State of Ohio
Environmental Protection Agency

Division of Surface Water

Biological and Water Quality Study of the East Fork Vermilion River

Lorain and Erie Counties

March 31, 2006

Bob Taft, Governor
Joseph P. Koncelik, Director

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Green Circle Growers
2005

Lorain and Erie Counties, Ohio

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OEPA Report EAS/2006-3-2

prepared for

State of Ohio Environmental Protection Agency
Division of Emergency and Remedial Response

prepared by

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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,

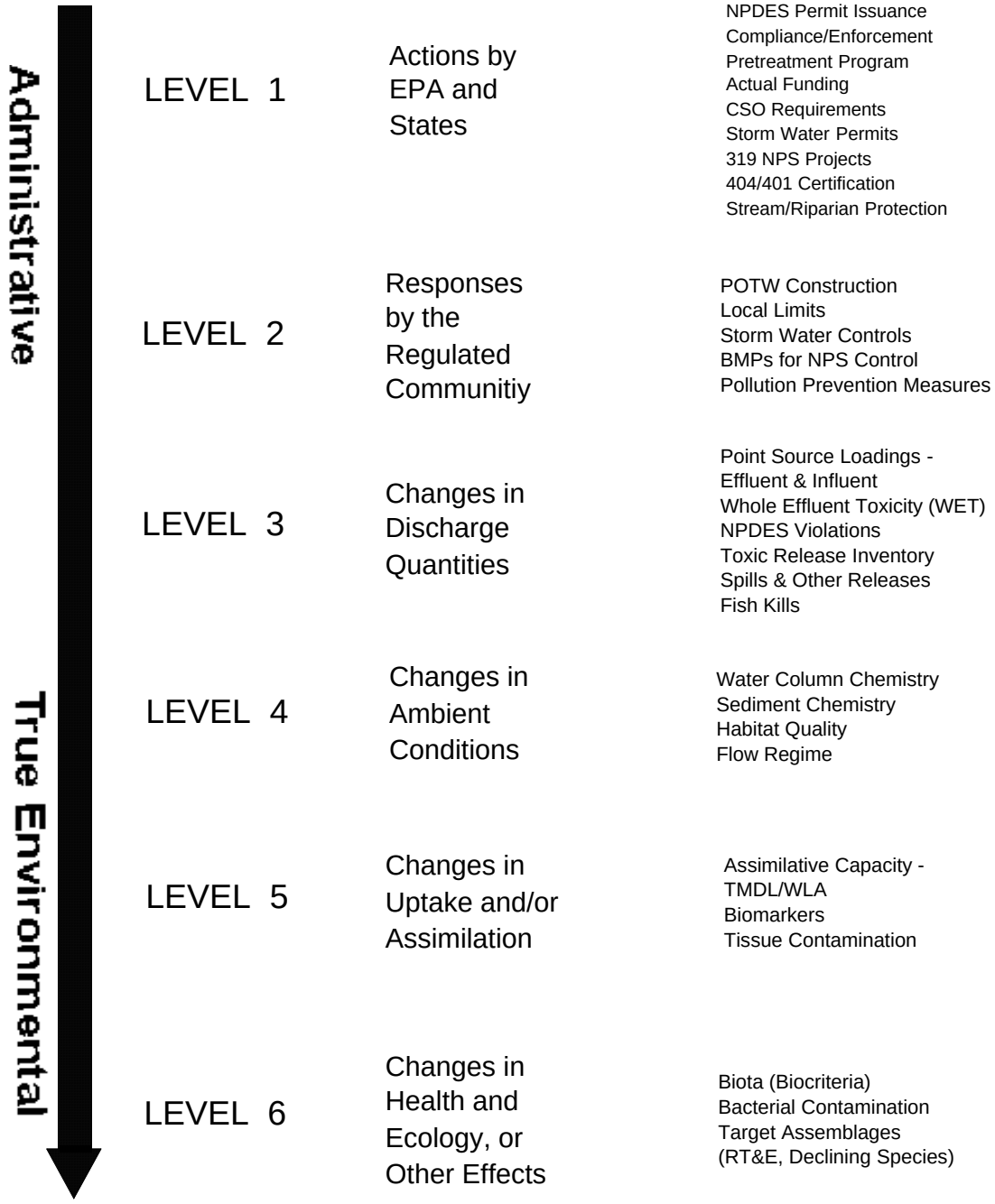


Figure 1. Hierarchy of administrative and environmental indicators which can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by the U.S. EPA.

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 Ohio EPA staff are acknowledged for their contribution to this report:
David Altfater, Mike Gray, Craig Kleinhenz, Scott Shane, Dennis Mishne, and Victoria Sigler

Reviewers - Jeff DeShon, Marc Smith

INTRODUCTION

In July 2002, Ohio EPA, US EPA and Ohio Bureau of Identification and Investigation initiated a criminal investigation into the operations of Green Circle Growers. As a result of the investigation, Green Circle Growers pled guilty and as part of its sentence funded this study.

Green Circle Growers is an Oberlin, Ohio based commercial greenhouse that is among the 25 largest in the country. In July 2002, while conducting a routine biological assessment, Ohio EPA biologists noticed a substantial decline in aquatic life in the East Fork Vermillion River adjacent to Green Circle Growers. They observed that the fish and benthic invertebrate populations were negatively affected for several miles downstream. In addition, they observed several discharge pipes in the section of the river that bisected Green Circle Grower's property. An investigation later determined that these and other discharge pipes were unpermitted. After making these observations, the biologists contacted the Ohio EPA's Office of Special Investigations (OSI). OSI is responsible for conducting criminal investigations for the agency.

A multi-agency criminal investigation ensued. The results of the investigation showed that for years Green Circle Growers had negligently discharged wastewater from multiple discharge points from its greenhouse operations into the river. The wastewater contained various pollutants, including pesticides, herbicides, and fertilizers used in the greenhouse operations. These pollutants had an adverse impact on the water quality of the stream and were the cause of a several mile segment of the river not meeting Ohio Water Quality Standards.

On February 25, 2005 Green Circle Growers pled guilty and was sentenced for negligently discharging wastewater to the East Fork Vermillion River. Green Circle Growers' sentence was:

- $50,000 fine and
- $200,000 restitution, which included the following:
  - $50,000 to the Lorain County Soil and Water Conservation District, a nonprofit organization which funds projects to protect and conserve waterways in the Lorain County watershed
  - $120,000 to a water quality project selected by Division of Surface Water, and
  - $30,000 to Ohio EPA to conduct this follow-up biological and chemical assessment of the impacted area.

During 2005, the Division of Surface Water evaluated surface water, sediment and biological conditions in the East Fork Vermilion River to assess river conditions since the elimination of point source discharges from the Green Circle Growers facility.

Specific objectives of this evaluation were to:

1) Establish biological conditions in the East Fork Vermilion River in the vicinity of the Green Circle Growers property by evaluating fish and macroinvertebrate communities,
2) Evaluate surface water and sediment chemical quality in the East Fork Vermilion River,
3) Determine the aquatic life use attainment status of the East Fork Vermilion River with regard to the Warmwater Habitat (WWH) aquatic life use designation codified in the Ohio Water Quality Standards, and
4) Compare 2005 results with biological and water quality samples collected in 2002.

SUMMARY

A total of 9.2 miles of the East Fork Vermilion River was assessed by the Ohio EPA in 2005. Based on the performance of the biological communities, the upper 6.1 mile section of the East Fork Vermilion River was in partial attainment of the Warmwater Habitat aquatic life use and the lower 3.1 miles were in full attainment of the WWH use (Table 1). This was an improvement from 2002 results, when 4.3 miles of river adjacent to and downstream from Green Circle Growers was in non-attainment of the WWH use. Macroinvertebrate communities at RMs 8.9 and 7.4 were impaired, which appeared to result from nutrient enrichment. Chemical constituents measured in the surface water of the East Fork Vermilion River during 2005 were below Ohio WQS criteria and pesticide results were reported as *none detected*. Water quality samples were collected during lower stream flow periods, and not influenced by recent runoff events. Water quality improved between 2002 and 2005 in the area adjacent to and immediately downstream from Green Circle Growers. Sediment collected from all four locations in the East Fork Vermilion River were not considered likely to be harmful to sediment-dwelling organisms. Sediment pesticide levels declined between 2002 and 2005 adjacent to Green Circle Growers.

