased numbers of small fish that prey on zooplankton. The Ohio DNR has been stocking top predators in the lake since the 1970s. It is recommended that a survey of the zooplankton community be conducted to determine the numbers and kinds of species present seasonally. The lake showed a complete loss of dissolved oxygen below the 4.0 m depth during the summer months, a common phenomenon for lakes in Ohio. It is recommended that any future addition of fish structures to enhance game fish populations be placed above the 4.0 m contour so that they can be utilized in summer months.

Note: Since the lake writeup was completed, the Ohio EPA modeling section conducted a complex TMDL load allocation report for Highlandtown Lake. For details of the report, please contact Chris Hunt at: *Christopher.Hunt@epa.state.oh.us*.

Table 30. US EPA Method 525.2, 531.1, and 547 pesticides in bottom water samples from Highlandtown Lake.

Parameter Date	Result (ug/l) 6/13/2005	Result (ug/l) 7/13/2005	WQS (ug/l)
US EPA Method 525.2 Pesticides			
Acetochlor	0.21	<0.20	na
Alachlor	0.23	<0.20	2.0[a]
Atrazine	<0.20	<0.20	3.0[a]
Benzo[a]pyrene	<0.51	<0.51	0.044[a] - 0.49[c]
Bis(2-Ethylhexyl) adipate	<0.51	<0.51	na
Bis(2-Ethylhexyl) phthalate	0.73	0.93	8.4[b] - 6.0[a]
Butachlor	0.29	<0.20	na
Cyanazine	<0.22	<0.22	na
Metolachlor	0.26	<0.20	na
Metribuzin	0.23	<0.20	na
Pentachlorophenol	<5.1(pH=7.15)	<5.1(pH=7.14)	4.0[d]
Propachlor	0.25	<0.20	na
Phenol, 2,6-dibromo-	0.30	ns	na
Simazine	<0.20	<0.20	4.0[a]
1,1,1-Tris (chloromethyl)ethane	ns	0.2	na
Tetradecanoic acid, hexadecyl ester	ns	0.8	na
US EPA Method 531.1 Pesticides			
Aldicarb	ns	<0.50	7.0[e]
Aldicarb sulfone	ns	<0.50	7.0[e]
Aldicarb sulfoxide	ns	<0.50	7.0[e]
Carbaryl	ns	<0.50	na
Carbofuran	ns	<0.50	40[a]
3-Hydroxycarbofuran	ns	<0.50	na
Methiocarb	ns	<0.50	na
Methomyl	ns	<0.50	na
Oxamyl	ns	<0.50	200[a]
Propoxur	ns	<0.50	na
US EPA Method 547 Pesticides			
Glyphosate	<5.0	<5.0	700[a]

na = no standards apply
ns = no sample analyzed
[a] Human health drinking standard
[b] OMZA aquatic life standard
[c] Non drinking human health standard
[d] OMZA aquatic life standard at pH = 6.5
[e] Standard is sum of aldicarb, aldicarb sulfone, aldicarb sulfoxide

Table 31. Results of chemical/physical sampling (field parameters) from Highlandtown Lake, 2005.

Location	Date	Depth (m)	Temp ^{0}C	DO (mg/l)	pH (su)	Conductivity (umhos/cm)
L-1	06/13/05	0.5	27.86	8.37	8.09	124
		1.0	27.80	8.24	7.95	124
		2.0	26.07	9.27	8.15	124
		thermocline				
		3.0	21.71	11.59	8.73	122
		4.0	17.10	4.51	7.71	125
		5.0	14.50	2.14	7.35	129
		6.0	11.63	0.58	7.09	145
L-1	07/13/05	0.5	28.10	9.39	8.09	122
		1.0	28.08	8.30	8.06	122
		2.0	27.69	7.97	7.88	122
		thermocline				
		3.0	25.54	5.05	7.24	123
		4.0	21.82	0.29	6.87	124
		5.0	16.67	0.20	6.89	148
		6.0	13.28	0.05	7.02	164
L-1	09/14/05	0.5	23.86	9.33	8.31	123
		1.0	23.65	9.36	8.31	123
		1.5	23.55	8.86	8.14	123
		2.0	23.43	8.67	8.02	123
		2.5	23.19	7.43	7.74	123
		3.0	22.84	5.22	7.43	123
		3.5	22.62	3.93	7.21	124
		4.0	22.41	2.69	7.04	124
		4.5	22.01	1.19	6.87	125
		5.0	21.26	0.16	6.76	128
		5.5	20.71	0.11	6.80	136
		6.0	18.84	0.11	7.00	163

REFERENCES:

Carlson, R.E. and J. Simpson. 1996. *Volunteer Lake Monitoring in the Upper Mid-west: Programs, Techniques, and Technical Recommendations.* North American Lake Management Society, Madison, WI.

DeShon, J.D. 1995. Development and application of Ohio EPA's invertebrate community index (ICI), *in* W.S. Davis and T. Simon (eds.). Biological assessment and criteria: tools for risk-based planning and decision making. CRC Press/Lewis Publishers, Ann Arbor.

Hughes, M.L. and Bowman, J.R. 2007. Acid-Mine Drainage Abatement and Treatment (AMDAT) Report for the Yellow Creek Watershed, Ohio. Technical Publication of the Voinovich School of Leadership & Public Affairs, Environmental Management Program, Ohio University

Hull & Assoc, Inc., 2005. Phase II Environmental Property Assessment. Prepared for Findlay/Brandman Clean Ohio Revitalization Fund Application to Ohio EPA.

