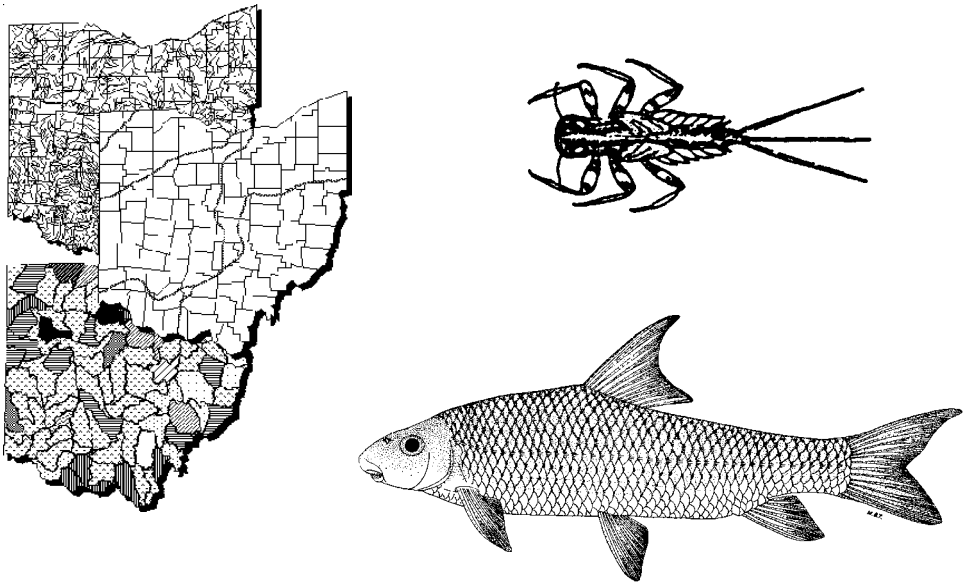
State of Ohio
Environmental Protection Agency

Division of Surface Water

Biological and Sediment Study of the Muskingum River

McConnelsville, Ohio



March 19, 2004

Bob Taft, Governor
Christopher Jones, Director

Biological and Sediment Study of the Muskingum River

Federal Mogul/Gould Electronics
5037 State Route 60
McConnelsville, Ohio

2003

Morgan County, Ohio

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State of Ohio Environmental Protection Agency
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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 1987), and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the existing chemical and whole effluent toxicity evaluation methods and criteria, figure prominently in the monitoring and assessment of Ohio's surface water resources.

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

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

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

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

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

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

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

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

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

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.

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

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

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 Ohio EPA conducts biosurveys in 6-10 different study areas with an aggregate total of 350-400 sampling sites.

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 Ohio EPA (*e.g.,* NPDES permits, Director's Orders, the Ohio Water Quality Standards [OAC 3745-1]), and are eventually incorporated into Water Quality Permit Support Documents (WQPSDs), State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the Ohio Water Resource Inventory (305[b] report).

Hierarchy of Indicators

A carefully conceived ambient monitoring approach, using cost-effective indicators comprised 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 is outlined in Figure 1 and includes a hierarchical continuum from administrative to true environmental indicators. The six "levels" of indicators include: 1) actions taken by regulatory agencies (permitting, enforcement, grants); 2) responses by the regulated community (treatment works, pollution prevention); 3) changes in discharged quantities (pollutant loadings); 4) changes in ambient conditions (water quality, habitat); 5) changes in uptake and/or assimilation (tissue contamination, biomarkers, wasteload allocation); and, 6) changes in health,

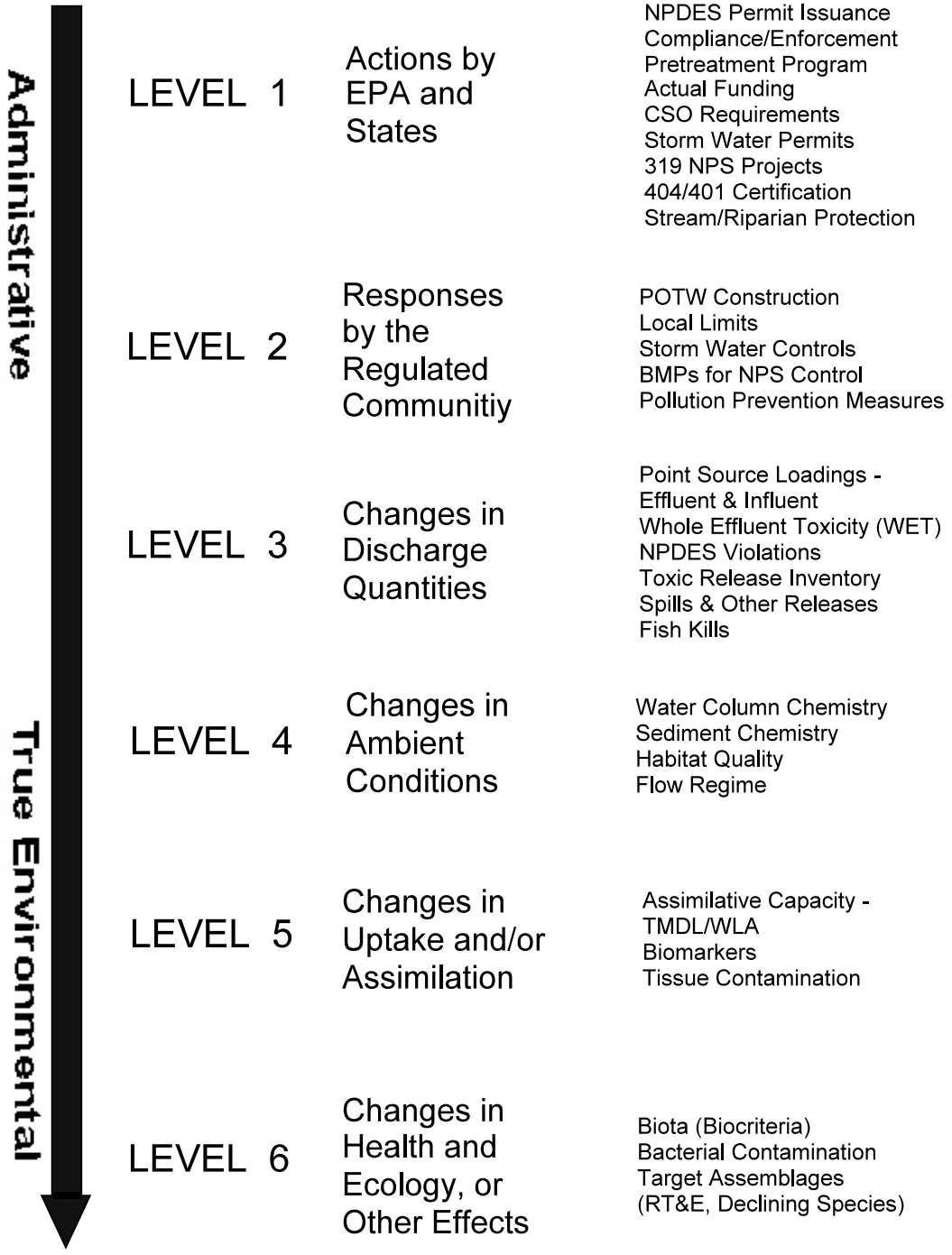

Figure 1. Hierarchy of administrative and environmental indicators which can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by U.S. EPA (1995).

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 scale is a biological and water quality report. These reports then provide the foundation for aggregated assessments such as the Ohio Water Resource Inventory (305[b] report), the Ohio Nonpoint Source Assessment, and other technical bulletins.

Ohio Water Quality Standards: Designated Aquatic Life Uses

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 cold water organisms and/or those which are stocked with salmonids with the intent of providing a put-and-take fishery on a year round basis which is further sanctioned by the Ohio DNR, Division of Wildlife; this use should not be confused with the Seasonal Salmonid Habitat (SSH) use which applies to the Lake Erie tributaries which support periodic "runs" of salmonids during the spring, summer, and/or fall.
4) *Modified Warmwater Habitat (MWH)* - this use applies to streams and rivers which have been subjected to extensive, maintained, and essentially permanent hydromodifications such that the biocriteria for the WWH use are not attainable *and where the activities have been sanctioned and permitted 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 water quality 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 is simply having a water depth of at least one meter over an area of at least 100 square feet or where canoeing is a feasible activity. If a water body is too small and shallow to meet either criterion the SCR use applies. The attainment status of PCR and SCR is determined using bacterial indicators (*e.g.,* fecal coliforms, *E. coli)* and the criteria for each are specified in the Ohio WQS.