RECOMMENDATIONS

Status of Aquatic Life Uses

The aquatic life use designation of Warmwater Habitat (WWH) for the East Fork Vermilion River has been confirmed in a previous Ohio EPA biological and water quality study. This study verified the WWH use designation for the East Fork Vermilion River.

Status of Non-Aquatic Life Uses

This study verified that the Primary Contact Recreation use is appropriate for the East Fork Vermilion River.

Table 1. Attainment status of the existing aquatic life use for the East Fork Vermilion River based on biological sampling conducted during July and August, 2005.

RIVER MILE Fish/Invert.	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status	Site Location
Eastern Corn Belt Plains (ECBP) - WWH Use Designation						
***East Fork Vermilion River* (2005)**						
10.5 / 10.5	32*	NA	44	66.0	PARTIAL	Upstream Green Circle Growers
8.9 / 8.9	36[ns]	NA	24*	65.0	PARTIAL	Adjacent Green Circle Growers
7.4 / 7.4	40	NA	14*	75.0	PARTIAL	Near field Green Circle Growers
2.3 / 2.3	46	8.5	MG[ns]	71.5	FULL	Far field Green Circle Growers
***East Fork Vermilion River* (2002)**						
10.9 / 10.9	34*	NA	MG[ns]	58.0	PARTIAL	Upstream Green Circle Growers
8.9 / 9.1	24*	NA	VP*	67.0	NON	Adjacent Green Circle Growers
7.4 / 7.4	36[ns]	NA	VP*	68.0	NON	Near field Green Circle Growers
2.3 / 2.3	38[ns]	8.0[ns]	MG[ns]	64.0	FULL	Far field Green Circle Growers

Ecoregion Biocriteria: Eastern Corn Belt Plains (ECBP)

INDEX	WWH	EWH
IBI-Headwater/ Wading	40	50
MIwb - Wading	8.3	9.4
ICI	36	46

[a] MIwb is not applicable to headwater streams with drainage areas <20mi^2.

[b] A qualitative narrative evaluation based on best professional judgement and sampling attributes such as community composition and EPT taxa richness was used when quantitative data were not available or considered unreliable due to sampling constraints. MG: marginally good, VP: very poor.

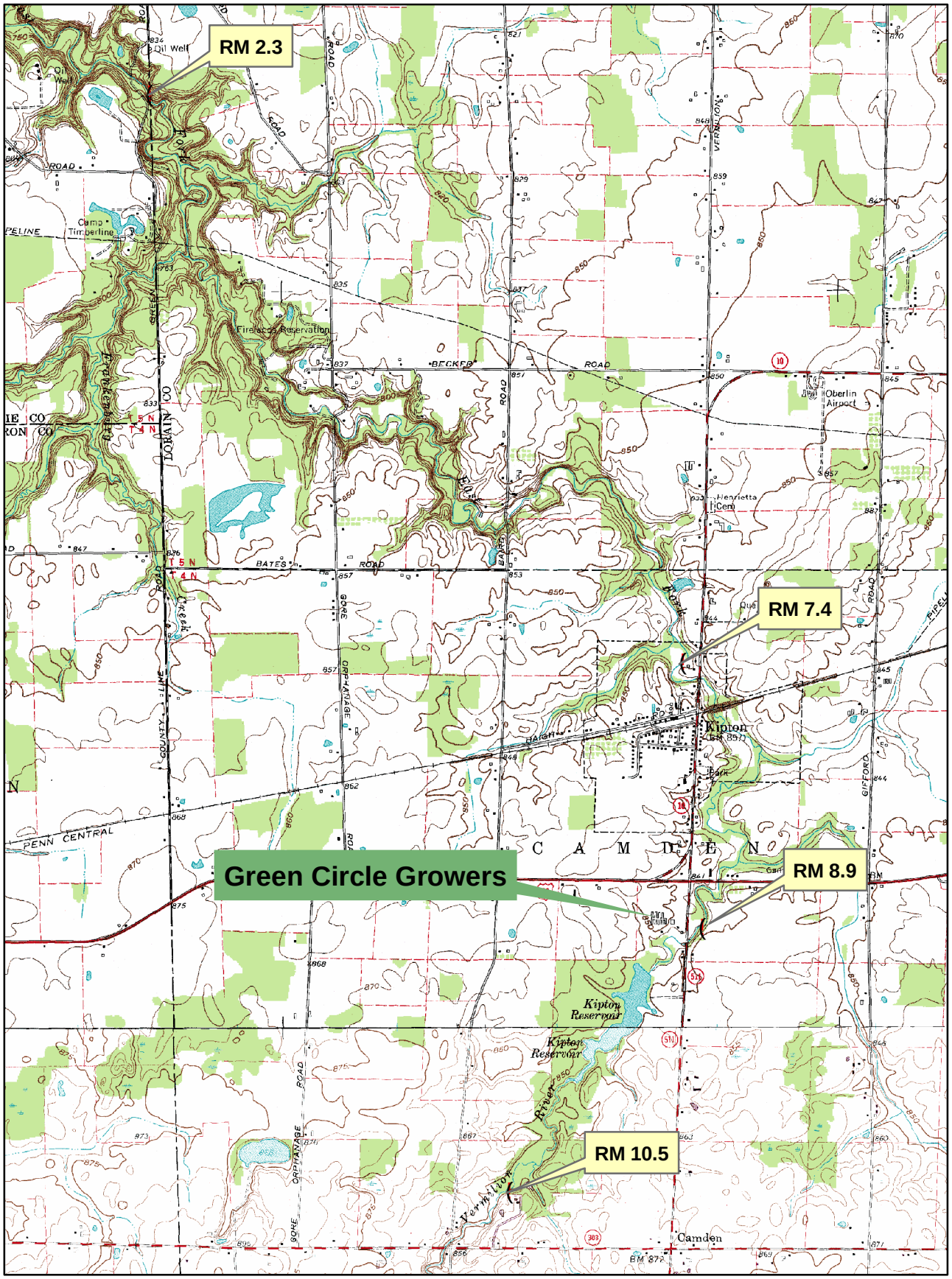
* Significant departure from ecoregion biocriterion; poor and very poor results are underlined.

[ns] Nonsignificant departure from ecoregion biocriterion ($\leq$4 IBI and ICI units, $\leq$0.5 MIwb units).

NA Not applicable.

Table 2. Sampling locations in the East Fork Vermilion River, 2005. Type of sampling included fish community (F), macroinvertebrate community (M), sediment (S) and surface water (W).

Stream/ River Mile	Type of Sampling	Latitude	Longitude	Landmark
East Fork Vermilion River				
10.5	F,M,S,W	41º 14' 28.0"	82º 18' 57.7"	Schawn Campground
8.9	F,M,S,W	41º 15' 21.0"	82º 18' 06.3"	Between SR 511& US 20
7.4	F,M,S,W	41º 16' 14.8"	82º 18' 11.2"	Downstream SR 10 @ Kipton
2.3	F,M,S,W	41º 18' 11.5"	82º 20' 35.7"	Upstream Green Road



5,000 2,500 0 5,000 Feet

Figure 2. Sampling locations in the East Fork Vermilion River, 2005.

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 2003a) and Biological Criteria for the Protection of Aquatic Life, Volumes I-III (Ohio Environmental Protection Agency 1987a, 1987b, 1989a, 1989b), 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 and Surface Water Assessment

Fine grain sediment samples were collected multi-incrementally in the upper 4 inches of bottom material at each East Fork Vermilion River 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 incremental samples were mixed in stainless steel pans (hand stirring using stainless steel spoon), transferred into glass jars with teflon lined lids, placed on ice (to maintain 4ºC) in a cooler, and shipped to an Ohio EPA contract lab or delivered to the Ohio Department of Agriculture lab. Sediment data is reported on a dry weight basis. Surface water samples were collected directly into appropriate containers, preserved and delivered to an Ohio EPA contract lab or the Ohio Department of Agriculture lab. Surface water samples were evaluated using comparisons to Ohio Water Quality Standards criteria, reference conditions, or published literature. Sediment evaluations were conducted using guidelines established in MacDonald *et al.* (2000) and USEPA Region 5 Ecological Screening Levels - ESLs (USEPA 2003), along with a comparison to Ohio Sediment Reference Values (Ohio EPA 2003b).