Karr, J.R. 1991**.** Biological integrity: A long-neglected aspect of water resource management. Ecological Applications 1(1): 66-84.

Karr, J.R., K.D. Fausch, P.L. Angermier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Ill. Nat. Hist. Sur. Spec. Publ. 5. 28 pp.

MacDonald, D.D., C. G. Ingersoll, T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39:20-31.

Milligan, J.D. 1987. Assessment of E. Coli Enterococci, and Fecal Coliform Bacteria in a Recreational Floatway *in* Lake and Reservoir Management, Vol III, pp 163-171).

Miner R. and D. Borton. 1991. Considerations in the development and implementation of biocriteria, Water Quality Standards for the 21st Century, U.S. EPA, Offc. Science and Technology, Washington, D.C., 115.

Multi-Resolution Land Characteristics Consortium, National Land Cover Dataset 2001, http://www.mrlc.gov/mrlc2k_nlcd.asp

Ohio Department of Natural Resources, Division of Water. *Gazetteer of Ohio Streams,* Second Edition. , Water Inventory Report 29. August 2001. Columbus, Ohio.

___ 1967. Division of Water. Drainage Areas of Ohio Streams (Supplement to Gazetteer of Ohio Streams). Columbus, Ohio.

___ 2008a. Cheryl Socotch. Division of Mineral Resources Management. Email message. April 23, 2008.

___ 2008b. Mitchell Farley. Division of Mineral Resources Management. Email message. April 23, 2008.

Ohio Environmental Protection Agency. 1987a. Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment. Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

___ 1987b. Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

___ 1989b. Addendum to biological criteria for the protection of aquatic life: Users manual for biological field assessment of Ohio surface waters. Division of Water Quality Planning and Assessment, Surface Water Section, Columbus, Ohio.

___ 1989c. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Division of Water Quality Planning and Assessment, Columbus, Ohio.

___ 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.

___ 1999. Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams. Technical Bulletin MAS/1999-1-1.

___ 2001. Sediment sampling guide and methodologies, 2nd edition. Nov. 2001. Division of Surface Water, Columbus, Ohio.

___ 2003. Summary biological assessment of the North Fork Yellow Creek in the vicinity of the Hammondsville AMD site. Jefferson County. March, 2003 OEPA Report EAS/2003-3-5.

___ 2002. Manual of Laboratory Operating Procedures. Volumes I,II,III and IV. Division of Environmental Services.Services, Columbus, Ohio.

___ 2003. *Ecological risk assessment guidance manual*. Feb. 2003. Division of Emergency and Remedial Response, Columbus, Ohio.

___ 2005. April 2005 update to Attachment 3: Coolwater/coldwater macroinvertebrate taxa *in* Field Evaluation Manual for Ohio's Primary Headwater Habitat Streams. Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

___ 2007, May 11 letter to Mayor of Salineville.

___ 2006. *Ohio EPA manual of surveillance methods and quality assurance practices, updated edition*. Division of Environmental Services, Columbus, Ohio.

Ohio State University Extension Data Center. Population by Government Units 2000. Retrieved January 27, 2005 http://www.osuedc.org/profiles/

Omernik, J.M. 1988. Ecoregions of the conterminous United States. Ann. Assoc. Amer. Geogr. 77(1): 118-125.

Pond, G.J., M.E. Passmore, and T. Norberg-King. 2006. *Ionic Stress in Appalachian Headwater Steams. Are Total Dissolved Solids Toxic?* Poster presentation at USEPA Workshop on Headwaters and Associated Wetlands in the Mid-Atlantic Highlands Regions, June 20-21, 2006 Philadelphia, Pennsylvania.

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

___ 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.

___ 2006. Unpublished data.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Official Soil Series Descriptions [Online WWW]. Available URL: "http://soils.usda.gov/technical/classification/osd/index.html" [Accessed 10 February 2004].

Study Area. http://factfinder.census.gov/home/saff/main.html?_lang=en

United States Department of the Interior-U.S. Geological Survey. 2004. Water Resources Data-Ohio Water Year 2005. *Volume 1. Ohio River Basin Excluding Project Data*. Water-Data report OH-03-1. 383 pp.

___ 2000. *Low Flow Characteristics of Streams in Ohio through Water Year 1997*. Report 01-4140. 421 pp.

United State Army Corps of Engineers Electronic references. Retrieved October 4, 2004 from http://www.lrl.usace.army.mil/cjbl/

United States Census Bureau. Population Division. Release Date: July 10, 2005. Table SUB-EST2002-07-39-Ohio Incorporated Place Population Estimates, Sorted Alphabetically: April 1, 2000 to July 1, 2002.

United States Environmental Protection Agency. poster

University of Cincinnati, Department of Geography. Robert Frohn, Richard Beck, Lin Liu, and Xinhao Wang. Project #01 (h)EPA-06, "Statewide Land Use Classification and Validation in Ohio"; Project start date 12/01/01; project end date 4/2005.

Yoder, C.O. 1989. The development and use of biological criteria for Ohio surface waters. U.S.EPA, Criteria and Standards Div., Water Quality Stds. 21st Century, 1989: 139-146.

___ 1991. Answering some concerns about biological criteria based on experiences in Ohio, *in* G. H. Flock (ed.) Water quality standards for the 21st century. Proceedings of a National Conference, U. S. EPA, Office of Water, Washington, D.C.

___ 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. 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.

___ 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.

___ 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.