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 and are detailed in other documents.

ACKNOWLEDGMENTS

The following individuals are acknowledged for their significant contribution to this report, including field sampling, data analysis, and database management.

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Reviewers - Jeff DeShon, Marc Smith

INTRODUCTION

Historical operational practices at the Gould Electronics and Federal Mogul facilities resulted in impacts to sediment, soil, groundwater, and surface water from chlorinated solvents and metals. The area surrounding these facilities has been characterized in a Remedial Investigation (RI) and Feasibility Study (FS) conducted in 1993 and 1996, respectively. The preferred remedy for impaired river sediments, as specified in the Ohio EPA Preferred Plan (Ohio EPA 1997), is sediment dredging in the area of both wastewater outfalls. However, because the RI included only a qualitative ecological assessment, the Preferred Plan required performing a quantitative assessment to determine whether sediment remediation is necessary. This ecological assessment of the Muskingum River in the vicinity of Federal Mogul and Gould Electronic wastewater discharges was implemented to evaluate sediment and biological conditions.

Specific objectives of this evaluation were to:

1) Establish the present biological condition of the Muskingum River in the vicinity of the Federal Mogul and Gould Electronics NPDES outfalls by evaluating fish and macroinvertebrate communities, and

2) Identify the relative levels of organic and inorganic contaminants in the surficial sediments of the Muskingum River adjacent, upstream and downstream from these two facilities.

SUMMARY

A total of 2.9 miles of the Muskingum River were assessed by the Ohio EPA in 2003. Based on the performance of the biological communities, the entire 2.9 miles of the Muskingum River were in partial attainment of the Warmwater Habitat aquatic life use (Table 1). The partial attainment was associated with fair fish results at each sampling location and fair macroinvertebrate communities at the upstream location. Fish community results, and macroinvertebrate ICI and Eckman dredge results, did not show any significant differences between upstream, adjacent to Gould and Federal Mogul, and downstream sampling locations The impounded condition of the Muskingum River within the study segment, along with excessive siltation of bottom substrates contributed to the impaired biological communities. The impaired biological conditions are not associated with chemical constituents released under current conditions or from chemically contaminated sediments at the Gould Electronics or Federal Mogul discharge locations. Elevated levels of copper, nickel and lead were recorded in sediments within the Federal Mogul discharge mixing zone; however, the biology of the river was not negatively impacted. Particularly important was the significant improvement in sediment chemical levels within the Gould and Federal Mogul mixing zones, for numerous metals and volatile organic compounds, between 1988 and the present study.

Sampling during 2003 confirmed the appropriateness of the Warmwater Habitat aquatic life use designation for the Muskingum River in the McConnellsville area. Presently, the Muskingum River is listed as Warmwater Habitat in the Ohio Water Quality Standards (WQS).

RECOMMENDATIONS

Status of Aquatic Life Uses
The aquatic life use designation of Warmwater Habitat (WWH) for the Muskingum River has been confirmed in previous Ohio EPA biological and water quality studies. This study verified the WWH use designation for the Muskingum River in the vicinity of McConnellsville, Ohio.

Status of Non-Aquatic Life Uses
This study verified that the Primary Contact Recreation use is appropriate for the Muskingum River.

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 Assurance Practices (Ohio Environmental Protection Agency 1989a) and Biological Criteria for the Protection of Aquatic Life, Volumes I-III (Ohio Environmental Protection Agency 1987a, 1987b, 1989b, 1989c), 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 2.

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

Habitat Assessment
Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by

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

Sediment Assessment

Fine grain sediment samples were collected in the upper 3 inches of bottom material at each Muskingum River location using decontaminated stainless steel Eckman dredges. Decontamination of sediment sampling equipment followed the procedures outlined in the Ohio EPA sediment sampling guidance manual (Ohio EPA 2001). Sediment composite samples were mixed in stainless steel pans (material for VOC analysis was not mixed), transferred into glass jars with teflon lined lids, placed on ice (to maintain 4°C) in a cooler, and shipped to an Ohio EPA contract lab. Sediment data is reported on a dry weight basis. Sediment evaluations were conducted using guidelines established in MacDonald *et al.* (2000), USEPA Region 5 Ecological Data Quality Levels - EDQLs (1998), and sediment reference values (SRVs) for metals (Ohio EPA 2003) .

Macroinvertebrate Community Assessment

Macroinvertebrates were collected from artificial substrates and from the natural habitats at the six Muskingum River sites. The artificial substrate collection provided quantitative data and consisted of a composite sample of five modified Hester-Dendy multiple-plate samplers colonized for six weeks. At the time of the artificial substrate collection, a qualitative multihabitat composite sample was also collected. This sampling effort consisted of an inventory of all observed macroinvertebrate taxa from the natural habitats at each site with no attempt to quantify populations other than notations on the predominance of specific taxa or taxa groups within major macrohabitat types (e.g., riffle, run, pool, margin).

Quantitative natural substrate samples were also collected at the six Muskingum River sampling locations. Four Eckman samples from each site were composited in a 40 screen bucket (0.425 mm mesh size). Excess silt was washed from the sample in the field. The retained macroinvertebrates and debris were preserved in 10% formalin. Macroinvertebrates in the samples were then identified and counted per standardized procedures. 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 twice at each site using pulsed DC electrofishing methods, with sampling distances of 500 meters at each site in the Muskingum River. Sampling was conducted during daylight hours. 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.

RESULTS

Sediment Chemistry

Sediment samples were collected at six locations in the Muskingum River by the Ohio EPA on October 9, 2003. All stream sampling locations are indicated by river mile in Figure 2. Samples were analyzed for volatile organic compounds (VOCs) and total analyte list inorganics. Specific chemical parameters tested and results are listed in Appendix Table 1.

Sediment data were evaluated using guidelines established in *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems* (MacDonald *et.al*. 2000), and USEPA Region 5, RCRA Appendix IX compounds - Ecological Data Quality Levels (EDQLs) (USEPA 1998). The consensus-based sediment guidelines define two levels of ecotoxic effects. A *Threshold Effect Concentration* (TEC) is a level of sediment chemical quality below which harmful effects are unlikely to be observed. A *Probable Effect Concentration* (PEC) indicates a level above which harmful effects are likely to be observed. Ecological data quality levels (EDQLs) are initial screening levels used by USEPA to evaluate RCRA site constituents. This tiered approach to evaluating sediment is consistent with OAC 3745-300-09. In addition, sediment reference values (SRVs) for metals (Ohio EPA 2003) are presented in Table 3 for comparison to Muskingum River results.

Sediment collected from five of six locations in the Muskingum River reflected non-contaminated conditions. At these five locations (RMs 52.42, 52.08, 51.81, 50.58, and 50.27) chemical parameters were reported as not detected or at very low concentrations. These chemical parameters were below ecologically harmful effects guidelines or sediment reference value levels. Sediment collected at RM 51.74, within the Federal Mogul mixing zone, revealed elevated levels of copper, nickel, and lead. Two of these parameters, nickel and lead, exceeded the PEC. Nearly all of the volatile organic compounds tested were reported below lab detection limits. Of the few VOCs with a reported concentration, all were very low and below sediment ecological screening levels.