Macroinvertebrate Community Assessment

Macroinvertebrates were collected from artificial substrates and from the natural habitats at the four East Fork Vermilion 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). 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 1989a).

Fish Community Assessment

Fish were sampled twice at each site using pulsed DC electrofishing methods, with sampling distances of 160 - 200 meters at each site in the East Fork Vermilion River. Fish were processed in the field, and included identifying each individual to species, counting, weighing (at RM 2.3 only), 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 1989a).

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

Surface Water Quality

Chemical analyses were conducted on surface water samples collected on July 7 and August 18, 2005 from four locations in the East Fork Vermilion River (Table 3, Appendix Tables 1 and 2). Surface water samples were analyzed for total analyte list inorganics (metals), nutrients, total dissolved solids, total suspended solids, and four pesticide parameters (chloropyriphos, bifenthrin, cyfluthrin, and imidacloprid). The pesticide parameters were only tested at RMs 10.5 and 8.9. Parameters which were in exceedence of Ohio WQS criteria are reported in Table 3.

For the four East Fork Vermilion River sampling locations, none of the tested chemical parameters exceeded Ohio WQS aquatic life criteria. Concentrations of all of the pesticide parameters tested (bifenthrin, chlorpyrifos, cyfluthrin, and imidacloprid) were reported as *none found* for the 2005 samples. Sample results from pesticide tests during 2002 documented detectable levels of chlorpyrifos (3 ug/l) and imidacloprid (0.016 ug/l) at RM 9.04 (SR 511). The chlorpyrifos level of 3 ug/l exceeded the USEPA aquatic life acute criterion of 0.083 ug/l (USEPA 1986). Metals concentrations were very low during 2005, with over half of the tested parameters less than lab detection limits. Nitrate-nitrite nitrogen and phosphorus levels were measured at each location and compared to ecoregional reference conditions (Figures 3 and 4) and to levels reported during a 2002 study (Ohio EPA 2004). Nitrate concentrations were substantially below 2002 levels and mean levels were at or below the 75th percentile range for Eastern Corn Belt Plains reference conditions at headwater streams ($\leq$ 20 sq. mi. drainage). Phosphorus levels instream experienced similar declines at the sampling stations located adjacent to and 1.5 miles downstream from Green Circle Growers facilities. Phosphorus concentrations at three of the four sampling areas were within ecoregion reference levels (Figure 4). The most upstream site (RM 10.5) was slightly above (mean = 0.13 mg/l) the 75th percentile phosphorus ecoregional reference level. Copper was a parameter of

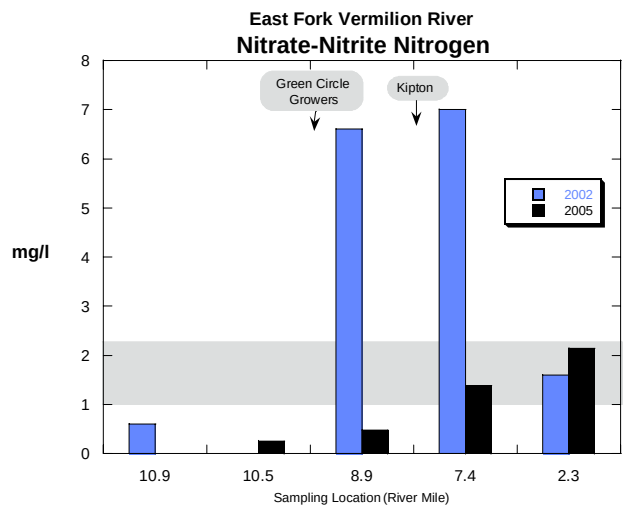


Figure 3. Mean concentrations of nitrate-nitrite nitrogen samples collected in the East Fork Vermilion River, 2005 and 2002. Shading represents the median and 75th percentile of reference sites in the ECBP ecoregion for headwater streams.

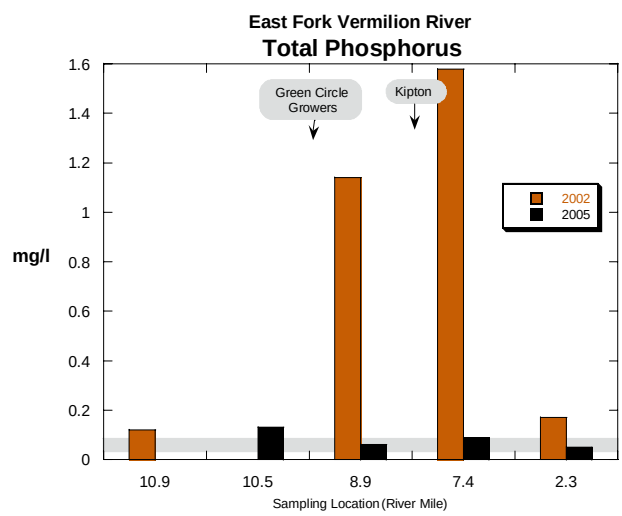


Figure 4. Mean concentrations of total phosphorus samples collected in the East Fork Vermilion River, 2005 and 2002. Shading represents the median and 75th percentile of reference sites in the ECBP ecoregion for headwater streams.

concern during 2002, with several measurements exceeding the Ohio WQS maximum copper criterion. Copper levels during 2005 were at background levels, with all four sampling sites below 5 ug/l (Figure 5). Biochemical oxygen demand - 5 day (BOD_5) measurements were generally low, with all but one value below the ecoregional 75th percentile reference level. Ammonia-N concentrations were below Ohio WQS criterion, however, mean levels at RMs 10.5, 8.9, and 7.4 were above the ecoregional 90th percentile reference range. Water quality was substantially improved between 2002 and 2005 adjacent to and immediately downstream from Green Circle Growers.

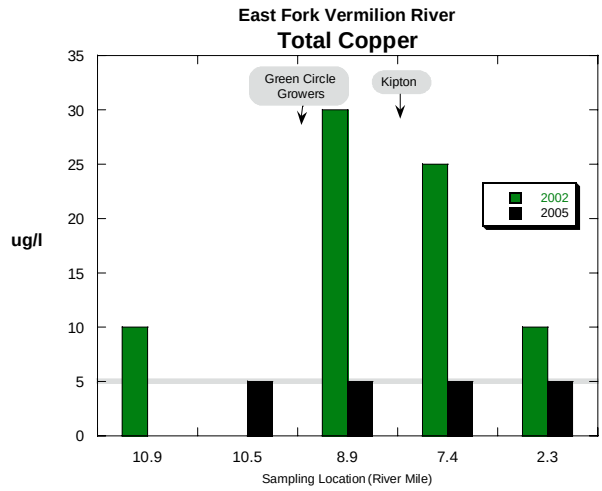


Figure 5. Mean concentrations of total copper samples collected in the East Fork Vermilion River, 2005 and 2002. Shading represents the median and 75th percentile of reference sites in the ECBP ecoregion for headwater streams.

Bacteriological parameters were not tested as part of this evaluation.

Table 3. Exceedences of Ohio Water Quality Standards criteria (OAC 3745-1) for chemical/physical parameters from the East Fork Vermilion River, 2005.

River Mile	Parameter (value)
10.5	None
8.9	None
7.4	None
2.3	None

Sediment Chemistry

Sediment samples were collected at four locations in the East Fork Vermilion River by the Ohio EPA on August 18, 2005. All stream sampling locations are indicated by river mile in Figure 2. Samples were analyzed for total analyte list inorganics (metals), and the same four pesticide parameters noted in the surface water section. The pesticide parameters were only tested at RMs 10.5 and 8.9. Specific chemical parameters tested and results are listed in Appendix Table 3.

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 Screening Levels (ESLs) (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 screening levels (ESLs) are initial screening levels used by USEPA to evaluate RCRA site constituents. In addition, sediment reference values (SRVs) for metals (Ohio EPA 2003) are presented in Appendix Table 3 for comparison to East Fork Vermilion River results.

Sediment collected from all four locations in the East Fork Vermilion River were not considered likely to be harmful to sediment-dwelling organisms (MacDonald *et.a*l. 2000). All inorganic/metal parameters were reported at levels below Ohio sediment reference values or TEC screening levels (Appendix Table 3). Metal sediment concentrations were not at levels likely to cause ecological impairment to the biota of the East Fork Vermilion River. Four pesticide parameters (bifenthrin, chlorpyrifos, cyfluthrin, and imidacloprid) were tested in sediment collected from two locations (RMs 10.5 and 8.9). These sites were located upstream from (RM 10.5) and adjacent to (RM 8.9) the Green Circle Growers facility. Pesticide results revealed detectable concentrations of chlorpyrifos and imidacloprid at both locations, with higher levels noted at the upstream location (Table 4). Substantial declines in all four pesticides were noted in the Green Circle Grower area of the East Fork Vermilion River between samples collected in 2005 and 2002 (Table 4). Screening benchmarks are unavailable to evaluate ecological risk from these pesticides.

Table 4. Sediment pesticide levels in the East Fork Vermilion River during 2005 and 2002. Samples were collected upstream and adjacent to the Green Circle Growers facility.

Location	chlorpyrifos (mg/kg)	imidacloprid (mg/kg)	bifenthrin (mg/kg)	cyfluthrin (mg/kg)
2005				
RM 10.5	18.2	0.292	Not Found	Not Found
RM 8.9	10.9	0.175	Not Found	Not Found
2002				
RM 9.12	None Detected	None Detected	None Detected	None Detected
RM 9.04	46.8	4.215	0.85	1.31

Physical Habitat For Aquatic Life

Physical habitat was evaluated in the East Fork Vermilion River at each fish sampling location. Qualitative Habitat Evaluation Index (QHEI) scores are detailed in Table 5.

QHEI scores for the East Fork Vermilion River sites ranged between 65.0 and 75.0. These scores reflect good river habitat and indicate the potential to support WWH biological communities. The four sampling locations were represented by various types of bottom substrates, and the predominant types included gravel, sand, and cobble. Bedrock was a predominant substrate only at RM 2.3. Good quality substrates were moderately to extensively embedded with silts, both in riffle and pool areas. Each site was composed of a natural stream channel.

Table 5. Qualitative Habitat Evaluation Index (QHEI) scores for the East Fork Vermilion River, 2005.

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 HL 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 ML MWH Attributes**	**(MWH HL+1)/(WWH+1) Ratio**	**(MWH ML+1)/(WWH+1) Ratio**
(21-002) East Fork Vermilion River																																			
Year: 2005																																			
10.5	**66.0**	5.26	■	■		■	■	■			■		6				♦	♦	2		●			●				●	●	●		5	0.43	1.14
8.9	**65.0**	9.62	■	■		■		■			■		5				♦	♦	2		●			●				●	●	●		5	0.50	1.33
7.4	**75.0**	10.87	■	■		■	■	■			■	■	7				♦		1		●							●	●	●		4	0.25	0.75
2.3	**71.5**	14.29	■	■		■		■			■		5					♦	1		●			●	●			●	●	●		6	0.33	1.33

Fish Community Assessment

Fish communities were assessed at four locations in the East Fork Vermilion River (Figure 2, Table 6, Appendix Tables 6 and 7). Sampling areas replicated locations sampled during 2002 and were designed to assess stream conditions since the elimination of point source discharges from the Green Circle Growers nursery facilities.

Fish communities ranged from fair to very good in the East Fork Vermilion River. Results from all four fish sampling locations showed incremental improvement from upstream to downstream, with no obvious trends associated with the Green Circle Growers nursery property. The most upstream sampling site, located approximately 1.5 miles upstream from Green Circle Growers, did not achieve the IBI ecoregional biocriterion. The score of 32 was reflective of fair biological quality, largely due to a dominance of pollution tolerant creek chub and blacknose dace. Improvement in fish community conditions were documented at the remaining three downstream sampling sites, with all three achieving the ecoregional biocriteria established for Warmwater Habitat (WWH) streams and rivers in Ohio (Table 6). Comparison of 2005 and 2002 fish results revealed improved biological integrity at the site adjacent to Green Circle Growers, along with improvement at the two downstream locations (Figure 6). Sampling during 2005 suggested that operations at the Green Circle Growers facilities did not negatively impact the fish community of the East Fork Vermilion River.

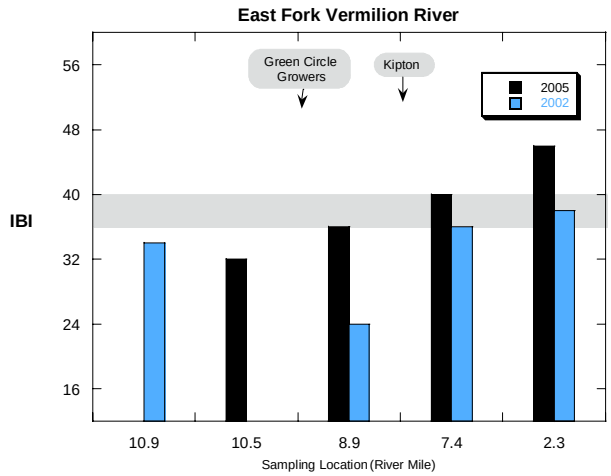


Figure 6. Index of Biotic Integrity (IBI) scores by location in the East Fork Vermilion River, 2005 and 2002. Shading represents the the non-significant departure range for the IBI biocriterion.

Table 6. Fish community summaries based on pulsed DC electrofishing sampling conducted by Ohio EPA in the East Fork Vermilion River from July and August, 2005. Relative numbers and weight for the East Fork Vermilion River sites are per 0.3 km. NA - not applicable for headwater sites. The applicable aquatic life use designation is WWH.

Stream/ River Mile	Mean Number of Species	Total Number Species	Relative Number	Relative Weight (kg)	QHEI	Modified Index of Well-Being	Index of Biotic Integrity	Narrative Evaluation
East Fork Vermilion River (2005)								
10.5	12.0	14	1198	NA	66.0	NA	32*	Fair
8.9	13.5	16	844	NA	65.0	NA	36^{ns}	Marg. Good
7.4	17.0	20	904	NA	75.0	NA	40	Good
2.3	19.0	22	1343	10.02	71.5	8.5	46	Very Good

Ecoregion Biocriteria: Eastern Corn Belt Plains (ECBP) Ohio Administrative Code: 3745-1-07, Table 7-15		
INDEX	**WWH**	**EWH**
IBI - Headwater/Wading	40	50
MIwb - Wading	8.3	9.4

* Significant departure from ecoregion biocriterion; poor and very poor results are underlined.
^{ns} Nonsignificant departure from ecoregion biocriterion ($\leq$4 IBI units, $\leq$0.5 MIwb units).

Macroinvertebrate Community Assessment

The macroinvertebrate communities at four East Fork Vermilion River sites were sampled in 2005 using qualitative (multi-habitat composite) and quantitative (artificial substrate) sampling protocols (Figure 2). Sampling areas replicated locations sampled in 2002 and were designed to assess stream conditions since the elimination of point source discharges from the Green Circle Growers nursery facilities. Results are summarized in Table 7. The ICI metrics with the associated scores for the Eastern Corn Belt Plains ecoregion and the raw data are attached as Appendix Tables 4 and 5.

The ICI scores for the four East Fork Vermilion River sites (RMs 10.5, 8.9, 7.4, and 2.3) were 44, 24, 14, and 26, respectively. The macroinvertebrate community at the upstream sampling location with an ICI of 44 was in attainment of the designated WWH use. The sites adjacent to and 1.5 miles downstream from the Green Circle Growers area were not in attainment of the designated use. The cause of the impairment appears to be nutrient enrichment. The large number of the genus Hydra (a predatory hydroid related to jellyfish) in the quantitative sample at RM 8.9 and the high proportion in the RM 7.4 sample are potential indicators of enrichment.