Historical sediment results from the Muskingum River (Ohio EPA 1993) at the Gould and Federal Mogul mixing zones (1982, 1986, 1988, 1992) revealed significantly improved conditions during the 2003 study. Highly elevated concentrations of copper, lead, chromium and zinc noted in previous years were substantially lower during the 2003 study. Historical lead values as high as 15,300 mg/kg and 7,700 mg/kg were recorded at RMs 51.74 and 51.81, respectively. During 2003, the maximum lead value was 273 mg/kg, recorded from the Federal Mogul mixing zone. Historical copper levels at these same two river mile locations were highly elevated, with concentrations ranging at high as 5,170 mg/kg. The maximum value recorded during 2003 was 64.5 mg/kg. Concentrations of chromium and zinc were elevated in previous samplings at RMs 51.81 and 51.74; however, sampling during 2003 revealed values below sediment reference values. Significant improvements have also been documented in numerous volatile organic compounds, including cis-1,2-dichloroethene, tetrachloroethene, and trichloroethene. Tetrachlorethene and trichloroethene were not detected in any sediment samples during the 2003 study, and cis-1,2-dichloroethene was detected at a very low level of 1.08 ug/kg at RM 51.74. These levels were far below sediment concentrations reported in 1988, which were in excess of 300 mg/kg.

Physical Habitat For Aquatic Life

Physical habitat was evaluated in the Muskingum River at each fish sampling location. Qualitative Habitat Evaluation Index (QHEI) scores are detailed in Table 4.

The three Muskingum River sampling locations were represented by comparable habitat conditions. These similarities were largely related to a low-head dam located downstream from the study segment at RM 49.0. Upstream from the dam at all three sampling sites, the channel was impounded, resulting in 100 percent pool habitat. The lack of riffle areas at all three sampling sites reduced the QHEI scores compared with natural free-flowing rivers. At the two downstream sites, silt and muck predominated the bottom substrates. Gravel and silt predominated the substrates at the most upstream site. Sediment deposition was prevalent at each site along the river bank where fish sampling occurred. Between fish sampling passes (between August and October) a noticeable layer of silt was deposited on the river bottom. This was so extensive at the downstream location (RM 50.4) that the Hester-Dendy samplers were completely buried. QHEI scores for the Muskingum River sites ranged between 50.5 and 46.0. These scores are indicative of fair river habitat.

Fish Community Assessment

Fish communities were assessed at three locations in the Muskingum River (Figure 2, Table 5, Appendix Tables 2 and 3). Sampling locations were selected to assess contributions of contaminants from the Gould Electronic and Federal Mogul effluent discharges and mixing zone sediment contaminants.

Fish communities ranged from fair to marginally good in the Muskingum River. Results from all three fish sampling locations indicated slight improvement from upstream to downstream, with no obvious negative trends associated with Gould or Federal Mogul. IBI scores were in the marginally good range in the Muskingum River, with scores of 36, 38, and 39, upstream to downstream, respectively. These IBI values achieved (nonsignificant departure) the ecoregional biocriterion established for Warmwater Habitat (WWH) streams and rivers in Ohio (Table 1). Modified Index of Well-Being scores were in the fair range, with values of 6.6, 7.3, and 7.2. These MIwb scores did not achieve the ecoregional biocriterion established for Warmwater Habitat (WWH) streams and rivers in Ohio. External anomalies on fish (deformities, eroded fins, lesions, tumors) occurred at relatively low levels (0-0.8 %) in the fish communities of the Muskingum River. One river redhorse, an Ohio Department of Natural Resources Special Interest fish species, was collected at RM 51.7, and ghost shiners were collected at each sampling location. As noted in the physical habitat section, silt was a predominant bottom substrate within each fish sampling area. Excessive fine grained sediment constitutes a major environmental factor in the degradation of stream fisheries (Waters 1995).

Macroinvertebrate Community Assessment

The macroinvertebrate communities at six Muskingum River sites were sampled in 2003 using qualitative (multi-habitat composite) and quantitative (artificial substrate) sampling protocols. In addition, a quantitative natural substrate sample consisting of a composite of four Eckman dredge samples at each of the sampling locations was collected. Results of the artificial substrate and

qualitative samples are summarized in Table 6. The ICI metrics with the associated scores for the Western Allegheny Plateau ecoregion and the raw data are attached as Appendix Tables 4 and 5 . The results of the Eckman sampling are summarized in Tables 7-9. The Eckman sample raw data is attached as Appendix Table 6.

The ICI scores for the two downstream sites (RM 50.58 and 50.27) are not available. The artificial substrate samplers at these locations were completely buried under a thick layer of silt during the six week colonization period. The results of the qualitative sampling did not document significant differences between the sites. The downstream dam limited sampling at all sites to the impounded dam pool. Elevated river flows during the sampling period severely limited the amount and quality of habitat that could be effectively sampled. Bottom substrates consisted entirely of silt. Submerged woody debris along the shore had not been substantially colonized by macroinvertebrates during the elevated flows. The two upstream sites (RM 52.42 and 52.08) had ICI scores of 30 and 16, which are at the high and the low end of the fair category indicating non-attainment of the WWH use by the macroinvertebrate community. The site at the Gould Electronics outfall (RM 51.81) had an ICI score of 32, evaluated as marginally good, which is a nonsignificant departure from attainment of the WWH criterion. The Federal Mogul outfall site (RM 51.74) had a macroinvertebrate community evaluated as good, with an ICI score of 38 which is in attainment of the WWH criterion. The ICI data for the macroinvertebrate communities at the upstream and adjacent sites did not show an adverse impact related to the Gould and Federal Mogul outfalls.

The 2003 artificial substrate sampling results documented a significant improvement in the macroinvertebrate community from previous samples. In 1988, sites at RM 52.3, 51.6, and 49.10 all had poor macroinvertebrates communities with ICI scores of 6, 10, and 10, respectively.

The quantitative natural substrate (Eckman) sampling results were evaluated using the Shannon Diversity Index and two Community Similarity Indices based on the number of taxa as well as their abundance. The computational formulas are discussed in Ohio EPA guidance documents.

The results of the Community Similarity Index analysis based on the number of taxa are presented in Table 7. Paired comparisons between each of the sites were calculated. A value of 1.0 indicates complete similarity and a value of 0.0 indicates no similarity. The similarity between the upstream sites to the outfall sites, while not high, is within the range of the other comparisons. The limited number of taxa collected in the Eckman samples reduces the utility of taxa based comparisons.

The results of the Community Similarity Index analysis based on the abundance of taxa are presented in Table 8. The similarity values for the upstream sites paired with the outfall sites ranged from 0.785 to 0.972 , indicating a high degree of similarity. The Eckman sampling results further support the artificial substrate ICI results which do not show negative impacts related to the outfalls.

The results of the Shannon Diversity Index analysis are presented in Table 9. The values range from 0.376 to 1.02. The diversity scores are lowest at the two outfall sites but they are not significantly different from the other sites. All sites have low diversity which is related to the lack of habitat diversity. Oligochaeta and Hexagenia limbata (burrowing mayflies) were the predominant taxa at all sites.