Stream flow conditions during the survey were low, which resulted in insufficient current velocities at the RMs 8.9, 7.4 and 2.3 artificial substrate sampling locations. The qualitative samples from these locations were evaluated. The macroinvertebrate community from RM 8.9 was evaluated as fair while RM 7.4 was at the low end of the fair range. These narrative evaluations are consistent with the ICI scoring for these sites. The RM 2.3 site was evaluated as marginally good which was higher than the ICI score for the site. The marginally good evaluation for the RM 2.3 site is a non-significant departure from attainment of the WWH use for the macroinvertebrate community.

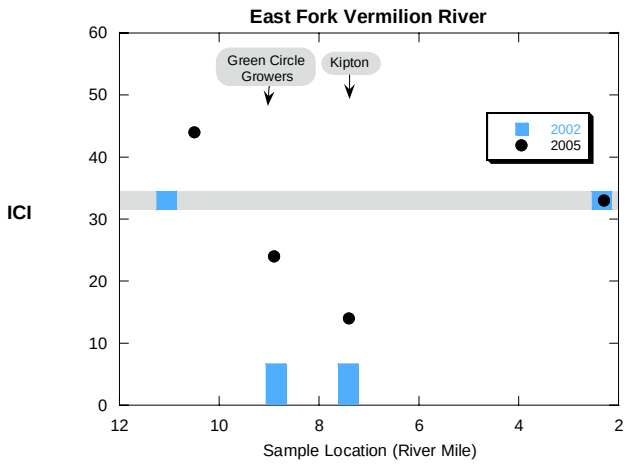


Figure 7. ICI and qualitative sample narrative evaluations by location in the East Fork Vermilion River, 2005 and 2002. Shading represents the non-significant departure range for the ICI biocriterion. Ranges for 2002 data reflect the ICI range based on the narrative evaluation.

A comparison of the 2005 and 2002 macroinvertebrate sampling results revealed improvement at RMs 8.9 and 7.4 in 2005 (Figure 7). The macroinvertebrate community at the site adjacent to Green Circle Growers (RM 8.9) and the first site downstream (RM 7.4) both improved from very poor in 2002 to fair in 2005. The quantitative sample from RM 2.3 appears to show a decline in the macroinvertebrate community in 2005 but the qualitative sample evaluation of marginally good is consistent with the 2002 sampling results for this site.

Table 7. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the East Fork Vermilion River, 2005.

River Mile	Density Number/ft^2	Total Taxa	Quantitative Taxa	Qualitative Taxa	Qualitative EPT[a]	ICI	Evaluation
East Fork Vermilion River							
10.5	172	42	27	22	4	44	Good
8.9	2087	40	29	22	3	24*	Fair
7.4	196	32	27	13	2	14*	Fair
2.3	211	47	33	24	8	26/MG[ns]	Fair/Marg. Good[b]

Ecoregion Biocriteria: Eastern Corn Belt Plains (ECBP) (Ohio Administrative Code 3745-1-07, Table 7-15)		
INDEX	WWH	EWH
ICI	36	46

[a] EPT= total Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa richness, a measure of pollution sensitive organisms.
[b] Fair rating based on the ICI score. Marginally good rating based on qualitative results.
* Significant departure from ecoregional biocriterion; poor and very poor results are underlined.

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APPENDICES

Appendix Table 1. Results of chemical surface water sampling conducted by Ohio EPA in the East Fork Vermilion River on July 7, 2005. Less than values were reported by the lab as not detected at or above the method detection limit.

Stream	**EF Vermilion River**	**EF Vermilion River**	**EF Vermilion River**	**EF Vermilion River**	**EF Vermilion River**
River Mile	**10.5**	**8.9**	**7.4**	**2.3**	**2.3**
Date Sampled	7/7/2005	7/7/2005	7/7/2005	7/7/2005	7/7/2005
Time Sampled	11:45 AM	9:40 AM	1:50 PM	4:05 PM	4:05 PM
					Duplicate
TAL Metals (ug/l)					
Mercury	0.136J	<0.10	<0.10	<0.10	<0.10
Aluminum	494	539	183	478	515
Silver	<5	<5	<5	<5	<5
Arsenic	2.66J	2.93J	<2	2.67J	<2
Barium	53.9	52.7	45	50.5	50.5
Beryllium	<0.25	<0.25	<0.25	<0.25	<0.25
Calcium	114,000	108,000	93,400	78,600	78,000
Cadmium	<2.5	<2.5	<2.5	<2.5	<2.5
Cobalt	<2.5	<2.5	<2.5	<2.5	<2.5
Chromium	<2.5	<2.5	<2.5	<2.5	<2.5
Copper	<5	<5	<5	<5	<5
Iron	630	660	247	498	536
Potassium	3,600	4,680	5,580	5,070	5,020
Magnesium	41,100	36,400	28,000	20,600	20,500
Manganese	98.7	103	52.7	23.1	22.5
Sodium	30,900	30,200	28,100	20,300	20,200
Nickel	<5	<5	<5	<5	<5
Lead	3.12J	2.92J	2.67J	2.57J	<2.5
Vanadium	<5	<5	<5	<5	<5
Zinc	<5	<5	<5	<5	<5
Antimony	<0.5	<0.5	<0.5	<0.5	<0.5
Selenium	<7.5	<7.5	<7.5	<7.5	<7.5
Thallium	<0.1	<0.1	<0.1	<0.1	<0.1
Inorganic & Nutrient Analytes (mg/l)					
Total Suspended Solids	9	10.5	<2.5	9	<2.5
Total Dissolved Solids	626	590	444	396	422
Nitrite-N	0.0166	0.0112	0.0322	0.0123	0.00733 J
Nitrate-Nitrite, Nitrogen	0.204	0.356	1.54	3.24	3.3
Total Kjeldahl Nitrogen	0.665	0.708	0.823	0.844	0.826
Phosphorus -T	0.154	0.079 J	0.097 J	<0.05	<0.05
Ammonia-N	0.156	0.166	0.189	0.104	0.099 J
BOD5	1.50 J	1.70 J	1.80 J	2.10 J	1.5 J
COD	<10.0	10.9 J	13.6 J	<10	17.6 J
Field Measurements					
Temperature (^{o}C)	20.1	20.4	21.7	21.3	21.3
Dissolved Oxygen (mg/l)	6.9	6.52	8.4	10.23	10.23
pH (S.U.)	7.7	7.29	8.16	8.51	8.51
Conductivity (umhos/cm)	790	740	673	528	528

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

< - Not detected at or above the method detection limit (MDL value reported with the less than symbol).

Appendix Table 2. Results of chemical surface water sampling conducted by Ohio EPA in the East Fork Vermilion River on August 18, 2005. Less than values were reported by the lab as not detected at or above the method detection limit.

Stream	**EF Vermilion River**	**EF Vermilion River**	**EF Vermilion River**	**EF Vermilion River**
River Mile	**10.5**	**8.9**	**7.4**	**2.3**
Date Sampled	8/18/2005	8/18/2005	8/18/2005	8/18/2005
Time Sampled	9:50 AM	11:35 AM	1:15 PM	3:00 PM
TAL Metals (ug/l)				
Mercury	<0.1	<0.1	<0.1	<0.1
Aluminum	262	255	240	323
Silver	<5	<5	<5	<5
Arsenic	2.24 J	2.72 J	2.24 J	2.69 J
Barium	54	51.1	48.6	64.1
Beryllium	<0.25	<0.25	<0.25	<0.25
Calcium	119,000	109,000	90,700	93,100
Cadmium	<2.5	<2.5	<2.5	<2.5
Cobalt	<2.5	<2.5	<2.5	<2.5
Chromium	<2.5	<2.5	<2.5	<2.5
Copper	<5	<5	<5	<5
Iron	321	624	335	381
Potassium	3,610	4,740	6,930	6,590
Magnesium	44,300	39,200	29,200	27,400
Manganese	54	87.4	49.4	23.1
Sodium	34,000	34,100	34,700	28,800
Nickel	<5	<5	<5	<5
Lead	3.75 J	3.67 J	2.89 J	3.70 J
Vanadium	<5	<5	<5	<5
Zinc	<5	<5	<5	6.45 J
Antimony	<0.5	<0.5	<0.5	<0.5
Selenium	<3	<3	<1.5	<1.5
Thallium	0.588	0.718	0.83	0.868
Inorganic & Nutrient Analytes (mg/l)				
Total Suspended Solids	5.5	6.5	5	3.5 J
Total Dissolved Solids	570	548	422	408
Nitrate-Nitrite, Nitrogen	0.3	0.594	1.22	1.01
Total Kjeldahl Nitrogen	0.465	0.615	0.818	0.707
Phosphorus -T	0.115	<0.05	0.078 J	0.052 J
Ammonia-N	0.097 J	0.109	0.221	<0.05
BOD5	<1.0	<1.0	1.1 J	<1.0
COD	<10	17.4 J	16.1 J	44.4
Field Measurements				
Temperature (^{o}C)	19.48	20.25	21.77	22.74
Dissolved Oxygen (mg/l)	7.12	7.3	9.04	10.6
pH (S.U.)	8.06	8	8.03	8.4
Conductivity (umhos/cm)	864	829	783	708

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

< - Not detected at or above the method detection limit (MDL value reported with the less than symbol).

Appendix Table 3. Results of Ohio EPA sediment sampling conducted in the East Fork Vermilion River, August 18, 2005. NA - not applicable. Shaded values exceed applicable TEC or SRV screening levels.

Stream	**EF Vermilion River**	**EF Vermilion River**	**EF Vermilion River**	**EF Vermilion River**		
River Mile	**10.5**	**8.9**	**7.4**	**2.3**	Sediment	MacDonald
Date Sampled	8/18/2005	8/18/2005	8/18/2005	8/18/2005	Reference	2000
Time Sampled	11:05 AM	12:40 PM	2:30 PM	4:30 PM	Values (SRV)	TEC
TAL Metals (mg/kg)						
Mercury	0.0348 J	0.0216 J	0.0292 J	0.0218 J	0.12	0.18
Aluminum	7,680	5,440	8,860	3,870	39,000	NA
Silver	<0.355	<0.297	<0.403	<0.338	0.43	NA
Arsenic	5.38	7.89	4.51	4.05	18	9.79
Barium	44.5	35.7	59.9	58.1	240	NA
Beryllium	0.519 J	0.413 J	0.512 J	0.282 J	0.8	NA
Calcium	15,400	11,300	7,140	7,840	120,000	NA
Cadmium	0.24 J	0.185 J	0.301 J	0.284 J	0.9	0.99
Cobalt	7.01	5.64	5.73	3.56	12	NA
Chromium	10.4	8.51	12.1	5.83	40	43.4
Copper	15.1	12.2	15.9	8.38	34	31.6
Iron	17,000	14,900	15,000	8,830	33,000	NA
Potassium	1,290	956	1,350	745	11,000	NA
Magnesium	4,520	3,550	3,000	1,890	35,000	NA
Manganese	400	209	342	230	780	NA
Sodium	38.6	48	41	22.2 J	NA	NA
Nickel	17.6	13	13.9	9.66	42	22.7
Lead	10.8	9	14.2	5.59	47	35.8
Vanadium	16.8	12.6	17.8	10.7	40	NA
Zinc	50.9	46.7	66.1	40.8	160	121
Antimony	<0.152	<0.127	<0.179	<0.134	0.92	NA
Selenium	<0.737	<0.633	0.531	0.488	2.3	NA
Thallium	0.237	0.175	0.233	0.218	4.7	NA
Other						
Percent Solids	65.8	74.5	55.9	73.3	NA	NA

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

< - Not detected at or above the method detection limit (MDL value reported with the less than symbol).

Appendix Table 4. Invertebrate Community Index (ICI) scores for the East Fork Vermilion River, 2005.

River Mile	Drainage Area (sq mi)	Number of Total Taxa	Number of Mayfly Taxa	Number of Caddisfly Taxa	Number of Dipteran Taxa	Percent: Mayflies	Percent: Caddis-flies	Percent: Tany-tarsini	Percent: Other Dipt/NI	Percent: Tolerant Organisms	Qual. EPT	Eco-region	ICI
East Fork Vermilion River (21-002)													
Year: 2005													
10.50	8.6	27(4)	3(2)	2(4)	14(4)	31.2(6)	4.5(6)	18.9(6)	42.2(4)	2.1(6)	4(2)	5	44
8.90	10.9	29(4)	2(0)	1(2)	17(4)	0.2(2)	1.2(4)	0.2(2)	98.3(0)	0.6(6)	3(0)	5	24
7.40	16.4	27(4)	0(0)	1(2)	18(4)	0.0(0)	1.9(2)	1.9(2)	96.0(0)	24.8(0)	2(0)	5	14
2.30	33.0	33(4)	4(2)	2(4)	20(6)	4.1(2)	0.8(2)	16.0(4)	79.1(0)	22.3(0)	8(2)	5	26

Appendix Table 5. Ohio EPA macroinvertebrate results from the East Fork Vermilion River, 2005.

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 08/18/2005 River Code: 21-002 RM: 10.50 Site: East Fork Vermilion River adj. Schawn

Taxa Code	Taxa	Quant/Qual	
01801	*Turbellaria*	1	
03600	*Oligochaeta*	2	
08250	*Orconectes (Procericambarus) rusticus*		+
11130	*Baetis intercalaris*	1	
11651	*Procloeon sp (w/o hindwing pads)*		+
13400	*Stenacron sp*	250	+
13521	*Stenonema femoratum*	18	+
21200	*Calopteryx sp*		+
21300	*Hetaerina sp*	8	
22300	*Argia sp*		+
23909	*Boyeria vinosa*		+
45900	*Notonecta sp*		+
51206	*Cyrnellus fraternus*	6	
52200	*Cheumatopsyche sp*	33	+
68075	*Psephenus herricki*		+
68130	*Helichus sp*		+
68708	*Dubiraphia vittata group*		+
68901	*Macronychus glabratus*	18	+
69400	*Stenelmis sp*	1	+
71100	*Hexatoma sp*		+
72700	*Anopheles sp*		+
77100	*Ablabesmyia sp*	3	
77500	*Conchapelopia sp*	43	
78140	*Labrundinia pilosella*	6	
78450	*Nilotanypus fimbriatus*	5	
80360	*Corynoneura "celeripes" (sensu Simpson & Bode, 1980)*		+
80370	*Corynoneura lobata*	243	
82121	*Thienemanniella lobapodema*	8	
82141	*Thienemanniella xena*	13	
83840	*Microtendipes pedellus group*		+
84440	*Polypedilum (Uresipedilum) aviceps*	3	
84450	*Polypedilum (Uresipedilum) flavum*	3	
84480	*Polypedilum (P.) laetum group*		+
85500	*Paratanytarsus sp*	3	
85625	*Rheotanytarsus sp*	117	
85800	*Tanytarsus sp*	3	
85821	*Tanytarsus glabrescens group sp 7*	40	
86100	*Chrysops sp*		+
87540	*Hemerodromia sp*	1	
93900	*Elimia sp*	13	+
96900	*Ferrissia sp*	16	
98600	*Sphaerium sp*	3	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 27 Total Taxa: 42
No. Qualitative Taxa: 22 ICI: **44**
Number of Organisms: 861 Qual EPT: 4

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 08/18/2005 River Code: 21-002 RM: 8.90 Site: East Fork Vermilion River dst. St. Rt. 511, upst.