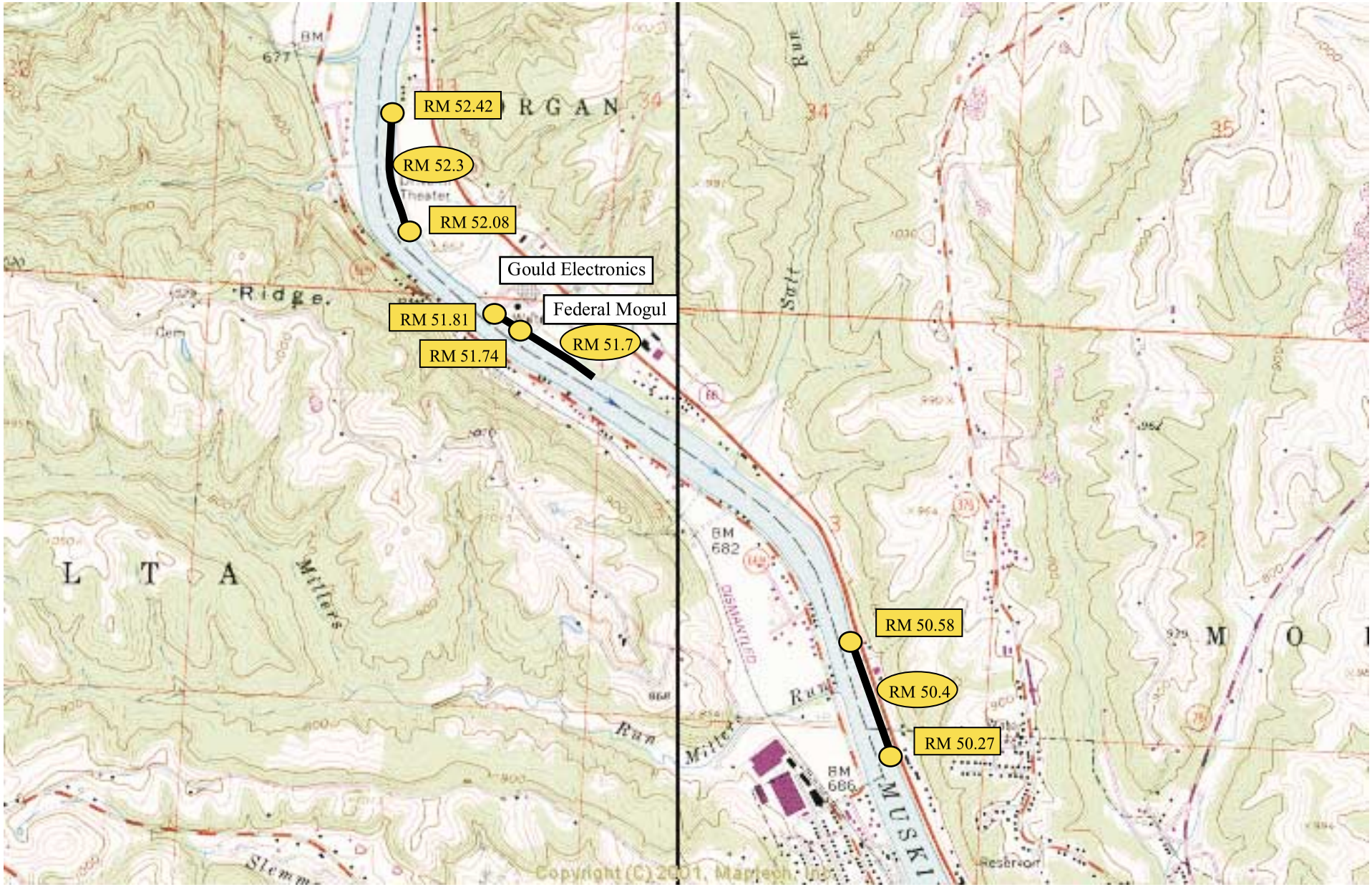

Figure 1. Map of the Muskingum River near McConnellsville, showing biological and sediment sampling locations, 2003.

Table 1. Attainment status of the existing aquatic life use for the Muskingum River based on biological sampling conducted during August and October, 2003.

RIVER MILE Fish/Invert.	IBI	MIwb	ICI	QHEI	Attainment Status	Site Location
Muskingum River	*Western Allegheny Plateau (WAP) - WWH Use Designation*					
52.3 /52.42 & 52.08	36^{ns}	6.6*	30* & 16*	50.5	PARTIAL	Upstream Federal Mogul/Gould
51.7 /51.81 & 51.74	38^{ns}	7.3*	32^{ns} & 38	46.0	PARTIAL	Adjacent Federal Mogul/Gould
50.4 /50.58 & 50.27	39^{ns}	7.2*	NA	46.5	PARTIAL	Downstream Federal Mogul/Gould

Ecoregion Biocriteria: Western Allegheny Plateau (WAP)

INDEX	WWH	EWH	MWH[a]
IBI-Boat	40	48	30
MIwb - Boat	8.6	9.6	6.6
ICI	36	46	NA

[a] Modified Warmwater Habitat for impounded areas.

* Significant departure from ecoregion biocriterion; poor and very poor results are underlined.

ns Nonsignificant departure from ecoregion biocriterion (≤4 IBI and ICI units, ≤0.5 MIwb units).

NA Not available, samplers buried in silt.

Table 2. Sampling locations in the Muskingum River, 2003. Type of sampling included fish community (F), macroinvertebrate community (M), and sediment (S).

Stream/ River Mile	Type of Sampling	Latitude	Longitude	Landmark
Muskingum River				
52.42	M, S	39 40.908	81 53.281	Most upstream background location
52.3	F	39 40.811	81 53.297	Upstream/background
52.08	M, S	39 40.654	81 53.232	Upstream/background site, lower end of fish zone
51.81	M, S	39 40.488	81 53.002	At Gould Electronics outfall area
51.74	M, S	39 40.453	81 52.937	At Federal Mogul outfall area
51.7	F	39 40.430	81 52.90	Gould/Federal Mogul outfalls mixing area and immediately downstream
50.58	M, S	39 39.757	81 51.995	Downstream Gould/Federal Mogul
50.4	F	39 39.609	81 51.937	Downstream Gould/Federal Mogul
50.27	M, S	39 39.515	81 51.893	Downstream Gould/Federal Mogul

Table 3. Chemical parameters measured above screening levels (metals) or detected (organics) in sediment samples collected by Ohio EPA from the Muskingum River, October, 2003. Contamination levels were determined for parameters using either consensus-based sediment quality guidelines (MacDonald et.al. 2000) or ecological data quality levels for RCRA appendix IX constituents (USEPA 1998). Sediment reference values (SRVs) are listed in the Ohio EPA Ecological Risk Assessment Guidance (2003).

	MUSKINGUM RIVER SEDIMENT							
Parameter	**RM 52.42**	**RM 52.08**	**RM 51.81**	**RM 51.74**	**RM 50.58**	**RM 50.58**	**RM 50.27**	**SRVs**
Silver (mg/kg)	1.05J	1.04J	1.28J	2.74J	1.27J	1.29J	1.56J	0.43
Copper (mg/kg)	16.4	15.7	23.6	64.5^{T}	18.3	17.8	18.1	33
Nickel (mg/kg)	24	24.2	25.6	86.4^{P}	27.4	26.5	26.9	61
Lead (mg/kg)	26.5	25.6	31	273^{P}	28.2	26.2	28.7	47
Acetone (ug/kg)	9.32U	9.34U	20.3J	9.68U	16.2J	10.4U	11.8U	-
Carbon disulfide (ug/kg)	0.932U	0.934U	1.08U	10.3	1.08U	1.04U	1.18U	-
cis-1,2-Dichloroethene (ug/kg)	0.932U	0.934U	1.08U	1.08J	1.08U	1.04U	1.18U	-
Naphthalene (ug/kg)	0.932U	0.934U	1.08U	1.48J	1.08U	1.04U	1.18U	-

J - The analyte was positively identified, but the quantitation was below the reporting limit (RL).
^{T} - Above Threshold Effect Concentration (below which harmful effects are unlikely to occur; MacDonald et.al. 2000).
^{P} - Above Probable Effect Concentration (above which harmful effects are likely to occur; MacDonald et.al. 2000).
^{E} - Above Ecological Data Quality Level (USEPA 1998).
U- Not detected at or above the method detection limit (MDL is the reported value).

Table 4. Qualitative Habitat Evaluation Index (QHEI) scores along with modified and warmwater attributes for the Muskingum River, 2003.

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 HI+1)/(WWH+1) Ratio**	**(MWH MI+1)/(WWH+1) Ratio**
(17-001) Muskingum River																																	
Year: 2003																																	
52.3	**50.5**	0.10	#	#		#		#		#			4	♦					1	•		•	•		•	•		•			6	0.40	1.60
51.7	**46.0**	0.10	#			#		#		#			3	♦					1	•		•	•		•	•		•			6	0.50	2.00
50.4	**46.5**	0.10	#			#		#		#			3	♦					1	•		•	•		•	•		•			6	0.50	2.00

Table 5. Fish community summaries based on pulsed DC electrofishing sampling conducted by Ohio EPA in the Muskingum River from August and October, 2003. Relative numbers and weight for the Muskingum River sites are per 1.0 km.