Taxa Code	Taxa	Quant/Qual	
00653	*Eunapius fragilis*		+
01320	*Hydra sp*	9963	+
01801	*Turbellaria*	80	+
08200	*Orconectes sp*		+
13400	*Stenacron sp*	19	+
13521	*Stenonema femoratum*	1	
21200	*Calopteryx sp*		+
22001	*Coenagrionidae*		+
23909	*Boyeria vinosa*		+
52200	*Cheumatopsyche sp*	123	+
59150	*Ceraclea resurgens group*		+
60900	*Peltodytes sp*		+
68707	*Dubiraphia quadrinotata*	4	+
68901	*Macronychus glabratus*	2	
69250	*Optioservus ovalis*		+
69400	*Stenelmis sp*	4	+
71900	*Tipula sp*		+
77120	*Ablabesmyia mallochi*	2	
77500	*Conchapelopia sp*	42	
77750	*Hayesomyia senata or Thienemannimyia norena*	2	
77800	*Helopelopia sp*	2	
78401	*Natarsia species A (sensu Roback, 1978)*	2	
78450	*Nilotanypus fimbriatus*		+
82730	*Chironomus (C.) decorus group*	13	+
84210	*Paratendipes albimanus or P. duplicatus*	17	+
84315	*Phaenopsectra flavipes*	17	+
84450	*Polypedilum (Uresipedilum) flavum*	30	
84460	*Polypedilum (P.) fallax group*	20	
84470	*Polypedilum (P.) illinoense*	5	+
84540	*Polypedilum (Tripodura) scalaenum group*	17	
84800	*Tribelos jucundum*	5	
85500	*Paratanytarsus sp*	10	
85625	*Rheotanytarsus sp*	2	
85800	*Tanytarsus sp*	8	
85821	*Tanytarsus glabrescens group sp 7*	5	
93900	*Elimia sp*	14	+
94603	*Pseudosuccinea columella*		+
95100	*Physella sp*	23	
96120	*Menetus (Micromenetus) dilatatus*	2	
98001	*Sphaeriidae*	2	

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 29 Total Taxa: 40
No. Qualitative Taxa: 22 ICI: **24**
Number of Organisms: 10436 Qual EPT: 3

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 08/18/2005 River Code: 21-002 RM: 7.40 Site: East Fork Vermilion River St. Rt. 10, just N of

Taxa Code	Taxa	Quant/Qual	
00401	*Spongillidae*		+
01320	*Hydra sp*	233	
01801	*Turbellaria*	297	+
03600	*Oligochaeta*	40	
21200	*Calopteryx sp*		+
21300	*Hetaerina sp*	1	
22001	*Coenagrionidae*		+
52200	*Cheumatopsyche sp*	19	+
52530	*Hydropsyche depravata group*		+
71900	*Tipula sp*	1	+
74100	*Simulium sp*		+
77500	*Conchapelopia sp*	23	
77750	*Hayesomyia senata or Thienemannimyia norena*	2	
78450	*Nilotanypus fimbriatus*	4	
82141	*Thienemanniella xena*	2	
83002	*Dicrotendipes modestus*	6	+
83040	*Dicrotendipes neomodestus*	10	
83051	*Dicrotendipes simpsoni*	57	
84210	*Paratendipes albimanus or P. duplicatus*	2	
84315	*Phaenopsectra flavipes*	27	
84450	*Polypedilum (Uresipedilum) flavum*	34	+
84470	*Polypedilum (P.) illinoense*	44	
84540	*Polypedilum (Tripodura) scalaenum group*	6	
84800	*Tribelos jucundum*	2	
85500	*Paratanytarsus sp*	13	
85625	*Rheotanytarsus sp*	2	
85800	*Tanytarsus sp*	2	
85821	*Tanytarsus glabrescens group sp 7*	2	
93900	*Elimia sp*	18	+
95100	*Physella sp*	11	+
95900	*Gyraulus sp*	30	+
96900	*Ferrissia sp*	91	

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 27 Total Taxa: 32
No. Qualitative Taxa: 13 ICI: **14**
Number of Organisms: 979 Qual EPT: 2

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 08/18/2005 River Code: 21-002 RM: 2.30 Site: East Fork Vermilion River Green Rd.

Taxa Code	Taxa	Quant/Qual	
01801	*Turbellaria*	1	+
03360	*Plumatella sp*		+
03600	*Oligochaeta*	17	
07860	*Cambarus (Puncticambarus) robustus*		+
11120	*Baetis flavistriga*		+
11130	*Baetis intercalaris*		+
11645	*Procloeon sp*	1	
13400	*Stenacron sp*	11	+
13521	*Stenonema femoratum*	11	+
13590	*Stenonema vicarium*	20	+
21200	*Calopteryx sp*	1	
21300	*Hetaerina sp*		+
48410	*Corydalus cornutus*		+
48620	*Nigronia serricornis*		+
51600	*Polycentropus sp*	1	
52200	*Cheumatopsyche sp*	7	+
52430	*Ceratopsyche morosa group*		+
52530	*Hydropsyche depravata group*		+
69400	*Stenelmis sp*		+
71900	*Tipula sp*		+
74100	*Simulium sp*		+
77120	*Ablabesmyia mallochi*	38	
77500	*Conchapelopia sp*	38	
78140	*Labrundinia pilosella*	15	
79085	*Telopelopia okoboji*	8	
80370	*Corynoneura lobata*	32	
80430	*Cricotopus (C.) tremulus group*		+
81650	*Parametriocnemus sp*	8	+
83040	*Dicrotendipes neomodestus*	315	
83051	*Dicrotendipes simpsoni*	38	
84210	*Paratendipes albimanus or P. duplicatus*	54	
84300	*Phaenopsectra obediens group*	23	
84315	*Phaenopsectra flavipes*	8	
84450	*Polypedilum (Uresipedilum) flavum*	8	
84460	*Polypedilum (P.) fallax group*	31	
84470	*Polypedilum (P.) illinoense*	8	
84800	*Tribelos jucundum*	38	+
85230	*Cladotanytarsus mancus group*	8	
85500	*Paratanytarsus sp*	69	
85625	*Rheotanytarsus sp*	15	+
85800	*Tanytarsus sp*	8	
85821	*Tanytarsus glabrescens group sp 7*	69	
86401	*Atherix lantha*		+
93900	*Elimia sp*	1	+
94400	*Fossaria sp*	12	
95100	*Physella sp*	7	+
96900	*Ferrissia sp*	134	

No. Quantitative Taxa: 33 Total Taxa: 47
No. Qualitative Taxa: 24 ICI: **26**
Number of Organisms: 1055 Qual EPT: 8

Appendix Table 6. Fish IBI and MIwb results for the East Fork Vermilion River, 2005.

				Number of						Percent of Individuals						
River Mile	Type	Date	Drainage area (sq mi)	Total species	Minnow species	Headwater species	Sensitive species	Darter & Sculpin species	Simple Lithophils	Tolerant fishes	Omni-vores	Pioneering fishes	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(0.3km)	IBI
E. Fk. Vermilion R. - (21-002)																
Year: 2005																
10.50	E	07/07/2005	8.6	11(3)	6(3)	2(3)	0(1)	2(3)	3(3)	79(1)	6(5)	62(1)	25(3)	0.0(5)	311(3)	34
10.50	E	08/18/2005	8.6	13(3)	5(3)	2(3)	1(1)	2(3)	2(1)	80(1)	7(5)	62(1)	23(3)	0.0(5)	188(1)	30
8.90	E	08/18/2005	10.9	13(3)	6(3)	2(3)	1(1)	3(3)	4(3)	48(3)	10(5)	62(1)	48(5)	0.0(5)	415(3)	38
8.90	E	07/07/2005	10.9	14(3)	8(5)	2(3)	0(1)	2(3)	3(1)	58(1)	7(5)	57(1)	37(3)	0.0(5)	378(3)	34
7.40	E	07/07/2005	16.4	16(3)	6(3)	2(3)	2(1)	4(3)	5(3)	56(1)	2(5)	40(3)	41(3)	0.0(5)	381(3)	36
7.40	E	08/18/2005	16.4	18(5)	8(5)	2(3)	4(3)	4(3)	5(3)	52(3)	2(5)	45(3)	44(3)	0.2(5)	449(3)	44

♦ - IBI is low end adjusted.

* - < 200 Total individuals in sample

** - < 50 Total individuals in sample

● - One or more species excluded from IBI calculation.

Appendix Table 6. Fish IBI and MIwb results for the East Fork Vermilion River, 2005.

				Number of					Percent of Individuals								
River Mile	Type	Date	Drainage area (sq mi)	Total species	Sunfish species	Sucker species	Intolerant species	Darter species	Simple Lithophils	Tolerant fishes	Omni-vores	Top carnivores	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(0.3km)	IBI	Modified Iwb
E. Fk. Vermilion R. - (21002)																	
Year: 2005																	
2.30	E	08/18/2005	33	20(5)	2(3)	2(3)	2(3)	4(3)	41(5)	11(5)	6(5)	1.0(3)	63(5)	0.0(5)	1470(5)	50	8.4
2.30	E	07/07/2005	33	18(3)	3(3)	1(1)	1(1)	3(3)	45(5)	16(5)	6(5)	0.6(1)	66(5)	0.0(5)	873(5)	42	8.6

na - Qualitative data, Modified Iwb not applicable.

♦ - IBI is low end adjusted.

* - < 200 Total individuals in sample

** - < 50 Total individuals in sample

● - One or more species excluded from IBI calculation.

Appendix Table 7. Ohio EPA fish results from the East Fork Vermilion River, 2005.

Species List

River Code: **21-002**	Stream: **East Fork Vermilion River**	Sample Date: **2005**
River Mile: **10.50**	Location: adj. Schawn Campground	Date Range: 07/07/2005
Time Fished: 5340 sec	Drainage: 8.6 sq mi	Thru: 08/18/2005
Dist Fished: 0.32 km	Basin: Vermilion River No of Passes: 2	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
Central Mudminnow		I	C	T	40	37.50	3.13			
White Sucker	W	O	S	T	26	24.38	2.03			
Blacknose Dace	N	G	S	T	229	214.69	17.92			
Creek Chub	N	G	N	T	655	614.06	51.25			
Striped Shiner	N	I	S		2	1.88	0.16			
Silverjaw Minnow	N	I	M		35	32.81	2.74			
Bluntnose Minnow	N	O	C	T	53	49.69	4.15			
Central Stoneroller	N	H	N		3	2.81	0.23			
White Crappie	S	I	C		3	2.81	0.23			
Smallmouth Bass	F	C	C	M	6	5.63	0.47			
Green Sunfish	S	I	C	T	9	8.44	0.70			
Bluegill Sunfish	S	I	C	P	1	0.94	0.08			
Johnny Darter	D	I	C		45	42.19	3.52			
Mottled Sculpin		I	C		171	160.31	13.38			
	Mile Total				1,278	1,198.13				
	Number of Species				14					
	Number of Hybrids				0					

Species List

River Code: **21-002**	Stream: **East Fork Vermilion River**	Sample Date: **2005**
River Mile: **8.90**	Location: dst. St. Rt. 511, upst. U.S. Rt. 20	Date Range: 07/07/2005
Time Fished: 5040 sec	Drainage: 10.9 sq mi	Thru: 08/18/2005
Dist Fished: 0.36 km	Basin: Vermilion River No of Passes: 2	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
Central Mudminnow		I	C	T	44	36.67	4.34			
White Sucker	W	O	S	T	19	15.83	1.88			
Golden Shiner	N	I	M	T	1	0.83	0.10			
Blacknose Dace	N	G	S	T	68	56.67	6.71			
Creek Chub	N	G	N	T	289	240.83	28.53			
Striped Shiner	N	I	S		6	5.00	0.59			
Spotfin Shiner	N	I	M		1	0.83	0.10			
Silverjaw Minnow	N	I	M		24	20.00	2.37			
Bluntnose Minnow	N	O	C	T	66	55.00	6.52			
Central Stoneroller	N	H	N		137	114.17	13.52			
Smallmouth Bass	F	C	C	M	11	9.17	1.09			
Green Sunfish	S	I	C	T	50	41.67	4.94			
Bluegill Sunfish	S	I	C	P	2	1.67	0.20			
Blackside Darter	D	I	S		1	0.83	0.10			
Johnny Darter	D	I	C		173	144.17	17.08			
Mottled Sculpin		I	C		121	100.83	11.94			
	Mile Total				1,013	844.17				
	Number of Species				16					
	Number of Hybrids				0					

Species List

River Code: **21-002**	Stream: **East Fork Vermilion River**	Sample Date: **2005**
River Mile: **7.40**	Location: St. Rt. 10, just N of Kipton	Date Range: 07/07/2005
Time Fished: 6240 sec	Drainage: 16.4 sq mi	Thru: 08/18/2005
Dist Fished: 0.40 km	Basin: Vermilion River No of Passes: 2	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
Central Mudminnow		I	C	T	10	7.50	0.83			
White Sucker	W	O	S	T	16	12.00	1.33			
Blacknose Dace	N	G	S	T	200	150.00	16.60			
Creek Chub	N	G	N	T	380	285.00	31.54			
Striped Shiner	N	I	S		44	33.00	3.65			
Sand Shiner	N	I	M	M	1	0.75	0.08			
Silverjaw Minnow	N	I	M		15	11.25	1.24			
Fathead Minnow	N	O	C	T	1	0.75	0.08			
Bluntnose Minnow	N	O	C	T	12	9.00	1.00			
Central Stoneroller	N	H	N		49	36.75	4.07			
Yellow Bullhead		I	C	T	3	2.25	0.25			
White Crappie	S	I	C		1	0.75	0.08			
Rock Bass	S	C	C		22	16.50	1.83			
Smallmouth Bass	F	C	C	M	10	7.50	0.83			
Green Sunfish	S	I	C	T	30	22.50	2.49			
Bluegill Sunfish	S	I	C	P	1	0.75	0.08			
Johnny Darter	D	I	C		79	59.25	6.56			
Greenside Darter	D	I	S	M	3	2.25	0.25			
Rainbow Darter	D	I	S	M	28	21.00	2.32			
Mottled Sculpin		I	C		300	225.00	24.90			
	Mile Total				1,205	903.75				
	Number of Species				20					
	Number of Hybrids				0					

Species List

River Code: **21-002**	Stream: **East Fork Vermilion River**	Sample Date: **2005**
River Mile: **2.30**	Location: Green Rd.	Date Range: 07/07/2005
Time Fished: 5700 sec	Drainage: 33.0 sq mi	Thru: 08/18/2005
Dist Fished: 0.40 km	Basin: Vermilion River No of Passes: 2	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
Northern Hog Sucker	R	I	S	M	6	4.50	0.34	0.05	0.52	11.67
White Sucker	W	O	S	T	80	60.00	4.47	4.13	41.22	68.81
Bigeye Chub	N	I	S	I	19	14.25	1.06	0.03	0.30	2.09
Blacknose Dace	N	G	S	T	20	15.00	1.12	0.07	0.65	4.37
Creek Chub	N	G	N	T	72	54.00	4.02	0.70	6.94	12.88
Redfin Shiner	N	I	N		1	0.75	0.06	0.00	0.03	4.00
Striped Shiner	N	I	S		248	186.00	13.85	1.53	15.30	8.24
Sand Shiner	N	I	M	M	108	81.00	6.03	0.18	1.81	2.24
Silverjaw Minnow	N	I	M		99	74.25	5.53	0.14	1.44	1.94
Bluntnose Minnow	N	O	C	T	30	22.50	1.68	0.10	1.03	4.58
Central Stoneroller	N	H	N		419	314.25	23.41	1.23	12.31	3.92
Stonecat Madtom		I	C	I	1	0.75	0.06	0.00	0.04	6.00
Rock Bass	S	C	C		1	0.75	0.06	0.05	0.52	69.00
Smallmouth Bass	F	C	C	M	12	9.00	0.67	0.05	0.45	5.00
Largemouth Bass	F	C	C		2	1.50	0.11	0.04	0.40	26.50
Green Sunfish	S	I	C	T	26	19.50	1.45	0.35	3.48	17.88
Bluegill Sunfish	S	I	C	P	3	2.25	0.17	0.03	0.34	15.00
Logperch	D	I	S	M	1	0.75	0.06	0.00	0.04	6.00
Johnny Darter	D	I	C		72	54.00	4.02	0.06	0.55	1.02
Greenside Darter	D	I	S	M	96	72.00	5.36	0.13	1.33	1.85
Rainbow Darter	D	I	S	M	294	220.50	16.42	0.34	3.43	1.56
Mottled Sculpin		I	C		180	135.00	10.06	0.79	7.85	5.83
	Mile Total				1,790	1,342.50		10.02		
	Number of Species				22					
	Number of Hybrids				0					