Stream/ River Mile	Mean Number of Species	Total Number Species	Mean Relative Number	Mean Relative Weight (kg)	Qual. Habitat Eval. Index (QHEI)	Mean Modified Index of Well-Being (MIwb)	Mean Index of Biotic Integrity (IBI)	Narrative Evaluation
Muskingum River (2003)								
52.3	10.5	14	623	57.34	50.5	6.6*	36[ns]	Marg. Good/Fair
51.7	12.5	17	1031	58.28	46.0	7.3*	38[ns]	Marg. Good/Fair
50.4	12.0	15	946	52.60	46.5	7.2*	39[ns]	Marg. Good/Fair

Ecoregion Biocriteria: Western Allegheny Plateau (WAP)
(Ohio Administrative Code 3745-1-07, Table 7-15)

INDEX	WWH	EWH	MWH[a]
IBI-Boat	40	48	30
MIwb - Boat	8.6	9.6	6.6

[a] Modified Warmwater Habitat for impounded areas.
* Significant departure from ecoregion biocriterion.
[ns] Nonsignificant departure from ecoregion biocriterion ($\leq$4 IBI units, $\leq$0.5 MIwb units).

Table 6. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Muskingum River, 2003.

River Mile	Density Number/ft^2	Total Taxa	Quantitative Taxa	Qualitative Taxa	Qualitative EPT[a]	ICI	Evaluation
			WWH Use Designation				
Muskingum River							
52.42	357	35	35	4	2	30*	Fair
52.08	979	28	28	6	2	16*	Fair
51.81	417	44	44	4	1	32[ns]	Marginally Good
51.74	406	46	46	4	3	38	Good
50.58	[C]	[C]	[C]	4	1	[C]	[C]
50.27	[C]	[C]	[C]	4	1	[C]	[C]

Ecoregion Biocriteria: Western Allegheny Plateau (WAP)
(Ohio Administrative Code 3745-1-07, Table 7-15)

INDEX	WWH	EWH	MWH[b]
ICI	36	46	NA

[a] EPT= total Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa richness, a measure of pollution sensitive organisms.
[b] The ICI is not applicable to Modified Warmwater Habitat for impounded areas.
[C] Data absent due to buried artificial substrate samplers.
* Significant departure from ecoregional biocriterion; poor and very poor results are underlined.

Table 7. Community Similarity Index based on number of taxa in Eckman samples..

River Mile	52.42	52.08	51.81	51.74	50.58	50.27
52.42	----					
52.08	.667	----				
51.81	.588	.533	----			
51.74	.471	.533	.429	----		
50.58	.588	.533	.571	.714	----	
50.27	.423	.50	.545	.727	.545	----

Table 8. Community Similarity Index based on taxa abundance in Eckman samples.

River Mile	52.42	52.08	51.81	51.74	50.58	50.27
52.42	----					
52.08	.759	----				
51.81	.972	.785	----			
51.74	.793	.948	.819	----		
50.58	.552	.752	.557	.727	----	
50.27	.634	.853	.658	.826	.862	----

Table 9. Shannon Diversity Index based on Eckman samples.

River Mile	52.42	52.08	51.81	51.74	50.58	50.27
Shannon Diversity Index	0.872	0.790	0.529	0.376	1.02	0.718

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APPENDICES

Appendix Table 1. Results of Ohio EPA sediment sampling conducted in the Muskingum River October 9, 2003.

Stream	Muskingum River	Muskingum River	Muskingum River	Muskingum River	Muskingum River	Muskingum River	Muskingum River
River Mile	**52.42**	**52.08**	**51.81**	**51.74**	**50.58**	**50.58**	**50.27**
Date Sampled	10/09/03	10/09/03	10/09/03	10/09/03	10/09/03	10/09/03	10/09/03
Time Sampled	10:55 AM	11:55 AM	12:40 PM	01:15 PM	02:00 PM	02:00 PM	02:50 PM
TAL Metals (mg/kg)						Duplicate	
Mercury	0.0814J	0.0710J	0.0835J	0.0833J	0.0976J	0.0794J	0.0703J
Aluminum	7,930	8,220	9,820	8,430	11,000	10,200	10,500
Silver	1.05J	1.04J	1.28J	2.74J	1.27J	1.29J	1.56J
Arsenic	11.6	12	14.8	13.4	14.5	14.3	16.6
Barium	87.6	82.7	96.2	86	106	100	105
Beryllium	0.663J	0.645	0.738	0.691J	0.792J	0.751J	0.759J
Calcium	8,420	5,820	7,010	8,240	7,810	7,680	6,640
Cadmium	0.514J	0.435J	0.521J	0.526J	0.540J	0.524J	0.571J
Cobalt	10.4	9.69	10.7	10.4	11.6	11.1	11.3
Chromium	17.7	18.9	19.7	21.2	21.3	20.5	20.9
Copper	16.4	15.7	23.6	64.5	18.3	17.8	18.1
Iron	18,800	17,500	19,500	19,100	21,400	20,600	21,600
Potassium	1020	1060	1300	1130	1480	1370	1350
Magnesium	2470	2390	2690	2560	2890	2740	2800
Manganese	1280	1060	1200	1110	1380	1330	1430
Sodium	86.4	74.6	93.9	127	98.4	101	112
Nickel	24	24.2	25.6	86.4	27.4	26.5	26.9
Lead	26.5	25.6	31	273	28.2	26.2	28.7
Vanadium	16.1	16.3	19.3	17.1	21.7	20.1	20.6
Zinc	95.9	93.2	100	103	109	103	106
Antimony	0.499J	0.467U	0.538U	0.742J	0.538U	0.649J	0.681J
Selenium	1.02	0.96	1.13	0.929	1.56	1.22	1.33
Thallium	3.73U	0.934U	0.43U	1.94U	0.431U	0.639J	2.36U
Volatile Organic Analytes (ug/kg)							
Acetone	9.32U	9.34U	20.3J	9.68U	16.2J	10.4U	11.8U
Benzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Bromobenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Bromochloromethane	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Bromodichloromethane	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Bromoform	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Bromomethane	1.86U	1.87U	2.15U	1.94U	2.15U	2.08U	2.36U
2-Butanone	4.66U	4.67U	5.38U	4.84U	5.38U	5.20U	5.89U
n-Butylbenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
sec-Butylbenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
tert-Butylbenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Carbon disulfide	0.932U	0.934U	1.08U	10.3	1.08U	1.04U	1.18U
Carbon tetrachloride	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Chlorobenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Chlorodibromomethane	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U

Appendix Table 1. Continued.

Stream	Muskingum River	Muskingum River	Muskingum River	Muskingum River	Muskingum River	Muskingum River	Muskingum River
River Mile	**52.42**	**52.08**	**51.81**	**51.74**	**50.58**	**50.58**	**50.27**
Date Sampled	10/09/03	10/09/03	10/09/03	10/09/03	10/09/03	10/09/03	10/09/03
Time Sampled	10:55 AM	11:55 AM	12:40 PM	01:15 PM	02:00 PM	02:00 PM	02:50 PM
Volatile Organic Analytes (ug/kg)						Duplicate	
Chloroethane	1.86U	1.87U	2.15U	1.94U	2.15U	2.08U	2.36U
2-Chloroethyl vinyl ether	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Chloroform	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
4-Chlorotoluene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,2-Dibromo-3-chloropropane	1.86U	1.87U	2.15U	1.94U	2.15U	2.08U	2.36U
1,2-Dibromoethane	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Dibromomethane	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,2-Dichlorobenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,3-Dichlorobenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,4-Dichlorobenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Dichlorodifluoromethane	1.86U	1.87U	2.15U	1.94U	2.15U	2.08U	2.36U
1,1-Dichloroethane	1.86U	1.87U	2.15U	1.94U	2.15U	2.08U	2.36U
1,2-Dichloroethane	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,1-Dichloroethene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
cis-1,2-Dichloroethene	0.932U	0.934U	1.08U	1.08J	1.08U	1.04U	1.18U
trans-1,2-Dichloroethene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,2-Dichloropropane	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,3-Dichloropropane	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
2,2-Dichloropropane	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
cis-1,3-Dichloropropene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
trans-1,3-Dichloropropene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,1-Dichloropropene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Ethylbenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
2-Hexanone	4.66U	4.67U	5.38U	4.84U	5.38U	5.20U	5.89U
Hexachlorobutadiene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Isopropylbenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
p-Isopropyltoluene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
4-Methyl-2-pentanone	4.66U	4.67U	5.38U	4.84U	5.38U	5.20U	5.89U
Methylene chloride	1.86U	1.87U	2.15U	1.94U	2.15U	2.08U	2.36U
Naphthalene	0.932U	0.934U	1.08U	1.48J	1.08U	1.04U	1.18U
n-Propylbenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Styrene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,1,1,2-Tetrachloroethane	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,1,2,2-Tetrachloroethane	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Tetrachloroethene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Toluene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,2,3-Trichlorobenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,2,4-Trichlorobenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,1,1-Trichloroethane	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,1,2-Trichloroethane	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Trichloroethene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Trichlorofluoromethane	1.86U	1.87U	2.15U	1.94U	2.15U	2.08U	2.36U

Appendix Table 1. Continued.

Stream	Muskingum River	Muskingum River	Muskingum River	Muskingum River	Muskingum River	Muskingum River	Muskingum River
River Mile	**52.42**	**52.08**	**51.81**	**51.74**	**50.58**	**50.58**	**50.27**
Date Sampled	10/09/03	10/09/03	10/09/03	10/09/03	10/09/03	10/09/03	10/09/03
Time Sampled	10:55 AM	11:55 AM	12:40 PM	01:15 PM	02:00 PM	02:00 PM	02:50 PM
Volatile Organic Analytes (ug/kg)							
1,2,3-Trichloropropane	1.19U	1.20U	1.38U	1.24U	1.38U	1.33U	1.51U
1,2,4-Trimethylbenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
1,3,5-Trimethylbenzene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
o-Xylene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
m-,p-Xylene	0.932U	0.934U	1.08U	0.968U	1.08U	1.04U	1.18U
Other							
Percent Solids	53.7	53.5	46.5	51.6	46.5	48.1	42.4

J - The analyte was positively identified, but the quantitation was below the reporting limit (RL).

U - Not detected at or above the method detection limit (MDL is the reported value).

Appendix Table 2. MIwb and IBI scores and metrics for the Muskingum River, 2003.

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Number of: Sunfish species	Number of: Sucker species	Number of: Intolerant species	Percent of Individuals: Rnd-bodied suckers	Percent of Individuals: Simple Lithophils	Percent of Individuals: Tolerant fishes	Percent of Individuals: Omni-vores	Percent of Individuals: Top carnivores	Percent of Individuals: Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(1.0 km)	IBI	Modified Iwb
Muskingum River - (17-001)																	
Year: 2003																	
52.30	A	08/20/2003	7406	11(3)	1(1)	2(1)	0(1)	1(1)	88(5)	1(5)	2(5)	2(1)	93(5)	1.0(3)	608(5)	36	7.1
52.30	A	10/08/2003	7406	8(1)	2(3)	0(1)	0(1)	0(1)	85(5)	3(5)	3(5)	2(1)	88(5)	0.6(3)	616(5)	36	6.1
51.70	A	08/20/2003	7415	12(3)	1(1)	2(1)	1(1)	0(1)	89(5)	0(5)	3(5)	2(1)	93(5)	0.0(5)	822(5)	38	7.7
51.70	A	10/08/2003	7415	10(3)	1(1)	1(1)	0(1)	0(1)	89(5)	1(5)	7(5)	0(1)	91(5)	0.0(5)	1226(5)	38	6.9
50.40	A	08/20/2003	7419	11(3)	0(1)	1(1)	0(1)	0(1)	85(5)	3(5)	5(5)	2(1)	91(5)	0.0(5)	746(5)	38	7.0
50.40	A	10/08/2003	7419	11(3)	2(3)	1(1)	0(1)	0(1)	88(5)	1(5)	5(5)	2(1)	91(5)	0.0(5)	1112(5)	40	7.3

Appendix Table 3. Fish species list

River Code: **17-001**	Stream: **Muskingum River**	Sample Date: **2003**
River Mile: **52.30**	Location: upst. Gould	Date Range: 08/20/2003
Time Fished: 3083 sec	Drainage: 7406.0 sq mi	Thru: 10/08/2003
Dist Fished: 1.00 km	Basin: Muskingum River No of Passes: 2	Sampler Type: A

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
Gizzard Shad		O	M		2	2.00	0.32	0.01	0.01	3.50
Smallmouth Buffalo	C	I	M		6	6.00	0.96	14.73	25.68	2,454.17
Shorthead Redhorse	R	I	S	M	2	2.00	0.32	1.08	1.88	540.00
Common Carp	G	O	M	T	11	11.00	1.77	28.35	49.43	2,576.91
Emerald Shiner	N	I	S		536	536.00	86.04	0.56	0.98	1.05
Spotfin Shiner	N	I	M		6	6.00	0.96	0.02	0.03	3.17
Ghost Shiner	N	I	M		4	4.00	0.64	0.00	0.01	1.00
Channel Catfish	F		C		11	11.00	1.77	3.50	6.10	317.73
Flathead Catfish	F	P	C		1	1.00	0.16	0.44	0.77	444.00
White Bass	F	P	M		1	1.00	0.16	0.06	0.10	56.00
Spotted Bass	F	C	C		8	8.00	1.28	1.07	1.86	133.63
Bluegill Sunfish	S	I	C	P	4	4.00	0.64	0.19	0.34	48.25
Orangespotted Sunfish	S	I	C		7	7.00	1.12	0.03	0.06	4.71
Green Sf X Bluegill Sf					1	1.00	0.16	0.09	0.15	86.00
Sauger X Walleye	E	P			2	2.00	0.32	0.72	1.25	359.00
Freshwater Drum			M	P	21	21.00	3.37	6.51	11.35	309.86
	Mile Total				623	623.00		57.34		
	Number of Species				14					
	Number of Hybrids				2					

River Code: **17-001**	Stream: **Muskingum River**	Sample Date: **2003**
River Mile: **51.70**	Location:	Date Range: 08/20/2003
Time Fished: 3772 sec	Drainage: 7415.0 sq mi	Thru: 10/08/2003
Dist Fished: 1.00 km	Basin: Muskingum River No of Passes: 2	Sampler Type: A

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
Longnose Gar		P	M		3	3.00	0.29	4.69	8.04	1,561.67
Gizzard Shad		O	M		49	49.00	4.75	4.55	7.81	92.91
Smallmouth Buffalo	C	I	M		7	7.00	0.68	16.70	28.65	2,385.71
River Redhorse [S]	R	I	S	I	1	1.00	0.10	1.00	1.71	995.00
Common Carp	G	O	M	T	7	7.00	0.68	17.20	29.51	2,457.14
Emerald Shiner	N	I	S		920	920.00	89.23	0.97	1.67	1.06
Spotfin Shiner	N	I	M		8	8.00	0.78	0.02	0.04	2.88
Ghost Shiner	N	I	M		3	3.00	0.29	0.00	0.00	0.67
Bullhead Minnow	N	O	C		2	2.00	0.19	0.01	0.01	3.00
Grass Carp	E		M		1	1.00	0.10	6.30	10.81	6,300.00
Channel Catfish	F		C		6	6.00	0.58	1.74	2.99	290.17
Flathead Catfish	F	P	C		2	2.00	0.19	2.70	4.63	1,350.00
Smallmouth Bass	F	C	C	M	1	1.00	0.10	0.05	0.09	51.00
Spotted Bass	F	C	C		6	6.00	0.58	0.76	1.30	126.67
Bluegill Sunfish	S	I	C	P	2	2.00	0.19	0.03	0.05	15.00
Orangespotted Sunfish	S	I	C		9	9.00	0.87	0.06	0.10	6.56
Freshwater Drum			M	P	4	4.00	0.39	1.51	2.58	376.50
Mile Total					1,031	1,031.00		58.28		
Number of Species					17					
Number of Hybrids					0					

River Code: **17-001**	Stream: **Muskingum River**	Sample Date: **2003**
River Mile: **50.40**	Location:	Date Range: 08/20/2003
Time Fished: 3112 sec	Drainage: 7419.0 sq mi	Thru: 10/08/2003
Dist Fished: 1.00 km	Basin: Muskingum River No of Passes: 2	Sampler Type: A

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
Gizzard Shad		O	M		28	28.00	2.96	2.69	5.10	95.90
Smallmouth Buffalo	C	I	M		10	10.00	1.06	23.13	43.97	2,312.50
Common Carp	G	O	M	T	8	8.00	0.85	15.91	30.25	1,989.10
Emerald Shiner	N	I	S		821	821.00	86.79	0.94	1.78	1.14
Spotfin Shiner	N	I	M		10	10.00	1.06	0.04	0.08	4.00
Sand Shiner	N	I	M	M	3	3.00	0.32	0.01	0.01	2.00
Ghost Shiner	N	I	M		7	7.00	0.74	0.01	0.02	1.43
Bluntnose Minnow	N	O	C	T	9	9.00	0.95	0.02	0.04	2.22
Channel Catfish	F		C		5	5.00	0.53	0.59	1.12	117.80
White Bass	F	P	M		1	1.00	0.11	0.15	0.29	153.00
Smallmouth Bass	F	C	C	M	3	3.00	0.32	0.16	0.31	54.67
Spotted Bass	F	C	C		16	16.00	1.69	2.64	5.02	165.13
Bluegill Sunfish	S	I	C	P	5	5.00	0.53	0.16	0.30	31.20
Orangespotted Sunfish	S	I	C		6	6.00	0.63	0.03	0.06	5.67
Sauger X Walleye	E	P			2	2.00	0.21	0.29	0.54	143.00
Freshwater Drum			M	P	12	12.00	1.27	5.84	11.10	486.42
	Mile Total				946	946.00		52.60		
	Number of Species				15					
	Number of Hybrids				1					

Appendix Table 4. ICI scores for the Muskingum River, 2003.

River Mile	Drainage Area (sq mi)	Number of				Percent:					Qual. EPT	Eco-region	ICI
		Total Taxa	Mayfly Taxa	Caddisfly Taxa	Dipteran Taxa	Mayflies	Caddis-flies	Tany-tarsini	Other Dipt/NI	Tolerant Organisms			
Muskingum River (17-001)													
Year: 2003													
52.42	7406	35(6)	7(6)	5(4)	13(6)	11.5(4)	5.9(2)	2.5(2)	80.0(0)	11.5(0)	2(0)	4	30
52.08	7406	28(4)	5(4)	3(2)	5(4)	1.9(2)	0.7(0)	0.0(0)	94.8(0)	6.6(0)	2(0)	4	16
51.81	7415	44(6)	10(6)	7(4)	15(6)	23.5(6)	11.3(2)	3.2(2)	57.7(0)	12.3(0)	1(0)	4	32
51.74	7415	46(6)	9(6)	9(6)	17(6)	18.3(6)	10.9(2)	9.1(6)	60.8(0)	6.7(0)	3(0)	4	38

Appendix Table 5. Macroinvertebrate results from Hester/Dendy multiplate samplers and qualitative sampling, Muskingum River, 2003.

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 10/09/2003 River Code: 17-001 RM: 52.42 Site: Muskingum River

Taxa Code	Taxa	Quant/Qual		Taxa Code	Taxa	Quant/Qual
01200	*Cordylophora lacustris*	4				
01320	*Hydra sp*	21				
01801	*Turbellaria*	19				
03221	*Pectinatella magnifica*	1				
03360	*Plumatella sp*	1				
03600	*Oligochaeta*	194	+			
06810	*Gammarus fasciatus*	13	+			
13400	*Stenacron sp*	56				
13510	*Stenonema exiguum*	3				
13550	*Stenonema mexicanum integrum*	4	+			
13570	*Stenonema terminatum*	52				
16700	*Tricorythodes sp*	88				
17200	*Caenis sp*	1				
18750	*Hexagenia limbata*	1	+			
25600	*Stylurus sp*	1				
47600	*Sialis sp*	1				
51206	*Cyrnellus fraternus*	87				
51600	*Polycentropus sp*	1				
52200	*Cheumatopsyche sp*	6				
52801	*Potamyia flava*	1				
59407	*Nectopsyche candida*	10				
68708	*Dubiraphia vittata group*	1				
74501	*Ceratopogonidae*	8				
77130	*Ablabesmyia rhamphe group*	34				
77750	*Hayesomyia senata or Thienemannimyia norena*	112				
80360	*Corynoneura "celeripes" (sensu Simpson & Bode, 1980)*	8				
80370	*Corynoneura lobata*	4				
83050	*Dicrotendipes lucifer*	56				
83300	*Glyptotendipes (G.) sp*	917				
83820	*Microtendipes "caelum" (sensu Simpson & Bode, 1980)*	11				
84460	*Polypedilum (P.) fallax group*	11				
84790	*Tribelos fuscicorne*	11				
85625	*Rheotanytarsus sp*	22				
85800	*Tanytarsus sp*	22				
87540	*Hemerodromia sp*	4				

No. Quantitative Taxa: 35 Total Taxa: 35
No. Qualitative Taxa: 4 ICI: **30**
Number of Organisms: 1786 Qual EPT: 2

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 10/09/2003 River Code: 17-001 RM: 52.08 Site: Muskingum River

Taxa Code	Taxa	Quant/Qual		Taxa Code	Taxa	Quant/Qual
01200	*Cordylophora lacustris*	9				
01320	*Hydra sp*	2				
01801	*Turbellaria*	84				
03073	*Lophopodella carteri*	1				
03221	*Pectinatella magnifica*	1				
03360	*Plumatella sp*	1				
03600	*Oligochaeta*	273	+			
06810	*Gammarus fasciatus*	25	+			
13521	*Stenonema femoratum*	5				
16700	*Tricorythodes sp*	51	+			
17200	*Caenis sp*	32				
18100	*Anthopotamus sp*	1				
18750	*Hexagenia limbata*	2	+			
22300	*Argia sp*	99				
24501	*Gomphidae*	1	+			
51206	*Cyrnellus fraternus*	28				
52200	*Cheumatopsyche sp*	1				
59407	*Nectopsyche candida*	3				
68601	*Ancyronyx variegata*	16				
68708	*Dubiraphia vittata group*	17	+			
69400	*Stenelmis sp*	1				
77750	*Hayesomyia senata or Thienemannimyia norena*	73				
80360	*Corynoneura "celeripes" (sensu Simpson & Bode, 1980)*	4				
80370	*Corynoneura lobata*	4				
83300	*Glyptotendipes (G.) sp*	4070				
84540	*Polypedilum (Tripodura) scalaenum group*	37				
95100	*Physella sp*	50				
98600	*Sphaerium sp*	5				

No. Quantitative Taxa: 28 Total Taxa: 28
No. Qualitative Taxa: 6 ICI: **16**
Number of Organisms: 4896 Qual EPT: 2

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 10/08/2003 River Code: 17-001 RM: 51.81 Site: Muskingum River

Taxa Code	Taxa	Quant/Qual	
01320	*Hydra sp*	28	
01801	*Turbellaria*	8	
03073	*Lophopodella carteri*	1	
03360	*Plumatella sp*	5	
03600	*Oligochaeta*	256	+
05800	*Caecidotea sp*	39	
06810	*Gammarus fasciatus*	42	
11130	*Baetis intercalaris*	1	
13000	*Leucrocuta sp*	1	
13400	*Stenacron sp*	57	
13521	*Stenonema femoratum*	3	
13550	*Stenonema mexicanum integrum*	3	
13570	*Stenonema terminatum*	76	
16700	*Tricorythodes sp*	53	
17200	*Caenis sp*	277	
18100	*Anthopotamus sp*	9	
18750	*Hexagenia limbata*	10	+
22300	*Argia sp*	40	
51206	*Cyrnellus fraternus*	181	
51300	*Neureclipsis sp*	3	
52200	*Cheumatopsyche sp*	3	
52521	*Hydropsyche bidens or H. orris*	2	
52570	*Hydropsyche simulans*	13	
52801	*Potamyia flava*	3	
59407	*Nectopsyche candida*	31	
68601	*Ancyronyx variegata*	17	
68700	*Dubiraphia sp*	25	
68901	*Macronychus glabratus*	7	
74501	*Ceratopogonidae*	48	+
77120	*Ablabesmyia mallochi*	22	
77750	*Hayesomyia senata or Thienemannimyia norena*	210	
77800	*Helopelopia sp*	44	
80360	*Corynoneura "celeripes" (sensu Simpson & Bode, 1980)*	4	
81231	*Nanocladius (N.) crassicornus or N. (N.) "rectinervis"*	22	
82820	*Cryptochironomus sp*	11	+
83000	*Dicrotendipes sp*	11	
83300	*Glyptotendipes (G.) sp*	408	
84540	*Polypedilum (Tripodura) scalaenum group*	22	
84800	*Tribelos jucundum*	11	
85500	*Paratanytarsus sp*	11	
85625	*Rheotanytarsus sp*	33	
85800	*Tanytarsus sp*	22	
87540	*Hemerodromia sp*	8	
98001	*Sphaeriidae*	4	

No. Quantitative Taxa: 44 Total Taxa: 44
No. Qualitative Taxa: 4 ICI: **32**
Number of Organisms: 2085 Qual EPT: 1

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 10/09/2003 River Code: 17-001 RM: 51.74 Site: Muskingum River

Taxa Code	Taxa	Quant/Qual
01320	*Hydra sp*	37
01801	*Turbellaria*	1
03360	*Plumatella sp*	1
03451	*Urnatella gracilis*	4
03600	*Oligochaeta*	134
06810	*Gammarus fasciatus*	4
13400	*Stenacron sp*	46
13510	*Stenonema exiguum*	9
13521	*Stenonema femoratum*	9
13550	*Stenonema mexicanum integrum*	18
13570	*Stenonema terminatum*	118
16700	*Tricorythodes sp*	65 +
17200	*Caenis sp*	100
18100	*Anthopotamus sp*	6
18750	*Hexagenia limbata*	1 +
22300	*Argia sp*	9
24501	*Gomphidae*	+
51206	*Cyrnellus fraternus*	155
51600	*Polycentropus sp*	9
52200	*Cheumatopsyche sp*	15
52430	*Ceratopsyche morosa group*	8
52510	*Hydropsyche aerata*	2
52520	*Hydropsyche bidens*	1 +
52570	*Hydropsyche simulans*	13
59400	*Nectopsyche sp*	15
59500	*Oecetis sp*	4
68601	*Ancyronyx variegata*	1
68901	*Macronychus glabratus*	8
74501	*Ceratopogonidae*	20
77130	*Ablabesmyia rhamphe group*	13
77750	*Hayesomyia senata or Thienemannimyia norena*	87
78750	*Rheopelopia paramaculipennis*	12
79085	*Telopelopia okoboji*	13
80350	*Corynoneura sp*	4
81631	*Parakiefferiella n.sp 1*	13
82121	*Thienemanniella lobapodema*	8
83000	*Dicrotendipes sp*	25
83300	*Glyptotendipes (G.) sp*	756
84300	*Phaenopsectra obediens group*	12
84540	*Polypedilum (Tripodura) scalaenum group*	12
84790	*Tribelos fuscicorne*	12
84800	*Tribelos jucundum*	12
85625	*Rheotanytarsus sp*	173
85800	*Tanytarsus sp*	12
87540	*Hemerodromia sp*	44
95100	*Physella sp*	2
98001	*Sphaeriidae*	8

No. Quantitative Taxa: 46 Total Taxa: 47
No. Qualitative Taxa: 4 ICI: **38**
Number of Organisms: 2031 Qual EPT: 3

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 10/07/2003 River Code: 17-001 RM: 50.58 Site: Muskingum River

Taxa Code	Taxa	Quant/Qual	Taxa Code	Taxa	Quant/Qual
03600	*Oligochaeta*	+			
18750	*Hexagenia limbata*	+			
22001	*Coenagrionidae*	+			
24501	*Gomphidae*	+			

No. Quantitative Taxa: 0 Total Taxa: 4

No. Qualitative Taxa: 4 ICI:

Number of Organisms: 0 Qual EPT: 1

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 10/09/2003 River Code: 17-001 RM: 50.27 Site: Muskingum River

Taxa Code	Taxa	Quant/Qual
03600	*Oligochaeta*	+
06810	*Gammarus fasciatus*	+
18750	*Hexagenia limbata*	+
24501	*Gomphidae*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 4
No. Qualitative Taxa: 4 ICI:
Number of Organisms: 0 Qual EPT: 1

Appendix Table 6. Macroinvertebrate results from Eckman dredge samples collected from the Muskingum River, 2003.

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 10/09/2003 River Code: 17-001 RM: 52.42 B Site: Muskingum River

Taxa Code	Taxa	Quant/Qual
03451	*Urnatella gracilis*	16
03600	*Oligochaeta*	569
04510	*Hirudinea*	1
05800	*Caecidotea sp*	1
18750	*Hexagenia limbata*	129
24501	*Gomphidae*	1
74501	*Ceratopogonidae*	32
77110	*Ablabesmyia annulata*	3
82820	*Cryptochironomus sp*	1
98600	*Sphaerium sp*	17

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 10 Total Taxa: 10
No. Qualitative Taxa: ICI:
Number of Organisms: 770 Qual EPT:

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 10/09/2003 River Code: 17-001 RM: 52.08 B Site: Muskingum River

Taxa Code	Taxa	Quant/Qual
03451	*Urnatella gracilis*	1
03600	*Oligochaeta*	360
18750	*Hexagenia limbata*	53
74501	*Ceratopogonidae*	16
77110	*Ablabesmyia annulata*	2
82820	*Cryptochironomus sp*	1
84520	*Polypedilum (Tripodura) halterale group*	16
85800	*Tanytarsus sp*	8

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 8 Total Taxa: 8

No. Qualitative Taxa: ICI:

Number of Organisms: 457 Qual EPT:

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 10/09/2003 River Code: 17-001 RM: 51.81 B Site: Muskingum River

Taxa Code	Taxa	Quant/Qual
03600	*Oligochaeta*	531
18750	*Hexagenia limbata*	100
24501	*Gomphidae*	1
72420	*Chaoborus sp*	1
74501	*Ceratopogonidae*	1
77110	*Ablabesmyia annulata*	4
84202	*Paratendipes basidens*	2

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 7 Total Taxa: 7

No. Qualitative Taxa: ICI:

Number of Organisms: 640 Qual EPT:

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 10/09/2003 River Code: 17-001 RM: 51.74 B Site: Muskingum River

Taxa Code	Taxa	Quant/Qual
03451	*Urnatella gracilis*	1
03600	*Oligochaeta*	378
18750	*Hexagenia limbata*	12
30000	*Plecoptera*	1
77110	*Ablabesmyia annulata*	1
82101	*Thienemanniella taurocapita*	8
84540	*Polypedilum (Tripodura) scalaenum group*	9

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 7 Total Taxa: 7

No. Qualitative Taxa: ICI:

Number of Organisms: 410 Qual EPT:

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 10/09/2003 River Code: 17-001 RM: 50.58 B Site: Muskingum River

Taxa Code	Taxa	Quant/Qual
03451	*Urnatella gracilis*	24
03600	*Oligochaeta*	218
18750	*Hexagenia limbata*	55
24501	*Gomphidae*	10
30000	*Plecoptera*	8
77110	*Ablabesmyia annulata*	3
77470	*Coelotanypus sp*	1

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 7 Total Taxa: 7

No. Qualitative Taxa: ICI:

Number of Organisms: 319 Qual EPT:

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 10/09/2003 River Code: 17-001 RM: 50.27 B Site: Muskingum River

Taxa Code	Taxa	Quant/Qual
03600	*Oligochaeta*	265
18750	*Hexagenia limbata*	53
77110	*Ablabesmyia annulata*	16
84540	*Polypedilum (Tripodura) scalaenum group*	8

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 4 Total Taxa: 4

No. Qualitative Taxa: ICI:

Number of Organisms: 342 Qual EPT: