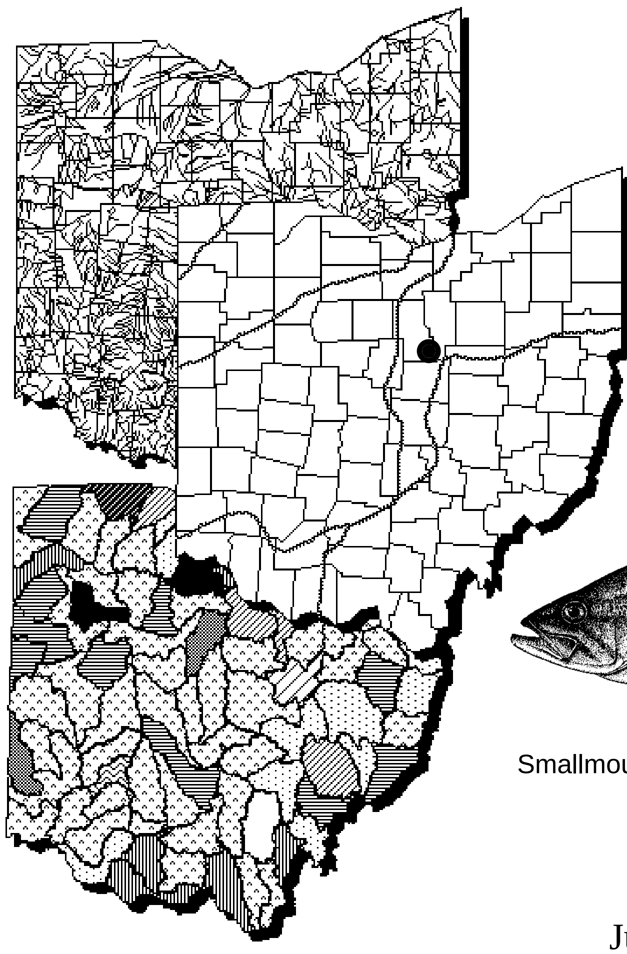
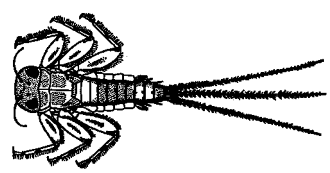
State of Ohio
Environmental Protection Agency

Ecological Assessment
Division of Surface Water

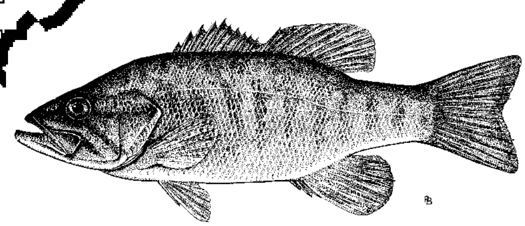
1998 Biological and Water Quality Study of the Black Fork, Clear Fork, Rocky Fork and Jerome Fork of the Mohican River and Selected Tributaries

Morrow, Richland and Ashland Counties, Ohio





Mayfly *(Stenonema)*



Smallmouth Bass *(Micropterus dolomieui)*

June 21, 2000

Bob Taft
Governor, State of Ohio

Chris Jones
Director, Ohio Environmental Protection Agency

P.O. Box 1040, Lazarus Government Center, 122 S. Front St., Columbus Ohio 43216-1049

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June 21, 2000

OEPA Technical Report
MAS/1999-12-2

Division of Surface Water
P.O. Box 1049
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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 new publications by Ohio EPA have become available. The following publications should also be consulted as they represent the latest information and analyses used by 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 can be obtained by writing to:

Ohio EPA, Division of Surface Water
Monitoring and Assessment Section
1685 Westbelt Drive
Columbus, Ohio 43228-3809
(614) 728-3377

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 10-15 different study areas with an aggregate total of 250-300 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

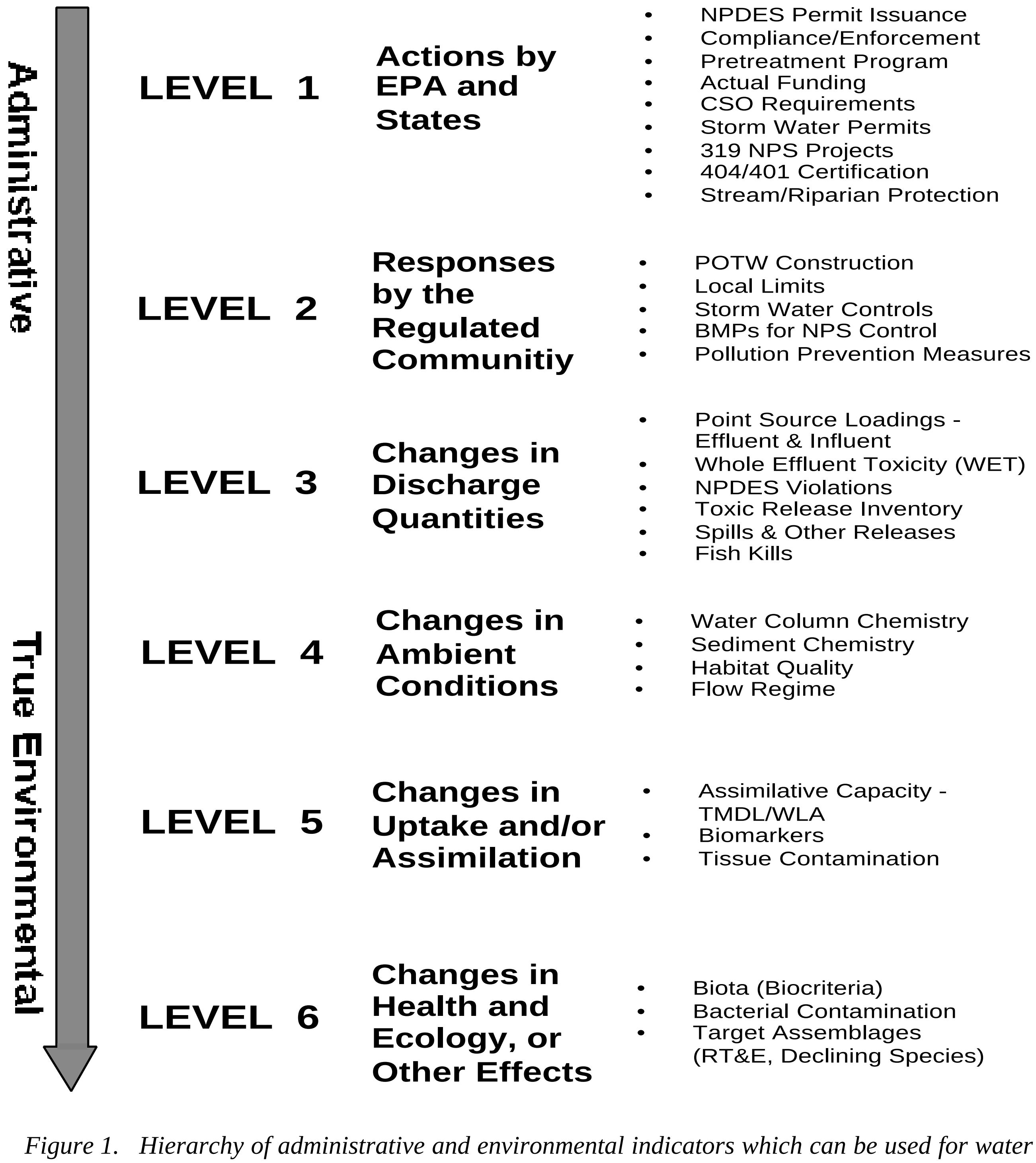

Figure 1. Hierarchy of administrative and environmental indicators which can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by U.S. EPA (1995).

uptake and/or assimilation (tissue contamination, biomarkers, wasteload allocation); and, 6) changes in health, ecology, or other effects (ecological condition, pathogens). In this process the results of administrative activities (levels 1 and 2) can be linked to efforts to improve water quality (levels 3, 4, and 5) which should translate into the environmental "results" (level 6). Thus, the aggregate effect of billions of dollars spent on water pollution control since the early 1970s can now be determined with quantifiable measures of environmental condition.

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

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

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Morrow, Richland and Ashland Counties, Ohio

INTRODUCTION

As part of the five-year basin approach for ambient monitoring and the National Pollution Discharge Elimination System (NPDES) permitting process, ambient biological, water column chemical and physical sampling was conducted by the Ohio EPA within the Mohican River and selected tributaries. The 1997 study area included Black Fork, Clear Fork, Rocky Fork and Jerome Fork of the Mohican River, Cedar Fork of Clear Fork, Possum Run, Pine Run, Lang Creek, Jamison Creek, Muddy Fork Town Run, Redhaw Creek and Tuby Run.

Specific objectives of this evaluation were to:

1) monitor and assess chemical, physical and biological integrity of the Mohican River study area,

2) determine the attainment status of current aquatic life use and non-aquatic use designations and recommend changes in use where appropriate,

3) evaluate impacts from combined sewer and stormwater overflows (CSOs) and municipal WWTPs on their respective receiving streams, and

4) incorporate previous Ohio EPA studies to evaluate environmental improvements to date and to expand Ohio EPA databases for trends analysis (e.g., 305[b]).

SUMMARY and CONCLUSIONS

The 1998 sampling effort totaled 90.4 river miles on the Black Fork, Clear Fork, Rocky Fork and Jerome Fork of the Mohican River and Selected Tributaries. Of the total miles assessed in 1998, 56.5 miles were in full attainment of the warmwater habitat (WWH) aquatic life use (63% of the study area); 19.0 miles demonstrated partial attainment (21% of the study area) and 14.9 miles were in non-attainment of the WWH use (16% of the study area). Aquatic life use attainment status and biocriteria scores for all sampling locations are presented in Table 1.

Clear Fork

Two reaches of the Clear Fork Mohican River are currently designated as Coldwater Habitat (CWH); from downstream from Clear Fork Reservoir (RM 30.5) to Pleasant Hill Reservoir (RM 13.0) and from downstream Pleasant Hill Reservoir (RM 4.8) to Pine Run (RM 0.2). The justification for this designation was put-and-take stocking of brown trout by Ohio DNR. In 1999, the criteria for the CWH designation was changed thus the Clear Fork no longer qualifies on the basis of trout stocking alone. Biological sampling failed to produce other results that would have continued the CWH aquatic life use designation. The percentage of coldwater fish varied widely between sites, from less than one percent to over 27 percent. Only two coolwater macroinvertebrate taxa were collected sporadically throughout the study area. A Warmwater Habitat (WWH) aquatic life use is a more appropriate use for all free-flowing segments of the Clear Fork based on the native fauna.

Generally, analytical results indicated very good to excellent chemical water quality. Several dissolved oxygen violations were documented downstream from the two reservoirs. These were violations of the more stringent CWH criteria and resulted from warmer lake water temperatures, which decrease oxygen solubility, and the functional loss of stream riffle habitats, which reaerate the water. These would not have resulted in violations of the D.O. criteria of the proposed WWH use.

By and large, the condition of the macrohabitats within the free flowing portions of the Clear Fork Mohican River were found fully capable of supporting WWH aquatic communities. Degraded macrohabitat was indicated at three sampling stations contained within the segment of the Clear Fork that flows through the city of Lexington, extending downstream to I-71. This reach was previously subjected to extensive channelization, with varying degrees of recovery evident. The stations bracketing the Lexington WWTP (RMs 27.6 and 27.4) were by far the in the worst condition. This was the only portion of the Clear Fork that did not attain the recommended WWH aquatic life use. The physical condition of the stream may have worsened an impact from the WWTP discharge and urban runoff by limiting reaeration and accumulating organic material.

Cedar Fork

Cedar Fork was designated as coldwater habitat (CWH) based on put-and-take stocking of brown trout. Biological sampling failed to produce significant populations of native coldwater fish and macroinvertebrates needed to justify the CWH aquatic life use designation. The upstream sampling location (RM 8.2) yielded a diverse macroinvertebrate fauna including four coolwater

Table 1. Aquatic life use attainment status for Clear Fork Mohican River, July-October, 1998 (unless otherwise noted). The Index of Biotic Integrity (IBI), Modified Index of Well being (MIwb), and Invertebrate Community Index (ICI) scores are based on the performance of fish (IBI, MIwb) or macroinvertebrate communities (ICI). The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support biological communities.

River Mile Fish/Invertebrate	IBI	MIwb	ICI	QHEI	Attainment Status[a]	Comments
Clear Fork Mohican River (1998)				*Erie - Ontario Lake Plain: WWH (existing)*		
35.7/35.0	46	N/A	44	72.0	FULL	Marion Ave.
		Erie Ontario Lake Plain: CWH (existing)/ WWH (proposed)				
29.6/29.6	45	8.4	38	60.0	FULL	Lex. Bicentenial Park
27.6 /27.7	36	7.0*	40	54.0	PARTIAL	ust Lexington WWTP
27.4/27.2	35	7.6	18*	54.5	PARTIAL	dst Lexington WWTP
-/24.3	-	-	48	-	(FULL)	Kocheiser Rd
23.5/23.5	35	7.5	46	58.5	FULL	Kings Corner Rd.
21.1/21.1	43	9.3	48	78.5	FULL	S.R. 97
16.8/16.8	46	9.3	52	76.0	FULL	adj. Gatton Rock Rd.
			Erie - Ontario Lake Plain: WWH (existing)			
11.7/11.8	44	9.1	48	92.0	FULL	dst. Butler
		Erie Ontario Lake Plain: CWH (existing)/ WWH (proposed)				
4.0/4.0	46	8.7	G	80.5	FULL	dst Pleasant Hill Res.
0.3/0.3	40	7.9	E	77.0	FULL	S.R. 3
Cedar Fk Mohican River (1998-1999)			*Erie - Ontario Lake Plain: CWH (existing)/ WWH (proposed)*			
8.0/8.2	60	N/A	E	76.0	FULL	West Point Bellville Rd.
3.2/3.2	46	9.6	VG	72.0	FULL	S.R. 546
0.8/0.8	44	8.3	VG	66.5	FULL	Bellville Johnsville Rd.
Possum Run (1998)			*Erie - Ontario Lake Plain: WWH (existing)*			
1.4/ -	46	N/A	-	55.5	(FULL)	Possum Run Rd.
Pine Run (1998)			*Erie - Ontario Lake Plain: WWH (existing)*			
0.1/ -	44	N/A	-	70.5	(FULL)	near mouth
Black Fork Mohican River (1998)				*Erie - Ontario Lake Plain: WWH (existing)*		
54.6/54.7	41	8.8	44	73.0	FULL	Stiving Rd.
53.4/53.4	44	9.4	36	45.0	FULL	ust. Tuby Run
53.2/53.2	48	8.5	28*	43.0	PARTIAL	dst. Tuby Run

Table 1. Continued.

River Mile Fish/Invertebrate	IBI	MIwb	ICI	QHEI	Attainment Status[a]	Comments
Black Fork Mohican River (1998 continued.)						
52.6/52.7	42	8.6	28*	59.0	PARTIAL	water treatment plant
50.7/50.7	36[ns]	6.2*	46	55.5	PARTIAL	lane off Bistline Rd.
50.0/50.0	*40*	*7.4*	*F*		*N/A*	*Shelby WWTP mixing zone*
49.6/49.5	40	6.5*	42	49.6	PARTIAL	Plymouth -Spring Mill Rd.
46.5/46.5	44	7.5[ns]	44	50.5	FULL	Miller Rd.
43.3/43.5	38	6.4*	46	51.0	PARTIAL	Ganges-Five Points Rd.
38.4/38.5	22*	5.1*	46	40.0	**NON**	Geisinger Rd.
Tuby Run (1998)				*Erie Ontario Lake Plain: WWH (existing)*		
0.7/0.7	40	N/A	P*	49.5	**NON**	ust. Copperweld 005 outfall
0.6/0.6	*42*	*N/A*	P*	*N/A*	*N/A*	*Copperweld 005 mixing zone*
0.1/0.2	40	N/A	VP*	41.0	**NON**	near mouth
Rocky Fork Mohican River (1998)				*Erie Ontario Lake Plain: WWH (existing)*		
16.4/16.3	40	N/A	46	58.0	FULL	Wilging Rd.
15.8/15.8	24*	N/A	22*	34.0	**NON**	Old Bowman Rd
- /14.47			*F*		*N/A*	*Armco 002 mixing zone*
14.3/14.2	33*	N/A	26*	46.0	**NON**	Longview Rd.
11.6/11.6	28*	5.9*	F*	68.0	**NON**	Illinois St. (dst Stone Container)
11.2/11.2	*26*	*5.0*	*P*		*N/A*	*Mansfield WWTP mixing zone*
10.2/10.2	29*	5.7*	F*	73.0	**NON**	SR 39
0.6/0.6	41	6.5*	36	77.0	PARTIAL	Applegate Rd.
Town Run (1998)				*Erie Ontario Lake Plain: WWH (existing)*		
0.3/0.1	46	N/A	MG[ns]	65.5	FULL	S.R. 42
Jamison Creek (1998)				*Erie Ontario Lake Plain: WWH (existing)*		
1.2/1.2	54	N/A	VG	-	FULL	ust. US 42
0.3/0.3	52	N/A	G	64.0	FULL	C.R. 1302
- /0.1	-	-	G		(FULL)	near mouth
Lang Creek (1998)				*Erie Ontario Lake Plain: WWH (existing)*		
3.2/3.2	46	N/A	58	56.0	FULL	T.R. 1104
0.4/0.4	46	8.5	G	56.5	FULL	ust. Ashland WWTP
0.34/0.34	*52*	*9.4*	*G*	-	*N/A*	*Ashland WWTP mixing zone*
0.3/0.3	44	9.0	G	82.5	FULL	dst. Ashland WWTP

Table 1. Continued.

River Mile Fish/Invertebrate	IBI	MIwb	ICI	QHEI	Attainment Status[a]	Comments
Jerome Fork (1998)				*Erie Ontario Lake Plain:*	*WWH (existing)*	
13.0/13.8	46	9.0	G	53.0	FULL	ust. Lang Creek
12.1/12.1	44	8.9	48	65.0	FULL	dst. Lang Creek)
10.5/10.5	36[ns]	6.8*	E	51.0	PARTIAL	S.R. 250
5.7/5.7	44	9.2	52	71.5	FULL	at Jeromesville
2.6/2.5	32*	6.7*	G	45.0	PARTIAL	C.R. 175
Muddy Fork Mohican River (1998)				*Erie Ontario Lake Plain:*	*WWH (existing)*	
18.4/18.4	42	8.3	44	61.5	FULL	Flemming Rd.
13.4/13.4	43	8.6	44	56.0	FULL	Martin Rd.
Red Haw Creek				*Erie Ontario Lake Plain:*	*WWH (existing)*	
- /2.1	-	-	58	-	(FULL)	ust. Martin Rd.

Ecoregional Biological Criteria: Erie-Ontario Lake Plain (EOLP)
(OAC Chapter 3745-1-07, Table 7-14)

INDEX - Site Type	WWH	MWH[b]
IBI - Headwater	40	24
IBI - Wading	38	24
MIwb - Wading	7.9	6.2
ICI	34	22

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

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

a - Attainment status based on one organism group is parenthetically expressed.

N/A- Headwater site; MIwb is not applicable to streams with drainage areas less than 20 mi^2.

b - Modified Warmwater Habitat criteria for channel modified habitats.

taxa. Macroinvertebrate community diversity at RMs 3.2 and 0.8 was reduced and only one coolwater taxon was collected. All stations were found to support fish assemblages consistent with a WWH aquatic life use. Water quality was determined to be excellent, with no violations documented. Most chemical pollutants evaluated were at or below detection levels. Macrohabitat quality exceeded the WWH threshold at all stations.

Black Fork Mohican River

In comparison with previous surveys, 1998 sampling results indicated considerable improvement in the environmental conditions of the Black Fork since 1984. Improved species richness and functional organization of the fish assemblage were reflected in higher IBI scores at nearly every site. The performance of this index indicated significant lessening of the impacts previously associated with Tuby Run and the Shelby WWTP. However, other impacts, particularly deficient habitat quality and elevated nutrients, were still evident. A high volume of raw sewage bypassed at the Shelby WWTP may have been a significant source of impairment. Of the total miles assessed in 1998, 2.8 miles were in full attainment of the warmwater habitat (WWH) aquatic life use (17% of the study area); 9.3 miles demonstrated partial attainment (57% of the study area) and 4.1 miles were in non-attainment of the WWH use (25% of the study area). In 1984, the entire sampled length, totaling 18 miles, was in non-attainment of the WWH use. Although recovery was incomplete, the severity of impact since 1984 decreased by 99% for the ICI ADV/mile statistic, 81% for the IBI/mile statistic and 54% as reflected in the MIwb ADV/mile statistic.

Biological and chemical sampling yielded generally good results upstream from Tuby Run. Partial attainment of the WWH use downstream from Tuby Run resulted from impairment to the macroinvertebrate community. Reductions in the density and diversity of relatively pollution sensitive mayfly and caddisfly taxa compared to upstream suggested that polluted water from Tuby Run may have contributed a toxic impact in addition to degradation associated with the surrounding urban land use. This result coincided with increases in nitrate, ammonia, and $BOD_{5.}$ These nutrients, along with flow modifications through the urban area (channelization, canopy removal), resulted in accelerated algal growth. Considerable increases in dissolved solids and sulfate attributable to Copperweld effluents also occurred. Sampling of the Shelby WWTP demonstrated that the discharge was not acutely toxic; however, tolerant macroinvertebrate taxa predominated in the mixing zone. Nitrate, phosphorus, and suspended solids were elevated downstream from the plant. Only one of four biological sampling locations fully attained ecoregional expectations downstream from the Shelby WWTP due to depressed fish index scores. It appeared that habitat alteration, possibly exacerbated by point source discharges and WWTP plant bypasses, was the primary cause for depressed fish community performance. Deficient near and instream habitats were indicated at over 80% of the fish sampling stations on the Black Fork. Poor IBI and MIwb scores were observed at the lowest station (RM 38.4). The combination of extremely low index values and elevated gross external anomalies suggested a complex, possibly toxic, impact compounding the existing problem of degraded habitat. Even though ICI scores were in the very good to exceptional range downstream from the Shelby WWTP, nutrient enrichment was indicated by the organisms that comprised the macroinvertebrate community at these sites.

Tuby Run

Tuby Run is a highly modified stream that originates in an agricultural area and then flows through the Copperweld industrial complex. The stream is culverted when it exits Copperweld and passes under the Shelby city school bus garage, and is free flowing from Walnut St. to its confluence with the Black Fork. Fish sampling results from Tuby Run met the applicable WWH criteria. Non-attainment of the WWH aquatic life use designation for Tuby Run was due to a predominance of tolerant macroinvertebrate taxa. The macroinvertebrate community was in poor condition upstream from the Copperweld 005 outfall and very poor near the confluence. The 005 discharge did not appear to be acutely toxic, however, toxicity was demonstrated in the macroinvertebrate assemblage near the mouth of Tuby Run. Chemical water quality near the mouth was determined to be poor, with reduced dissolved oxygen and elevated dissolved solids, and fecal coliform bacteria levels. Additionally, there was a heavy oil sheen at this site that worsened if sediments were disturbed. Sources of degradation included agricultural and urban runoff, Copperweld discharges, and contaminated sediments.

Rocky Fork

With the exception of the uppermost site, biological sampling results failed to attain the WWH aquatic life use. Nevertheless, improvements were noted in the fish and macroinvertebrate communities when compared with results from similar sampling conducted in 1993. Macroinvertebrate assemblages that were rated as poor or very poor in 1993 were considered to be in fair condition in 1998. Sampling locations which were nearly devoid of fish in 1993 supported significant numbers of fish in 1998. Perhaps the most compelling positive change observed within the fish assemblage of the Rocky Fork was the drastic reduction in the incidence of deformities, eroded fins/barbels, lesions, and tumors (DELT) anomalies. The occurrence of DELT anomalies reached as high as 20% in 1993. The rate at any station did not exceed 0.2% in 1998. This suggests that the severe acute toxicity present in 1993 associated with discharges from the Armco facility has been eliminated following changes in treatment processes. The Armco 002 effluent did, however, exhibit toxicity in a June, 1998 bioassay test; a subsequent test in July did not. Significant instream impacts remained due to sediment contamination, urban runoff, channelization and enrichment associated with the Mansfield WWTP. These impacts limited the establishment of typical warmwater fish and macroinvertebrate communities along most of the sampled reach in 1998. As a result, only 0.7 miles of stream (4% of the study area) were in full attainment of the designated WWH aquatic life use and the severity of impact declined by only 6% since 1993 as reflected in the MIwb ADV/mile statistic. The ICI and IBI ADV/mile values were reduced 61% and 74%, respectively.

Chemical sampling documented increases in suspended solids associated with high flow events, accompanied by higher metal concentrations, especially copper and lead. This was likely due to impacts from urban storm water runoff and the resuspension of contaminated sediment. In contrast, the high flows diluted the nutrient enrichment impact downstream from the Mansfield WWTP. Generally in 1998, water quality was good during low flow periods and very poor during high flows.

Results for sediment metals and organics sampling indicated a major concern for environmental impact, especially regarding PCBs, beginning in the vicinity of the metal scrap yards at Old Bowman Rd. and extending along the entire remaining length of the Rocky Fork. The shearing of scrap metal and the use of cutting oils and lubricants at the scrap yards is the likely source of contamination. There may also be an impact from the Armco facility. It is likely that sediment from the Mansfield urban industrial area is resuspended and transported downstream.

Town Run

Full attainment of the WWH aquatic life use was documented for Town Run in 1998. No exceedences of water quality standards were documented. However, daytime dissolved oxygen measurements were very elevated due to an abundance of filamentous algae and the macroinvertebrate community was rated only marginally good. These were indications that D.O. levels may drop below criteria in the evenings. Additionally, elevated DELT anomalies were documented within the fish community in Town Run. It appeared that urban runoff poses a threat to the continued attainment of the WWH use.

Jamison Creek

Full attainment of the WWH aquatic life use was documented for Jamison Creek in 1998. The only documented water quality exceedences were for fecal coliform bacteria. This result is significantly improved compared with the findings of the 1984 survey. Wastewater discharges from the National Latex Co., Philway Products Corp., and United Brand Corp. have been eliminated since 1984. Exceptional fish communities were indicated at both Jamison Creek stations. Despite, the positive findings of the 1998 survey, elevated DELT anomalies suggest lingering chronic effects from past industrial practices within the basin. Attainment of WWH aquatic life use increased from 0.4 miles in 1984 to 1.2 miles in 1998 (100% of the study area).

Lang Creek

Full attainment of the WWH aquatic life use was documented for Lang Creek in 1998. The only water quality exceedences documented were of the thirty day average fecal coliform bacteria value. No acute toxicity was indicated within the Ashland WWTP mixing zone of. However, increases in nitrate and phosphorus concentrations occurred downstream from the WWTP. Sediment sampling identified elevated to highly elevated DDT, metals, and PAH levels primarily downstream from the Ashland WWTP and the Ashland urban area. Conditions were significantly improved compared with the severe impacts that existed in 1984. WWH aquatic life use attainment increased from zero miles in 1984 to 3.2 miles in 1998 (100% of the study area).

Jerome Fork

In 1984, the stream was severely impacted by the confluence of Lang Creek. Conditions included a persistent dissolved oxygen sag, highly elevated nutrient and metal concentrations, and severely impaired fish and macroinvertebrate communities. The situation was dramatically improved in 1998. This can be attributed to upgrades at the Ashland WWTP (on Lang Creek) along with the implementation of an industrial pretreatment program and elimination of toxic discharges to Jamison Creek which also affected Lang Creek and Jerome Fork. Attainment of the WWH aquatic life use increased from 0.7 miles in 1984 to 8.9 miles in 1998 (76% of the study area).

Generally, 1998 analytical results indicated good water quality, however, there was a significant increase in nutrient concentrations downstream from Lang Creek. Nutrient parameters gradually declined with increased distance from the confluence but remain elevated compared with background conditions. The fish community provided evidence of chronic sublethal stress in the form of an elevated incidence of DELT anomalies at nearly all stations beginning at RM 12.1 (downstream from Lang Creek). Biological sampling identified two stream segments totaling 2.9 miles that were partially attaining the WWH use due to the presence of only fair fish communities. Departure from the WWH criteria at these sites were the result of the combined effects of altered physical habitat and point sources of pollution.

Muddy Fork Mohican River

Water quality was determined to be good, with no violations documented at Flemming Rd (RM 18.4). There was a slight potential for a nutrient enrichment impact, since some nutrient levels, especially phosphorus, were elevated due to loadings from the West Salem WWTP. Water quality at C.R. 100 (RM 13.40) was determined to be very good. The upper station appeared in a natural, or unmodified state, possessing a minimum compliment of positive physical features. The remaining station was likely channelized in the past, but limited recovery was evident. Each site was found to support assemblages of fishes and macroinvertebrates, fully consistent with the WWH biocriteria.

Redhaw Creek

The macroinvertebrate community of Redhaw Creek at RM 2.1 was in excellent condition owing, in part, to an abundance of coarse stable substrates that resisted high flow scouring that affected many sampling locations in the Jerome Fork basin.

Pine Run

Water quality was determined to be excellent in Pine Run, with no violations documented. Most chemical pollutants evaluated were at or below detection levels. As measured by the QHEI, macrohabitat quality at the single sampling site on Pine Run was in very good condition. Sampling in Pine Run yielded fish communities that fully met the WWH biological criteria.

Possum Run

Water quality was determined to be excellent in Possum Run, with no violations documented. Most chemical pollutants evaluated were at or below detection levels. As measured by the QHEI, macrohabitat quality at the single sampling site on Possum Run was near the WWH threshold. Habitat derived impairment the WWH aquatic life use was not reflected in the biological sampling results. Sampling in Possum Run yielded fish communities that fully met the WWH biological criteria.

Public Lakes and Reservoirs

Clear Fork Reservoir

Sampling results indicated that the Clear Fork Reservior was in full attainment of its designated uses, however this status was threatened. Some of the parameters that contributed to this assessment include turbidity, elevated non-priority pollutants (iron and manganese), and a eutrophic class status. The lake was also classified as eutrophic in 1993.

Pleasant Hill Reservoir

Pleasant Hill Reservoir was in full attainment of applicable designated uses, however this status was threatened. Some of the parameters that contributed to this assessment include turbidity, elevated non-priority pollutants (iron and manganese), anoxia in the hypolimnion, volume loss due to sedimentation, and a eutrophic class status. The trophic status has shown an improvement since 1993, when the lake was classified as hypereutrophic.

Charles Mill Reservoir

Charles Mill Reservoir was in partial attainment of its designated uses. Some of the parameters that contributed to this assessment included turbidity, elevated non-priority pollutants (iron and manganese), volume loss due to sedimentation, and a hypereutrophic class status. Sediment dredging was performed during the summer of 1998 to improve navigation channels.

RECOMMENDATIONS

Status of Aquatic Life Uses

Biological sampling failed to produce results in support of retainining the CWH aquatic life use for the Clear Fork Mohican River and Cedar Fork. A Warmwater Habitat (WWH) aquatic life use is a more appropriate use for Cedar Fork and all free-flowing segments of the Clear Fork based on native fauna.

All other sampled stream segments should retain a WWH use. Most stream segments have been physically altered to some degree. However, in the absence of ongoing stream maintenance programs, natural recovery is proceeding which makes WWH the appropriate use.

Status of Non-Aquatic Life Uses

The Rocky Fork Mohican River from the Mansfield WWTP to Applegate Rd. is currently designated for Secondary Contact Recreation use. Because 1 meter deep pools of greater than $100ft^2$ exist, the use designation should be changed to Primary Contact Recreation. All other non-aquatic life uses should remain as presently designated in the Ohio Water Quality Standards (Table 2).

Other Recommendations

Black Fork

- A total of 34.3 million gallons of untreated wastewater was bypassed at the Shelby WWTP in 1998. The volume of raw influent bypassed needs to be reduced.
- The package plant discharge from the mobile home park located at London West Rd. needs to be eliminated or regulated.

Tuby Run

- Efforts to further reduce oil and grease loadings to Tuby Run from the Copperweld facility should continue.

Rocky Fork

- Contaminated sediment in the Rocky Fork remains a concern. Water quality standard violations and exceedences for metals documented during the study period were associated with storm events that resuspended contaminated material. Along with in-place contaminants, scrap yards are a continuing source of additional metals. Better runoff controls from the scrap yards is needed before remediation of in-place contaminates can be addressed.

Clear Fork

- The frequency of residual chlorine violations at the Butler WWTP needs to be reduced. The NPDES permit limit was violated a total of 127 days during the May-October recreation season.

Table 2. Existing and recommended beneficial use designations for the Mohican River study area. Recommendations are based on the results from the 1998 Mohican River basin survey.

River/Stream Affected Segment	Beneficial Use Designations												
	Aquatic Life Habitat							Water Supply			Recreation		
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR
Muddy Fork Mohican River													
Entire Length		*+							*+	*+		*+	
Redhaw Creek													
Entire Length		*+							*+	*+		*+	
Jerome Fork													
Entire Length		+							+	+		+	
Lang Creek													
Entire Length		+							+	+		+	
Jamison Creek													
Entire Length		+							+	+		+	
Town Run													
Entire Length		+							+	+		+	
Black Fork Mohican River													
Charles Mill Reservoir to confluence with Mohican River	*	*							*	*		*	
at RM 54		+						+	+	+		+	
all other segments		+							+	+		+	

Table 2. Continued.

River/Stream Affected Segment	**Beneficial Use Designations**												
	Aquatic Life Habitat							**Water Supply**					
	SRW	**WWH**	**EWH**	**MWH**	**SSH**	**CWH**	**LRW**	**PWS**	**AWS**	**IWS**	**BW**	**PCR**	**SCR**
Rocky Fork Mohican River													
Wilging Rd to Mansfield WWTP		*+							*+	*+		*+	
Mansfield WWTP to Applegate Rd.		+							+	+		Δ	
all other segments		*							*	*		*	
Tuby Run													
Entire Length		+							+	+			+
Clear Fork Mohican River													
Clear Fork Reservoir (RM 30.5) to Pleasant Hill Reservoir (RM 13.0)	*	Δ							*+	*+		+	
Pleasant Hill Reservoir to downstream Pleasant Hill Reservoir (RM 4.8)	*	+							*	*		+	
Downstream Pleasant Hill Reservoir to Pine Run (RM 0.2)	*	Δ							*+	*+		+	
Pine Run													
Entire Length	*	Δ							*+	*+		*+	

Table 2. Continued.

River/Stream Affected Segment	**Beneficial Use Designations**												
	Aquatic Life Habitat							**Water Supply**					
	SRW	**WWH**	**EWH**	**MWH**	**SSH**	**CWH**	**LRW**	**PWS**	**AWS**	**IWS**	**BW**	**PCR**	**SCR**
Possum Run													
Entire Length		*+							*+	*+		*+	
Cedar Fork													
Entire Length		Δ							*+	*+		+	

+- Designated use based on the results of an integrated ambient biological assessment performed by Ohio EPA (verified).

*+- Designated use based on 1978 water quality standards and supported by the 1998 ambient biological field assessment.

Δ Designates new recommended use based on findings of this report

Lang Creek

- Reductions in the frequency and duration of equalization basin bypasses at the Ashland WWTP should be pursued. The facility reported bypasses totaling of 174 hours in duration in 1998.

Future Monitoring Needs

Black Fork

- The source of sediment load to the Black Fork from a tributary confluent at RM 45.88 needs to be identified.

Tuby Run

- Additional inquiry is needed to identify sources of low D.O. and elevated suspended solids. Toxicity testing should be continued at Copperweld and the possibility of other toxic sources investigated.

Rocky Fork

- The source of fathead minnow toxicity in Armco Inc. outfall 002 effluent documented in Ohio EPA bioassay number 98-2074-NW needs to be identified and eliminated.

- Potential aquatic life impacts from hazardous waste sites located at Armco Inc. and Mansfield Products should be monitored.
- Sediment sampling revealed that small pockets or “hot spots” of highly contaminated sediment were present in the Rocky Fork. Additional sediment sampling is needed to delineate the source(s), location and extent of these areas. Biological sampling bracketing the affected areas is needed to determine the degree to which contamination contributes to impairment.
- Potential water quality and human health impacts from unsewered area located in Amoy should be evaluated.

Clear Fork

- Potential water quality and human health impacts from unsewered areas located in Millsboro, Blooming Grove, Kings Corners, Darlington, Newville, Hastings, North Woodbury, and Shauck should be evaluated.
- Monitoring is needed to identify potential aquatic life impacts from the hazardous waste site located at United Technologies.

Jerome Fork

- Potential water quality and human health impacts from unsewered areas located in Nankin, Polk, Hayesville, and Jeromesville should be evaluated.
- Sources of elevated fecal coliform bacteria levels in the Jerome Fork sub-basin need to be identified.

Black Fork

- Localized studies are recommended to evaluate water quality and human health impacts from unsewered areas located in Rome, Ganges, Taylortown, and Planktown.

Additional investigation for further delineating the source that resulted in the poor fish community at RM 38.4 is needed.

POINT SOURCE DISCHARGE SUMMARIES

The following WWTP reviews are provided as permit support information and include relevant operational, water quality and dissolved metals translator recommendations. These follow the general outline found in Section 1 of the Permit Support Document (PSD).

Mansfield WWTP

The City of Mansfield WWTP, Ohio EPA permit # 2PE00001, is located at 385 S. Illinois Ave., Mansfield, OH. The current permit became effective on 1 November, 1995 and expires on 31 March, 2000. Treatment includes an influent bypass, two bar screens, an aerated grit tank, 5.0

million gallon flow equalization basin, two preaeration tanks, two primary clarifiers, primary bypass, eight aeration tanks, three secondary clarifiers, chlorination, and dechlorination. Sludge is anaerobically digested and dewatered prior to disposal at an on-site stockpile area. Runoff from this area is collected and pumped to the WWTP headworks. The facility operates under an Ohio EPA approved pretreatment program implemented in 1984. Approximately 20% of the hydraulic load is from industrial sources. Final effluent discharges to the Rocky Fork Mohican River at RM 11.18. The collection system is comprised of 100% separate sewers and has nine lift stations. The average design capacity of the facility is 15.0 MGD, the hydraulic capacity is 25.0 MGD, and the annual average discharge is 10.5 MGD.

Ohio EPA conducted 48-hr. acute screening bioassays at the Mansfield WWTP as part of a toxics evaluation in conjunction with permit reissuance in 1998. Bioassay number 98-2028-NW was conducted in March 1998. Bioassay number 98-2071-NW was conducted in June 1998. Test results concluded that outfall 001 effluents were not acutely toxic.

Following upgrades completed in 1987 loads for BOD_5, ammonia, and suspended solids particularly showed significant decreases (Figure 6). Several permit violations were documented in 1998, especially regarding $cBOD_5$ in July and August.

Ambient Water and Sediment Quality

The Rocky Fork is a tributary confluent to the Black Fork at RM 14.02 that is designated WWH, PCR, AWS, and IWS. The river originates in a rural agricultural area and then flows through the City of Mansfield urban-industrial area. Although it is preferred to collect survey samples during low flow conditions to evaluate worst case impacts from point source pollutants, two of five data sets were collected after heavy rainstorms. This led to some interesting results, as depicted by the graphs in Figure 13 where high flow and low flow results are plotted separately. The increase in suspended solids associated with high flow events was accompanied by higher metal concentrations, especially copper and lead. This is likely due to impacts from urban storm water runoff and the resuspension of contaminated sediment. In contrast, the high flows diluted the nitrate concentration downstream from the Mansfield WWTP. Generally, water quality was good during low flow periods and very poor during high flows. All of the violations that were documented except one iron value were associated with the high flow samples.

Water quality sampling upstream from the Mansfield WWTP (Illinois Ave., RM 11.59) yielded one AAC violation for copper, one CAC violation for lead, two CAC violations for iron, and one fecal coliform bacteria violation were documented. The iron results also violated the AWS criterion. A site at S.R. 39 (RM 10.13) was established to evaluate impact from the Mansfield WWTP discharge at RM 11.18. Approximately 20% of the total hydraulic load to the Mansfield WWTP originates from industrial pretreatment sources. There is also some potential for an impact from the Therm-O-Disk facility effluent via a tributary confluent at RM 10.70. During a portion of the study period, there was construction associated with the extension of sanitary sewers just upstream from S.R. 39. This activity included the construction of a temporary dam across the river. Two CAC violations for copper, two CAC violations for iron, and one fecal coliform bacteria violation were documented. The iron results also violated the AWS criterion. Copper, iron and fecal coliform bacteria exceedances occurred throughout the study area with at least one exceedence recorded at every station regardless of its position relative to theMansfield WWTP.

Results for metals and organics in riverine sediments indicated a major concern for environmental impact, especially regarding PCBs. The station located downstream from the Mansfield urban area at Illinois Ave. (RM 11.59) had total PCBs that were ranked as extremely elevated and exceeded the ER-M and LEL at 45,508 ppb (46 ppm). It is not known definitively whether this would exceed the SEL, because TOC is needed in the calculation. However, for a sediment with 5% TOC, the SEL would be 26.5 ppm, so it is likely the value of 46 ppm was having an significant impact. Barium, nickel, zinc, and cadmium were ranked as elevated, copper and lead as highly elevated, and chromium as extremely elevated. This sample was located in a small pocket or "hot spot" approximately 100 ft. upstream from the bridge on the left bank. It is likely that many sources contributed and it is also likely that many more "hot spots" exist in the Rocky Fork that have not been identified. Total DDT was ranked as elevated and exceeded the ER-L and LEL at 14.0 ppb and a total PAHs exceeded the ER-L at 15.33 ppm. The station located downstream from the Mansfield WWTP at S.R. 39 (RM 10.13) had total PCBs that were ranked as elevated and exceeded the ER-L and LEL at 136.0 ppb. No metals were ranked above slightly elevated. The station located at Applegate Rd. (RM 0.57) had total PCBs that were ranked as highly elevated and exceeded the ER-M and LEL at 717.0 ppb. Chromium was ranked as elevated and all other metals were nonelevated or slightly elevated. The PCBs detected at these last two stations are undoubtedly transported downstream from the Mansfield urban-industrial area.

The macroinvertebrate community was impaired upstream from the Mansfield WWTP (RM 11.6), but was substantially improved compared to the severely degraded conditions present in 1993. The site was rated as very poor in 1993 versus a fair rating in 1998. A high percentage of tolerant taxa within this reach demonstrated that toxicity remained a factor. Sources may include effluent outfalls, contaminated sediments and/or runoff from the urban/industrial area. The Mansfield WWTP effluent (RM 11.2) was not acutely toxic; however, it appeared to contribute a significant nutrient load to the stream. The mixing zone yielded high numbers of tolerant midges and blackflies. The macroinvertebrate community was in fair condition at SR 39 (RM 10.2) based on qualitative sampling and appeared to be marginally improved compared to results from the 1993 sampling. Tolerant midges of the genus *Cricotopus* and blackflies predominated the natural substrates. Filter feeding caddisflies (Hydropsycidae) were present in low numbers

but no mayflies were collected. It appeared that a high level of nutrient enrichment along with some lingering toxicity were impacting the biota. The biocriterion was exceeded at RM 0.6, (ICI = 36) however, an enrichment affect was still evidenced by the large number of filter feeding caddisflies and blackflies. This site scored in the exceptional range (ICI = 46) in 1993.

Sites upstream and downstream from the Mansfield WWTP were found to support degraded fish communities. As the Rocky Fork flows through the greater Mansfield area, multiple chemical and physical stressors impinge upon the overall environmental quality of the segment. The combined effects of municipal and industrial dischargers, highly modified near and instream habitat, and contaminated urban/industrial runoff rendered most of the mainstem impaired. Community features observed throughout the impacted reach included, lower than expected species richness, simplified trophic structure, and a predominance of environmentally tolerant taxa.

Trend Assessment
With the exception of the uppermost site, the 1998 biological sampling results failed to attain WWH aquatic life use expectations (Table 1). Nevertheless some improvement was noted in the fish and macroinvertebrate communities when compared with results from similar sampling conducted in 1993. Macroinvertebrate assemblages that were rated as poor or very poor in 1993 were considered to be in fair condition in 1998. Sampling locations which were nearly devoid of fish in 1993, at least, supported significant numbers of fish in 1998. Perhaps the most compelling positive change observed within the fish assemblage of the Rocky Fork was the drastic reduction in the incidence of Deformities, Eroded fins/barbels, Lesions, and Tumors (DELT) anomalies. The occurrence of DELT anomalies reached as high as 20% in 1993. The rate at any station did not exceed 0.2% in 1998. This suggests that the severe toxicity present in 1993 associated with discharges from the Armco Mansfield facility has been eliminated due to changes in treatment processes. Significant impacts remained, however, due to sediment contamination, urban runoff, channelization and enrichment associated with the Mansfield WWTP. These impacts limited the establishment of typical warmwater fish and macroinvertebrate communities along most of the sampled reach in 1998.

DMT Recommendation
The results from the 1998 intensive survey demonstrated nonattainment of the WWH biological criteria, and sediment contamination upstream and downstream from the Mansfield WWTP. Given the performance of these and other environmental indicators, it is therefore recommended that this segment of the Rocky Fork Mohican River be placed in a moderate risk category with respect to the acceptable level of risk for use impairment associated with the total recoverable

metals WLA. The recommended total recoverable metals limits for copper, lead, cadmium, and zinc were derived from WWH wadeable streams in the ELOP ecoregion triggers (Ohio EPA Technical Bulletin MAS/1997-12-4) and are presented in Table 3.

Conclusions
The results from the 1998 survey documented significant improvement in water quality since 1993; however, biological communities remained impaired upstream and downstream from the Mansfield WWTP. Sources of impacts to the Rocky Fork included sediment contamination, urban runoff, channelization and enrichment associated with the Mansfield WWTP.

It is recommended that the Rocky Fork be considered in the moderate risk category for calculation of the total recoverable metals WLA.

Table 3. The recommended total recoverable metals limits for copper, lead, cadmium, and zinc derived from WWH wadeable streams in the EOLP ecoregion moderate risk triggers (Ohio EPA Technical Bulletin MAS/1997-12-4).

Parameter	**Total Recoverable (µg/l)**	**Calculated from WQS (µg/l)**	**Ambient Hardness (mg/l)**
Cadmium (Cd)	1.18	5.24	262
Copper (Cu)	37.18	21.25	262
Lead (Pb)	26.09	21.88	262
Zinc (Zn)	196.01	270.98	262

Armco Inc.-Mansfield Operations

Armco Inc.-Mansfield Operations, Ohio EPA permit # 2ID00003, is located at 913 Bowman St., Mansfield, OH. The current permit became effective on 1 November, 1995 and expires on 31 March, 2000. The facility uses scrap steel to manufacture carbon, silicon, and stainless steel coils and sheets. There are four outfalls which discharge to the Rocky Fork Mohican River. Outfall 001 contains blowdown from the hot strip mill and continuous caster, non-contact cooling water from the electric arc furnace, and stormwater and discharges at RM 14.95. This water is retained in a series of two sedimentation lagoons before discharge. Outfall 002 contains non-contact cooling water from the annealing furnace and DX machine in the cold mill, blowdown from the oil cracking plant, and stormwater and discharges to the Rocky Fork at RM 14.48. This water passes through an oil and water separator before discharge. Outfall 003 contains boiler and skimmer blowdown from the plant boiler house and overflow from the main office pond and discharges to the Rocky Fork at RM 14.73 without treatment. Outfall 004 contains overflow from the cold mill, non-contact cooling water from the boiler house air compressor, and stormwater and discharges to the Rocky Fork at RM 14.70 without treatment.

Ohio EPA conducted 48-hr. acute screening bioassays at Armco as part of a toxics evaluation in conjunction with permit reissuance in 1998. Bioassay number 98-2074-NW was conducted in June 1998. Test results concluded that outfall 002 effluents were acutely toxic to fathead minnows. Fathead minnow mortality was 10 and 15% in the effluent composite and day 2 grab samples, respectively, with seventeen fish in the composite and one in the grab sloughing from the gills. The fathead minnow definitive bioassay results indicated that effluent toxicity decreases over time. The 24-hr. EC50 was 83% and an EC50 could not be calculated for exposure times greater than 48 hrs. because less than half the fish were affected. Bioassay number 98-2094-NW was conducted in July 1998. Test results concluded that outfall 002 effluents were not acutely toxic.

The removal of pretreated wastewater from the oil cracking unit that historically discharged internally to outfall 002 has improved effluent quality (Figure 5.) Combined loadings of oil and grease and suspended solids both exhibited a decreasing trend beginning around 1994. The only permit violations documented in 1998 were for zinc at outfall 001 and oil and grease at outfall 004 in March and copper at outfall 001 in December.

Ambient Water and Sediment Quality

The Rocky Fork is a tributary confluent to the Black Fork at RM 14.02 that is designated WWH, PCR, AWS, and IWS. The river originates in a rural agricultural area and then flows through the City of Mansfield urban-industrial area. Although it is preferred to collect survey samples during low flow conditions to evaluate worst case impacts from point source pollutants, two of five data sets were collected after heavy rainstorms. This led to some interesting results, as depicted by the graphs in Figure 13 where high flow and low flow results are plotted separately. The increase in suspended solids associated with high flow events was accompanied by higher metal concentrations, especially copper and lead. This is likely due to impacts from urban storm water runoff and the suspension of contaminated sediment. In contrast, the high flows diluted the nitrate concentration downstream from the Mansfield WWTP. Generally, water quality was good during low flow periods and very poor during high flows. All of the violations that were documented except one iron value were associated with the high flow samples.

Sediment sampling results for metals and organics indicated a major concern for environmental impact, especially regarding PCBs. The background station at Wilging Rd. (RM 16.29) had no organics detected and all metals were ranked as non-elevated, except aluminum, which was slightly elevated. The station located downstream from the Omni-Source and Luntz metal scrap yards at Old Bowman Rd. (RM 15.75) had total PCBs that were ranked as highly elevated and exceeded the ER-L and LEL at 313.7 ppm. Copper, lead, and cadmium were ranked as elevated, zinc as highly elevated, and chromium as extremely elevated, although this result was qualified as estimated. Most of these also exceeded respective LELs and the chromium exceeded both the ER-M and SEL. The process of shearing scrap metal and associated use of cutting oils and lubricants at the scrap yards is the likely source of contamination. There may also be an impact from slag and coke piles and the electric arc furnace dust landfill located in the Armco facility. An oil sheen was visible at this site when sediments were disturbed. The station located downstream from the Armco facility at Longview Ave. (RM 14.23) had total PCBs that were ranked as highly elevated and exceeded the ER-L and LEL at 214.0 ppb. Lead and nickel were ranked as elevated and chromium as extremely elevated. Disturbing sediments at this site also created an oil sheen. It is likely that sediment from Old Bowman Rd. is resuspended and transported to this location, although the Armco facility is also known to contribute contamination here. Site inspections have detected PCBs and heavy metals in soil at Armco. Sediment collected during a previous study from the outfall 002 mixing zone had nearly 3 ppm of PCBs and 2 ppm of chromium (Biological and Water Quality Study of the Rocky Fork Mohican River, Ohio EPA, 1994). Total DDT was ranked as elevated and exceeded the ER-L and LEL at 13.06 ppb. The station located downstream from the Mansfield urban area at Illinois Ave. (RM 11.59) had total PCBs that were ranked as extremely elevated and exceeded the ER-M and LEL at 45,508 ppb (46 ppm). It is not known definitively whether this would exceed the SEL, since TOC is needed in the calculation. However, for a sediment with 5% TOC, the SEL would be 26.5 ppm, so it is likely the value of 46 ppm was having an significant impact. Barium, nickel, zinc, and cadmium were ranked as elevated, copper and lead as highly elevated, and chromium as extremely elevated. This sample was located in a small pocket or "hot spot" approximately 100 ft. upstream from the bridge on the left bank. It is likely that many sources contributed and it is also likely that many more "hot spots" exist in the Rocky Fork that have not been identified.

A very good macroinvertebrate community (ICI = 46) was present at Wilging Rd. but a decline was evident in the highly modified industrial area at RM 15.8 (Figure 21). The community was in fair condition as a result of the suboptimal channelized habitat and polluted runoff. Qualitative sampling of the Armco 002 mixing zone demonstrated that the acute toxic condition present in 1993 had been corrected. Pollution tolerant taxa were predominant but a number of comparatively sensitive taxa were also collected. The community was impaired downstream from the Armco 002 (RM 14.2) and upstream from the Mansfield WWTP (RM 11.6), but was substantially improved compared to the severely degraded conditions present in 1993. These sites were rated as very poor in 1993 versus a fair rating in 1998. A high percentage of tolerant taxa within this reach demonstrated that toxicity remained a factor despite improved treatment processes at Armco. Sources may include effluent outfalls, contaminated sediments and/or runoff from the urban/industrial area.

As measured by the IBI, WWH fish communities were indicated at the station that marked the upper limit of the mainstem sampling effort. Advantageous features present at the site included, adequate physical habitat and relatively unimpacted water quality. As the Rocky Fork flows through the greater Mansfield area, multiple chemical and physical stressors impinge upon the overall environmental quality of the segment. The combined effects of municipal and industrial dischargers, highly modified near and instream habitat, and contaminated urban/industrial runoff rendered most of the mainstem impaired. Community features observed throughout the impacted reach included lower than expected species richness, simplified trophic structure, and a predominance of environmentally tolerant taxa.

Trend Assessment

Analysis of historical data revealed significant improvement in the overall environmental conditions downstream from Armco-Mansfield since the initial survey in 1993. These improvements appear well correlated with pollution abatement efforts implemented by the facility over the intervening five years. Even though biological expectations were not attained upstream and downstream from Armco, the 1998 results represented a substantial recovery when compared with the severely degraded conditions documented in 1993. Macroinvertebrate assemblages that were rated as poor or very poor in 1993 were considered to be in fair condition in 1998. Sampling locations which were nearly devoid of fish in 1993, at least, supported significant numbers of fish in 1998. Perhaps the most compelling positive change observed within the fish assemblage of the Rocky Fork was the drastic reduction in the incidence of Deformities, Eroded fins/barbels, Lesions, and Tumors (DELT) anomalies. The occurrence of DELT anomalies reached as high as 20% in 1993. The rate at any station did not exceed 0.2% in 1998. This suggests that the severe toxicity present in 1993 associated with discharges from the Armco Mansfield facility has been eliminated due to changes in treatment processes. Significant impacts remained, however, due to sediment contamination, urban runoff, channelization and enrichment associated with the Mansfield WWTP. These impacts limited the establishment of typical warmwater fish and macroinvertebrate communities along most of the sampled reach in 1998.

DMT Recommendation

The results from the 1998 intensive survey demonstrated non-attainment of the WWH biological criteria, and sediment contamination upstream and downstream from the Armco Mansfield facility. Given the performance of these and other environmental indicators, it is therefore recommended that this segment of the Rocky Fork Mohican River be placed in a moderate risk category with respect to the acceptable level of risk for use impairment associated with the total recoverable metals WLA. The recommended total recoverable metals limits for copper, lead, cadmium, and zinc were derived from WWH wadeable streams in the ELOP ecoregion triggers, (Ohio EPA Technical Bulletin MAS/1997-12-4) and are presented in Table 4.

Conclusions
The results from the 1998 survey documented significant improvement in water quality since 1993, however, biological communities remained impaired upstream and downstream from the Armco Inc.-Mansfield Operations. Sources of impacts to the Rocky Fork included sediment contamination, urban runoff, channelization and enrichment associated with the Mansfield WWTP.

It is recommended that the Rocky Fork be considered in the moderate risk category for calculation of the total recoverable metals WLA.

Table 4. The recommended total recoverable metals limits for copper, lead, cadmium, and zinc derived from WWH wadeable streams in the EOLP ecoregion moderate risk triggers (Ohio EPA Technical Bulletin MAS/1997-12-4).

Parameter	**Total Recoverable (µg/l)**	**Calculated from WQS (µg/l)**	**Ambient Hardness (mg/l)**
Cadmium (Cd)	1.18	5.24	262
Copper (Cu)	37.18	21.25	262
Lead (Pb)	26.09	21.88	262
Zinc (Zn)	196.01	270.98	262

Ashland WWTP

The City of Ashland WWTP, Ohio EPA permit # 2PD00010, is located at 865 U.S. 42, Ashland, OH. The current permit became effective on 1 November, 1995 and expires on 1 October, 1999. A trickling filter plant was constructed to provide secondary treatment at a design flow of 1.28 MGD in 1940. This plant was expanded to a design capacity of 2.5 MGD in 1957. Another improvement project converted the plant to an advanced treatment facility utilizing the trickling filter-solids contact process in 1989. Treatment includes an influent bypass, bar screens, aerated grit chamber, two aerated flow equalization tanks, four primary clarifiers, primary bypass, two trickling filters, three solids contact chambers, two secondary clarifiers, ultraviolet disinfection, and cascade aeration. The stormwater tanks receive flows in excess of 10.0 MGD and bypass in excess of 15.0 MGD. Sludge is stabilized using hydrated lime, dewatered using belt filter presses, and land applied at agronomic rates under an approved sludge management plan. The facility operates under an Ohio EPA approved pretreatment program implemented in 1984. Final effluent discharges to Lang Creek at RM 0.34. The collection system is comprised of 100% separate sewers and has 13 lift stations, which have no bypasses and three overflows (SSOs). Approximately 1% of the service area does not have sewers. The average design capacity of the facility is 10.0 MGD, the hydraulic capacity is 15.0 MGD, and the annual average discharge is 3.8 MGD.

Ohio EPA conducted 48-hr. acute screening bioassays at the Ashland WWTP as part of a toxics evaluation in conjunction with permit reissuance in 1998. Bioassay number 98-2032-NW was conducted in March, 1998. Bioassay number 98-2063-NW was conducted in May, 1998. Test results concluded that outfall 001 effluents were not acutely toxic. No mortality or any other adverse acute effects occurred to either test organism in any of the samples submitted.

Loading trends from outfall 001 are displayed in Figure 11. Treatment improvements as a result of expansion completed in 1989 are well represented in the graphs. Loads of BOD5, ammonia, and suspended solids all decline significantly after the expansion went on line. A steadily increasing trend in discharge rate is also indicated, likely due to sewer extensions and the addition of industrial pretreatment sources. Several permit violations for metals were documented in 1998. They are likely due to loadings from pretreatment industries. The city has pursued administrative activity under the authority of its pretreatment program in an attempt to eliminate these violations. There is a significant concern for the frequency of bypasses from the equalization basins. The facility reported bypasses totaling a duration of 174 hours in 1998. The overflow is located just upstream from outfall 001.

Ambient Water and Sediment Quality

Conditions in Lang Creek were significantly improved compared with the severe impacts that existed in 1984. This can be attributed to upgrades at the Ashland WWTP along with connection of industrial process wastes to the city sewer and implementation of a pretreatment program. Full attainment of the WWH aquatic life use was documented for Lang Creek in 1998. The only water quality exceedences documented were for fecal coliform bacteria. No acute toxicity was indicated within the zone of initial mixing of the Ashland WWTP. However, increases in nitrate and phosphorus concentrations occurred downstream from the WWTP. Sediment sampling identified elevated to highly elevated DDT, metals, and PAH levels primarily downstream from the Ashland WWTP and the Ashland urban area. Attainment of the WWH aquatic life use increased from zero miles in 1984 to 3.2 miles in 1998 (100% of the study area)

DMT Recommendation

The results from the 1998 intensive survey demonstrated attainment of the WWH biological criteria, and no sediment metals contamination upstream and downstream from the Ashland WWTP. Given the performance of these and other environmental indicators, it is therefore recommended that this segment of the Lang Creek be placed in a high risk category with respect to the acceptable level of risk for use impairment associated with the total recoverable metals WLA. The recommended total recoverable metals limits for copper, lead, cadmium, and zinc were derived from WWH wadeable streams in the ELOP ecoregion triggers, Ohio EPA Technical Bulletin MAS/1997-12-4, and are presented in Table 5.

Conclusions

The results from the 1998 survey documented significant improvement in water quality since 1984.

It is recommended that the Lang Creek be considered in the high risk category for calculation of the total recoverable metals WLA.

Table 5. The recommended total recoverable metals limits for copper, lead, cadmium, and zinc derived from WWH wadeable streams in the EOLP ecoregion high risk triggers (Ohio EPA Technical Bulletin MAS/1997-12-4).

Parameter	**Total Recoverable (µg/l)**	**Calculated from WQS (µg/l)**	**Ambient Hardness (mg/l)**
Cadmium (Cd)	2.13	8.37	270
Copper (Cu)	59.04	21.8	270
Lead (Pb)	41.97	22.73	270
Zinc (Zn)	390.1	277.98	270

STUDY AREA DESCRIPTION

The Mohican River watershed is located in north central Ohio mainly in Richland and Ashland counties, with small areas in Crawford, Morrow, Knox, and Holmes counties, and the mouth in Coshocton county. The river is 64.2 miles long and basin covers nearly 1000 square miles. It drains approximately 640,000 acres of Ohio farmland, and flows into the Walhonding River, which is tributary to the Muskingum and Ohio Rivers. The 1998 study area included the Black Fork, Rocky Fork, Clear Fork, Muddy Fork, Jerome Fork, and seven tributaries in these five subwatersheds of the Mohican Fiver basin. The forks flow through several cities and towns including Mansfield, Ashland, Shelby, Lexington, Belleville, and Butler. Other towns in the watershed that were not evaluated in the study are Mifflin, Perrysville, and Loudonville.

Three reservoirs were also evaluated during this study. The Charles Mill Reservoir was formed by impounding the Black Fork Mohican River; and Pleasant Hill Reservoir is an impoundment of the Clear Fork Mohican River. Both of these reservoirs are owned and administered by the Muskingum Watershed Conservancy District for flood control and recreation. The Clear Fork Reservoir, another impoundment of the Clear Fork Mohican River, is managed by the City of Mansfield as a public water supply.

Most of the watershed is located in the Erie - Ontario Lake Plain (EOLP) ecoregion of Ohio. Low lime glacial drift deposits blanket the rolling landscape composed of low rounded hills with scattered end moraines and kettles. Its terrain is distinct from the unglaciated, wooded, hilly country of the Western Allegheny Plateau ecoregion which is found in the Walhonding and Muskingum river basins southeast of this area. The soils are often lower in carbonate and less naturally fertile than the high lime till plains in the Eastern Corn Belt Plains ecoregion.

Urban/industrial activity is common in the EOLP and is mixed with dairy, livestock, and grain farming, although the growing season length decreases in the ecoregion as you move away from Lake Erie. The heavily industrialized areas of Mansfield in the Rocky Fork watershed, and Ashland in the Jerome Fork watershed are located in this watershed. Woodlands occur along the ridges and lowlands in this ecoregion, and Mohican State Forest is in this study area.

Soils in the EOLP ecoregion are formed of low lime glacial deposits found on nearly level to very steep terrain in the watershed. The deep, moderately well drained soils located away from the main river valleys are generally medium textured subsoils of the Bennington-Cardington or Rittman-Wadsworth associations in the upper half of the watershed north and west of Ashland, and the Wooster-Canfield association in the lower half of the watershed south and east of Mansfield. Soils in the flood plains and valleys of the main forks of the Mohican River are formed in alluvium and glacial outwash deposits. Found on terraces and kames, these moderately steep, well drained, coarse textured subsoils are generally of the Shoals and Chili-Wheeling associations.

The Eastern Corn Belt Plains (ECBP) ecoregion is a rich agricultural area that covers the northwest part of Richland County around the City of Shelby in the headwaters of the Black Fork. The area has light colored loamy, somewhat poorly drained soils formed from glacial deposits of the Wisconsinan age that were originally covered by natural beech forests. Today, extensive grain and livestock farming occurs in this ecoregion throughout west central Ohio. The ECBP ecoregion has deep clayey, high lime soils formed in glacial till. Found on gently sloping terrain, these medium to moderately fine textured soils are generally of the Fitchville-Luray-Bennington and Pewamo-Bennington associations.

Land use in the watershed consists mainly of cropland (49%), pasture (9%), and forest (23%). The cropland is a mixture of agricultural crops including corn, soybeans, wheat, oats, grasses and legumes. Dairy is the main type of livestock operation, but there are also beef, swine and poultry operations throughout the watershed. Urban, industrial, rural residential, and recreational areas account for the remaining 19% of land use. Approximately 5,610 acres of land and water in the watershed is administered by the Muskingum Watershed Conservancy District. Equal portions (39% each) are distributed between water (reservoir) and forest in the district, with the balance of land use as permanent homes, seasonal cottages, recreational, and cropland (USDA, 1993).

Portions of the Mohican River and its tributaries are potentially impacted by a combination of point and nonpoint sources of pollution. The Rocky Fork, upper part of the Black Fork, and Jerome Fork subbasins receive significant amounts of effluent from industrial and municipal point sources. Effluents from municipal wastewater treatment plants, separate sewer overflows (SSO),and plant bypasses contribute to documented impairments in the system. There are approximately eighteen (18) unsewered areas in the watershed that discharge inadequately or untreated sewage from rural homes into streams in all five subbasins of the study area.

Potential nonpoint source impacts within the watershed include sedimentation from agricultural lands, and improperly managed silviculture (forest harvesting) operations, and nutrient enrichment from livestock operations and failed home sewage systems. Urban storm sewers, old unregulated storm water discharges from industrial sites, spills, and leachate from closed landfills and old township dumps have contributed to sediment contamination in the Rocky Fork, Black Fork, and urban streams in the Jerome Fork. Table 6 lists the stream characteristics and pollution sources for the streams sampled during the 1998 survey.

Table 6. Stream characteristics and significant identified pollution sources in the Mohican River basin study Area.

River/Stream	Length (mi.)	Gradient (ft./mi.)	Drainage Area (sq. mi.)	Nonpoint Sources	Point Sources
Black Fork Mohican	58.4	5.4	350.9	Agriculture Crop production Livestock pasture/ On-site WW systems Channelization CSOs Noble Rd. Landfill Copperweld Landfill Old township dumps	Shelby WWTP Briarwood Estates MHP Abraxas Foundation Lust Subd. Country Meadows Subd.
Tuby Run	-	-	-	Channelization Spills	Copperweld (17 outfalls)
Rocky Fork Mohican	24.9	10.8	86.8	Channelization On-site WW systems Contaminated sediments Richland Co. Landfill Mansfield Landfill Old township dump	Mansfield WWTP Lucas WWTP Armco Inc. Luntz Corp. Ohio Air National Guard Mansfield Foundry New Artesian Ideal Electric Stone Container Therm-O-Disc Harp Subd. Heatherwood Subd.
Jerome Fork	24.5	9.1	159.0	Agriculture Crop production Livestock pasture/ feedlots Contaminated sediments Ashland City Landfill Jeromesville Landfill Old township dumps	Jeromesville WTP BP Oil - Ashland Pipeline Ashland County JVS Ashland County landfill

Table 6. Continued.

River/Stream	Length (mi.)	Gradient (ft./mi.)	Drainage Area (sq. mi.)	Nonpoint Sources	Point Sources
Lang Creek	9.3	23.8	32.7	Agriculture Crop production Livestock pasture/ feedlots Contaminated sediments	Ashland WTP Ashland WWTP
Jamison Creek	5.4	52.0	13.9	Agriculture Urban runoff Storm sewers Contaminated sediments	Timken Co. General Latex and Chemical
Town Run	5.6	42.7	6.82	Agriculture Crop production Urban runoff Storm sewers	Hedstrom Corp. Abbott Laboratories BP Oil-Ashland Bulk Plant
Muddy Fork	28.9	8.9	105.2	Agriculture Crop production Livestock pasture/ feedlots On-site WW systems Old township dumps	West Salem WWTP Cinnamon Lake Subd.
Clear Fork Mohican	36.6	11.0	218.5	Agriculture Crop production Livestock pasture/ feedlots Forest harvesting Reforestation Residue management Old township dumps	Lexington WWTP Bellville WWTP Butler WWTP Mansfield WTP Brown Derby Roadhouse United Technologies GMC Fisher Body Griffeth Nursing Home Mateer Ford Inc. Mohican State Park Lodge Mohican State Park Campground Mohican Youth Center Pleasant Hill Lake

Table 6. Continued.

River/Stream	Length (mi.)	Gradient (ft./mi.)	Drainage Area (sq. mi.)	Nonpoint Sources	Point Sources
Cedar Fork	9.6	18.5	47.8	Agriculture Crop production Pasture Specialty crop prod. On-site WW systems	
Possum Run	7.8	25.6	15.8	On-site WW systems	
Pine Run	8.2	37.3	13.9	Agriculture Forest harvesting	

A Section 319 grant was awarded to the Richland Soil and Water Conservation District (SWCD) in January, 1995 for a nonpoint source implementation project in the Black Fork Mohican subwatershed. The project, which concluded in March, 1998 had these goals: 1) reduce sedimentation by improving the crop residue management program, 2) reduce pesticide and nutrient runoff to the steams by installing buffer strips and managing farm chemicals and animal waste, and 3) improve rural home sewage disposal systems by replacing failed systems and educating homeowners on system maintenance. The program was successful in offering cost share incentives in the Black Fork watershed for the purchase of conservation tillage equipment, establishment of 52 acres of new buffer strips along streams, repair or replacement of 40 sewage systems, and education programs to increase public awareness of nonpoint source pollution issues (Richland SWCD, 1998).

Conservation programs in farming are being promoted by the Natural Resources Conservation Service (NRCS) and local Soil and Water Conservation Districts in Richland and Ashland counties. Conservation tillage practices have increased across the watershed in the last ten years, especially in the Black Fork watershed due to the 319 grant incentives. There are several federal incentive and stewardship programs to assist landowners with management of forest lands, and landowners and recreational users of Charles Mill Reservoir have been participating in an ongoing Citizens Lake Improvement Program (CLIP) water quality monitoring program (Richland SWCD, 1997).

METHODS

All chemical, physical, 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), and The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application (Rankin 1989). Chemical, physical and biological sampling locations are listed in Table 7.

Determining Use Attainment Status

The attainment status of aquatic life uses (*i.e.*, FULL, PARTIAL, and **NON**) is determined by using the biological criteria codified in the Ohio Water Quality Standards (WQS; Ohio Administrative Code [OAC] 3745-1-07, Table 7-14). The biological community performance measures that are used include the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), based on fish community characteristics, and the Invertebrate Community Index (ICI) which is based on macroinvertebrate community characteristics. The IBI and ICI are multimetric indices patterned after an original IBI described by Karr (1981) and Fausch *et al.* (1984). The ICI was developed by Ohio EPA (1987b) and further described by DeShon (1994). The MIwb is a measure of fish community abundance and diversity using numbers and weight information and is a modification of the original Index of Well-Being originally applied to fish community information from the Wabash River (Gammon 1976; Gammon *et al.* 1981). Performance expectations for the principal aquatic life uses in the Ohio WQS (Warmwater Habitat [WWH], Exceptional Warmwater Habitat [EWH], and Modified Warmwater Habitat [MWH]) were developed using the regional reference site approach (Hughes *et al.* 1986; Omernik 1988). This fits the practical definition of biological integrity as the biological performance of the natural habitats within a region (Karr and Dudley 1981). Attainment of the aquatic life use is FULL if all three indices (or those available) meet the applicable biocriteria, PARTIAL if at least one of the indices does not attain and performance at least fair, and **NON**-attainment if all indices fail to attain or any index indicates *poor* or *very poor* performance. Partial and non-attainment indicate that the receiving water is impaired and does not meet the designated use criteria specified by the Ohio WQS.

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, 1994). 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 in-stream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the metrics used to determine the QHEI score

Table 7. Sampling locations (chemical - C, effluent - E, sediment - S, Datasonde® continuous monitors - D, macroinvertebrates - M, fish - F, tissue - T) in the 1998 Mohican River study area.

Stream/ River Mile	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad. Map
Jerome Fork				
13.8	M	405341/821734	SR 58	Ashland North
13.0	C,S,D,F,T	405303/821705	S.R. 42 (ust. Lang Creek)	Ashland North
12.1	C,D,M,F,T	405232/821619	C.R. 1302 (dst. Lang Creek)	Ashland North
10.6	F	405129/821518	S.R. 250	Jeromesville
10.5	M	405126/821516	S.R. 250	Jeromesville
9.15	C,S	405033/821414	T. R. 1500	Jeromesville
5.7	M	404811/821205	at Jeromesville	Jeromesville
5.6	C,F,T	404809/821202	C.R. 30A	Jeromesville
2.6	C,S	404636/820929	C.R. 175	Jeromesville
2.5	M	404035/820926	dst. C.R. 175	Jeromesville
0.9	D,F	404545/820801	T.R. 75	Jeromesville
Lang Creek				
3.2	C,S,M,F	405406/821847	T.R. 1104 (ust. Ashland, Oh.)	Ashland North
0.4	C,S,M[q],F	405234/821655	Ust. Ashland WWTP, dst.	Ashland North
0.34	E,M,F	405234/821653	Ashland WWTP mixing zone	Ashland North
0.3	C,S,M[q],F	405235/821617	Dst. Ashland WWTP	Ashland North
Jamison Creek				
1.2	M,F	405137/821758	Ust. US 42	Ashland South
1.0	C	405146/821709	Main St. (ust. Town Run)	Ashland South
0.3	C,M,F	405228/821657	C.R. 1302 (dst. Town Run)	Ashland South
0.1	C,M	405231/821657	Dst. unnamed trib.	Ashland North
Town Run				
0.3	C,F	405217/821705	S.R. 42	Ashland South
0.1	M	405219/821655	at mouth	Ashland South

Table 7. Continued.

Stream/ River Mile	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad. Map
Muddy Fork				
18.4	C,S,M,F	405702/820709	Flemming Rd.	West Salem
13.4	C,S,F	405403/820819	Martin Rd.	Polk
Red Haw Creek				
2.1	M	405404/820909	ust. Martiin Rd.	Polk
Black Fork Mohican River				
54.7	M	405140/823941	Stiving Rd.	Shelby
54.6	C,S,D,F,T	405143/823942	Stiving Rd.	Shelby
53.6	C,S	405234/823937	Tucker Ave.	Shelby
53.4	M,F	405247/823934	Ust. Tuby Run	Shelby
53.2	C,S,M,F,T	405255/823935	Main St. (dst. Tuby Run)	Shelby
52.7	M	405321/823934	Water treatment plant	Shelby
52.6	S,D,,F	405324/823934	Water treatment plant	Shelby
51.3	C,S, D	405430/823924	London West Rd.	Shelby
50.7	M,F	405455/823916	lane off Bistline Rd.	Shelby
50.0	E,M^{2q},F	405455/823829	Shelby WWTP mixing zone	Shelby
49.6	C,S,D,F,T	405457/823801	Plymouth -Spring Mill Rd.	Shelby
49.5	M	405459/823800	dst. Plymouth -Spring Mill Rd.	Shelby
46.5	C,S,M,F	405522/823613	Miller Rd.	Shiloh
43.5	M	405425/823347	ust. Ganges-Five Points Rd	Shiloh
43.2	C,S,F	405431/823355	Ganges-Five Points Rd.	Shiloh
38.5	M	405404/823133	Geisinger Rd.	Shiloh
38.4	C,S,D,F	405404/823135	Geisinger Rd.	Shiloh
Tuby Run				
0.7	C,M^{q},F	405241/824015	Ust. Copperweld 005 outfall	Shelby
0.6	E,M^{2q},F	405244/824012	Copperweld 005 mixing zone	Shelby
0.2	C,S,M^{q},	405247/823942	Gamble St.	Shelby
0.1	F	405247/823939	near mouth	Shelby

Table 7. Continued.

Stream/ River Mile	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad. Map
Rocky Fork Mohican River				
16.4	F	404754/823213	Wilging Rd.	Mansfield North
16.3	C,S,D,M,T	404755/823214	Wilging Rd. (ust. scrapyards)	Mansfield North
15.8	C,S,D,M,F	404707/823151	Old Bowman Rd	Mansfield North
14.47	E,M[2q],F	404647/823137	Armco 002 mixing zone	Mansfield North
14.3	F	404647/823054	Ust. Longview Rd.	Mansfield North
14.2	C,S,D,M,T	404635/823059	Longview Rd.	Mansfield North
11.7	F	404502/822908	Ust Illinios St.	Pavonia
11.6	C,S,D,M,T	404505/822955	Illinois St. (dst Stone Container)	Pavonia
11.2	E,M,F	404456/823120	Mansfield WWTP mixing zone	Lucas
10.2	M,F	404429/822750	SR 39	Lucas
10.1	C,S,D,T	404427/822747	SR 39	Lucas
0.6	C,S,D,M,F	404210/822107	Applegate Rd.	Perrysville
Clear Fork Mohican River				
35.7	C,M,F	404437/823817	Marion Ave.	Blooming Grove
29.6	C,D,M,F	404133/823541	Lex. Bicentenial Park	Mansfield South
27.7	M	404039/823446	Ust. Lexington WWTP	Mansfield South
27.6	C,F	404027/823439	Ust. Lexington WWTP	Mansfield South
27.4	F	403419/823421	Dst. Lexington WWTP	Mansfield South
27.2	M	404020/823424	Dst. Lexington WWTP	Mansfield South
24.3	M,C	403905/823258	Kocheiser Rd.	Mansfield South
23.5	D,M,F	403827/823306	Kings Corner Rd.	Mansfield South
21.1	C,M,F	403725/823152	S.R. 97 (ust. Bellville)	Bellville
16.8	M,F	403606/822811	Adj. Gatton Rock Rd	Butler
16.2	C	403554/822757	Cutnaw Rd.	Butler
11.8	C,D,M,F	403640/822333	Adj. Butler Newville Rd.	Butler
4.0	C,M,F	403642/821842	At covered bridge (dst Pleasant	Jelloway
0.3	C,D,M,F	403622/821528	S.R. 3	Jelloway

Table 7. Continued.

Stream/ River Mile	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad. Map
Cedar Fork				
8.2	M[q],F	403816/824006	West Point Bellville Rd.	Blooming Grove
3.2	M[q],F	403706/823520	S.R. 546	Bellville
0.8	C,M[q],F	403724/823305	Bellville Johnsville Rd.	Bellville
Possum Run				
1.4	C,F	403740/822430	Wander bridge off Possun Run	Lucas
Pine Run				
0.1	C,F	403620/821530	Near mouth	Jelloway

that generally ranges from 20 to 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. Scores greater than 75 frequently typify habitat conditions that have the ability to support exceptional warmwater faunas.

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Macroinvertebrate Community Assessment

Macroinvertebrates were sampled quantitatively using multiple-plate, artificial substrate samplers (modified Hester/Dendy) in conjunction with a qualitative assessment of the available natural substrates. During the present study, macroinvertebrates collected from the natural substrates were also assessed using a new assessment tool. This method relies on tolerance values derived for each taxon, based upon the abundance data for that taxon from artificial substrate (quantitative) samples collected throughout Ohio. To determine the tolerance value of a given taxon, ICI scores at all locations where the taxon has been collected are weighted by its abundance on the artificial substrates. The mean of the weighted ICI scores for the taxon results in a value which represents its relative level of tolerance on the ICI's 0 to 60 scale. For the qualitative collections in the Mohican River study area, the median tolerance value of all organisms from a site resulted in a score termed the Qualitative Community Tolerance Value (QCTV). The QCTV shows potential as a method to supplement existing assessment methods using the natural substrate collections. QCTV scores for sampling locations in the study area were used in conjunction with other aspects of the community data to make evaluations and were not unilaterally used to interpret quality of the sites or aquatic life use attainment status.

Fish Community Assessment

Fish were sampled using wading or boat method pulsed DC electrofishing gear. The wading method was used at a frequency of one or two samples at each site. The boat method was used at a frequency of two samples at each site.

Area of Degradation Value (ADV)

An Area Of Degradation Value (ADV; Rankin and Yoder 1991; Yoder and Rankin 1995) was calculated for the study area based on the longitudinal performance of the biological community indices. The ADV portrays the length or "extent" of degradation to aquatic communities and is simply the distance that the biological index (IBI, MIwb, or ICI) departs from the applicable biocriterion or the upstream level of performance (Figure 2). The "magnitude" of impact refers to the vertical departure of each index below the biocriterion or the upstream level of performance. The total ADV is represented by the area beneath the biocriterion (or upstream level) when the results for each index are plotted against river mile. The results are expressed as ADV/mile to normalize comparisons between segments, sampling years, and other streams and rivers.

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 the principal arbiter of aquatic life use attainment and impairment (partial and non-attainment). The rationale for using the biological criteria in the role of principal arbiter 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 1991a; Yoder 1994). 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, biomonitoring results, land use data, and the

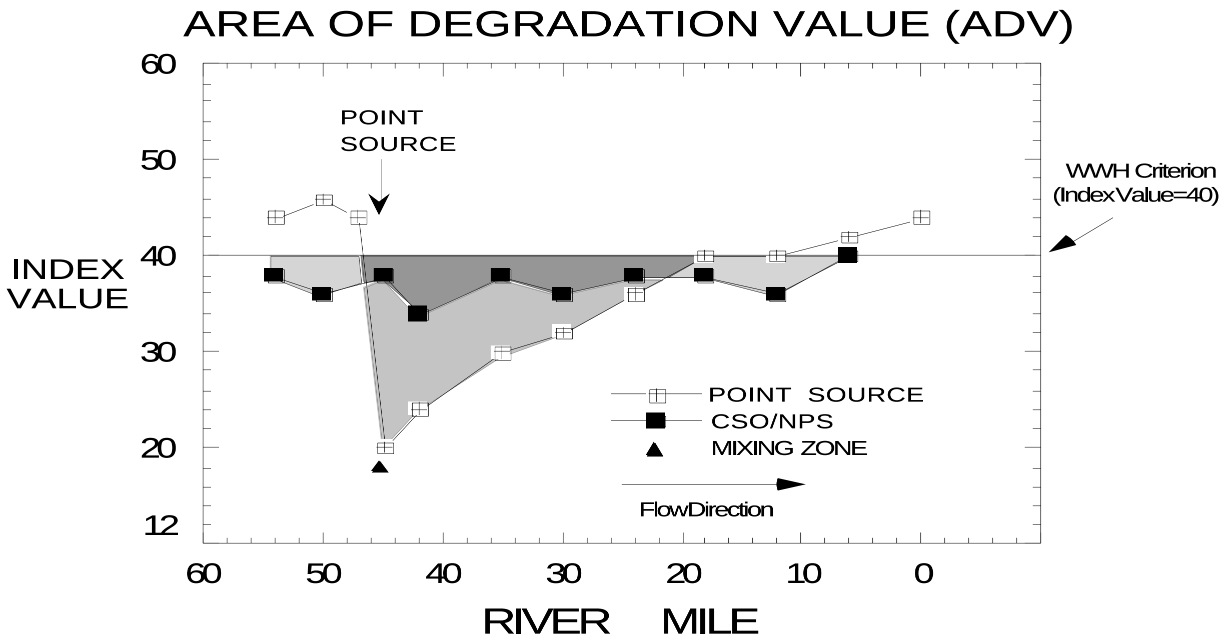

Figure 2. Graphic illustration of the Area of Degradation Value (ADV) based on the ecoregion biocriterion (WWH in this example). The index value trend line indicated by the unfilled boxes and solid shading (area of departure) represents a typical response to a point source impact (mixing zone appears as a solid triangle); the filled boxes and dashed shading (area of departure) represent a typical response to a nonpoint source or combined sewer overflow impact. The blended shading represents the overlapping impact of the point and nonpoint sources.

biological response signatures (Yoder and Rankin 1994) within the biological data itself. Thus the assignment of principal causes and sources of impairment in this report do not represent a true "cause and effect" analysis, but rather represent the association of impairments (based on response indicators) with stressor and exposure indicators whose links with the biosurvey data are based on previous research or experience with analogous situations and impacts. The reliability of the identification of probable causes and sources is increased where many such prior associations have been identified. The process is similar to making a medical diagnosis in which a doctor relies on multiple lines of evidence concerning patient health. Such diagnoses are based on previous research which experimentally or statistically linked symptoms and test results to specific diseases or pathologies. Thus a doctor relies on previous experience in interpreting symptoms (*i.e.*, multiple lines from test results) to establish a diagnosis, potential causes and/or sources of the malady, a prognosis, and a strategy for alleviating the symptoms of the disease or condition. As in medical science, where the ultimate arbiter of success is the eventual recovery and the well-being of the patient, the ultimate measure of success in water resource management is 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) here we are referring to the process for identifying biological integrity and causes/sources associated with observed impairment, not whether human health and ecosystem health are analogous concepts.

RESULTS AND DISCUSSION

Pollutant Loadings

Division of Surface Water

The Ohio EPA, Division of Surface Water (DSW) is responsible for the implementation of portions of the Clean Water Act. This includes administering the National Pollutant Discharge Elimination System (NPDES) by issuing permits to facilities that treat and dispose of wastewater. In support of this permitting program, the DSW conducts compliance inspections, reviews effluent monitoring data, issues Notice of Violation (NOV) letters if appropriate, and initiates administrative action if necessary. Several facilities in the study area are regulated under the NPDES permit system. A summary of these facilities is presented in Table 8 and several are discussed in detail below. Pollutant loadings (kg/day) discharged from several of these facilities were evaluated using the Liquid Effluents Analysis Processing (LEAP) system, a database that contains self monitoring results submitted in monthly operation reports (MORs). A graphical summary of this data for the facilities discussed below is presented in the histograms contained in Figures 3-11. A summary of NOVs submitted to these facilities is listed in Table 9.

Table 8. NPDES regulated outfalls discharging to the Mohican River basin study area.

Facility	**Ohio Permit #**	**Receiving Stream**	**River Mile**	**Treatment Process**
Briarwood Estates MHP	2PY00018001	tributary to Black Fork	58.77	extended aeration with polishing lagoon
Abraxas Foundation	2PR00076001	tributary to Black Fork	58.77	extended aeration with sand filter
Lust Subdivision	2PG00077001	tributary to Black Fork	53.42	extended aeration with sand filter and polishing lagoon
Copperweld	2ID00002023	Tuby Run to Black Fork	0.92 53.38	oil-water separator
Copperweld	2ID00002022	Tuby Run	0.81	oil-water separator
Copperweld	2ID00002020	Tuby Run	0.77	no treatment
Copperweld	2ID00002021	Tuby Run	0.70	no treatment
Copperweld	2ID00002005	Tuby Run	0.66	combined outfalls 601-602

Table 8. Continued.

Facility	**Ohio Permit #**	**Receiving Stream**	**River**	**Treatment Process**
Copperweld	2ID00002601			neutralization, thickening, filtration, and series of sedimentation lagoons
Copperweld	2ID00002602			scale pits, oil-water separator, cooling tower, and retention pond with oil skimmer
Copperweld	2ID00002004	Tuby Run	0.65	no treatment
Copperweld	2ID00002018	Tuby Run	0.64	no treatment
Copperweld	2ID00002006	Tuby Run	0.63	no treatment
Copperweld	2ID00002017	Tuby Run	0.61	no treatment
Copperweld	2ID00002016	Tuby Run	0.60	no treatment
Copperweld	2ID00002003	Tuby Run	0.55	no treatment
Coperweld	2ID00002015	Tuby Run	0.49	no treatment
Copperweld	2ID00002002	Tuby Run	0.33	no treatment
Copperweld	2ID00002013	Black Fork	52.10	no treatment
Copperweld	2ID00002014	Black Fork	51.83	no treatment
Shelby WWTP	2PD00036001	Black Fork	50.07	secondary
Country Meadows Subdivision	2PG00074001	Leatherwood Creek to Black Fork	44.85	extended aeration with sand filter
Luntz Corp.	2IN00076001	Rocky Fork	15.85	retention pond with oil skimmer
Ohio Air National Guard	2IN00189002	tributary to Rocky Fork	15.5	oil-water separator
Armco Inc.	2ID00003001	Rocky Fork	14.95	retention pond with oil skimmer and sedimentation lagoon
Armco Inc.	2ID00003003	Rocky Fork	14.73	no treatment
Armco Inc.	2ID00003004	Rocky Fork	14.70	no treatment
Armco Inc.	2ID00003002	Rocky Fork	14.48	oil-water separator
Mansfield Foundary	2IN00097003	Rocky Fork	13.84	no treatment
Mansfield Foundary	2IN00097002	Rocky Fork	13.80	no treatment
Mansfield Foundary	2IN00097001	Rocky Fork	13.79	series of two cooling ponds
New Artesian	2IN00063001	Touby Run	4.8	sedimentation lagoon
Ideal Electric	2IN00058001	Rocky Fork	12.4	no treatment

Table 8. Continued.

Facility	Ohio Permit #	Receiving Stream	River	Treatment Process
Ideal Electric	2IN00058002	Rocky Fork	12.4	no treatment
Stone Container	2IA00001002	Rocky Fork	11.68	no treatment
Mansfield WWTP	2PE00001001	Rocky Fork	11.18	secondary
Therm-O-Disk	2IS00028001	tributary to Rocky Fork	4.75 10.70	no treatment
Harp Subdivision	2PG00075001	tributary to Rocky Fork	7.07	extended aeration with sand filter
Heatherwood Subd.	2PG00008001	tributary to Rocky Fork	3.90 7.07	extended aeration with sand filter
Lucas WWTP	2PB00038001	Rocky Fork	3.65	extended aeration
GMC-Fisher Body Division	2IS000450001	tributary to Clear Fork	36.31	sedimentation lagoon
Brown Derby Roadhouse	2PR00049001	tributary to Clear Fork	34.91	extended aeration
Mansfield Water Treatment Plant	2IV00052001	Buck Ck to Clear Fork	0.77 29.28	sedimentation lagoon
United Technologies	2IN00107001	tributary to Clear Fork	28.33	air strippers
Lexington WWTP	2PB00019001	Clear Fork	27.20	series of two aerated lagoons
Griffeth Nursing Home	2PR00118001	tributary to Clear Fork	24.94	extended aeration with sand filter
Bellville WWTP	2PB00057001	Clear Fork	19.17	rotating biological contactors
Mateer Ford Inc.	2PR00065001	tributary to Honey Ck to Clear Fork	1.77 17.15	extended aeration with sand filter
Butler WWTP	2PA00044001	Clear Fork	13.90	rotating biological contactors
Mohican State Park Lodge	2PP00033001	Clear Fork	5.68	extended aeration
U.S. Army CoE-Pleasant Hill Lake	2PN00000001	Clear Fork	4.91	extended aeration with sand filter
Mohican State Park Campground	2PP00033001	Clear Fork	3.80	extended aeration with sand filter
Mohican Youth Center	2PP00005001	Clear Fork	3.70	extended aeration
Cinnamon Lake Subd.	2PR00009001	Muddy Fork	25.50	extended aeration with sand filter and polishing lagoon

Table 8. Continued.

Facility	Ohio Permit #	Receiving Stream	River	Treatment Process
West Salem WWTP	3PB00053001	Muddy Fork	20.27	oxidation ditches
Ashland WTP	2IW00002003	Lang Creek	1.16	sedimentation pond
Ashland WTP	2IW00002002	Lang Creek	1.07	sedimentation pond
Ashland WTP	2IW00002001	Lang Creek	0.98	sedimentation pond
Ashland WWTP	2PD00010001	Lang Creek	0.34	advanced secondary
Timkin Co.	2IC00043001	sewer to tributary to Jamison Ck	1.51 3.05	oil-water separator
General Latex and Chemical	2IR00011001	tributary to Jamison Ck	0.40 0.09	no treatment
Hedstrom Corp.	2IR00021001	sewer to Town Run	1.49	no treatment
Abbott Laboratories	2IN00054001	sewer to Town Run	1.49	no treatment
BP Oil-Ashland Bulk Plant	2IN00181001	sewer to Town Run	1.49	oil-water separator and sedimentation pond
BP Oil-Ashland Pipeline	2IN00071001	Jerome Fork	10.49	sedimentation pond
Jeromesville WTP	2IZ00072001	Jerome Fork	5.60	settling tank
Jeromesville WTP	2IZ00072002	tributary to Jerome Fork		sand filter
Ashland Co. JVS	2PT00011001	tributary to Oldtown Run	4.70	extended aeration with sand filter
Ashland Co. Landfill	2IN00103002	tributary to Oldtown Run	4.10	sedimentation pond
Ashland Co. Landfill	2IN00103001	ditch to tributary to Oldtown Run	4.10	sedimentation pond

Table 9. Summary of NPDES Notice of Violation letters issued in the Mohican River basin study area, 1998. (Only facilities discussed in the pollutant loadings text section were evaluated.) Violations are summarized for monthly minimum concentration (MCMN), monthly average concentration (MCAV), monthly maximum concentration (MCMX), monthly average loading (MQAV), and monthly maximum loading (MQMX).

		Number and Type of Violation				
Month	**Parameter**	**MCMN**	**MCAV**	**MCMX**	**MQAV**	**MQMX**
Copperweld-Shelby Division						
August	TSS (602)				1	2
Armco Inc.-Mansfield Operations						
March	zinc (001)				1	1
	oil and grease (004)			1		
December	copper (001)		1			
Mansfield WWTP						
June	pH			1		
July	$cBOD_5$		1	3	1	1
August	$cBOD_5$		1	2	1	1
October	mercury		1			
Bellville WWTP						
October	pH	5				
Butler WWTP						
February	$cBOD_5$				1	1
March	$cBOD_5$				1	
April	$cBOD_5$				1	2
May	$cBOD_5$				1	
	residual chlorine			20		
June	residual chlorine			20		
July	residual chlorine			23		
August	residual chlorine			21		
September	residual chlorine			21		
October	residual chlorine			22		
Ashland WWTP						
July	dissolved oxygen	1				
	fecal coliform			1		
October	zinc			1		1
	lead		1	1		
November	zinc			1		
	lead			1		
	copper		1			

Shelby WWTP

The City of Shelby wastewater treatment plant (WWTP), Ohio EPA permit # 2PD00036, is located at 3626 London East Rd., Shelby, Ohio. The current permit became effective on 13 September, 1996 and expires on 31 March, 2001. The activated sludge plant was originally constructed in 1955 to provide secondary sewage treatment at a design flow of 1.5 million gallons per day (MGD). The plant eventually became severely overloaded in part due to excessive inflow and infiltration in the collection system. Frequent bypasses and permit violations led to a major plant expansion that was completed in 1988. Treatment includes an influent bypass, 2.0 million gallon flow equalization lagoon, comminutor, aerated grit chamber, two primary clarifiers, primary bypass, four aeration tanks, two secondary clarifiers, chlorination, post aeration, and dechlorination. Sludge is anaerobically digested, dried on beds, and land applied at agronomic rates under an approved sludge management plan. The facility does not operate under an Ohio EPA approved pretreatment program. Approximately 6.5% of the hydraulic load is from industrial sources. Final effluent from the facility discharges to the Black Fork at river mile (RM) 50.07. The collection system is comprised of 100% separate sewers and has no lift stations. Approximately 5% of the service area does not have sewers. The average design capacity of the facility is 2.5 MGD, the hydraulic capacity is 5.0 MGD, and the annual average discharge is 2.0 MGD. Ohio EPA conducted 48-hr. acute screening bioassays at the Shelby WWTP as part of a toxics evaluation in conjunction with permit reissuance in 1998. Grab and composite derived outfall 001 effluents and Black Fork upstream and in the acute (near-field) mixing zone were evaluated using the fathead minnow *Pimephales promelas* and daphnid *Ceriodaphnia dubia* as test organisms. Effluent is considered to be acutely toxic if 20%, or more, of either species of test organism in 100% effluent exhibits any combination of mortality, immotility, or loss of equilibrium. Test results are invalid if more than 10% of either species of test organism in the control exhibits the adverse effects. When sufficient adverse effects occur to determine a median lethal concentration (LC50) or a median effect concentration (EC50), *P. promelas* and *C. dubia* static-acute definitive toxicity tests are initiated using a 24-hr composite derived effluent sample. Bioassay number 98-2025-NW was conducted in March, 1998. Test results concluded that outfall 001 effluents were not acutely toxic. Fathead minnow mortality was 5% in the mixing zone. *C. dubia* mortality was 5% in the Black Fork upstream sample. No other mortality or adverse acute effects occurred. Bioassay number 98-2067-NW was conducted in May, 1998. Test results concluded that outfall 001 effluents were not acutely toxic. Fathead minnow mortality was 5% in the Black Fork upstream and mixing zone samples and 10% in the effluent composite. No other mortality or adverse acute effects occurred.

Loading trends from outfall 001 are displayed in Figure 3. The expansion completed in 1988 is somewhat represented in the graphs, especially regarding BOD5 and suspended solids. It is suspected that the reason more noticeable changes in effluent quality did not occur is because of

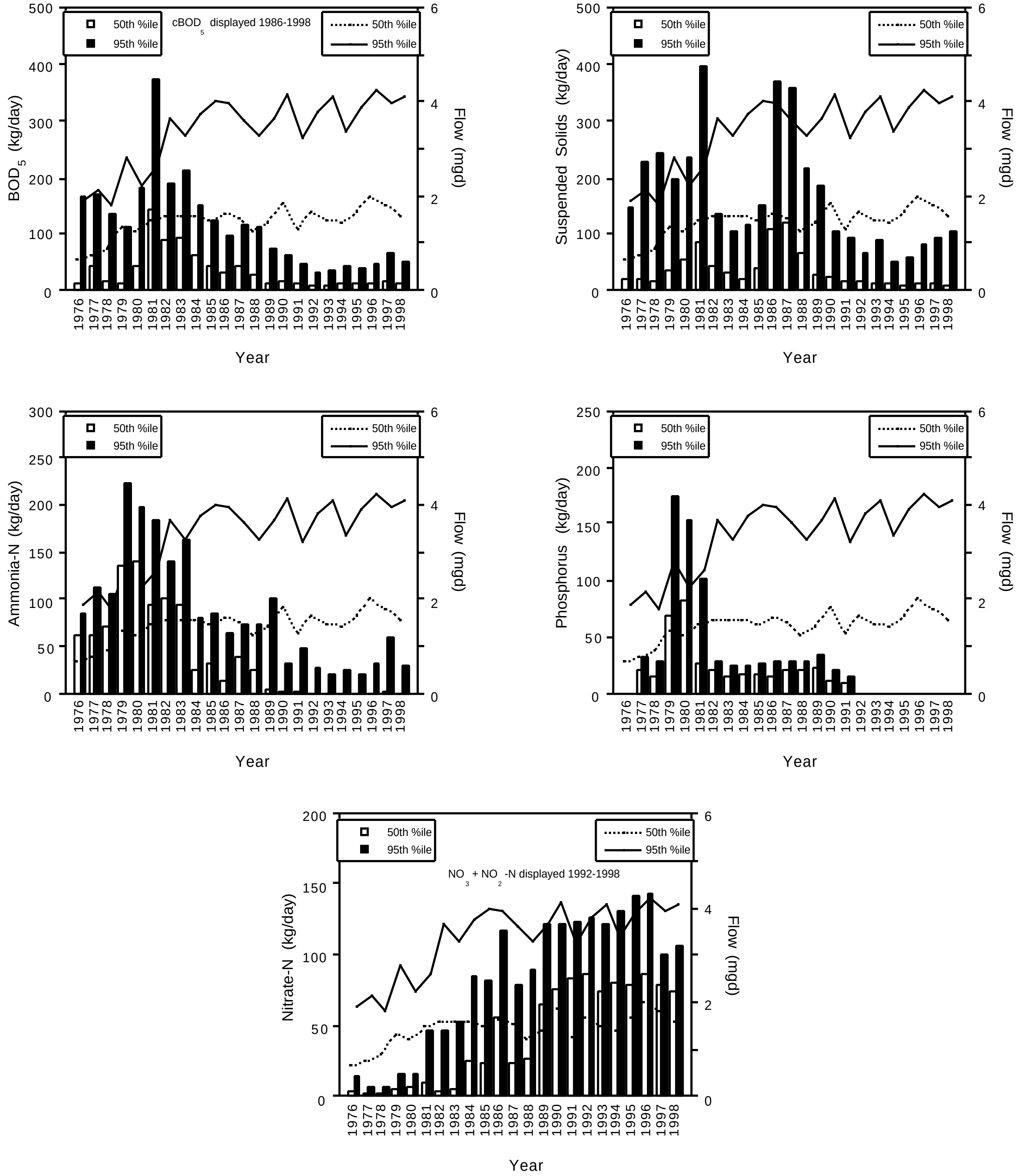

Figure 3. Median and 95th percentile annual phosphorus, nitrate, BOD_5, suspended solids, and ammonia-N loadings to the Black Fork Mohican River by the Shelby WWTP, 1976-1998.

the availability of an influent bypass. Although no permit violations were documented in 1998, there is a significant concern for these raw bypasses. The facility reported raw bypasses totaling 34.3 million gallons during 1998. No primary bypasses were reported.

Copperweld-Shelby Division (f.k.a. Ohio Steel Tube)

Copperweld-Shelby Division, Ohio EPA permit # 2ID00002, is located at 132 W. Main St., Shelby, OH. The current permit became effective on 1 November, 1996 and expires on 28 October, 2001. The facility manufactures welded and seamless steel tubing. Manufacturing processes include hot forming, acid pickling, alkaline cleaning, and cold forming. Treated process effluent discharges to Tuby Run at RM 0.66 from outfall 005. Tuby Run is confluent to the Black Fork at RM 53.38. Outfall 005 includes the combined flows from internal outfalls 601 and 602. Outfall 601 consists of caustic and acidic wastewater and boiler blowdown. It is treated at the industrial wastewater treatment plant (IWWTP) by neutralization, gravity thickening, and pressure filtration and pumped to a series of four 1.0 million gallon settling lagoons. The effluent is allowed to counter flow by gravity through at least two lagoons at all times and discharges from a stand pipe to outfall 005. Outfall 602 consists of recirculation mill water, contact cooling water, non-contact cooling water, and stormwater. This wastewater is treated by scale pits, an oil-water separator, and cooling tower and discharged to the west pond, which is a 7.0 million gallon lagoon equipped with an oil skimmer. Much of this water is re-used; however, if necessary, the west pond overflows to a 1.0 million gallon pond which has a stand pipe overflow to outfall 005. The remaining permitted outfalls discharge stormwater. Outfalls 002-004, 006, and 020 discharge stormwater to Tuby Run from the plant # 1 grounds without treatment. Outfalls 015, 016, 018, and 021 discharge stormwater to Tuby Run from the plant # 1 roadway without treatment. Outfall 017 discharges stormwater to Tuby Run from the IWWTP grounds without treatment. Outfall 022 discharges to Tuby Run from the plant # 2 stormwater detention pond after passing through oil and grit separators and receives flow from deleted outfalls 007-011. Outfall 023 discharges to Tuby Run from the plant # 2 stormwater retention pond after passing through an oil and grit separator and receives flow from deleted outfalls 012 and 019. All sanitary waste is discharged to the City of Shelby sanitary collection system.

Copperweld operated a landfill for the disposal of neutralized sulfuric acid pickle liquor sludge along the right (east) bank of the Black Fork downstream from Spring St. (RMs 52.18-51.83) from 1943-1968. The facility estimated that approximately 24 million gallons of sludge was disposed in the landfill (a.k.a. "ferrous park"). A remediation project was performed at the site to minimize future impacts to the Black Fork. This included stabilizing the stream bank by grading the slope and placing rock, installing a clay cutoff wall (1100 ft. long x 17 ft. deep x 3 ft. thick) to prevent groundwater seepage, and stabilizing the top of the landfill by grading and installing an impermeable cap. This project was completed on September 24, 1991. Outfalls 013 and 014 discharge stormwater to the Black Fork from the ferrous park grounds without treatment.

Ohio EPA conducted 48-hr. acute screening bioassays at Copperweld as part of a toxics evaluation in conjunction with permit reissuance in 1998. Grab and composite derived outfall 005 effluents and Tuby Run upstream and in the acute mixing zone were evaluated using the fathead minnow *Pimephales promelas* and daphnid *Ceriodaphnia dubia* as test organisms. Bioassay number 98-2024-NW was conducted in March 1998. Test results concluded that outfall 005 effluents were not acutely toxic. Fathead minnow mortality was 5% in the effluent composite sample. *C. dubia* mortality was 5% in both effluent grabs and 10% in the composite. No other mortality or adverse effects occurred. Bioassay number 98-2065-NW was conducted in May 1998. Test results concluded that outfall 005 effluents were not acutely toxic. Fathead minnow mortality was 5% in the effluent composite and Tuby Run upstream samples. *C. dubia* mortality was 15% in the composite sample.

Loading trends from outfall 005 are displayed in Figure 4. Most load rates appear to only fluctuate with discharge. There does appear to be an improvement in zinc removal beginning around 1993. Improvements in oil and grease removal occurred in 1996. The only permit violation documented in 1998 was for suspended solids during August at outfall 602 (Table 9).

Armco Inc.-Mansfield Operations (f.k.a. Empire Detroit Steel)

Armco Inc.-Mansfield Operations, Ohio EPA permit # 2ID00003, is located at 913 Bowman St., Mansfield, OH. The current permit became effective on 1 November, 1995 and expires on 31 March, 2000. The facility uses scrap steel to manufacture carbon, silicon, and stainless steel coils and sheets. Scrap steel is melted in two electric arc furnaces in the melt shop, which includes a continuous caster that casts the melted steel into slabs. The slabs are reheated, rolled into strips, and wound into coils in the hot strip mill. The coils are then transferred to the cold strip mill for pickling and cold rolling. Raw water used at the facility includes sources from wells, the Rocky Fork, and City of Mansfield municipal supply. Oily water emulsions are sent to the oil cracking and evaporator plant to separate the mixture and recover the waste oil. Wastewater from this process is discharged to the municipal sewer. Pickle line rinse water is pretreated and either discharged to the municipal sewer or transported off site for deep well disposal. A water recirculation reservoir receives contact cooling water from the hot strip mill through a series of underground pipes. Oil is skimmed and stored in an adjacent pond and the remaining water is recycled to the hot strip mill. Waste oil is sold to a refiner and solids are hauled to a landfill. There are four outfalls which discharge to the Rocky Fork Mohican River. Outfall 001 contains blowdown from the hot strip mill and continuous caster, non-contact cooling water from the electric arc furnace, and stormwater and discharges at RM 14.95. This

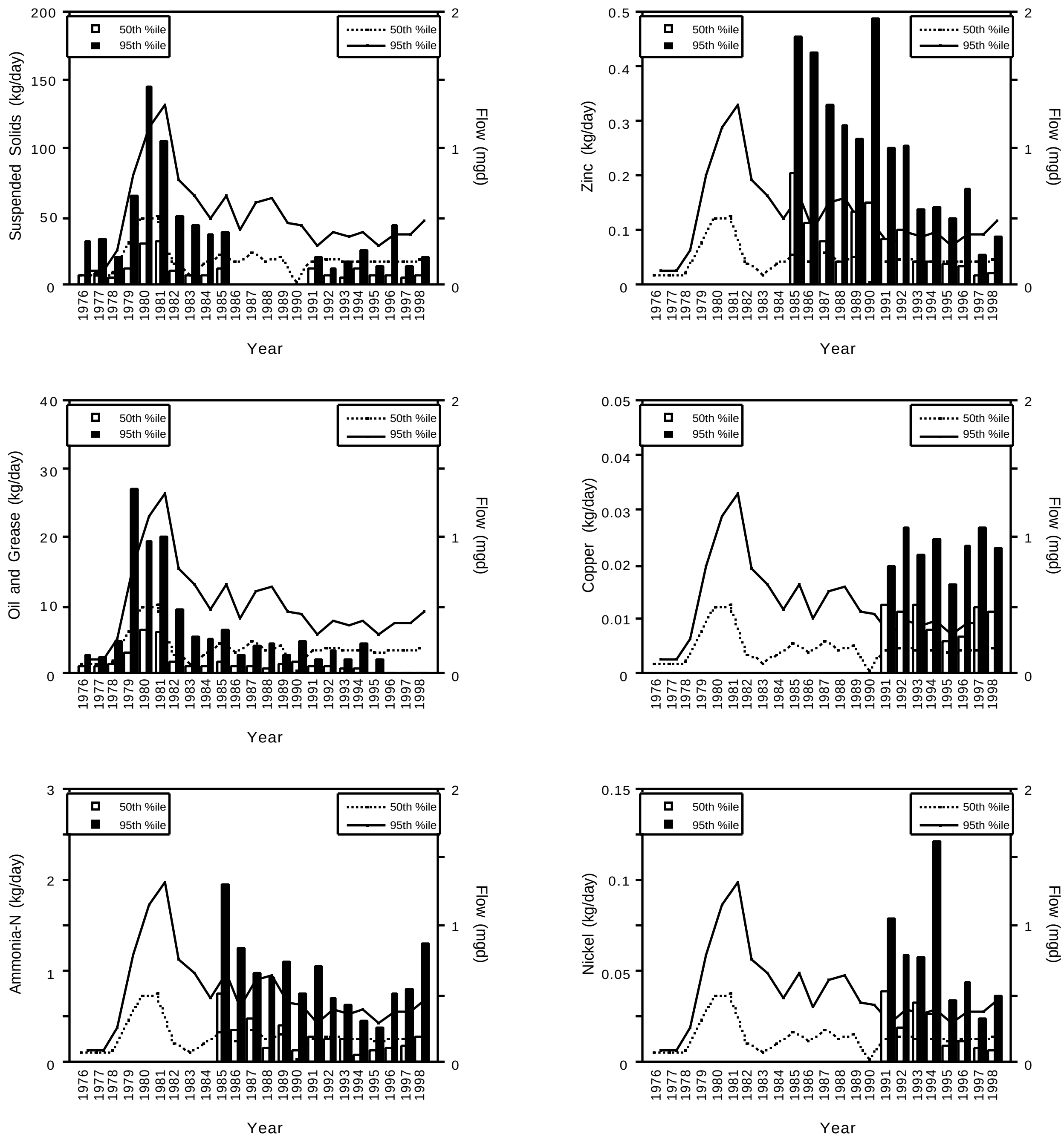

Figure 4. Median and 95th percentile annual suspended solids, oil and grease, ammonia-N, zinc, copper, nickel and flow to the Tuby Run by the Copperweld 005 outfall, 1976-1998.

water is retained in a series of two sedimentation lagoons before discharge. Outfall 002 contains non-contact cooling water from the annealing furnace and DX machine in the cold mill, blowdown from the oil cracking plant, and stormwater and discharges to the Rocky Fork at RM 14.48. This water passes through an oil and water separator before discharge. Outfall 003 contains boiler and skimmer blowdown from the plant boiler house and overflow from the main office pond and discharges to the Rocky Fork at RM 14.73 without treatment. Outfall 004 contains overflow from the cold mill, non-contact cooling water from the boiler house air compressor, and stormwater and discharges to the Rocky Fork at RM 14.70 without treatment.

Ohio EPA conducted 48-hr. acute screening bioassays at Armco as part of a toxics evaluation in conjunction with permit reissuance in 1998. Grab and composite derived outfall 002 effluents and Rocky Fork upstream and in the acute mixing zone were evaluated using the fathead minnow *Pimephales promelas* and daphnid *Ceriodaphnia dubia* as test organisms. Bioassay number 98-2074-NW was conducted in June, 1998. Test results concluded that outfall 002 effluents were acutely toxic to fathead minnows. Fathead minnow mortality was 10 and 15% in the effluent composite and day 2 grab samples, respectively, with seventeen fish in the composite and one in the grab sloughing from the gills. The day 1 effluent grab and Rocky Fork samples were not acutely toxic to fathead minnows. No *C. dubia* died or displayed adverse effects in any of the samples assessed. The fathead minnow definitive bioassay results indicated that effluent toxicity decreases over time. The 24-hr. EC50 was 83% and an EC50 could not be calculated for exposure times greater than 48 hrs. because less than half the fish were affected. Bioassay number 98-2094-NW was conducted in July, 1998. Test results concluded that outfall 002 effluents were not acutely toxic.

Combined loading trends from outfalls 001-004 are displayed in Figure 5. The removal of pretreated wastewater from the oil cracking unit that historically discharged internally to outfall 002 has improved effluent quality. Combined loadings of oil and grease and suspended solids both exhibit a decreasing trend beginning around 1994. The only permit violations documented in 1998 were for zinc at outfall 001 and oil and grease at outfall 004 in March and copper at outfall 001 in December (Table 9).

Mansfield WWTP

The City of Mansfield WWTP, Ohio EPA permit # 2PE00001, is located at 385 S. Illinois Ave., Mansfield, OH. The current permit became effective on 1 November, 1995 and expires on 31 March, 2000. Sewage treatment facilities were first introduced to Mansfield when a primary plant was constructed in 1901. It was upgraded in 1915 to include Imhoff tanks, trickling filters, and secondary clarifiers. An activated sludge plant was constructed to provide secondary treatment at a design flow of 4.5 MGD in 1937. This facility eventually became overloaded due

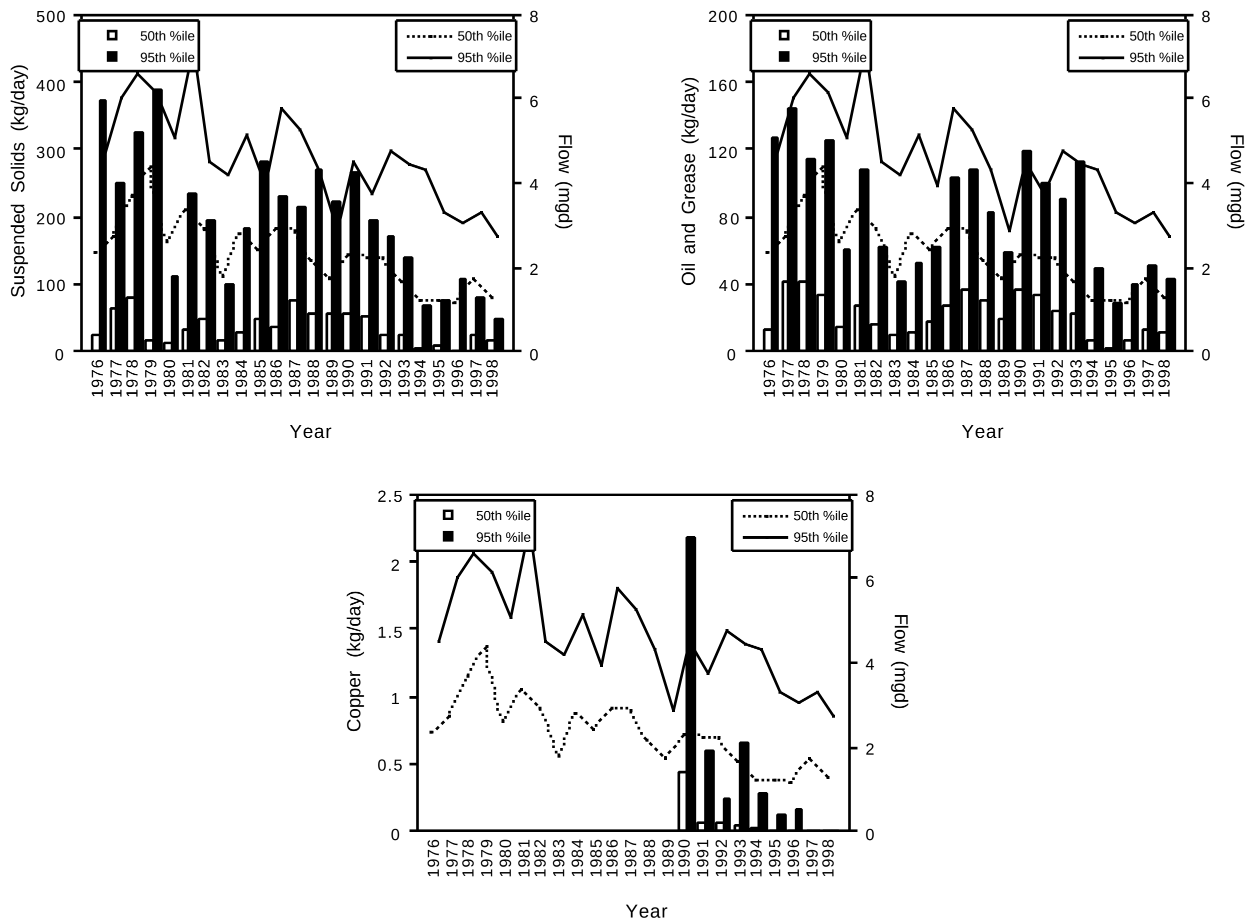

Figure 5. Median and 95th percentile annual suspended solids, oil and grease, copper loadings and flow to the Rocky Fork Mohican River by the Armco Inc. 001-004 outfalls, 1976-1998.

to rapid growth, combined sewers, and excessive inflow and infiltration in the collection system. In 1960 an expansion was completed and this increased plant capacity to 15.0 MGD. Facilities remained unchanged until 1982, when construction of the Phase I project began. This mainly improved sludge handling with the addition of screening prior to the digesters. The Phase II project involved a major rehabilitation and separation of the collection system. Most of these upgrades were completed by 1987. Treatment includes an influent bypass, two bar screens, an aerated grit tank, 5.0 million gallon flow equalization basin, two preaeration tanks, two primary clarifiers, primary bypass, eight aeration tanks, three secondary clarifiers, chlorination, and dechlorination. Sludge is anaerobically digested and dewatered prior to disposal at an on site stockpile area. Runoff from this area is collected and pumped to the WWTP headworks. The facility operates under an Ohio EPA approved pretreatment program implemented in 1984. Approximately 20% of the hydraulic load is from industrial sources. Final effluent discharges to the Rocky Fork Mohican River at RM 11.18. The collection system is comprised of 100% separate sewers and has nine lift stations. The average design capacity of the facility is 15.0 MGD, the hydraulic capacity is 25.0 MGD, and the annual average discharge is 10.5 MGD.

Ohio EPA conducted 48-hr. acute screening bioassays at the Mansfield WWTP as part of a toxics evaluation in conjunction with permit reissuance in 1998. Grab and composite derived outfall 001 effluents and Rocky Fork upstream and in the acute mixing zone were evaluated using the fathead minnow *Pimephales promelas* and daphnid *Ceriodaphnia dubia* as test organisms. Bioassay number 98-2028-NW was conducted in March, 1998. Test results concluded that outfall 001 effluents were not acutely toxic. No mortality or any other adverse acute effects occurred to either test organism in any of the samples submitted. Bioassay number 98-2071-NW was conducted in June, 1998. Test results concluded that outfall 001 effluents were not acutely toxic. *C. dubia* mortality was 85 and 95% in the upstream and mixing zone, respectively. No other mortality or adverse acute effects occurred.

Loading trends from outfall 001 are displayed in Figure 6. Treatment improvements due to upgrades completed in 1987 are well documented in the graphs. Loads for BOD5, ammonia, and suspended solids particularly showed significant decreases. Several permit violations were documented in 1998, especially regarding cBOD5 in July and August (Table 9).

Lucas WWTP

The Village of Lucas WWTP, Ohio EPA permit # 2PB00038, is located on Broad St., Lucas, OH. The current permit became effective on 1 February, 1995 and expired on 31 January, 2000. The Sewage treatment facility began as a primary treatment plant was constructed in 1954. This plant was subsequently replaced with the existing facility in 1987. Treatment includes a comminutor, bar screen bypass, 40,000 gallon flow equalization tank, two extended aeration tanks, two final clarifiers, and ultraviolet disinfection. The stormwater tank receives flows in excess of 0.216 MGD and bypasses in excess of 0.507 MGD. Bypasses occasionally occurred due to excessive inflow and infiltration in the collection system. All overflows combine with outfall 001 effluent prior to discharge. Sludge is aerobically digested, dried on beds, and land applied at agronomic rates under an approved sludge management plan. Final effluent discharges to the Rocky Fork at RM 3.65. The collection system is comprised of 100% separate sewers and has two lift stations, one which contains a bypass. The average design capacity of the facility is 0.096 MGD, the hydraulic capacity is 0.507 MGD, and the annual average

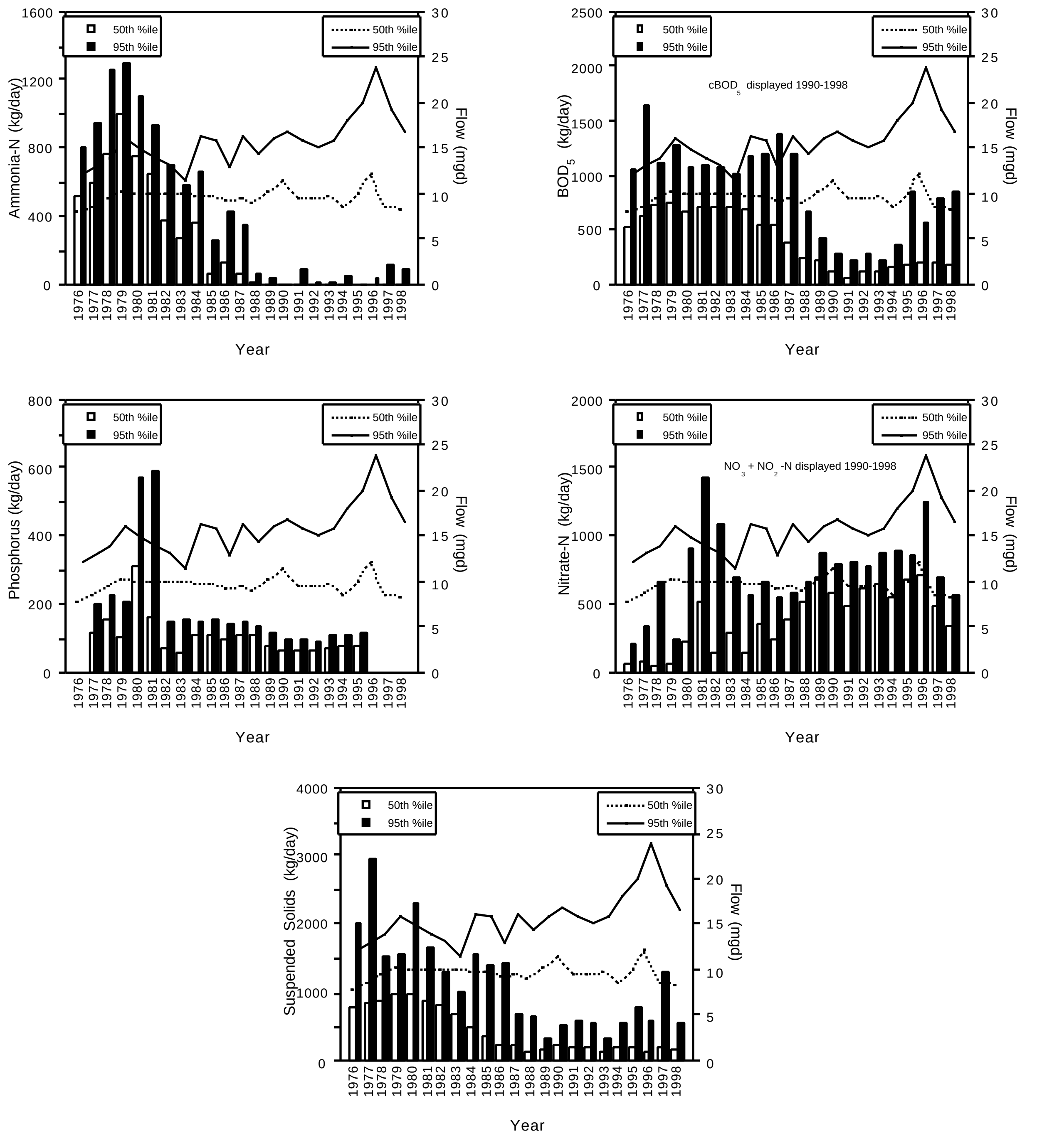

Figure 6. Median and 95th percentile annual ammonia-N, BOD_5, phosphorus, nitrate, suspended solids loadings and flow to the Rocky Fork Mohican River by the Mansfield WWTP, 1976-1998.

discharge is 0.076 MGD.

Loading trends from outfall 001 are displayed in Figure 7. Treatment improvements due to the renovation completed in 1987 is well represented in the graphs. Loadings and discharge rates appear to be increasing significantly in recent years and this should be monitored closely to ensure the facility is not being overloaded. No permit violations were documented in 1998.

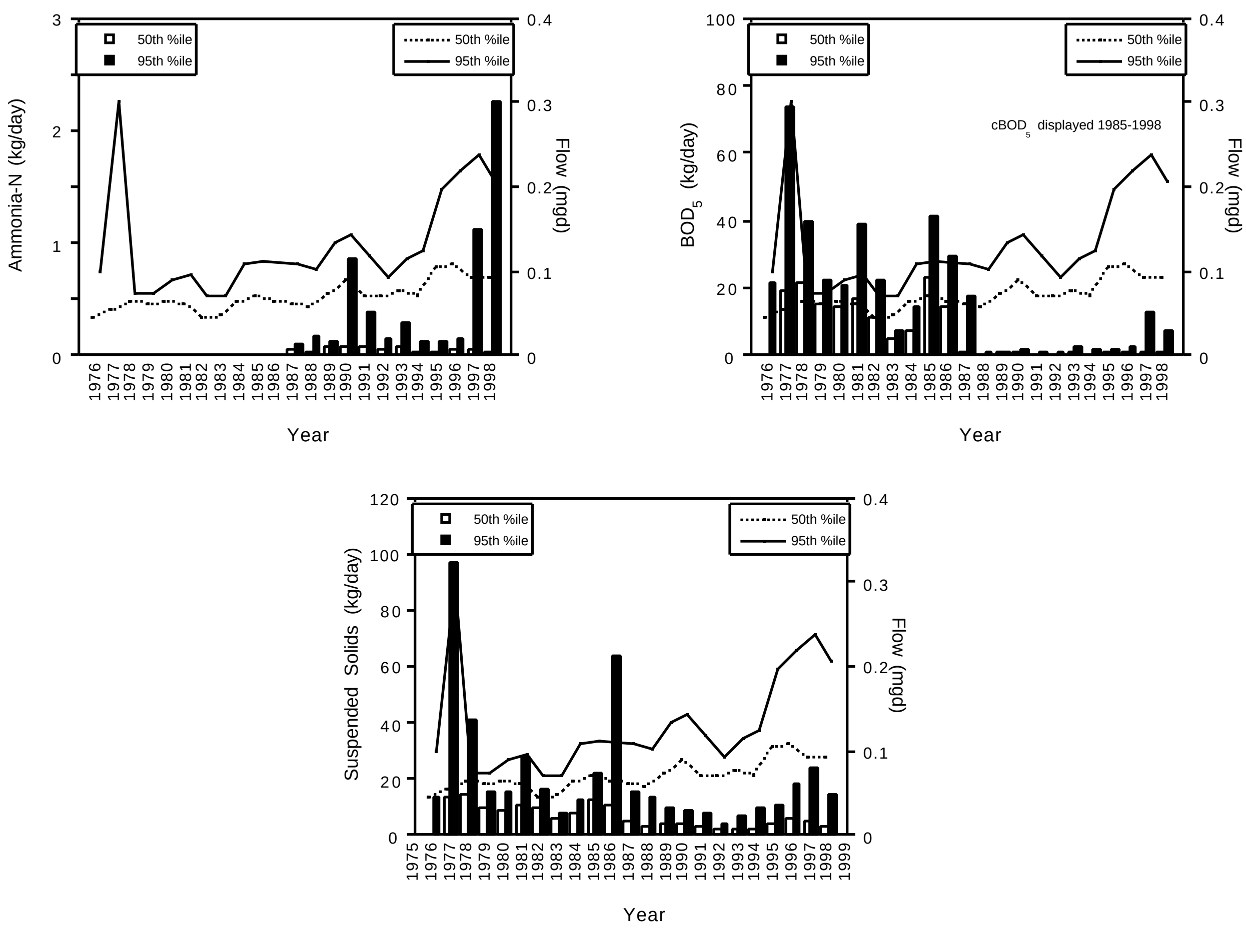

Figure 7. Median and 95th percentile annual ammonia-N, BOD_5, suspended solids loadings and flow to the Rocky Fork Mohican River by the Lucas WWTP, 1976-1998.

Lexington WWTP

The Village of Lexington WWTP, Ohio EPA permit # 2PB00019, is located at 205 S. Mill St., Lexington, OH. The current permit became effective on 1 July, 1995 and expires on 27 July, 2000. Sewage treatment facilities were first introduced to Lexington when an Imhoff tank, trickling filter, and secondary clarifier were constructed in 1954. This plant was subsequently replaced with the existing facility in 1969. Treatment includes a series of two aerated waste stabilization lagoons with chlorination and dechlorination. Final effluent discharges to the Clear Fork at RM 27.20. The collection system is comprised of 100% separate sewers and has one lift station, which has no bypass or overflow. Approximately 2% of the service area does not have sewers. The average design capacity of the facility is 0.678 MGD and the annual average discharge is 0.550 MGD.

Loading trends from outfall 001 are displayed in Figure 8. Since there have been no major upgrades to the facility during the monitoring period, no increasing or decreasing trend in loadings is apparent. Peak flows occasionally exceed design criteria, but this does not appear to result in permit violations, since none were documented in 1998.

Bellville WWTP

The Village of Bellville WWTP, Ohio EPA permit # 2PB00057, is located at 199 S. School St., Bellville, OH. The current permit became effective on 1 August, 1996 and expires on 28 July, 2001. Sewage treatment facilities were first introduced to Bellville in 1937 and this plant was replaced with the existing facility in 1978. Treatment includes an influent bypass, comminutor, bypass bar screen, two primary clarifiers, two rotating biological contactors (RBCs), two secondary clarifiers, and ultraviolet disinfection. The RBCs installed in 1978 never operated properly and failed in February 1984. The facility continued to operate in a primary treatment mode until new RBCs went on line in 1987. Ultraviolet disinfection facilities were installed in 1992. Sludge is aerobically digested, hauled, and land applied at agronomic rates under an approved sludge management plan. Sludge handling facilities were upgraded from two anaerobic digesters in 1994. Final effluent discharges to the Clear Fork at RM 19.17. The collection system is comprised of 100% separate sewers and has three lift stations, none of which contain bypasses or overflows. The average design capacity of the facility is 0.330 MGD, hydraulic capacity is 0.825 MGD, and annual average discharge is 0.189 MGD.

Loading trends from outfall 001 are displayed in Figure 9. Treatments improvements due to the installation of new RBCs in 1987 is well documented in the graphs. It is also evident that the facility was only operating in a primary treatment mode from late 1984 to early 1987. The sludge handling upgrade is most

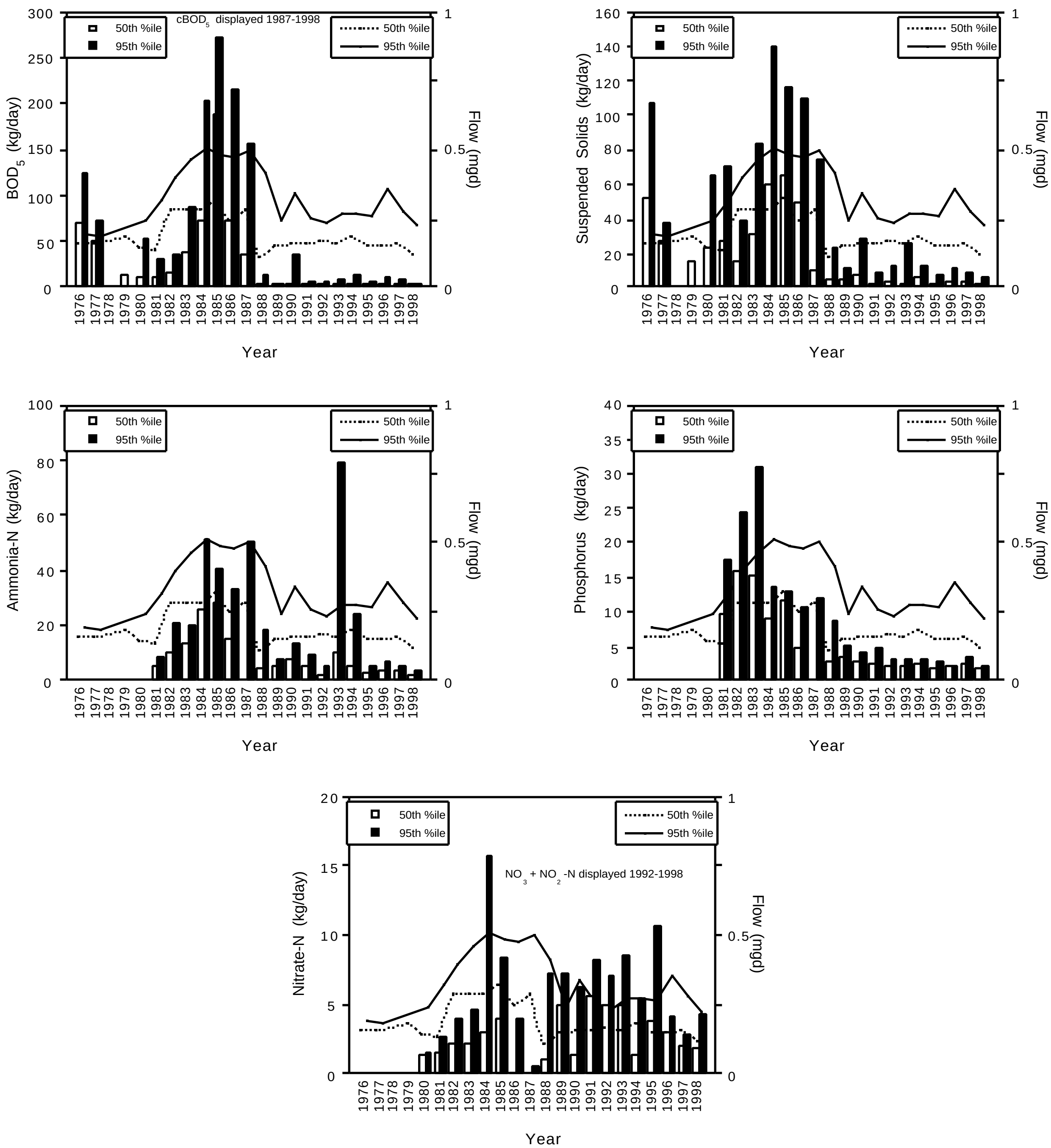

Figure 8. Median and 95th percentile annual BOD_5, suspended solids, ammonia-N, phosphorus, nitrate loadings and flow to the Clear Fork Mohican River by the Lexington WWTP, 1976-1998.

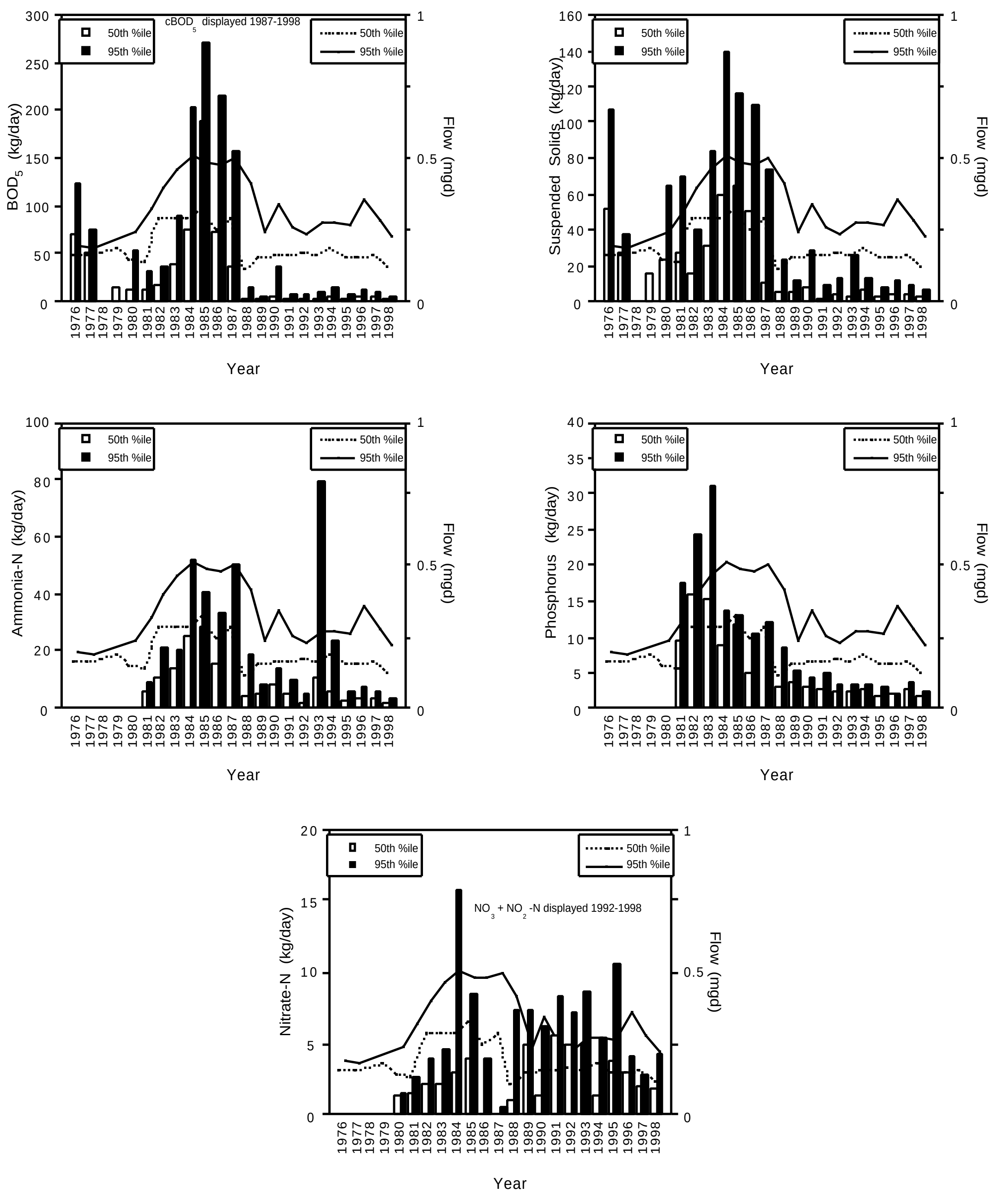

Figure 9. Median and 95th percentile annual BOD_5, suspended solids, ammonia-N, phosphorus, nitrate loadings and flow to the Clear Fork Mohican River by the Bellville WWTP, 1976-1998.

notable by the decrease of ammonia loadings. The only permit violations documented in 1998 were for pH in October (Table 9).

Butler WWTP

The Village of Butler WWTP, Ohio EPA permit # 2PA00044, is located on S.R. 95 East, Butler, OH. The current permit became effective on 2 January, 1995 and expires on 31 December, 2000. Sewage treatment facilities were first introduced to Butler in 1956 and this plant was replaced with the existing facility in 1982. Treatment includes a comminutor, bypass bar screen, two 27,200 gallon aerated flow equalization tanks, Imhoff tank (used as primary unit), primary clarifier, two RBCs, two secondary clarifiers, and chlorination. The stormwater tanks receive flows in excess of 0.20 MGD and bypass in excess of 0.30 MGD. Bypasses occasionally occur due to excessive inflow and infiltration in the collection system. Sludge is aerobically digested, dried on beds, and land applied at agronomic rates under an approved sludge management plan. Final effluent discharges to the Clear Fork at RM 13.90. The collection system is comprised of 100% separate sewers and has one lift station. The average design capacity of the facility is 0.12 MGD, the hydraulic capacity is 0.30 MGD and the annual average discharge is 0.16 MGD.

Loading trends from outfall 001 are displayed in Figure 10. Treatment improvements due to the expansion completed in 1982 is well documented in the graphs. It is also evident that peak flows exceed the hydraulic capacity of the facility. Numerous permit violations for residual chlorine were documented in 1998 and are summarized in Table 9. The facility is currently investigating the feasibility of a dechlorination unit to alleviate these violations. Several violations for cBOD5 were also documented.

Ashland WWTP

The City of Ashland WWTP, Ohio EPA permit # 2PD00010, is located at 865 U.S. 42, Ashland, OH. The current permit became effective on 1 November 1995 and expired on 1 October, 1999. A trickling filter plant was constructed to provide secondary treatment at a design flow of 1.28 MGD in 1940. This plant was expanded to a design capacity of 2.5 MGD in 1957. Another improvement project converted the plant to an advanced treatment facility utilizing the trickling filter-solids contact process in 1989. Treatment includes an influent bypass, bar screens, aerated grit chamber, two aerated flow equalization tanks, four primary clarifiers, primary bypass, two trickling filters, three solids contact chambers, two secondary clarifiers, ultraviolet disinfection, and cascade aeration. The stormwater tanks receive flows in excess of 10.0 MGD and bypass in excess of 15.0 MGD. Sludge is stabilized using hydrated lime, dewatered using belt filter presses, and land applied at agronomic rates under an approved sludge management plan. The facility operates under an Ohio EPA approved pretreatment program implemented in 1984.

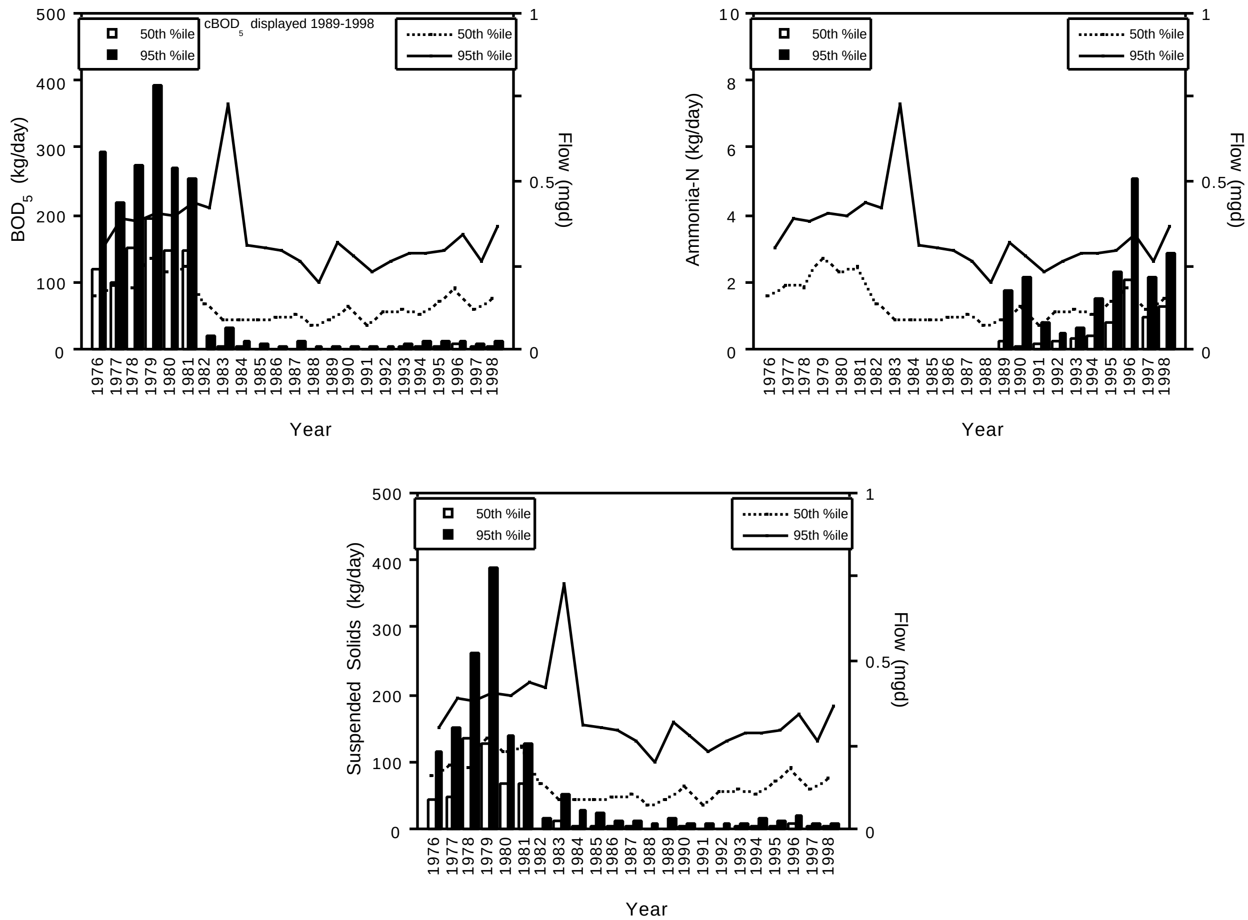

Figure 10. Median and 95th percentile annual BOD_5, suspended solids, ammonia-N, phosphorus, nitrate loadings and flow to the Clear Fork Mohican River by the Butler WWTP, 1976-1998.

Final effluent discharges to Lang Creek at RM 0.34. The collection system is comprised of 100% separate sewers and has 13 lift stations, which have no bypasses and three overflows (SSOs). Approximately 1% of the service area does not have sewers. The average design capacity of the facility is 10.0 MGD, the hydraulic capacity is 15.0 MGD, and the annual average discharge is 3.8 MGD.

Ohio EPA conducted 48-hr. acute screening bioassays at the Ashland WWTP as part of a toxics evaluation in conjunction with permit reissuance in 1998. Grab and composite derived outfall

001 effluents and Lang Creek upstream and in the acute mixing zone were evaluated using the fathead minnow *Pimephales promelas* and daphinid *C. dubia* as test organisms. Bioassay number 98-2032-NW was conducted in March, 1998. Test results concluded that outfall 001 effluents were not acutely toxic. No mortality or any other adverse acute effects occurred to either test organism in any of the samples tested. Bioassay number 98-2063-NW was conducted in May 1998. Test results concluded that outfall 001 effluents were not acutely toxic. No mortality or any other adverse acute effects occurred to either test organism in any of the samples submitted.

Loading trends from outfall 001 are displayed in Figure 11. Treatment improvements due to the expansion completed in 1989 is well documented in the graphs. Loads of BOD5, ammonia, and suspended solids all declined significantly after the expansion went on line. A steadily increasing trend in discharge rate was also indicated, likely due to sewer extensions and the addition of industrial pretreatment sources. Several permit violations for metals were documented in 1998 and are summarized in Table 9. They were likely due to loadings from pretreatment industries. The city has pursued administrative activity under the authority of its pretreatment program in an attempt to eliminate these violations. There is a significant concern for the frequency of bypasses from the equalization basins. The facility reported bypasses totaling a duration of 174 hours in 1998. The overflow is located just upstream from outfall 001.

Division of Hazardous Waste Management

The Ohio EPA Division of Hazardous Waste Management (DHWM) is responsible for the implementation of the Resource Conservation and Recovery Act (RCRA). The division regulates facilities that treat, store, and dispose of hazardous wastes (TSDFs) and facilities that generate and temporarily store wastes through a permit, inspection, and enforcement action process. There are no TSDFs in the Mohican River Watershed study area. Facilities are characterized as large quantity generators (LQG) if they generate > 1000 kg of waste per month, small quantity generators if they generate 100-1000 kg per month, and conditionally exempt generators if they generate < 100 kg per month. There are a total of 420 facilities classified as hazardous waste handlers in Richland and Ashland counties, of which 61 are considered LQG. Many are located in the cities of Mansfield, Ashland, and Shelby and include Armco, Therm-O-Disk, Ashland Chemical, Abbott Labs, and Copperweld. Any of these handlers have the potential to impact stream ecology if its wastes are improperly managed. Facilities determined to be out of compliance during an inspection are issued a notice of violation letter that contains terms and conditions required to return to compliance. Common violations include failure to amend contingency plans, properly train employees, inspect and maintain emergency equipment and storage areas, properly label containers, etc. These are the types of violations that can cause a stream impact if an accidental spill or other catastrophic event occurs.

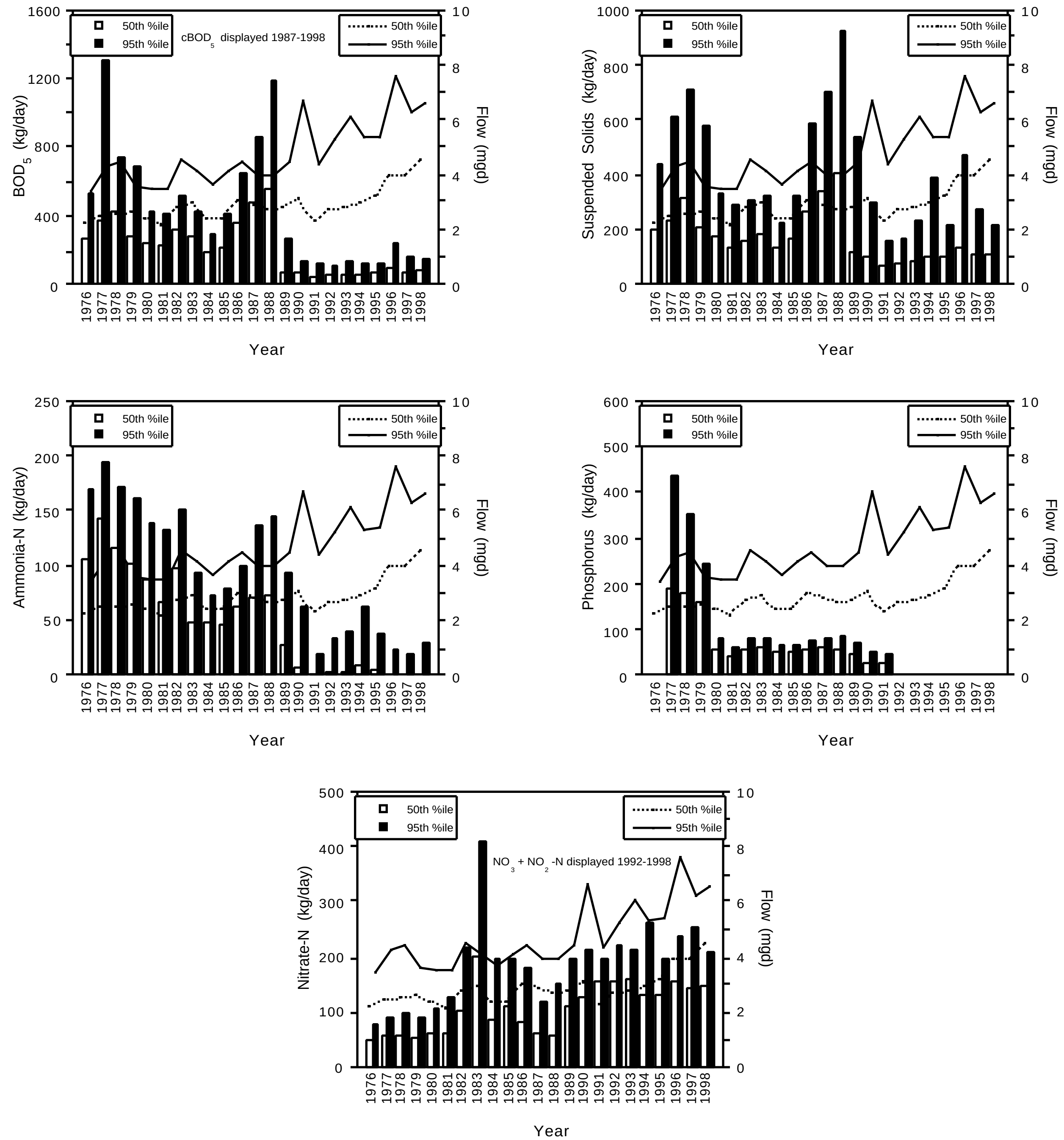

Figure 11. Median and 95th percentile annual BOD_5, suspended solids, ammonia-N, phosphorus, nitrate loadings and flow to Lang Creek by the Ashland WWTP, 1976-1998.

Division of Solid and Infectious Waste Management

The Ohio EPA Division of Solid and Infectious Waste Management (DSIWM) regulates the disposal of solid waste, construction and demolition waste, and infectious waste. The division reviews permits for new landfills and expansions of existing sites, transfer stations, and solid waste composting facilities, oversees the county solid waste planning process, and provides assistance and oversight to county health department solid waste programs. Facilities located in the study area that fall under regulation are discussed below. Prior to Ohio EPA regulatory authority there were several municipal, township, and private dumps active in the study area. These facilities accepted a variety of industrial, commercial, and residential wastes and did not operate under current siteing and closure requirements. Most of these sites closed around 1969. A list of known dumps is presented in Table 10. Testing conducted at the Ashland County sites in 1994 and 1995 indicated that no explosive gas hazard is present.

Richland Co. Landfill

The Richland Co. Landfill is a 133 acre site located in Mansfield. The site is bordered by Cairns Rd. to the south, Crall Rd. to the north, and Lahm Municipal Airport to the east. The facility began operation in 1970 and accepted both municipal and industrial waste, some of which were later characterized as hazardous under RCRA. These wastes were commingled until about 1980, when the facility began to dispose hazardous wastes in two distinct cells. This continued until 1986 when the two cells were certified closed. Solid waste disposal continued until 1988. The remaining acreage was used to dispose construction and demolition debris and was certified closed in 1993. Groundwater monitoring indicates several metals and VOCs are elevated above background and that leachate migration down gradient of the landfill is occurring. Surface drainage is to the Rocky Fork.

Noble Rd. Landfill

The Noble Rd. Landfill is a 288 acre site located in Butler Township, Richland County. This is an active site bordered by Noble Rd. to the north, Fowler Woods Nature Preserve to the east, and is about one-half mile east of S.R. 13. A Permit-To-Install (PTI) was issued by the Ohio EPA in May 1994 which allowed for placement of solid waste within 102 of the 288 acres available at the site. The landfill siteing, design, and construction comply with best available technology, including a bottom liner consisting of recompacted soil in combination with a geosynthetic liner, a leachate collection and management system, a recompacted soil cap system, explosive gas venting and monitoring, surface water management, groundwater monitoring, and post-closure care. The facilities projected life expectancy is approximately 34 years. Surface drainage is to the Black Fork via Whetstone Creek.

Table 10. Approximate location and sub-basin of closed dumps operated in the Mohican River Watershed study area prior to Ohio EPA regulation.

Dump	Location
Black Fork	
Blooming Grove Twp.	S.R. 603 and T.R. 224
Butler Twp.	S.R. 13 and T.R. 246
Franklin Twp.	C.R. 232 and T.R. 234
Weller Twp.	T.R. 89 and T.R. 249
Mifflin Twp.	C.R. 293 and T.R. 296
Sharon Twp.	S.R. 61 and T.R. 61
City of Shelby	C.R. 191 and C.R. 58
Jackson Twp.	C.R. 90 and T.R. 208
Village of Shiloh	S.R. 603 and C.R. 50
Rocky Fork	
Monroe Twp.	S.R. 39 and T.R. 355
City of Mansfield	Cairns Rd.
Clear Fork	
Worthington Twp.	S.R. 97 and T.R. 381
Jefferson Twp.	S.R. 97 and C.R. 341
Perry Twp.	C.R. 27 and C.R. 121
Washington Twp.	S.R. 13 and T.R. 324
Troy Twp.	T.R. 325 and T.R. 130
Sandusky Twp.	C.R. 47 and T.R. 173
Jerome Fork	
Orange Twp.	S.R. 58 and C.R. 1175
City of Ashland	U.S. 42 and Cleveland Ave.
Village of Jeromesville	S.R. 89 and C.R. 30-A
Vermillion Twp.	T.R. 2104 and T.R. 585
Muddy Fork	
Jackson Twp.	C.R. 800 and T.R. 251
Perry Twp.	C.R. 175 and T.R. 1550

Ashland Co. Landfill

The Ashland Co. Landfill is a 195 acre site located in Vermillion Township, Ashland County. The site is bordered by C.R. 1754 to the north and C.R. 655 to the east. It was in operation from 1974-1997. Post-closure activities at the site include clay cap maintenance, leachate management, groundwater monitoring, and explosive gas monitoring. Surface drainage is to the Jerome Fork via Oldtown Run.

Division of Emergency and Remedial Response

The Ohio EPA Division of Emergency and Remedial Response (DERR) oversees cleanups at sites active prior to RCRA based on the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). This law provides broad authority to investigate and remediate otherwise uncontrolled hazardous waste sites. A master sites list (MSL) for Ohio was compiled to ensure that investigations were conducted at these unregulated sites. Sites located in the study area are discussed below.

Armco Inc.- Mansfield Operations (f.k.a. Empire-Detroit Steel)

The Armco facility is located at 913 Bowman St., Mansfield, OH. The facility consists of a steel plant located on a 787 acre parcel of land that has been in operation since circa 1900. Armco is a secondary steel plant that utilizes scrap steel, steel ingots, and coke to produce its final product. It does not have primary steel production capabilities, which would include coke oven and blast furnace facilities. Environmental concern is associated with electric arc furnace dust, waste pickle liquor, cooling water, and coke and slag storage piles. Between 1964 and 1980, the electric arc furnace dust was landfilled in the northeast section of the facility property. It is now hauled off-site and landfilled. Between 1968 and 1970 approximately 11 million gallons of spent pickle liquor was injected into an on site disposal well. This well was abandoned and filled with cement and an acid recovery system is now operated to handle this waste. Coke and slag by-product are stored in large uncovered piles before either being used in the refining process or sold as fill. The facility was classified as an unpermitted TSDF from 1989 until it underwent a RCRA closure in 1995. Several spills affecting the Rocky Fork have recently occurred, including 50 gallons of emulsified rolling oil on January 15, 1981, 200 gallons of emulsified oil on May 31, 1985, 100-200 gallons of sulfuric acid in July 1988, and 100-200 gallons of oil and 11,000 gallons of waste acid in October 1988. Soil sampling has revealed elevated concentrations of volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and metals at the facility. Groundwater monitoring has detected elevated concentrations of trichloroethene (TCE), tetrachloroethene or perchloroethene (PCE), and chloroform.

Lincoln Fields

The Lincoln Fields site is located in a residential and commercial area of Madison Township, Richland County. The Lincoln Fields Water Cooperative served a small organization of homes here with drinking water supplied from wells. The wells were closed in 1993 when high levels of TCE, PCE, cis-1,2-dichloroethene (DCE), and 1,1,1-trichloroethane (TCA) were detected in routine samples collected to comply with Safe Drinking Water Act requirements.

City of Mansfield Landfill

The City of Mansfield Landfill site is a 44 acre parcel located in Madison Township, Richland County. The site is bordered by Cairns Rd. to the north and Harrington Memorial Rd. to the east and is just to the south of the former Richland County landfill. It was in operation from 1953 to 1976 and accepted municipal and industrial waste. Waste was reportedly buried in trenches ranging from 5 to 10 ft. deep. A major underground fire burned at the site for more than 2 years during the 1970s. The migration of explosive gas has been a major concern in the past. Surface drainage is to the Rocky Fork.

Mansfield Products Co.

The Mansfield Products site is located at 246 E. 4th St., Mansfield, OH. The facility was originally used to manufacture stoves and from 1936 to 1990 was used to manufacture washers, dryers, and other home appliances. White Consolidated Industries purchased the Mansfield Products site from Westinghouse Electric Corporation in 1975 and operated the facility until it was closed in 1990. The majority of the site is now owned by Mansfield Commerce Center and is used for packaging and warehousing. Manufacturing operations included milling aluminum, chemical etching, electroplating, alkaline phosphate washing, painting, enamel coating, and assembly. Chemicals used in the process included nickel, chromium, zinc, copper, sodium cyanide, chromic acid, sulfuric acid, paints, enamel, and polypropylene pellets. Environmental concern is associated with contaminants contained in contact and non-contact process waters and stormwater discharged to the adjacent Rocky Fork. The contact wastewater was discharged untreated until the construction of an on site industrial wastewater treatment plant in 1960 and an NPDES permit was not issued until 1976. Remedial activities at the site have included the closure of a cyanide pot and storage pit in 1990, removal of ten underground storage tanks used to contain solvents, fuels, and oils and the removal of associated contaminated soil in 1988, and a groundwater recovery system in 1990. A screening site inspection conducted in 1990 revealed elevated concentrations of PCBs (arochlor-1260), PAHs, and metals in soil and sediment samples.

Ohio Air National Guard- 179th Tactical Air Wing

The Ohio Air National Guard facility is located at 1947 Harrington Memorial Rd., Mansfield, OH. The facility has used hazardous materials and generated small amounts of waste during mission oriented operations and maintenance since 1948. Some of these operations include maintenance of aircraft, ground equipment, and vehicles and petroleum lubricant management and distribution. Hazardous materials handled include waste oil, paints, thinners, strippers, and solvents. Several areas of concern include sites where fire training was conducted using waste fuels and solvents, drum storage areas, and locations of fuel and oil spills. Surface drainage is to the Rocky Fork.

Ohio Brass Co.

The Ohio Brass site is located at 380 N. Main St., Mansfield, OH. The facility closed in 1984 and a portion was purchased by Mansfield Ferrous Castings. Production included melting, casting, machining, and galvanizing of brass, aluminum, and steel. Stormwater and non-contact cooling water was discharged to both the Rocky Fork and Tuby Run from several permitted outfalls.

Omni Source Corp.

The Omni Source facility is located at 1500 Old Bowman Rd., Mansfield, OH. It recycles various types of scrap metal, including steel, ferrous, aluminum, and copper. A metal shear is operated at the site and leakage of hydraulic fluid is collected in an oil water separator. The fluid is routinely hauled off-site, although there is potential for material to overflow into the Rocky Fork during storm events.

Prestolite Electric (f.k.a. Allied Signal)

The Prestolite Electric site is located at 1125 National Pkwy., Mansfield, OH. Prestolite purchased the facility from Allied Corp. in 1986. The facility manufactured and assembled solenoids, contactors, and electronic equipment. A solvent containing TCA was stored and used in the plant for parts cleaning, along with a detergent containing phosphoric acid. Spent fluids were reportedly disposed in small quantities on plant property adjacent to the buildings. These compounds have been detected at elevated levels in monitoring wells and soil samples. Surface drainage is to a tributary of Tuby Run, which flows into the Rocky Fork.

United Technologies (f.k.a. Hamilton Standard)

The United Technologies site is located at 147 Plymouth St., Lexington, OH. Stevens Manufacturing originally constructed the facility in 1954 for metals machining and component fabrication. Hamilton Standard Controls, Inc. manufactured and assembled electronic components at the facility until 1988 when it was sold to Stemco Sensors and Switches, Inc. An active production facility was operated at the site by the Columbus Electric Manufacturing Company until November 1995. The building is currently used as a warehouse. Sometime around 1987 elevated levels of TCE, PCE, and DCE were detected in samples from two groundwater wells used to supply non-contact cooling water. Subsequently, two air stripper towers were installed to treat the groundwater before it is discharged to a tributary of the Clear Fork.

Ashland Chemical Co.- Specialty Polymers and Adhesives Facility

The Ashland Chemical facility is located at 1745 Cottage St., Ashland, OH. It manufactures specialty adhesives and sealants for the automotive, roofing, and construction industries. It was originally constructed by the Goodyear Tire and Rubber Co. in 1969 and was purchased by Ashland Chemical in 1984. Contaminant sources at the site include a hazardous waste container storage area, an above ground storage tank farm, and several leach beds used to treat stormwater. Ashland Chemical upgraded the gravel based tank farm used to store raw materials in 1987 by constructing an impervious concrete base and containment diking. It was during this activity that solvent contamination was identified in the underlying soils. The hazardous waste storage area was certified as closed in 1992 and all leach beds have since been rendered inactive. A remedial investigation was initiated in 1993 under an administrative consent order with the Ohio EPA. This investigation concluded that residual contamination present in soils and groundwater pose little, if any, risk to human health and the environment or potential for off-site migration to the Jerome Fork.

Unsewered Areas

Several villages and rural developments in the study area do not have centralized collection and treatment facilities for sanitary wastewater. These areas are typically served by a variety of "on-lot" systems, such as septic tanks, home aeration systems, and sub-surface sand filters. Sometimes these systems are coupled with leach and tile fields. When lots are too small to accommodate leach fields, or if either shallow bedrock or poorly drained soils are present, or if systems are not sufficiently maintained and operated, effluent will typically collect in a storm sewer and eventually discharge to a stream. Villages in the study area which do not have facilities include, but are not limited to Taylortown, Planktown, Rome, and Ganges in the Black Fork subbasin, Amoy in the Rocky Fork sub-basin, Millsboro, Blooming Grove, Kings Corners, Darlington, Newville, Hastings, North Woodbury, and Shauck in the Clear Fork sub-basin, Nankin, Polk, Hayesville, and Jeromesville in the Jerome Fork sub-basin, and Albion in the Muddy Fork sub-basin. Generally, soil types in this region are well drained and favorable for on-lot systems. As long as they are properly installed, operated, and maintained their impacts to water quality should be minimal. Common chemical impacts include elevated concentrations of ammonia, nitrate, and phosphorus. These impacts can result in toxicity to aquatic life. Human health is also an issue due to the presence of fecal coliform bacteria in sewage and the heavy recreational use in the watershed. Aesthetics are affected due to the presence of putrid odors, grey or black water, sludge accumulation, and growths of white filamentous bacteria.

Pollutant Spills

The Ohio EPA has a Release Reporting System (RRS) administered by the DERR that allows for spills to be reported to the agency via a toll free number. The dispatcher on duty then determines if an On-Scene Coordinator should respond to oversee clean-up efforts. A summary of spills reported in the study area during 1998 are presented in Table 11. The majority of reported incidents were sewage bypasses released from the Shelby and Ashland WWTPs. A condition contained in their NPDES permit requires these bypasses to be reported. They typically result from hydraulic overloading caused by excessive inflow and infiltration in the collection system, especially during storm events. Several permit violations were also reported by the Mohican State Park Campground WWTP. These were due to shock loads occurring during peak camping times. It will likely be necessary to install an equalization basin to alleviate these problems. Several fuel spills were reported due to auto accidents. Fortunately, response teams are often able to contain and recover the majority of these materials before they cause extensive environmental damage. Most other spills reported were from industrial facilities and were incidents related to damaged or failing equipment or broken or leaking product pipelines.

Table 11. Summary of pollutants spilled in the Mohican River Watershed study area reported to the Ohio EPA Division of Emergency and Remedial Response during 1998.

Date	Entity	Material	Cause	Waterway
01-01	citizen	fuel oil (20 gal)	storage tank	trib. to Tuby Run
01-07	Shelby WWTP	sewage	storm bypass	Black Fork
01-09	Ashland WWTP	sewage	storm bypass	Lang Creek
01-12	Ashland WWTP	sewage	storm bypass	Lang Creek
01-14	citizen	gasoline	car accident	Muddy Fork
01-30	Therm-O-Disk	oil (30 gal)	accident	trib. to Rocky Fk.
02-10	Synergy Production	ferric chloride	accident	trib. to Rocky Fk.
02-10	Synergy Production	iron precipitate	accident	trib. to Rocky Fk.
02-18	Ashland WWTP	sewage	storm bypass	Lang Creek
02-18	Shelby WWTP	sewage	storm bypass	Black Fork
02-19	Ashland WWTP	sewage	storm bypass	Lang Creek
03-16	United Technologies	wastewater	mother nature	trib. to Clear Fk.
03-21	Shelby WWTP	sewage	storm bypass	Black Fork
03-23	Ashland WWTP	sewage	storm bypass	Lang Creek
03-30	Abbott Labs	oil (50 gal)	accident	sewer to Town R.
03-31	Abbott Labs	oil (50 gal)	accident	sewer to Town R.
03-31	Copperweld	acid rinse (400 gal)	lagoon overflow	sewer to Tuby R.
04-09	Sensmeier Ind.	oil (100 gal)	storage tank	Black Fork
04-16	Shelby WWTP	sewage	storm bypass	Black Fork
04-17	Ashland WWTP	sewage	storm bypass	Lang Creek
05-03	Shelby WWTP	sewage	storm bypass	Black Fork
05-05	Ashland WWTP	sewage	storm bypass	Lang Creek
06-17	Ashland WWTP	sewage	storm bypass	Lang Creek
06-19	Mohican St. Pk. WWTP	permit violation	plant upset	Clear Fork
06-24	Copperweld	cooling water	lagoon overflow	Tuby Run
06-29	Ashland WWTP	sewage	storm bypass	Lang Creek
06-30	Ashland WWTP	sewage	storm bypass	Lang Creek
07-01	Ashland WWTP	sewage	storm bypass	Lang Creek
07-07	citizen	pig manure	complaint	Jerome Fork
07-10	Mohican St. Pk. WWTP	permit violation	plant upset	Clear Fork
07-13	Mohican St. Pk. WWTP	permit violation	plant upset	Clear Fork
07-16	Mohican St. Pk. WWTP	permit violation	plant upset	Clear Fork
07-18	Mohican St. Pk. WWTP	permit violation	plant upset	Clear Fork

Table 11. Continued.

Date	**Entity**	**Material**	**Cause**	**Waterway**
07-22	Ashland WWTP	sewage	storm bypass	Lang Creek
07-23	citizen	diesel fuel (150 gal)	truck accident	trib. to Jerome Fk.
07-27	citizen	crude oil	truck accident	trib. to Jerome Fk.
07-27	citizen	brine	truck accident	trib. to Jerome Fk.
08-04	Mohican St. Pk. WWTP	permit violation	plant upset	Clear Fork
08-12	Mohican St. Pk. WWTP	permit violation	plant upset	Clear Fork
08-17	Mohican St. Pk. WWTP	permit violation	plant upset	Clear Fork
08-18	citizen	unknown material	complaint	Town Run
08-25	Shelby WWTP	sewage	storm bypass	Black Fork
08-26	Ashland WWTP	sewage	storm bypass	Lang Creek
09-14	Rapid United Steel Hauler	diesel fuel (125 gal)	truck accident	Shipp Creek
10-28	Ashland WWTP	sewage	storm bypass	Lang Creek
10-28	Sunrise Finishing	anodizing water	unknown	trib. to Lang Cr.
10-28	Mansfield Plumbing Prod.	wastewater	unknown	Black Fork
11-03	Ashland WWTP	sewage	storm bypass	Lang Creek
11-16	Ashland WWTP	sewage	storm bypass	Lang Creek
12-09	Ashland WWTP	sewage	storm bypass	Lang Creek
12-11	Therm-O-Disk	wastewater	unknown	trib. to Rocky Fk.
12-22	Ashland WWTP	sewage	storm bypass	Lang Creek

Chemical Water Quality

Streams

Five sets of surface water grab samples for inorganic compound analysis and two sets for microbiological analysis were submitted from forty stream sampling stations in the Mohican River Watershed study area during July-September, 1998. Five sets of effluent grab samples were submitted from the Shelby, Mansfield, and Ashland municipal wastewater treatment plants (WWTPs) and the Copperweld and Armco Inc. industrial facilities. Stream sampling stations were selected to provide information on ambient water quality and to assess potential impacts from a number of pollution sources, including nonpoint types such as atmospheric deposition, agricultural storm water runoff, stream channel modifications, and on-lot sewage systems and point types such as urban storm water sewers, combined sewer overflows, and regulated municipal and industrial discharges. For purposes of this study, efforts were made to minimize nonpoint pollutant impacts by collecting samples during dry weather periods. The collection of several samples following heavy rain storms was unavoidable, especially in the Rocky Fork. Surface water quality was evaluated based on numerical Ohio Water Quality Standards (WQS criteria) codified in Ohio Administrative Code (OAC) Chapter 3745-1. These criteria were developed to protect aquatic life, human health, wildlife, recreation, agricultural and industrial uses, and aesthetic conditions. Both statewide (3745-1-07) and Ohio River drainage basin (3745-1-34) criteria apply to samples collected in the study area. The statewide aquatic life and recreation criteria (Table 7-1) are dependent on stream specific use designations (i.e Warmwater Habitat; Primary Contact Recreation) that are assigned in 3745-1-24 (Muskingum River Basin). The Ohio River drainage basin aquatic life criteria are listed in Tables 34-1, 34-2, and 34-3 and are established to prevent lethality (inside mixing zone maximum), acute toxicity (outside mixing zone maximum), and chronic toxicity (outside mixing zone 30 day average). These are also known as the final acute value (FAV), acute aquatic criteria (AAC), and chronic aquatic criteria (CAC), respectively. The human health and wildlife criteria are listed in Table 34-4 and are established to protect public water supplies and to prevent contamination of fish tissue. Ohio Water Quality Standards violations which were documented in the stream samples are compiled in Table 12. Data displayed graphically are presented in Figures 12-16.

Black Fork Mohican River

The Black Fork is a tributary confluent to the Mohican River at RM 27.57 (forming its mainstem along with the Clear Fork) that is designated as State Resource Water (SRW) downstream from the Charles Mill Reservoir dam (RM 18.67), Warmwater Habitat (WWH), Primary

Table 12. Violations (maximum-minimum criteria) and exceedences (average criteria) of Ohio Water Quality Standards criteria which were documented in the Mohican River Watershed study area during 1998. Values are evaluated based on both Ohio River Basin criteria and statewide criteria that are associated with specific use designations: aquatic life habitat- Coldwater Habitat (CWH), and Warmwater Habitat (WWH); recreation- Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR); and water supply- Public Water Supply (PWS) and Agricultural Water Supply (AWS). Units are mg/l for dissolved oxygen, ammonia, and dissolved solids, °C for temperature, # colonies/100 ml for fecal coliform bacteria, and µg/l for metals.

Stream RM	Parameter (value)
Black Fork (WWH PCR PWS [54.0] AWS)	
53.6	manganese (54[ws] 80[ws] 85[ws] 127[ws] 132[ws]);
	fecal coliform (2700[‡‡])
53.28	fecal coliform (2300[‡‡])
49.57	fecal coliform (2100[‡‡])
46.48	ammonia (2.28[†])
Tuby Run (WWH SCR AWS)	
0.10	dissolved oxygen (4.6[†]); dissolved solids (2000[†] 1910[†]); fecal coliform (51000[‡‡])
Rocky Fork (WWH PCR AWS)	
16.29	fecal coliform (27000[‡‡])
15.75	copper (18[*]); fecal coliform (16000[‡‡])
14.23	copper (22[*]); fecal coliform (56000[‡‡])
11.59	copper (27[**]); lead (14[*]); fecal coliform (58000[‡‡])
10.13	copper (16[*] 21[*]); fecal coliform (40000[‡‡])
0.57	copper (30[*] 33[**]); lead (27[*] 160[* ws]); fecal coliform (56000[‡‡])
Clear Fork (CWH [30.59-13.00 and 4.91-0.22] WWH PCR AWS)	
29.57	dissolved oxygen (6.0[†] 5.4[††] 5.4[††] 6.2[†] 5.1[††]); fecal coliform (1100[‡])
27.45	dissolved oxygen (6.5[†] 5.8[††] 6.2[†] 6.6[†] 5.5[††])
24.39	dissolved oxygen (6.6[†] 6.0[†] 5.2[††] 6.2[†] 5.9[††])
Jerome Fork (WWH PCR AWS)	
12.98	fecal coliform (1100[‡])
Lang Creek (WWH PCR AWS)	
3.15	fecal coliform (1100[‡])
0.35	fecal coliform (1600[‡])
0.33	fecal coliform (1400[‡])

Table 12 continued.

Stream RM	Parameter (value)
Jamison Creek (WWH PCR AWS)	
1.03	fecal coliform (1600 ‡)
0.30	fecal coliform (1800 ‡)
0.01	fecal coliform (1200 ‡)

Statewide Aquatic Life, Recreation, and Water Supply Criteria
†† violation of minimum or maximum criteria established to protect aquatic life uses.
† exceedence of average criteria established to protect aquatic life uses.
‡‡ violation of maximum criteria established to protect recreation uses.
‡ exceedence of average criteria established to protect recreation uses.
ws exceedence of average criteria established to protect water supply uses.

Ohio River Basin Aquatic Life Criteria
** violation of maximum criteria established to prevent acute toxicity (AAC).
* exceedence of average criteria established to prevent chronic toxicity (CAC).

Contact Recreation (PCR), Public Water Supply (PWS) at RM 54.0, Industrial Water Supply (IWS), and agricultural water supply (AWS). The site at Stiving Rd. (RM 54.61) was established to evaluate background water quality upstream from the City of Shelby. There is potential for an impact from package sewage plants operated by the Abraxas Foundation Youth Rehabilitation Center and Briarwood Estates mobile home park, which discharge to a tributary confluent at RM 58.77, and a tributary that drains agricultural land confluent at RM 57.10. Water quality was determined to be very good, with no violations documented and no indication of an impact from either the point or nonpoint sources. The site at Tucker Ave. (RM 53.62) was established to evaluate attainment of the PWS use and potential impacts from urban storm water and agricultural nonpoint runoff from a tributary confluent at RM 54.46. The raw water intake that supplies two upground reservoirs is located at RM 54.0. Water quality was determined to be good, although several exceedences of the PWS criteria for iron and manganese were documented. The concentrations of these compounds were considerably higher than at Stiving Rd. and their increase is likely due to some urban impact. There was also a fecal coliform bacteria violation, possibly due to sewage from a residential home either not connected to the city sewer or located outside the service area. The site at Main St. (RM 53.28) was established to evaluate impacts from Seltzer Run and Tuby Run, tributaries which are confluent at RM 53.42 and 53.38, respectively. A package sewage plant from the Lust Subdivision discharges to Seltzer Run and Copperweld-Shelby Division discharges both process wastewater and storm water to Tuby Run. There are also urban storm water impacts to both of these streams. Water quality was determined to be good, with only a fecal coliform bacteria violation documented. However, there is a noticeable increase in nitrate, ammonia, and BOD5 (Figure 12) from point source loadings. These nutrients, along with flow modifications through the urban area (channelization, canopy removal), have resulted in accelerated algal growth. An abundance of filamentous algae were attached to the substrates and dissolved oxygen levels were elevated. These dissolved oxygen measurements were taken during daylight hours and associated with photosynthetic activity, raising a concern that levels may drop below criteria in the evenings during periods of algal respiration. Considerable increases in dissolved solids and sulfate also occurred. A review of Copperweld effluent data indicated that these increases are attributable to their discharges. The site at London West Rd. (RM 51.32) was established to evaluate impacts from the Copperweld ferrous park landfill. The landfill ranges from RMs 52.18-51.83 along the east side of the river (right bank) and has two associated storm water outfalls. It was formerly operated to dispose neutralized pickle liquor sludge and was capped in 1991. A discharge from a mobile home park package sewage plant was discovered on the west side of the bridge (left bank), opposite of where samples were collected. This discharge operates without a NPDES permit and the mixing zone often had a septic appearance. Due to the proximity of the package plant discharge in relation to the sampling site, it is unlikely that it would affect sample results. Water quality was determined to be good, with no violations documented. Although nitrate continues to be above background levels, there is no apparent impact from the landfill. The site at Plymouth-Springmill Rd. (RM 49.57) was established to evaluate impacts from the Shelby WWTP discharge at RM 50.07 and nonpoint impacts from Marsh Run and Bear Run, tributaries confluent at RMs 50.83 and 49.94, respectively. Industrial sources contribute approximately 6.5% of the hydraulic load to the Shelby WWTP. Water quality was determined to be good, with one fecal coliform bacteria violation documented. The fecal coliform bacteria violation is associated with a sampling event that was conducted when chlorination facilities at the WWTP were not operational because equipment repairs were being conducted. Noticeable increases in nitrate, phosphorus, and suspended solids occurred, while ammonia, BOD5, and dissolved oxygen are relatively unchanged. The site at Miller Rd. (RM 46.48) was established to evaluate recovery downstream from the WWTP. Water quality was determined to be good, although a CAC violation for ammonia was documented. The site at Ganges-Five Points Rd. (RM 43.18) was established to evaluate impacts from both an unnamed tributary and Leatherwood Creek, confluent at RMs 45.88 and 44.85, respectively. The unnamed tributary was observed to carry a heavy sediment load following rain storms. A package sewage plant from the Country Meadows Subdivision discharges to Leatherwood Creek. Water quality was determined to be good, with no violations. Suspended solids continually increase downstream from this location, due in large part to loadings from the unnamed tributary. The source of this sediment was not identified. The tributary drains a large agricultural area and extends north to the Village of Shiloh. The site at Geisinger Rd. (RM 38.42) was established to evaluate impacts from both Shipp Creek and the Village of Ganges. Shipp Creek is confluent at RM 40.96 and flows adjacent to the Village of Rome. Both Rome and Ganges are unsewered

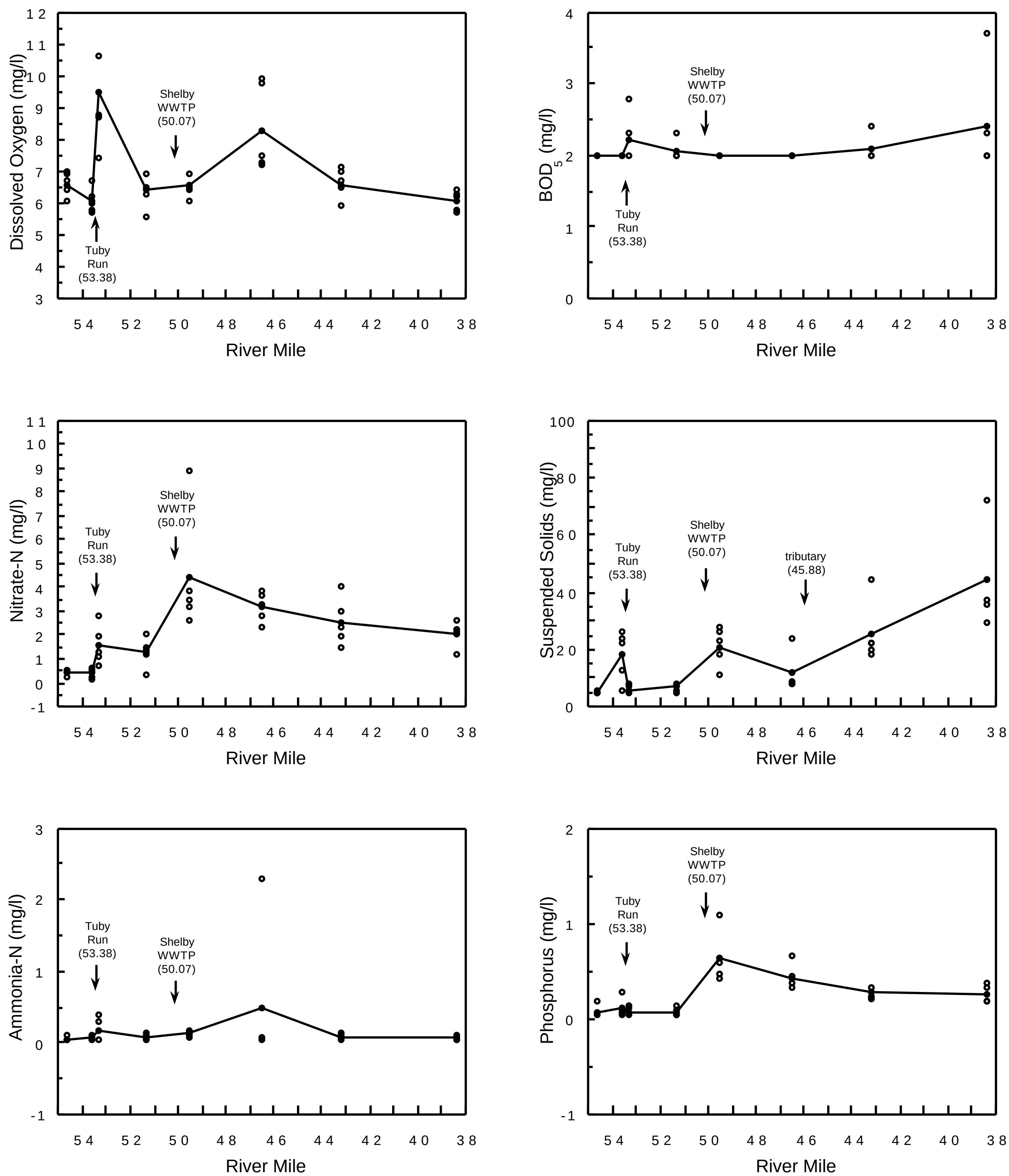

Figure 12. Concentrations of dissolved oxygen, biochemical oxygen demand, nitrate, suspended solids, ammonia-N and phosphorus from Black Fork Mohican River, 1998.

communities. Water quality was determined to be good, with no violations documented. A more localized study is recommended to evaluate impacts from Rome and Ganges.

Tuby Run

Tuby Run is a tributary confluent to the Black Fork at RM 53.38 that is designated as WWH, SCR, AWS, and IWS. It originates in an agricultural area, flows through the Copperweld industrial complex, is culverted when it exits Copperweld and passes under the city school bus garage, and is free flowing from Walnut St. to its confluence with the Black Fork. The site at a small concrete spillway inside the Copperweld facility property (RM 0.70) was established to evaluate background water quality. There is potential for impact from Copperweld storm water outfalls 020-023 and agricultural runoff. Water quality was determined to be good, with no violations documented, although there was occasionally a very slight oil sheen visible. The site at a foot bridge near Gamble St. adjacent Skiles Stadium (RM 0.10) was established to evaluate Copperweld outfalls 002-006 and 016-018 and municipal storm water. Water quality was determined to be poor, with a CAC violation for dissolved oxygen , two CAC violations for dissolved solids, and one fecal coliform bacteria violation documented. On each occasion that samples were collected at this site, there was a heavy oil sheen that worsened if sediments were disturbed.

Rocky Fork Mohican River

The Rocky Fork is a tributary confluent to the Black Fork at RM 14.02 that is designated as WWH, PCR, AWS, and IWS. The river originates in a rural agricultural area and then flows through the City of Mansfield urban-industrial area. Although it is preferred to collect survey samples during low flow conditions to evaluate worst case impacts from point source pollutants, two of five data sets were collected after heavy rainstorms. This led to some interesting results, as depicted by the graphs in Figure 13 where high flow and low flow results are plotted separately. The increase in suspended solids associated with high flow events was accompanied by higher metal concentrations, especially copper and lead. This is likely due to impacts from urban storm water runoff and the suspension of contaminated sediment. In contrast, the high flows diluted the nutrient enrichment impact downstream from the Mansfield WWTP. Generally, water quality was good during low flow periods and very poor during high flows. All

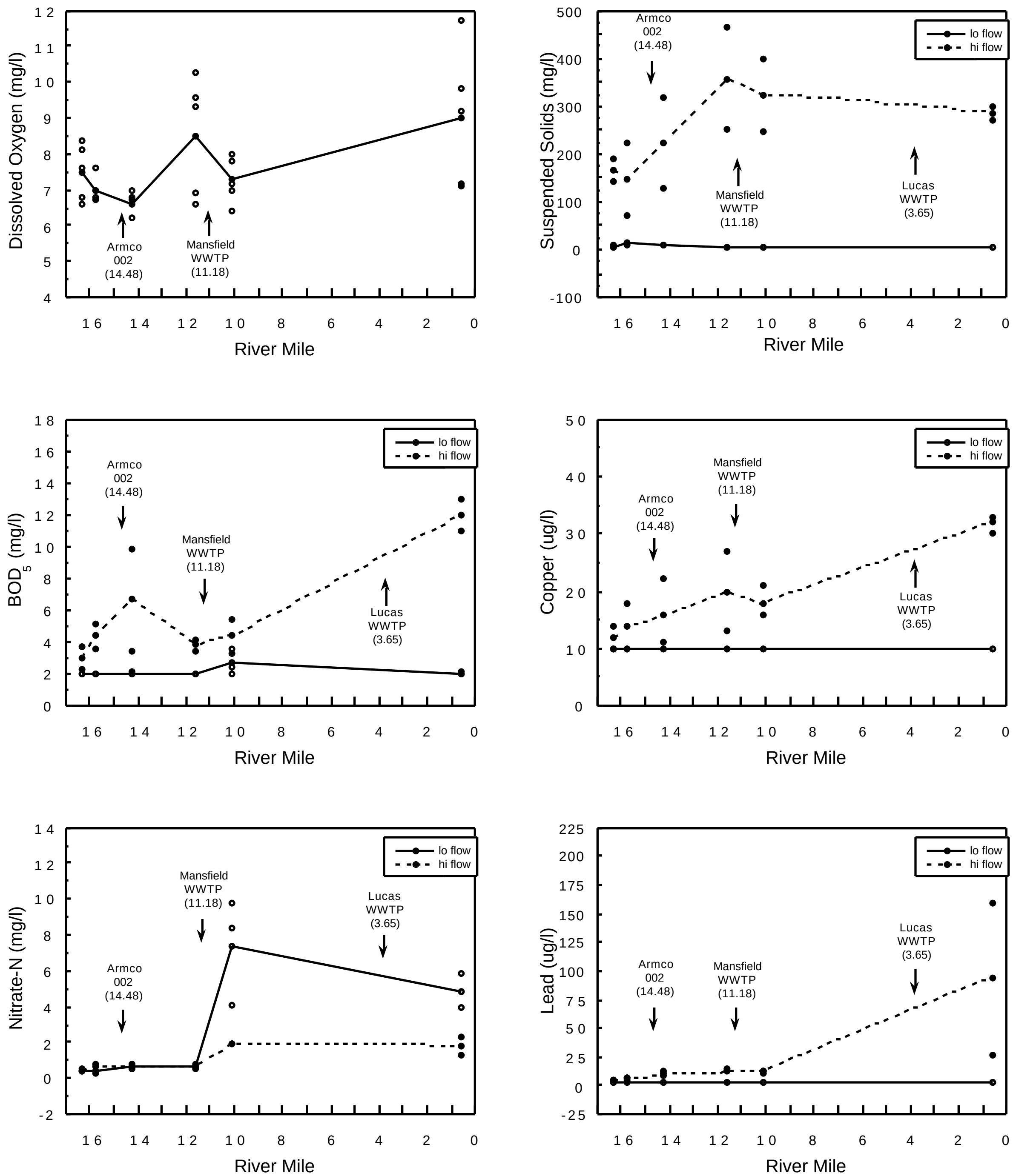

Figure 13. Concentrations of dissolved oxygen, suspended solids, biochemical oxygen demand, copper, nitrate, and lead from Rocky Fork Mohican River, 1998.

of the violations that were documented were associated with the high flow samples. The site at Wilging Rd. (RM 16.29) was established to evaluate background water quality. There is some potential for impact from an area excavated for top soil adjacent to this site. One AWS exceedence for iron and one fecal coliform bacteria violation were documented. The site at Old Bowman Rd. (RM 15.75) was established to evaluate the impact from storm water discharged by the Omni Source and Luntz Corp. metal scrap yards. There is also some potential for an impact from slag and scrap metal storage piles and a closed electric arc furnace dust landfill located inside the Armco facility. Significant channel modifications have been performed in this segment and this reduces bank stability and increases erosion. One CAC exceedence for copper, one AWS exceedence for iron, and one fecal coliform bacteria violation were documented. The site at Longview Ave. (RM 14.23) was established to evaluate the impacts from the effluent discharged by Armco outfalls 001-004. There is also some potential for an impact from an intermittent storm water discharge operated by the Ohio Air National Guard facility. One CAC exceedence for copper, two AWS exceedences for iron, and one fecal coliform bacteria violation were documented. The site at Illinois Ave. (RM 11.59) was established to evaluate the impacts from urban storm water, discharges from the Mansfield Foundry Corp., Ideal Electric, and Stone Container industrial facilities, and the confluence of Touby Run at RM 13.73, which includes a discharge from the New Artesian facility. One AAC violation for copper, one CAC exceedence for lead, two AWS exceedences for iron, and one fecal coliform bacteria violation were documented. The site at S.R. 39 (RM 10.13) was established to evaluate impact from the Mansfield WWTP discharge at RM 11.18. Approximately 20% of the total hydraulic load to the Mansfield WWTP originates from industrial pretreatment sources. There is also some potential for an impact from the Therm-O-Disk facility discharge to a tributary confluent at RM 10.70. During a portion of the study period, there was construction associated with the extension of sanitary sewers just upstream from S.R. 39. This activity included the construction of a temporary dam across the river. Two CAC exceedences for copper, two AWS exceedences for iron, and one fecal coliform bacteria violation were documented. The site at Applegate Rd. (RM 0.57) was established to evaluate impact from the Village of Lucas WWTP discharge at RM 3.65. Package sewage plants operated by the Harp and Heatherwood Subdivisions, which discharge to a tributary confluent at RM 7.07, may also have an affect. One AAC violation and one CAC exceedence for copper, two CAC exceedences for lead, two AWS exceedences for iron, and one fecal coliform bacteria violation were documented. One of the lead results also violated the AWS criterion.

Clear Fork Mohican River

The Clear Fork is a tributary confluent to the Mohican River at RM 27.57 (forming its mainstem along with the Black Fork) that is designated as SRW, both WWH and CWH aquatic life use (CWH), PCR, AWS, and IWS. The CWH use applies to two stream segments: 1) from the Clear Fork Reservoir dam (RM 30.59) to the headwaters of Pleasant Hill Reservoir (RM 13.0) and 2) from the Pleasant Hill Reservoir dam (RM 4.91) to the confluence of Pine Run (RM 0.22). All other segments were designated WWH. Generally, analytical results indicated very good to excellent water quality. Several dissolved oxygen values below either the minimum daily or 24 hour average criteria were documented downstream from the two reservoirs. These were departures from the more stringent CWH criteria and result from warmer lake water temperatures, which decrease oxygen solubility, and the functional loss of stream riffle habitats, which reaerate the water from the atmosphere. Both reservoirs discharge water over the dam from the hypolimnion, or warmer surface layer. Samples at Lexington-Ontario Rd. had a green hue due to an abundance of algae, which also likely affects dissolved oxygen levels and attainment of the CWH criteria. Most chemical pollutants evaluated in the Clear Fork drainage were at or below detection levels. The site at Marion Ave. (RM 35.70) was established to evaluate background water quality. There is some potential for an impact from an intermittent storm water discharge to a tributary confluent at RM 36.31 operated by the General Motors Corp.-Fisher Body facility in Mansfield. No violations were documented. This indicated no impact from the General Motors facility. The site at Lexington-Ontario Rd. (RM 29.57) was established to evaluate the impact from Clear Fork Reservoir. The river is impounded at RM 30.59 to form the reservoir. It serves as both a public water supply for Mansfield and as a source of recreation. There was also some potential for an impact from a package sewage plant discharge to a tributary confluent at RM 34.91 operated by the Brown Derby Roadhouse restaurant. Three AAC violations and two CAC departures of the dissolved oxygen criteria were documented and the mean dissolved oxygen concentration decreased from 8.9 mg/l to 5.6 mg/l (Figure 14). This indicated a significant impact on stream ecology resulting from the impoundment. The site adjacent South Mill St. (RM 27.45) was established to evaluate impact from the wastewater discharged by the United Technologies facility to a tributary confluent at RM 28.33. This is a closed facility that formerly manufactured electrical sensors and switches. The discharge consists of solvent contaminated groundwater that is collected from pumping wells and treated by air strippers. Dissolved oxygen problems persisted with two AAC violations and three CAC departures of the CWH dissolved oxygen criteria. No impact to the Clear Fork from United Technologies, either through a contaminated groundwater plume or wastewater discharge, was evident in these samples. The site at Kocheiser Rd. (RM 24.39) was established to evaluate impact from the Lexington WWTP discharge at RM 27.48. There was also some potential for an impact from a package sewage plant discharge to a tributary confluent at RM 24.94 operated by the Griffeth Nursing Home. Two AAC violations and three CAC departures of the CWH dissolved oxygen criteria were documented. The dissolved oxygen violations likely persisted from upstream. The continued lack of riffle habitats in this segment contributed to a slow recovery. This may be a natural phenomenon or the result of past channel modifications. Only slight impacts to water chemistry were evident from the Lexington WWTP, with minor increases in ammonia and nitrate occurring (Figure 15). The site at S.R. 97 (RM 21.10) was established to evaluate recovery and impact from the confluence of Cedar Fork at RM 21.45. No violations were documented. The lack of dissolved oxygen violations was encouraging and likely due to an increase in stream gradient and return of riffle habitats, along with slightly cooler water temperatures. The site at Cutnaw Rd. (RM 16.17) was established to evaluate the Bellville WWTP discharge at RM 19.17. There was also some potential for an impact from a package sewage plant discharge to a tributary of Honey Creek operated by Mateer Ford. Honey Creek is

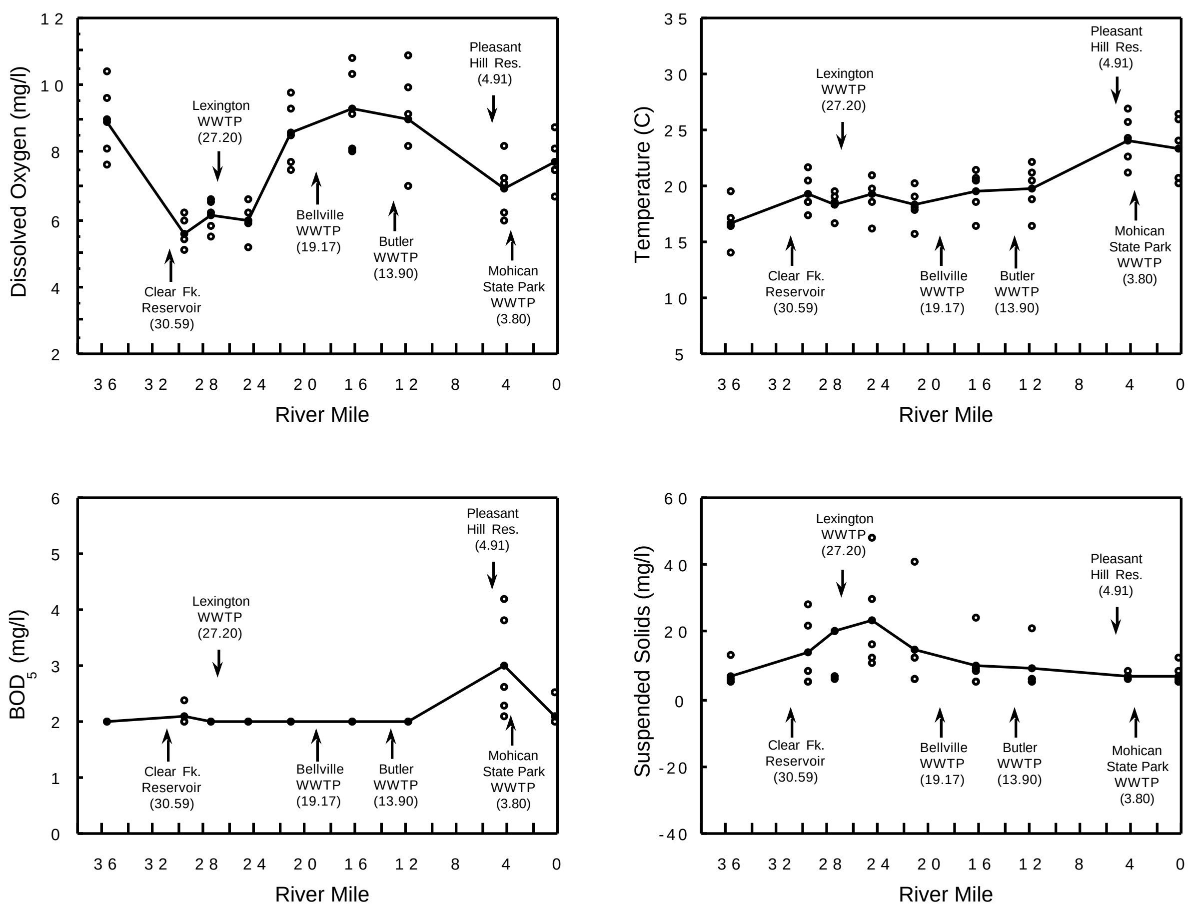

Figure 14. Concentrations of dissolved oxygen, temperature, biochemical oxygen demand and suspended solids from Clear Fork Mohican River, 1998.

confluent to the Clear Fork at RM 17.15. No violations were documented and no impact from the two point sources was evident. The site at Butler-Newville Rd. (RM 11.76) was established to evaluate the Butler WWTP discharge at RM 13.90. Again, no violations were documented and no point source impact was evident. The site at the state forest "covered bridge" (RM 4.23) was established to evaluate impact from the Pleasant Hill Reservoir and package sewage plant discharges from both the Mohican State Park Lodge and the Pleasant Hill dam picnic area (U.S. Army Corps of Engineers) at RMs 5.68 and 4.91, respectively. The confluences of Possum Run and Switzer Creek located at RMs 9.72 and 8.55, respectively, may also have an impact. The river was impounded at RM 4.91 to form the reservoir. It serves as both a flood control structure and as a source of recreation. Its impact to the stream was evident, although not as severe as that resulting from Clear Fork Reservoir, perhaps due to the river maintaining a high gradient through the gorge area downstream from the dam. Two CAC dissolved oxygen

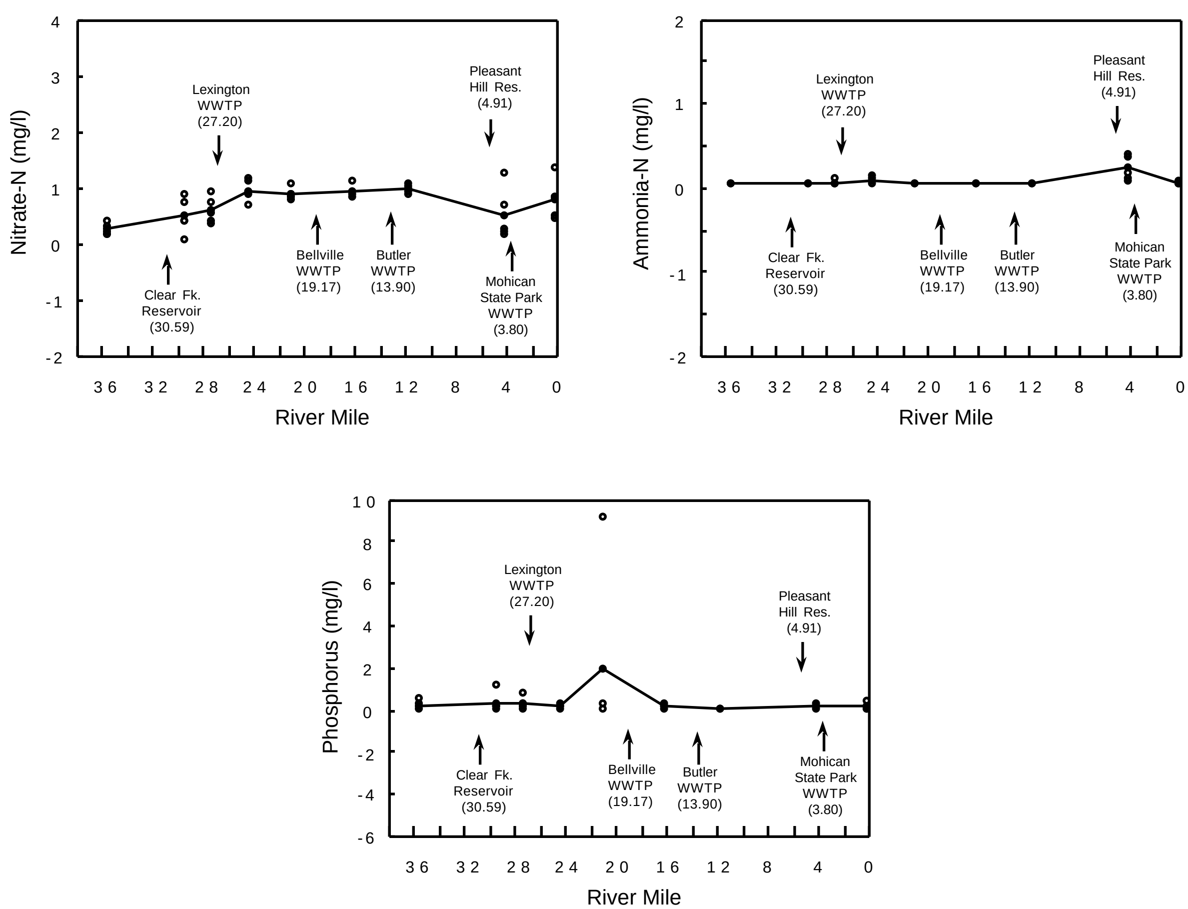

Figure 15. Concentrations of nitrate, ammonia-N and phosphorus from Clear Fork Mohican River, 1998.

departures were documented. The site at S.R. 3 (RM 0.33) was established to evaluate the package sewage plant discharges from both the Mohican State Park Campground and the Mohican Youth Center at RMs 3.80 and 3.70, respectively. One CAC departure for dissolved oxygen was documented. This indicated no impact from the two point sources.

Cedar Fork

Cedar Fork is a tributary confluent to the Clear Fork at RM 21.45 that is designated as CWH, PCR, AWS, and IWS. The stream drains predominately forested land, although some agricultural and residential areas are present. Ambient water quality was evaluated from one site located at Bellville-Johnsville Rd. (RM 0.76). There were no point sources under permit discharging to Cedar Fork. Water quality was determined to be excellent, with no violations documented. Most chemical pollutants evaluated were at or below detection levels.

Possum Run

Possum Run is a tributary confluent to the Clear Fork at RM 9.72 that is designated WWH, PCR, AWS, and IWS. The stream drains predominately forested land, although some agricultural and residential areas are present. There were no point sources under permit discharging to Possum Run. The Ohio Nonpoint Assessment identifies on-site wastewater treatment systems as a potential cause of aquatic life impairment. Ambient water quality was evaluated from one site located adjacent to Possum Run Rd. (RM 1.35). Water quality was determined to be excellent, with no violations documented. Most chemical pollutants evaluated were at or below detection levels. It did not appear that on-site septic systems were having a significant impact on water quality. Most soil types in the area are favorable for properly operating treatment systems.

Pine Run

Pine Run is a tributary confluent to the Clear Fork at RM 0.22 that is designated as SRW, seasonal salmonid habitat (SSH), PCR, AWS, and IWS. The stream drains the Mohican State Forest. The Ohio Nonpoint Assessment identifies silviculture (forest management) as a potential cause of aquatic life impairment. Ambient water quality was evaluated from one station located at T.R. 629 (RM 0.03). Water quality was determined to be excellent, with no violations documented. Most chemical pollutants evaluated were at or below detection levels. It did not appear that forest management practices were having a significant impact on water quality.

Jerome Fork Mohican River

Jerome Fork is a tributary confluent to the Lake Fork Mohican River at RM 14.10 (forming its mainstem along with the Muddy Fork) that is designated as WWH, PCR, and AWS. The river originates at the confluence of Orange Creek and Leidigh Mill Creek at RM 14.72. It flows through a predominately rural agricultural area. Generally, analytical results indicated good water quality, except for some elevated fecal coliform counts. The confluence of Lang Creek has a significant impact on Jerome Fork water quality, especially regarding nutrient concentrations. The chemical impact was severe enough to expect a nutrient enrichment response in the biota. The site at U.S. 42 (RM 12.98) was established to evaluate background water quality. There was some potential for an impact from septic runoff discharged by the Village of Nankin, which was unsewered and drains into Orange Creek. One PCR exceedence for fecal coliform was documented. The site at C.R. 1302 (RM 12.08) was established to evaluate impact from the confluence of Lang Creek at RM 12.28. Lang Creek includes pollutant loadings from both the Ashland water treatment plant (WTP) and WWTP, as well as inputs from Jamison Creek and Town Run. One PCR exceedence for fecal coliform was documented. However, there was a significant increase in nutrient levels due to the effluent loadings (Figure 16). The site at T.R. 1500 (RM 9.15) was established to evaluate recovery and potential impact from an intermittent storm water discharge operated by the BP Oil Co.-Ashland Pipeline at RM 10.49. One fecal coliform bacteria violation was documented. Nutrient levels decreased somewhat but continued to be above background levels. The fecal coliform bacteria violation indicated that there may be a source of septic runoff from residential areas outside the Ashland collection system. The site at C.R. 30-A (RM 5.65) was established to evaluate impact from septic runoff discharged by the Village of Jeromesville, which is unsewered. Two PCR exceedences for fecal coliform were documented. Nutrient levels continued to decrease from the Lang Creek impact. The river right proximity of sample collection was not appropriate to sufficiently evaluate impact from Jeromesville. There were septic sewer overflows located river left 50 yds. upstream and 10 yds and 75 yds. downstream from the bridge. A more localized study is recommended to evaluate these impacts. The site at C.R. 175 (RM 2.56) was established to evaluate impact from an intermittent softener backwash discharge operated by the Jeromesville WTP at RM 5.60 and the confluence of Oldtown Run at RM 4.29. There were discharges to tributaries of Oldtown Run from the Ashland Co. Landfill storm water sedimentation ponds and a package sewage plant operated by the Ashland Co. JVS. Two PCR exceedences for fecal coliform were documented. Again, nutrient levels decreased somewhat, but continued to be above background. No significant impact resulting from the point sources was evident.

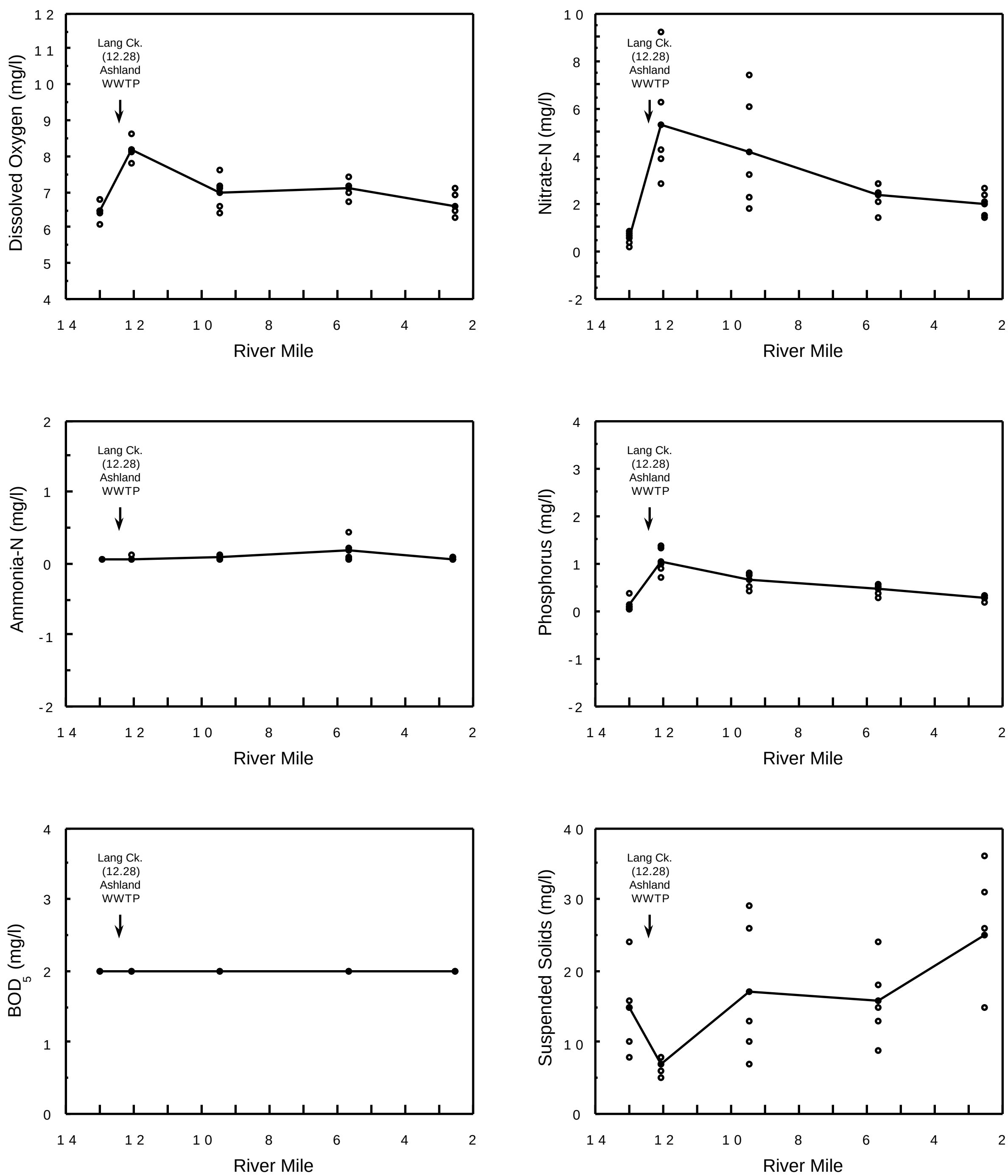

Figure 16. Concentrations of dissolved oxygen, nitrate, ammonia-N, phosphorus, biochemical oxygen demand and suspended solids from Jerome Fork Mohican River, 1998.

Lang Creek

Lang Creek is a tributary confluent to the Jerome Fork at RM 12.28 that is designated as WWH, PCR, AWS, and IWS. Lang Creek originates in a rural agricultural area before it flows through the Ashland urban area. Generally, analytical results indicated good to very good water quality. There was one PCR exceedence for fecal coliform bacteria documented at each sampled site. The potential for a nutrient enrichment impact exists downstream from the Ashland WWTP. The site at T.R. 1104 (RM 3.15) was established to evaluate background water quality. Most pollutant levels were at or below detection. The site upstream from the Ashland WWTP (RM 0.35) was established to evaluate the impact from lime sludge supernatant discharged by the Ashland WTP sedimentation lagoons at RMs 1.16, 1.07, and 0.98. These discharges were intermittent and records show that no flow was reported during the July-September study period. There was also potential impact from the confluence of Jamison Creek at RM 0.42, since several industrial facilities discharge storm water to this creek. Only minor changes in chemistry occurred compared to background, indicating no impact from the confluence of Jamison Creek. The site downstream from the Ashland WWTP (RM 0.33) was established to evaluate the discharge at RM 0.34 and the plant bypass located 100 ft. upstream. Approximately 20% of the total hydraulic load to the facility originates from industrial pretreatment sources. Significant increases in nitrate and phosphorus concentrations occurred and some metal concentrations also increased, especially copper, lead, and zinc.

Jamison Creek

Jamison Creek is a tributary confluent to Lang Creek at RM 0.42 that is designated as WWH, PCR, AWS, and IWS. The stream predominately drains the Ashland urban area. Generally, analytical results indicated good to very good water quality. There was one PCR exceedence for fecal coliform documented at each site. The site at Main St. (RM 1.03) was established to evaluate background water quality. There was some potential for impact from an intermittent storm water and non-contact cooling water discharge to a tributary confluent at RM 3.05 operated by the Timken Co. Most pollutant levels were at or below detection. The site at C.R. 1302 (RM 0.30) was established to evaluate the confluence of Town Run. The Hedstrom Corp. (f.k.a. Eagle Rubber), Abbott Laboratories (f.k.a. Faultless Rubber), and BP Oil Co.-Ashland Bulk Plant have intermittent storm water discharges to Town Run. Very little if any chemical change occurred compared to background, indicating that Town Run was not having an impact on Jamison Creek. The site at RM 0.01 was established to evaluate impact from an unnamed tributary confluent at RM 0.09. The General Latex and Chemical Co. has an intermittent non-contact cooling water discharge to this tributary. Again, no impact was indicated. Wastewater discharges from the National Latex Co., Philway Products Corp., and United Brand Corp. have been eliminated since the survey previously conducted in 1984.

Town Run

Town Run is a tributary confluent to Jamison Creek at RM 0.30 that is designated as WWH, PCR, AWS, and IWS. The stream exclusively drains portions of the Ashland urban area. The site at U.S. 42 (RM 0.34) was established to determine ambient water quality. There was some potential for an impact here from intermittent storm water discharges operated by the Hedstrom Corp., Abbott Laboratories, and BP Oil Co.-Ashland Bulk Plant via a sewer at RM 1.49. Water quality was determined to be good, with no violations documented. However, daytime dissolved oxygen measurements were very elevated due to an abundance of filamentous algae, raising a concern that levels may drop below criteria in the evenings.

Muddy Fork Mohican River

Muddy Fork is a tributary confluent to the Lake Fork Mohican River at RM 14.10 (forming its mainstem along with the Jerome Fork) that is designated as WWH, PCR, AWS, and IWS. It drains predominately agricultural land and was impounded at RM 25.95 to form Cinnamon Lake. The site at Flemming Rd. (RM 18.40) was established to evaluate impacts from the Cinnamon Lake Subdivision package sewage plant discharge at RM 25.50 and the Village of West Salem WWTP discharge at RM 20.27. Water quality was determined to be good, with no violations documented. There was a slight potential for a nutrient enrichment impact, since some nutrient levels, especially phosphorus, were elevated. It was likely that this increase in nutrients was due to loadings from the West Salem WWTP. The site at C.R. 100 (RM 13.40) was established to evaluate ambient water quality and downstream recovery. Water quality was determined to be very good, with no violations documented. Nutrient levels decrease somewhat compared to Flemming Rd.

Public Lakes and Reservoirs

The monitoring and assessment of the health of natural lakes, impounded reservoirs, and up ground drinking water supply reservoirs was one component of the Ohio EPA five year surface water quality monitoring strategy. As the focus on water resource management shifts to the level of the watershed unit, the assessment of natural lakes and reservoirs becomes an important compliment to the study of river, stream, and wetland surface water ecosystems. Lakes and reservoirs act as watershed sinks for the deposition of upstream releases of nutrients, soil, pesticides, and toxic pollutants. Thus, the assessment of lakes may be the best indicator of the combined effects that both point and nonpoint source loadings have on surface water quality. In Ohio, lakes and reservoirs serve as both the primary recreational surface water resource and public drinking water supply for millions of citizens.

The attainment or non-attainment of designated uses for lakes and reservoirs in Ohio was determined using a multi-parameter Ohio Lake Condition Index (LCI) assessment technique (Davic and Deshon, 1989; Water Resource Inventory Report, Vol. III, Ohio EPA, 1996). Fourteen metrics were assessed to determine the biological, chemical, physical, and aesthetic conditions of the lake or reservoir water resource. Attainment of designated uses (i.e. aquatic life, recreation, public water supply, and fish consumption) was determined by the relative number of threatened and impaired metric conditions for each designated use. Criteria used to determine metric conditions include violations of Ohio WQS criteria and best professional judgement.

Three impoundments located in the Mohican River Watershed study area were sampled in May and September, 1998. Each lake was monitored near the dam (L-1) and in its upper impounded reach (L-2). At each location, inorganic chemical analysis was performed with samples collected both near the surface and about 1.0 meter from the bottom. A top to bottom profile of temperature, dissolved oxygen, pH, and conductivity measurements was also conducted. Secchi transparency depth and chlorophyll concentration were determined to calculate trophic status. Clear Fork Lake and Pleasant Hill Lake were previously sampled in 1993 and Charles Mill Lake in 1990.

Clear Fork Reservoir

Clear Fork Reservoir is a 1,010 acre lake created by the impoundment of the Clear Fork Mohican River. It is owned and operated by the City of Mansfield as a public water supply. Boating is limited to a maximum speed of 6 m.p.h. Sampling results indicated that the lake was in full attainment of its designated uses, but in a threatened status. Some of the parameters that contributed to this threatened status included turbidity, elevated non-priority pollutants (iron and manganese), and a eutrophic class status. The lake was also classified as eutrophic in 1993.

Pleasant Hill Reservoir

Pleasant Hill Reservoir is a 850 acre lake created by the impoundment of the Clear Fork Mohican River in 1940. The dam is owned and operated by the U.S. Army Corps of Engineers (U.S. Army COE) for flood control. The reservoir and surrounding land is owned and administered by the Muskingum Watershed Conservancy District (MWCD) for flood control and recreation. The reservoir is leased to the Ohio Department of Natural Resources, Division of Wildlife (Ohio DNR, DOW) and administered for fish and game propagation and management. Boating is unlimited in the upper half of the lake and limited to a maximum speed of 6 m.p.h. in the lower half. Sampling results indicated that the lake was in full attainment of its designated uses, but in a threatened status. Some of the parameters that contributed to this assessment included turbidity, elevated non-priority pollutants (iron and manganese), anoxia in the hypolimnion, volume loss due to sedimentation, and a eutrophic class status. The trophic status has shown an improvement since 1993, when the lake was classified as hypereutrophic.

Charles Mill Reservoir

Charles Mill Reservoir is a 1350 acre lake created by the impoundment of the Black Fork Mohican River in 1935. The dam is owned and operated by the U.S. Army COE for flood control. The reservoir and surrounding land is owned and administered by the MWCD for flood control and recreation. The reservoir is leased to the Ohio DNR, DOW and administered for fish and game propagation and management. Boating is limited to a maximum horsepower of 10. Sediment dredging was being performed during the summer to improve navigation channels. Sampling results indicated that the lake was in partial attainment of its designated uses. Some of the parameters that contributed to this assessment included turbidity, elevated non-priority pollutants (iron and manganese), volume loss due to sedimentation, and a hypereutrophic class status. The lake was also classified as hypereutrophic in 1990.

Chemical Sediment Quality

There are many sources that contribute pollutants to the aquatic environment, including rural and urban stormwater, industrial and municipal wastewater, spills, and atmospheric deposition. Some pollutants enter bound to eroded upland soils and others attach to the surface electrical charges associated with silt and clay particles suspended in the water column. Additional compounds enter and settle due to their high specific gravity. As the particles settle, accumulate, and combine with other organic and inorganic materials, a layer of sediment was created. Some compounds bound to sediment are extremely persistent in the environment, are toxic to aquatic life, bioaccumulate in the food chain, and affect human health if contaminated fish or other wildlife are consumed. Two such compounds are polychlorinated biphenyls (PCBs) and dichloro diphenyl trichloroethane (DDT). PCBs were chiefly used as insulation in electrical condensers, additives in extreme pressure lubricants, and as a coating in foundry use. They have been documented to cause cancer in lab animals and are strongly suspected as a human carcinogen. DDT was used primarily as an insecticide until it was discovered to cause cancer in animals and have a severe effect on the central nervous system in humans. Another route of exposure to contaminated sediments was direct contact. This was especially a concern regarding polynuclear aromatic hydrocarbons (PAHs). These compounds are commonly the by-products of fossil fuel combustion and are contained in substances such as creosote and coal tar. Several PAH compounds (i.e. benzo[a]pyrene) have been documented to cause skin cancer in lab animals and are strongly suspected human carcinogens. Metals are another contaminant present in sediment that can potentially bioaccumulate and affect human health, especially mercury and lead.

Sediment is its most physically, chemically, and biologically reactive at the surface where it contacts the water column. Samples of this surface layer can be chemically analyzed and compared to various guidelines and criteria to predict the potential for impact to human health and wildlife. One guideline used to rank the relative concentrations of metals from non to extremely elevated is a classification system developed by Ohio EPA (1996). This system was derived from samples collected at ecoregional reference sites. Classes are based on the median analytical value plus 1, 2, 4, and 8 inter-quartile values. This system is similar to one first described by Kelly and Hite (1984) for Illinois sediments and is used here to rank PCBs and pesticides. While these two systems simply rank concentrations, the potential for aquatic life toxicity can be predicted based on guidelines described by Long and Morgan (1990) for the National Oceanic and Atmospheric Administration and criteria developed by Persaud, Jaagumagi, and Hayton (1993) for the Ontario Ministry of the Environment. Long and Morgan reviewed literature and summarized the results by defining an effects range-low (ER-L) value, which indicated the low end of the range of concentrations in which toxic effects were observed or predicted among most organisms and an effects range-median (ER-M) value, which indicated the concentration above which toxic effects were frequently or always observed or predicted among most organisms. Persaud et al describe three levels of ecotoxic effects which were defined based on the chronic effects of contaminants on benthic organisms. These include the No Effect Level (NEL), at which no toxic effects were observed on aquatic organisms; the Lowest Effect Level (LEL), indicating a level of sediment contamination that can be tolerated by the majority of benthic organisms; and the Severe Effect Level (SEL), indicating the level at which pronounced disturbance of the sediment dwelling community can be expected.

A total of twenty-one sediment samples were collected from streams in the Mohican River basin study area. Samples were collected according to guidelines established in the Ohio EPA Sediment Sampling Guide and Methodologies Manual (1996). Physical and chemical analyses which were performed included % particle size, % moisture, metals, semi-volatile organic compounds (method 8270), organochlorine pesticides (method 8081), and PCBs (method 8082). Results for metals and physical attributes are presented in Table 13 and those for detected organic compounds in Table 14.

Black Fork Mohican River

Results for metals and organics indicated little concern for environmental impact. Most organics were below detection and none were detected at RMs 53.62, 49.57, 43.18, and 38.42. The only location with any significant organic levels was adjacent the Shelby Water Treatment Plant (RM 52.60). This site was downstream from downtown Shelby, the confluences of Switzer Run and Tuby Run, and the Copperweld ferrous park landfill. Total PAHs exceeded the ER-L at 11.65 ppm and the PCB congener arochlor-1260 was just above detection. The PCBs were likely

Table 13. Analytical results for physical attributes (%) and metals (mg/kg) in stream sediment samples collected in the Mohican River basin study area in 1998.

	Black Fork Mohican River					
	RM 53.62	RM 52.60	RM 51.32	RM 49.57	RM 43.18	RM 38.42
solids	71.6	64.0	72.9	66.0	59.5	67.8
sand	81.1	72.7	79.0	74.8	69.3	70.3
silt	16.5	23.4	17.3	20.4	26.2	25.5
clay	2.4	3.9	3.7	4.8	4.5	4.2
aluminum	12200 [b]	10700 [a]	14500 [b]	13000 [b]	12100 [b]	14200 [b]
barium	71.4 [a]	58.3 [a]	88.1 [a]	83.6 [a]	80.9 [a]	87.4 [a]
calcium	14600	26600	22600	21400	10800	3820
chromium	<13.7	24 [c]	26 [c]	‡ **33.4 [d]**	19.9 [b]	21.8 [c]
copper	7.78 [a]	‡ 19.8 [b]	15.9 [a]	‡ **87.8 [e]**	‡ 17.1 [a]	11.5 [a]
iron	12100 [a]	14600 [a]	15000 [a]	18400 [a]	15000 [a]	15500 [a]
lead	<18.3	‡ 31.8 [b]	<19.2	<20.9	29.6 [b]	22.4 [a]
magnesium	5040	7290	6260	7310	3990	2730
manganese	202 [a]	213 [a]	236 [a]	353 [a]	223 [a]	297 [a]
nickel	<18.3	‡ 21.4 [b]	‡ 22.1 [b]	‡ 28.7 [b]	<22.8	<21.8
potassium	3200	3120	4330	3660	3420	3820
sodium	<2290	<2600	<2410	<2610	<2850	<2730
strontium	42.6	62	50.5	50.2	36.5	29
zinc	55 [a]	† ‡ 142 [c]	114 [b]	† ‡ 127 [b]	93.4 [a]	73.7 [a]
mercury	<0.0319	0.0509	<0.0312	<0.0318	<0.0333	<0.0284
arsenic	‡ 6.14 [a]	‡ 6.56 [a]	‡ 7.84 [a]	‡ 8.52 [a]	‡ 6.1 [a]	‡ 5.9 [a]
cadmium	0.307 [a]	‡ 0.656 [b]	0.558 [b]	‡ 0.758 [c]	0.587 [b]	0.486 [b]
selenium	<0.916	<1.04	<0.963	<1.04	<1.14	<1.09

	Rocky Fork Mohican River					
	RM 16.29	RM 15.75	RM 14.23	RM 11.59	RM 10.13	RM 0.57
solids	70.7	68.4	73.5	64.1	74.0	68.0
sand	76.6	3.4	86.8	75.1	71.8	92.3
silt	16.9	90.6	10.8	20.7	27.0	5.5
clay	6.5	6.0	2.4	4.2	1.2	2.2
aluminum	11800 [b]	14300 [b]	8920 [a]	12800 [b]	9290 [a]	6840 [a]
barium	67.7 J [a]	111 J [b]	62.3 J [a]	183 J [c]	66.5 [a]	64.4 [a]
calcium	1520 J	46700 J	7900 J	13000 J	5940	6070
chromium	<15.2	†† ‡‡ **300 J [e]**	‡ **60.1 J [e]**	‡ **60.5 J [e]**	<16.2	‡ 26.1 [c]
copper	9.6 [a]	‡ 25.3 [c]	‡ 21.1 [b]	‡ **57.1 [d]**	‡ 17.3 [b]	14.9 [a]

Table 13. Continued.

	Rocky Fork Mohican River (continued)					
	RM 16.29	RM 15.75	RM 14.23	RM 11.59	RM 10.13	RM 0.57
iron	10900 J [a]	18300 J [a]	14500 J [a]	16700 [a]	11000 [a]	11400 [a]
lead	<20.2	† ‡ 48.4 [c]	† ‡ 43 [c]	† ‡ **95** **[d]**	<21.6	‡ 31.3 [b]
magnesium	1520	6180	2630	4320	2700	2330
manganese	140 [a]	1000 [b]	298 [a]	318 [a]	197 [a]	242 [a]
nickel	<20.2	<22.5	‡ 29.8 [c]	† ‡ 35 [c]	<21.6	<18.7
potassium	3030	3370	2630	3360	2700	1870
sodium	<2520	<2810	<2190	<2400	<2700	<2330
strontium	33.8	360	34.2	44.2	20.5	21.5
zinc	37.9 [a]	† ‡ **220** **[d]**	112 [b]	† ‡ 197 [c]	53 [a]	70 [a]
mercury	<0.0276	0.0672	0.0655	0.0636	0.0344	<0.0318
arsenic	‡ 6.21 [a]	‡ 8.32 [a]	‡ 6.93 [a]	‡ 8.74 [a]	‡ 7.46 [a]	5.37 [a]
cadmium	0.192 [a]	‡ 0.804 [c]	0.443 [b]	‡ 0.802 [c]	0.194 [a]	0.210 [a]
selenium	<1.01	<1.12	<0.878	<0.960	<1.08	<0.934

	Tuby Run	Jerome Fk.	Jerome Fk.	Muddy Fk	Muddy Fk.
	RM 0.25	RM 9.15	RM 2.56	RM 18.40	RM 13.40
solids	68.9	26.5	30.8	27.9	20.5
sand	7.1	87.4	66.4	75.9	78.3
silt	85.9	9.8	33.6	22.8	18.1
clay	7.0	2.8	0.0	1.3	3.6
aluminum	17600 [c]	**29500** **[d]**	21100 [c]	**35300** **[d]**	**67400** **[e]**
barium	122 [b]	236 [c]	142 [b]	183 [c]	**417** **[d]**
calcium	27200	15400	8740	28200	26800
chromium	‡ **58** **[e]**	<41.9	<37.5	<38.4	‡ **72.7** **[e]**
copper	‡ **42.4** **[d]**	‡ **58.7** **[d]**	‡ 26.2 [c]	‡ 25.6 [c]	‡ **42.1** **[d]**
iron	‡ 28600 [b]	‡ 37300 [c]	‡ 33700 [b]	‡ 36800 [c]	‡‡ **66200** **[d]**
lead	† ‡ **87.1** **[d]**	<55.9	<50.0	<51.2	<76.5
magnesium	8290	6990	5000	10200	11500
manganese	459 [a]	838 [b]	687 [a]	681 [a]	1630 [c]
nickel	† ‡ 44.7 [c]	<55.9	<50.0	<51.2	<76.5
potassium	4610	6990	3750	7680	17200
sodium	<2300	<6990	<6240	<6400	<9560
strontium	56.7	64.3	<37.5	78.1	132
zinc	† ‡ **216** **[d]**	† ‡ **242** **[d]**	† ‡ 172 [c]	† ‡ 133 [b]	† ‡ **256** **[d]**
mercury	0.125	0.0717	<0.0628	<0.0765	<0.0854
arsenic	‡ 11.3 [a]	‡ 18.2 [a]	‡ 17.0 [a]	‡ 17.5 [a]	† ‡ 37.7 [c]

Table 13. Continued.

	Tuby Run	Jerome Fk.	Jerome Fk.	Muddy Fk	Muddy Fk.
	RM 0.25	RM 9.15	RM 2.56	RM 18.40	RM 13.40
cadmium	‡ 0.848 [c]	‡ 0.908 [c]	0.562 [b]	‡ 0.666 [b]	‡ 0.976 [c]
selenium	<0.922	<2.80	<2.50	<2.56	<3.82

	Lang Creek			
	RM 3.15	RM 0.44	RM 0.35	RM 0.33
solids	33.9	30.4	32.8	48.6
sand	66.4	77.9	69.7	2.8
silt	29.0	19.1	27.3	90.7
clay	4.6	3.0	3.0	6.5
aluminum	16900 [c]	**29000 [d]**	19400 [c]	11900 [b]
barium	104 [b]	195 [c]	159 [c]	92.8 [b]
calcium	23400	22300	24000	17600
chromium	<33.4	‡ **39.5 [d]**	‡ **32.7 [d]**	20.2 [c]
copper	‡ 24.5 [c]	‡ 27.3 [c]	‡ **61 [e]**	‡ **65.3 [e]**
iron	‡ 25400 [a]	‡ 32500 [b]	‡ 32200 [b]	19200 [a]
lead	<44.5	<40.5	† ‡ 68.6 [c]	† ‡ 37.2 [b]
magnesium	5560	7080	7620	4570
manganese	459 [a]	591 [a]	596 [a]	376 [a]
nickel	<44.5	<40.5	<43.6	<26.1
potassium	4450	7080	4360	2610
sodium	<5560	<5060	<5440	<3270
strontium	67.9	73.9	50.1	39.8
zinc	112 [b]	† ‡ 190 [c]	† ‡ **248 [d]**	† ‡ 195 [c]
mercury	<0.0569	<0.0632	0.0963	0.0695
arsenic	‡ 14.1 [a]	‡ 17.1 [a]	‡ 21.3 [b]	‡ 10.6 [a]
cadmium	‡ 0.612 [b]	‡ 0.607 [b]	‡ 0.735 [c]	‡ 0.614 [b]
selenium	<2.23	<2.02	<2.18	<1.31

Values preceded by a < were below the method detection limit and those preceded by a J are estimated because quality control criteria were not met. Relative concentrations are ranked based on a system developed by Ohio EPA (1996) for the erie-ontario lake plains ecoregion. [[a] non-elevated; [b] slightly elevated; [c] elevated; **[d] highly elevated**; **[e] extremely elevated**] Those preceded by a (†) exceed an effects range low value and those by a (††) exceed an effects range median value described by Long and Morgan (1990). Those preceded by a (‡) exceed a lowest effect level and those by a (‡‡) exceed a severe effect level described by Persaud et al (1992).

Table 14. Analytical results for organic compounds detected in stream sediment samples collected in the Mohican River Watershed study area during 1998 (sites that had no compounds detected are not presented).

	Black Fork Mohican River		Tuby Run
	RM 52.60	RM 51.32	RM 0.25
polynuclear aromatic hydrocarbons (mg/kg)			
benzo[a]pyrene	0.99	<0.52	<0.55
benzo[b]fluoranthene	1.1	<0.52	0.59
benzo[g,h,i]perylene	0.87	<0.52	<0.55
benzo[k]fluoranthene	1.0	<0.52	<0.55
chrysene	1.4	0.53	0.74
fluoranthene	2.3	0.97	1.4
indeno[1,2,3	0.79	<0.52	<0.55
phenanthrene	1.2	0.53	0.72
pyrene	2.0	0.77	1.2
Total PAHs	† 11.65	2.8	† 4.65
phthalates (mg/kg)			
bis (2-ethylhexyl) phthalate	0.67	<0.52	<0.55

	Black Fork Mohican River		Tuby Run
	RM 52.60	RM 51.32	RM 0.25
organochlorine pesticides (ug/kg)			
4,4'-DDE	<6.02	<5.39	‡ † 7.70
heptachlor	<6.02	<5.39	11.7
heptachlor epoxide	<6.02	<5.39	‡ 33.1
polychlorinated biphenyls (ug/kg)			
arochlor-1248	<31.0	<26.9	64.9
arochlor-1260	31.8	<26.9	93.7
total PCBs	31.8	-	‡ † 158.6

Table 14. Continued.

	Rocky Fork	Mohican River				
	RM 16.29	RM 15.75	RM 14.23	RM 11.59	RM 10.13	RM 0.57
polynuclear aromatic hydrocarbons (mg/kg)						
benzo[a]pyrene	<0.56	<0.60	<0.59	1.3	<0.54	<0.59
benzo[b]fluoranthene	<0.56	<0.60	<0.59	1.3	<0.54	<0.59
benzo[g,h,i]perylene	<0.56	<0.60	<0.59	1.2	<0.54	<0.59
benzo[k]fluoranthene	<0.56	<0.60	<0.59	1.2	<0.54	<0.59
chrysene	<0.56	<0.60	<0.59	1.8	<0.54	<0.59
fluoranthene	<0.56	<0.60	0.66	3.2	0.61	1.1
indeno[1,2,3	<0.56	<0.60	<0.59	0.93	<0.54	<0.59
3&4 methylphenol	<0.56	<0.60	1.4	<0.57	3.1	1.6
phenanthrene	<0.56	<0.60	<0.59	1.8	<0.54	<0.59
pyrene	<0.56	<0.60	<0.59	2.6	<0.54	0.91
Total PAHs	-	-	2.06	† 15.33	3.71	3.61
phthalates (mg/kg)						
bis (2-ethylhexyl) phthalate	<0.56	0.89	<0.59	1.1	0.90	0.69
organochlorine pesticides (ug/kg)						
4,4'-DDD	<5.82	<6.19	6.25	14.0	<5.49	<5.71
4,4'-DDE	<5.82	<6.19	6.81	<6.12	<5.49	<5.71
Total DDT	-	-	‡ † 13.06 [c]	‡ † 14.0 [c]	-	-
polychlorinated biphenyls (ug/kg)						
arochlor-1248	<29.1	273	214	45200	136	717
arochlor-1260	<29.1	40.7	<29.8	308	<27.5	<28.6
Total PCBs	-	‡ † **313.7** [d]	‡ † **214** [d]	‡ †† **45508** [e]	‡ † 136 [c]	‡ †† **717** [d]

Table 14. Continued.

	Jerome Fork RM 9.15	Lang Ck. RM 0.44	RM 0.35	RM 0.33
polynuclear aromatic hydrocarbons (mg/kg)				
anthracene	<0.54	<0.54	0.69	<0.73
benzo[a]pyrene	<0.54	<0.54	2.8	0.86
benzo[b]fluoranthene	<0.54	<0.54	2.6	1.0
benzo[g,h,i]perylene	<0.54	<0.54	1.8	0.80
benzo[k]fluoranthene	<0.54	<0.54	2.5	0.87
chrysene	<0.54	<0.54	3.1	1.1
dibenz[a,h]anthracene	<0.54	<0.54	0.62	<0.73
fluoranthene	<0.54	0.69	6.2	2.0
indeno[1,2,3	<0.54	<0.54	1.8	0.77
3&4 methylphenol	<0.54	<0.54	<0.56	3.4
phenanthrene	<0.54	<0.54	2.9	0.85
pyrene	<0.54	<0.54	4.8	1.5
Total PAHs	-	0.69	† 23.61	† 10.09
phthalates (mg/kg)				
bis (2-ethylhexyl) phthalate	0.67	0.55	2.8	6.4
organochlorine pesticides (ug/kg)				
4,4'-DDD	<5.01	38.2	5.89	<7.33
4,4'-DDE	<5.01	26.8	<5.61	<7.33
4,4'-DDT	<5.01	35.6	<5.61	<7.33
Total DDT	-	‡ † 100.6	† 5.89	-

Concentrations preceded by a < were below the method detection limit (MDL). Relative concentrations are ranked based on a stream sediment classification system described by Kelly and Hite (1984) [[a] non-elevated; [b] slightly elevated; [c] elevated; **[d] highly elevated; [e] extremely elevated**]. Concentrations preceeded by a (†) exceed an effects range low value and those by a (††) exceed an effects range median value described by Long and Morgan (1990). Concentrations preceeded by a (‡) exceed a lowest effect level and those by a (‡‡) exceed a severe effect level described by Persaud et al (1992).

migrating from Tuby Run and the PAHs were present at levels commonly detected in urban areas. Most metals were ranked as either nonelevated or slightly elevated. Only a few samples were considered elevated or above and some of these also exceeded the LEL. The greatest concern was at Plymouth-Springmill Rd. (RM 49.57), where chromium was ranked as highly elevated and copper extremely elevated. The likely source of these metals was contributions to the Shelby WWTP effluent from industrial sources. Overall sediment quality in the Black Fork was good. Sand, which is a relatively inert material to which most compounds do not bind, predominated the sediment deposits.

Tuby Run

The only sample collected was just downstream from Walnut St. (RM 0.25). This site was downstream from both the Copperweld facility and the city bus garage. Results for metals and organics indicated a moderate concern for environmental impact, especially regarding PCBs and pesticides. Heptachlor epoxide was ranked as extremely elevated and exceeded the LEL at 33.1 ppb and total DDT was slightly elevated and exceeded the ER-L at 7.70 ppb. Both of these compounds were historically used as insecticides. It was unknown if heptachlor epoxide would exceed the SEL, since total organic carbon (TOC) is needed in the calculation. However, for a sediment with 5% TOC, the SEL would be 250 ppb, so it was unlikely in this instance. Total PCBs were ranked as elevated and exceeded both the ER-L and LEL at 158.6 ppb and total PAHs exceeded the ER-L at 4.65 ppb. Most metals were ranked as elevated or greater and some exceeded respective LELs. Of most concern were highly elevated levels of copper, lead, and zinc and an extremely elevated level of chromium. The Copperweld facility was the likely source of these metals, although urban storm water and activities at the bus garage may contribute as well. Substrate in Tuby Run consisted mostly of rock and few sediment deposits were present. The sediment that was present was of poor quality and was expected to impact intolerant organisms. Some areas in the stream contained heavy deposits of detritus that were causing anoxic conditions.

Rocky Fork Mohican River

Results for metals and organics indicated a major concern for environmental impact, especially regarding PCBs. No organics were detected at the background station at Wilging Rd. (RM 16.29). All metals were ranked as non-elevated, except aluminum which was slightly elevated. The station located downstream from the Omni-Source and Luntz metal scrap yards at Old Bowman Rd. (RM 15.75) had total PCBs that were ranked as highly elevated and exceeded the ER-L and LEL at 313.7 ppm. Copper, lead, and cadmium were ranked as elevated, zinc as highly elevated, and chromium as extremely elevated, although this result was qualified as estimated. Most of these results also exceeded respective LELs with chromium exceeding both the ER-M and SEL. The process of shearing scrap metal and associated use of cutting oils and lubricants at the scrap yards were the likely sources of contamination. There may have also been an impact from slag and coke piles and the electric arc furnace dust landfill located in the Armco facility. An oil sheen was visible at this site when sediments were disturbed. The station located downstream from the Armco facility at Longview Ave. (RM 14.23) had total PCBs that were ranked as highly elevated and exceeded the ER-L and LEL at 214.0 ppb. Lead and nickel were ranked as elevated and chromium as extremely elevated. Disturbing sediments at this site also created an oil sheen. It was likely that sediment at Old Bowman Rd. has been transported to this location, although the Armco facility was also known to contribute contamination here. Site inspections have detected PCBs and heavy metals in soil at Armco and sediment collected during a previous study from the outfall 002 mixing zone had nearly 3 ppm of PCBs and 2 ppm of chromium (Biological and Water Quality Study of the Rocky Fork Mohican River, Ohio EPA, 1994). Total DDT was ranked as elevated and exceeded the ER-L and LEL at 13.06 ppb. The station located downstream from the Mansfield urban area at Illinois Ave. (RM 11.59) had total PCBs that were ranked as extremely elevated and exceeded the ER-M and LEL at 45,508 ppb (46 ppm). It was not known whether this would exceed the SEL, since TOC is needed in the calculation. However, for a typical sediment with 5% TOC, the SEL would be 26.5 ppm, so an exceedence was likely in this instance. Barium, nickel, zinc, and cadmium were ranked as elevated, copper and lead as highly elevated, and chromium as extremely elevated. This sample was located in a small pocket or "hot spot" approximately 100 ft. upstream from the bridge on the left bank. It was likely that many sources contributed and it was also likely that many more "hot spots" exist in the Rocky Fork that have not been identified. It should be noted that any materials classified as waste and containing >50 ppm PCBs are regulated under the Toxic Substances and Control Act (TSCA). These materials must be disposed in either an incinerator or hazardous waste landfill that meets very specific technical requirements (40 CFR761.60). Total DDT was ranked as elevated and exceeded the ER-L and LEL at 14.0 ppb and total PAHs exceeded the ER-L at 15.33 ppm. The station located downstream from the Mansfield WWTP at S.R. 39 (RM 10.13) had total PCBs that were ranked as elevated and exceeded the ER-L and LEL at 136.0 ppb. No metals were ranked above slightly elevated. The station located at Applegate Rd. (RM 0.57) had total PCBs that were ranked as highly elevated and exceeded the ER-M and LEL and at 717.0 ppb. Chromium was ranked as elevated; all other metals were nonelevated or slightly elevated. The PCBs detected at these last two stations were undoubtedly transported downstream from the Mansfield urban-industrial area.

Jerome Fork Mohican River

Results for metals and organics indicated little concern for environmental impact. Only one organic compound was detected in the two samples collected. The station located downstream from the confluence of Lang Creek and the Ashland urban area at T.R. 1500 (RM 9.15) had several metals that were ranked as elevated or greater. Aluminum, copper, and zinc were highly elevated and barium, iron, and cadmium were elevated.

Lang Creek

Results for metals and organics indicated a moderate concern for environmental impact, especially regarding DDT. The background station located upstream from the City of Ashland urban area at T.R. 1104 (RM 3.15) had no organics detected. An unexpected result was that aluminum and copper were ranked as elevated, while several other metals exceeded their respective LELs. It's possible that an impact resulted from storm water runoff and deterioration of the bridge, since this sample was collected downstream from the road. Downstream from the Ashland water treatment plant and former city landfill (RM 0.44), total DDT was ranked as highly elevated and exceeded the ER-L and LEL at 100.6 ppb. This DDT likely persists from its historical use to control mosquitoes and was at a level that could result in toxicity to aquatic life. Barium, copper, and zinc were ranked as elevated and aluminum and chromium as highly elevated. Storm water from the urban area and perhaps the closed landfill contributed to these metals. Downstream from Jamison Creek and the WWTP bypass (RM 0.35), total PAHs exceeded the ER-L at 23.61 ppm. It is not unusual to detect these levels of PAHs in an urban area, especially if industry is present. Aluminum, barium, lead, and cadmium were ranked as elevated, chromium and zinc as highly elevated, and copper as extremely elevated. This showed an impact from the Ashland WWTP bypass and possibly loadings from Jamison Creek. Approximately 20-25% of the WWTP influent originates from industrial sources and the facility reported bypassing for a duration of 174 hours in 1998. Downstream from the WWTP effluent (RM 0.33), PAHs exceeded the ER-L at 10.09 ppm. Chromium and zinc were ranked as elevated and copper as extremely elevated. Most pollutant levels exhibited a decline at this site compared to downstream from the bypass.

Muddy Fork Mohican River

Results for metals and organics indicated a moderate concern for environmental impact, especially regarding metals. No organic compounds were detected in the two samples collected. Downstream from the Village of West Salem at Flemming Rd. (RM 18.40), barium, copper, and iron were elevated and aluminum was highly elevated. This indicated an impact from the West Salem WWTP and storm water runoff. Adjacent the Village of Redhaw at C.R. 1100 (RM 13.40), manganese, arsenic, and cadmium were elevated, barium, copper, iron, and zinc were highly elevated, and aluminum was extremely elevated. These were unexpected results for a predominately rural area. Sources of contamination may include storm water and illegal dumping.

Lakes

Two sediment samples were collected from Clear Fork, Pleasant Hill, and Charles Mill Reservoirs. One sample was collected near the dam (L-1) and one in the upper reach of each lake (L-2). Chemical analyses performed were similar to the stream samples, with some additional inorganic compounds evaluated. Results are presented in Table 15.

Table 15. Analytical results for physical attributes (%), metals (mg/kg), and several other inorganic compounds (mg/kg) in lake sediment samples collected in the Mohican River basin study area during 1998.

Parameter	**Charles Mill L-1**	**Charles Mill L-2**	**Clear Fork L-1**	**Clear Fork L-2**	**Pleasant Hill L-1**	**Pleasant Hill L-2**
sand (%)	23.2	17.4	18.9	21.4	31.0	8.4
silt (%)	63.7	71.4	63.9	62.1	32.7	76.3
clay (%)	13.1	11.2	17.2	16.5	36.3	15.3
solids	37.3	45.8	31.8	35	25.3	42.8
volatile solids	13.1	5.8	7.26	6.29	9.76	5.67
t-organic carbon	‡ 2.1	‡ 2.1	‡ 2.2	‡ 1.8	‡ 3.4	‡ 2.4
chromium	‡ **46.1** [d]	‡ 29.6 [c]	‡ 26.6 [c]	‡ **41.1** [d]	<45.6	‡ 28.2 [c]
copper	‡ 22.9 [b]	‡ 19.8 [b]	‡ 26.1 [c]	‡ 29.6 [c]	‡ 30.4 [c]	‡ 22.9 [b]
iron	‡ 37100 [c]	‡ 28200 [b]	‡ 34500 [c]	‡‡ 42500 [c]	‡‡ 42700 [c]	‡ 29300 [b]
lead	19 [a]	21 [a]	28.8 [b]	28.1 [a]	<60.8	<35.3
manganese	738 [b]	553 [a]	757 [b]	762 [b]	1160 [c]	591 [a]
nickel	† ‡ 34.6 [c]	‡ 27.2 [b]	† ‡ 30.9 [c]	† ‡ 38.4 [c]	<60.8	<35.3
mercury	<0.0567	0.0707	0.0639	<0.0414	<0.0719	0.0496
arsenic	‡ 13.3 [a]	‡ 14.1 [a]	‡ 16.1 [a]	‡ 20.4 [b]	‡ 26.8 [b]	‡ 15 [a]
cadmium	0.52 [b]	0.714 [c]	0.484 [b]	0.517 [b]	0.441 [b]	0.502 [b]
selenium	0.807	0.516	0.806	0.837	<3.04	<1.76
ammonia	124	72.3	95.6	72.6	200	47.7
chemical O_2	14700	46700	30500	2220	70400	54700
cyanide	<1.26	<1.00	<1.36	<1.23	<1.84	<0.938
phosphorus	‡ 916	‡ 885	‡ 624	‡ 929	‡ 1100	‡ 1050

Concentrations preceded by a < were below the method detection limit. Relative concentrations are ranked based on a stream sediment classification system developed by Ohio EPA (1996). [[a] non-elevated; [b] slightly elevated; [c] elevated; **[d] highly elevated**; **[e] extremely elevated**] Concentrations preceeded by a (†) exceed an effects range low value and those by a (††) exceed an effects range median value described by Long and Morgan (1990). Concentrations preceeded by a (‡) exceed a lowest effect level and those by a (‡‡) exceed a severe effect level described by Persaud et al (1992).

Results for samples collected in Clear Fork, Pleasant Hill, and Charles Mill Reservoirs were very similar. Results for metals and organics indicated little concern for environmental impact. Only one organic was detected and this was present in the two Pleasant Hill samples. Several metals were classified as elevated, while chromium was highly elevated in two samples. Some exceeded the LEL, nickel exceeded both the LEL and ER-L in three samples, and iron exceeded the SEL in two samples. These results indicated a slight potential for a toxic response by benthic organisms, although most species should be resistant. It would be difficult to identify any one source as the cause for these elevated metal concentrations, since the reservoirs drain such a large area. Atmospheric deposition and urban and rural storm water were likely large contributors, although point sources must also be considered. Results for particle size distribution indicated that the lake sediments contain a high percentage of silt and clay. This would be expected, since the impoundment of rivers results in a sink for fine particles. Phosphorus exceeded the LEL in all samples, likely due to its use as an agricultural fertilizer and its propensity to bind to eroded soil.

Water Quality Trend Assessment

The following is an evaluation of trends in chemical water quality that have occurred in the Mohican River Basin.

Black Fork

Water quality was previously evaluated in the Black Fork in 1989. Historical data is contained in the Biological and Water Quality Study of the Black Fork Mohican River (Ohio EPA, 1990). Mean concentrations of dissolved oxygen, BOD5, ammonia, nitrate, phosphorus, and suspended solids are presented in Figure 17. Trends in pollutant concentrations was very similar between the two study periods. However, significant declines in average nitrate and phosphorus have occurred.downstream from the Shelby WWTP. While dissolved solids exceedences were documented in the Black Fork downstream from Tuby Run in 1989, none were documented in 1998. However, dissolved solids concentrations continued to be exceeded in Tuby Run. There also seems to be a persistent trend in fecal coliform bacteria violations in the Shelby urban area, indicating either a problem with the sewage collection system or runoff from outside the service area.

Rocky Fork

Water quality was previously evaluated in the Rocky Fork in 1993. Historical data is contained in the Biological and Water Quality Study of the Rocky Fork Mohican River (Ohio EPA, 1994). Only data from low flow events in 1998 included included in Figure 18. Trends in pollutant concentrations was similar between the two study periods. Overall, there

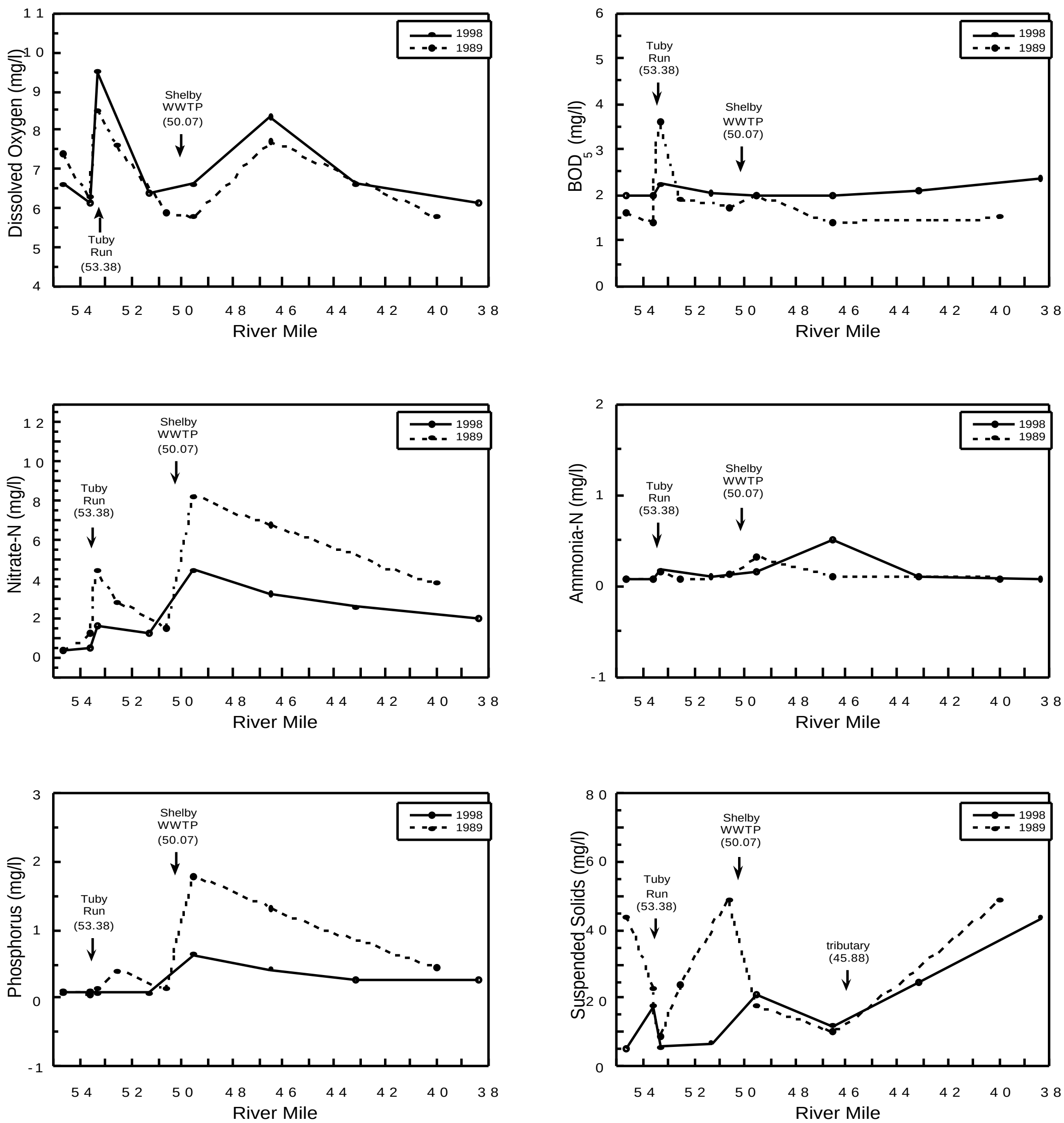

Figure 17. Concentrations of dissolved oxygen, nitrate, ammonia-N, phosphorus, biochemical oxygen demand and suspended solids from Black Fork Mohican River, 1989 and 1998.

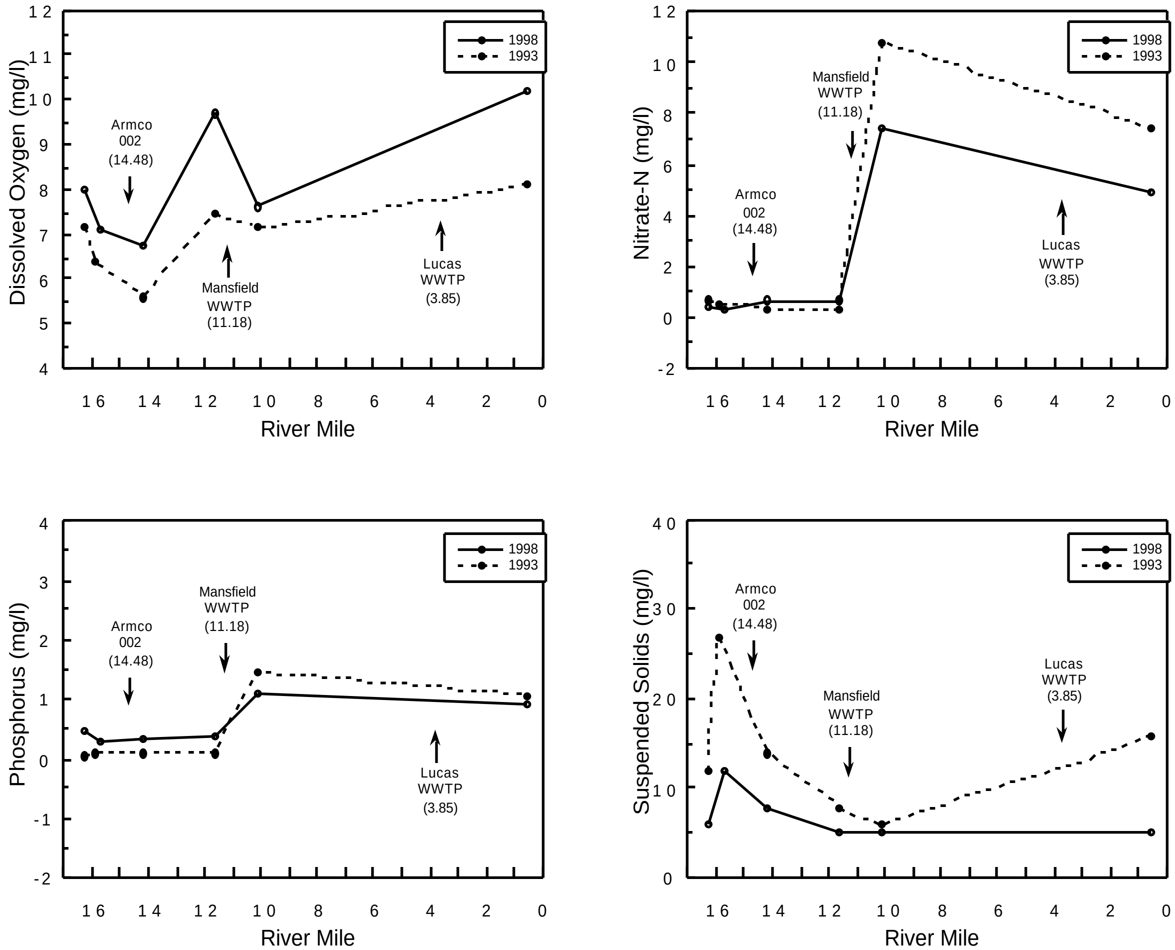

Figure 18. Concentrations of dissolved oxygen, nitrate, ammonia-N, phosphorus, biochemical oxygen demand and suspended solids from Rocky Fork Mohican River, 1993 and 1998.

did appear to be a slight decreasing trend and there was a reduction in the number of Ohio WQS criteria violations. Problems with chromium documented in 1993 seem to have been resolved; there were no results above detection in any of the stream samples in 1998. However, copper continued to be a concern. There was also a reduction in nitrate levels downstream from the Mansfield WWTP, which should minimize nutrient enrichment impacts.

Jerome Fork

Water quality was previously evaluated in the Jerome Fork in 1984. Historical data is contained in the Biological and Water Quality Study of the Jerome Fork including Lang Creek, Jamison Creek, Town Run, and an Unnamed Tributary (Ohio EPA, 1986). Few similarities in the pattern of pollutant concentrations exist between the two study periods. The Jerome Fork was severely impacted by pollution from Lang Creek. Conditions in 1984 included a persistent dissolved oxygen sag and highly elevated concentrations of ammonia, phosphorus, BOD_5, zinc, lead, nickel, and copper (Figure 19). Conditions dramatically improved in 1998. This can be attributed to upgrades at the Ashland WWTP along with connection of industrial process wastes to the city sewer and implementation of a pretreatment program.

Sediment Quality Trend Assessment

The following is an evaluation of trends in chemical sediment quality that have occurred in the Mohican River Basin. Effort was taken to duplicate sampling locations as much as possible, although the shifting nature of sediment deposits and accumulation of "hot-spots" made this difficult. Metals data collected from the Black Fork in 1989 and the Rocky Fork in 1993 are presented in Table 16 and organics in Table 17.

Black Fork

Sediments were previously evaluated for metals in the Black Fork in 1989. Historical data is contained in the Biological and Water Quality Study of the Black Fork Mohican River (Ohio EPA, 1990). The only site duplicated in 1998 was at Plymouth-Springmill Rd. (RM 49.57). This site was located downstream from the Shelby urban area, Copperweld facility, and the Shelby WWTP. Values obtained in 1989 were ranked in the nonelevated to slightly elevated range, while 1998 values were in the nonelevated to extremely elevated range. Many sediment metals concentrations increased as much as four fold for chromium and copper, which resulted in elevated to extremely elevated levels, repectively. This may have been the result of pollutant loadings accumulating in the sediment because of the low stream gradient through the channelized urban section.. It may also be due to the sampling of a hot-spot in the latter sample.

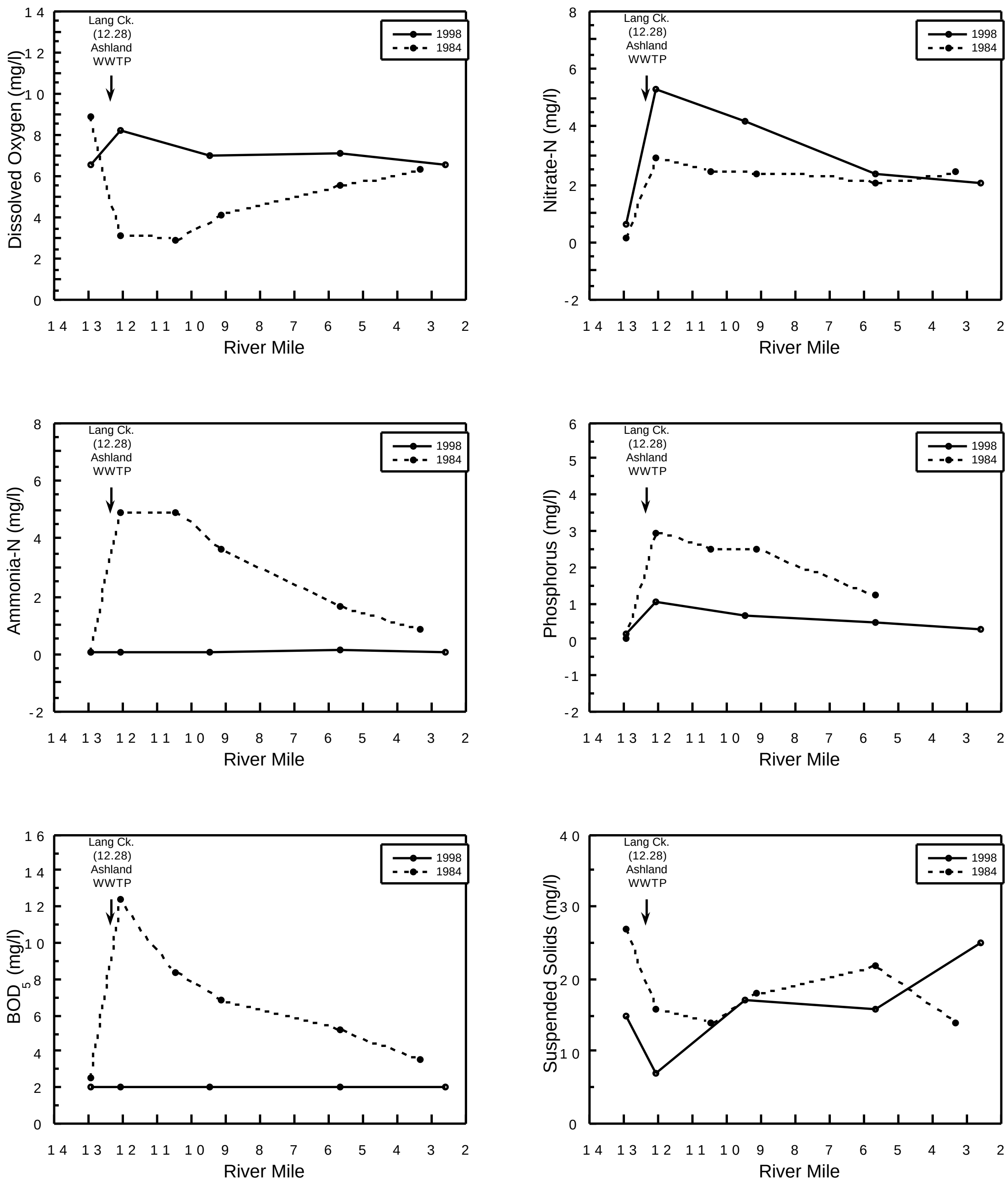

Figure 19. Concentrations of dissolved oxygen, nitrate, ammonia-N, phosphorus, biochemical oxygen demand and suspended solids from Jerome Fork Mohican River, 1984 and 1998.

Table 16. Analytical results for metals (mg/kg) in stream sediment samples collected in the Black Fork in 1989 and Rocky Fork in 1993.

Black Fork Mohican River (1989)

	RM 54.61	RM 53.28	RM 50.60	RM 49.57
chromium	17 [b]	**116** [e]	<12 [a]	7.36 [a]
copper	18.7 [b]	**58.4** [d]	11.9 [a]	21.7 [b]
lead	20.3 [a]	**136** [e]	<19.6 [a]	33.6 [b]
nickel	21.1 [a]	**55.5** [d]	15.3 [a]	18.4 [a]
zinc	92.7 [a]	**655** [e]	54.8 [a]	108 [b]
arsenic	10.3 [a]	13.2 [a]	4.5 [a]	3.36 [a]
cadmium	0.385 [a]	4.79 [b]	0.167 [a]	0.769 [c]

Rocky Fork Mohican River (1993)

	RM 16.29	RM 15.75	RM 14.47	RM 14.23	RM 10.13	RM 0.57
chromium	13.8 [a]	**33.7** [d]	**1670** [e]	**712 J** [e]	**916** [e]	**55.7** [e]
copper	12.3 [a]	18.6 [b]	**711** [e]	**353** [e]	**462** [e]	**51.7** [d]
iron	15000 [a]	18400 [a]	51300 [c]	45500 [c]	40400 [c]	18500 [a]
lead	13.5 [a]	20.2 [a]	**79.5** [d]	**182** [e]	**959** [e]	41.0 [b]
nickel	9.14 [a]	13.8 [a]	**54.9** [d]	**287** [e]	**83.5** [e]	27.5 [b]
zinc	72.5 [a]	145 [c]	**431** [e]	**549** [e]	**1170** [e]	168 [c]
arsenic	5.24 [a]	11.4 [a]	22.7 [b]	18.6 [b]	12.8 [a]	9.93 [a]
cadmium	0.280 [a]	0.470 [b]	1.20 [c]	**2.74** [e]	**49.1** [e]	0.510 [b]

Values preceded by a < were below the method detection limit. Relative concentrations are ranked based on a system developed by Ohio EPA (1996) for the erie-ontario lake plains ecoregion. [[a] non-elevated; [b] slightly elevated; [c] elevated; [d] **highly elevated**; [e] **extremely elevated**]

Rocky Fork

Sediments were previously evaluated for metals and organics in the Rocky Fork in 1993. Historical data is contained in the Biological and Water Quality Study of the Rocky Fork Mohican River (Ohio EPA, 1994). Several sites were duplicated in 1998 including Wilging Rd. (RM 16.29), Old Bowman Rd. (RM 15.75), Longview Ave. (RM 14.23), S.R. 39 (RM 10.13), and Applegate Rd. (RM 0.57). Results from the background site at Wilging Rd. were very similar between the two studies. All of the metals evaluated in 1993 were ranked non-elevated. They continued to be non-elevated in 1998 and there was a general decreasing trend. Results at Old Bowman Rd. had a general increasing trend, especially chromium, lead, zinc, and PCBs.

Table 17. Analytical results for organic compounds detected in stream sediment samples collected in the Rocky Fork during 1993.

	Rocky Fork Mohican River					
	RM 16.29	RM 15.75	RM 14.47	RM 14.24	RM 10.13	RM 0.57
polynuclear aromatic hydrocarbons (mg/kg)						
benz[a]anthracene	<0.6	<0.5	<1.0	1.5	1.5	<0.5
benzo[a]pyrene	<0.6	<0.5	<1.0	1.2	1.5	<0.5
benzo[b&k]fluoranthene	<0.6	<0.5	<1.0	3.6	3.5	<0.5
benzo[g,h,i]perylene	<0.6	<0.5	<1.0	<0.9	2.4	<0.5
chrysene	<0.6	<0.5	<1.0	0.9	1.3	<0.5
fluoranthene	<0.6	<0.5	<1.0	2.3	2.9	<0.5
indeno[1,2,3-cd]pyrene	<0.6	<0.5	<1.0	<0.9	2.9	<0.5
phenanthrene	<0.6	<0.5	1.0	1.4	1.9	<0.5
pyrene	<0.6	<0.5	<1.0	1.8	3.0	<0.5
Total PAHs	-	-	1.0	12.7	20.9	-
phthalates (mg/kg)						
bis (2-ethylhexyl) phthalate	<0.6	<0.5	<1.0	8.3	1.1	1.1
butylbenzyl phthalate	<0.6	<0.5	<1.0	1.4	<0.7	<0.7
di-N-butyl phthalate	<0.6	<0.5	<1.0	2.6	1.6	0.7
organochlorine pesticides (ug/kg)						
aldrin	<0.56	<0.60	46.75 J	<0.86	12.03 J	9.28 J
a-BHC	<0.56	<0.60	4.88	<0.86	1.13	<0.68
b-BHC	<0.56	<0.60	42.74	<0.86	<0.72	<0.68
d-BHC	4.80	<0.60	28.16 J	2.86	<0.72	<0.68
y-BHC	<0.56	1.17	11.70	7.72	<0.72	<0.68
4,4'-DDD	<1.67	<1.79	<3.15	54.85	<2.15	2.58
4,4'-DDE	<0.56	0.66	29.92 J	19.30	2.72 J	4.26 J
4,4'-DDT	<1.67	3.52	13.61	<2.58	5.54	3.17
dieldrin	<0.56	<0.60	**11.32 J** [d]	3.37 [b]	2.30 J [a]	1.86 J [a]
endosulfan I	<0.56	<0.60	25.13	<0.86	2.67	2.17
endrin aldehyde	<1.67	<1.79	6.84	<2.58	<2.15	<2.05
endosulfan II	<0.56	<0.60	<1.05	2.19	8.58 J	6.49 J

Table 17. Continued.

	Rocky Fork Mohican River					
	RM 16.29	RM 15.75	RM 14.47	RM 14.24	RM 10.13	RM 0.57
methoxychlor	<2.79	<2.98	8.24	15.59	21.22	10.45
hexachlorobenxene	<0.56	<0.60	<1.05	1.39	<0.72	<0.68
mirex	<2.79	<0.60	<5.24	<4.30	3.85	<3.41
Total DDT	-	4.18 [a]	**43.53 J** [d]	**74.15** [d]	-	-
<u>polychlorinated biphenyls</u> (ug/kg)						
arochlor-1248	<27.88	<29.79	2977.39	<43.00	581.97	497.85
Total PCBs	-	-	**2977.39** [e]	-	**581.97** [d]	**497.85** [d]

Values preceded by a < were below the method detection limit and those followed by a J are estimated because of matrix interference. Relative concentrations are ranked based on a stream sediment classification system described by Kelly and Hite (1984) [[a] non-elevated; [b] slightly elevated; [c] elevated; [d] **highly elevated**; [e] **extremely elevated**].

PCBs were detected at a highly elevated level where there were none detected in 1993. This raises a concern for storm water impacts from metal scrap yards and slag storage piles. The Omni Source scrap yard treats storm water with an oil-water separator and did not have an NPDES permit. The Luntz facility treats storm water in a retention pond equipped with an oil skimmer and was regulated by a permit. It was unclear where storm water from this portion of the Armco facility drains. Continuing downstream from Longview Ave. to S.R. 39 and Applegate Rd., all metal concentrations decreased significantly. Many of the metals that were ranked as highly or extremely elevated in 1993 were now at non or slightly elevated levels in 1998. PCBs continued a slight increasing trend. These results indicated that, except for PCBs, point source controls have significantly reduced pollutant loadings downstream from Mansfield and/or the more contaminated sediments have been flushed out of the system.

Physical Habitat for Aquatic Life

Jerome Fork Mohican River

As part of the 1998 fish sampling effort, the quality of near and instream macrohabitats of the Jerome Fork Mohican River were evaluated at five locations. QHEI values ranged between 45 (RM 2.6, CR 175) and 71.5 (RM 5.7, CR 30), with a mean reach score of 57.1 (±10.8 SD). Mean QHEI values from rivers or large river segments greater than 60 generally indicated a level of macrohabitat quality sufficient to support an assemblage of aquatic organisms fully consistent with the WWH aquatic life use designation. A matrix of habitat features and QHEI values for each fish sampling station is presented in Table 18.

Macrohabitat quality, as measured by the QHEI, displayed considerable longitudinal variation. As all stations contained evidence of past channel modification, the variation between sites appeared a result of disparate levels of physical recovery. Specifically, channel features at RM 12.1 and RM 5.7 appeared largely recovered, possessing adequate sinuosity and depth heterogeneity. Positive habitat features associated with the more natural and diverse wetted channel included coarser and overall less embedded substrates. These latter characteristics were the result of mixed current velocities and the attendant effects on substrate distribution/segregation within the active channel, during both high and low flows. The positive effect of these features (channel configuration, substrate type and condition) yielded QHEI values at or greater than the WWH threshold. In contrast, the remaining stations demonstrated little recovery from past modification. Largely trenched and deeply incised, the channel configuration at these sites remained monotonous. This coupled with low gradient resulted in substrate composition that was typically finer and more embedded, when compared with the stations in a more advanced state of recovery.

Given the disparities in habitat quality throughout Jerome Fork, its effect on ambient biological performance is best evaluated in the aggregate. The reach average of 57.1 would suggest less than optimal macrohabitat quality; however, the level of degradation was not uniform, and cumulatively not terribly severe. Ultimately, Jerome Fork appeared in the process of a long and protracted recovery from significant and systematic channel modification, and the negative influence of deficient macrohabitats must be considered as a potential limiting factor.

Selected Jerome Fork Tributaries

The quality of near and instream macrohabitats of selected Jerome Fork tributaries were evaluated as part of the 1998 biosurvey. This effort was limited to the Lang Creek subbasin and included the following streams: Lang Creek, Jamison Creek, and Town Run. As measured by the

Table 10. Qualitative Habitat Evaluation Index (QHEI) matrix showing modified and warmwater habitat characteristics for Mohican River study area, 1998.

Key
QHEI
Components

			WWH Attributes											MWH Attributes: High Influence						MWH Attributes: Moderate Influence														
River Mile	QHEI	Gradien (ft/mile)		strates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+1)/(WWH+1) Ratio	(MWH M.I.+1)/(WWH+1) Ratio
(17-750) Clear Fork Mohican River																																		
Year: 1998																																		
35.7	72.0	35.71	n		n	n	n	n	n	n	n		9			l			1					s	s							2	0.20	0.40
29.6	60.0	5.43		n				n			n		3	l					1	s	s			s	s			s	s	s		7	0.50	2.25
27.6	54.0	3.94						n			n		2				l		1	s	s			s	s			s	s		s	7	0.67	3.00
27.4	54.5	3.94						n			n		2	l					1		s			s	s			s	s		s	6	0.67	2.67
23.5	58.5	8.85		n						n	n		3				l		1	s	s			s	s			s	s	s		7	0.50	2.25
21.1	78.5	7.22	n	n		n		n	n	n	n		8						0		s				s				s	s		4	0.11	0.56
16.8	76.0	11.70	n	n		n		n	n	n	n	n	8				l		1	s					s							2	0.22	0.44
11.7	92.0	7.53	n	n		n	n	n	n	n	n		9						0													0	0.10	0.10
4.0	80.5	9.30	n	n		n		n	n	n	n	n	8				l		1						s							1	0.22	0.33
0.4	77.0	9.44	n	n		n		n	n	n	n	n	8						0	s				s	s							3	0.11	0.44
(17-751) Pine Run																																		
Year: 1998																																		
0.1	70.5	3.08	n	n		n		n		n	n		7			l			1					s	s			s		s		4	0.25	0.75
(17-754) Opossum Run																																		
Year: 1998																																		
1.4	55.5	29.41	n	n		n					n		4			l	l		2					s	s			s	s	s		5	0.60	1.60
(17-761) Cedar Fork																																		
Year: 1998																																		
8.0	76.0	23.26	n	n		n	n	n	n	n	n	n	9			l			1						s							1	0.20	0.30
3.2	72.0	13.51	n	n		n		n	n	n	n	n	8						0	s					s							2	0.11	0.33
0.8	66.5	10.53		n	n				n	n	n	n	6	l			l		2	s				s	s							3	0.43	0.86

Table 10. continued.

Table 10. continued.

QHEI, macrohabitat quality at or above the WWH threshold was observed within Jamison Creek and Town Run, and the lower 0.3 miles of Lang Creek. Within these areas, positive habitat attributes were predominant, with fully exceptional conditions indicated for the lower reach of Lang Creek (QHEI=82.5). Impairment of the WWH aquatic life use, derived solely from deficient habitat, did not appear likely for these streams or stream segments.

Deficient macrohabitats were indicated for the remaining upstream reach of Lang Creek. Both stations within this segment (RMs 0.4 and 3.2) appeared to have been channelized in the past, with only limited recovery evident. The potential of habitat limitation must be duly considered through the upper portion of Lang Creek.

Muddy Fork Mohican River

The quality of near and instream macrohabitats of Muddy Fork were evaluated as part of the 1998 biosurvey. This effort was limited to the evaluation of two stations located at RMs 18.4 and 13.4. As measured by the QHEI, aggregate habitat quality of Muddy Fork was found to be at or just below the WWH threshold. The station located at RM 18.4 (Flemming Rd.) achieved a score of 61.5, while the remaining station (RM 13.4, Martin Rd.) indicated marginally deficient conditions (QHEI=56.0). The upper station appeared in a natural, or unmodified state, possessing a minimum compliment of positive physical features. The remaining station was likely channelized in the past, but limited recovery was evident. In comparison with the upper station, this site was deficient in substrate (composition and level of embeddedness), sinuosity, and cover diversity.

With such a small sampling of Muddy Fork, it is difficult to evaluate aggregate habitat quality, and describe (with confidence) its ultimate effect on ambient biological performance. However, the lower reach did yield a subpar evaluation, and potential negative influence on ambient biological performance must be considered.

Black Fork Mohican River

As part of the 1998 fish sampling effort, the quality of near and instream macrohabitats of the Black Fork Mohican River were evaluated at nine locations. QHEI values ranged between 40.0 (RM 38.4, Geisinger Rd.) and 73.0 (RM 54.6, Stiving Rd.), with a mean reach score of 52.9 (±10.2 SD). A matrix of habitat features and QHEI values for each fish sampling station is presented in Table 18.

Deficient near and instream habitats were indicated at over 80% of the fish sampling stations on the Black Fork. In fact, fully 50% of the QHEI scores were at or below 51.0, well beneath the WWH threshold of 60.0. Nearly all stations appeared to have been subjected to significant channel modification in the past, with little recovery evident. As a result, channel development was generally monotonous, with little functional sinuosity. Substrates consisted mainly of finer sand and gravel, often excessively burdened with clayey silts.

Free flowing natural stream habitats were observed at only one station, located within the upper limits of the study area at RM 54.6 (Stiving Rd.). This site contained abundant coarse substrates, good-fair channel development, diverse cover types, and mixed current velocities. The cumulative effect of these positive habitat features (and others) was reflected in a QHEI score of 73.0, the highest recorded for the Black Fork, and well in excess of the WWH threshold. However, based upon the qualitative habitat evaluations performed within the basin, the predominance and systematic nature of the impacts to physical habitat throughout the Black Fork would easily overwhelm the relatively small and likely isolated reach of high quality habitat in terms of its contribution, in the aggregate, to the ability of this stream to support diverse and representative aquatic assemblages. Ultimately, the deficient physical features that typify the evaluated portion of the Black Fork likely exert a negative influence on ambient biological performance, and ultimately the attainability of the WWH ambient biological criteria.

Tuby Run

As part of the 1998 sampling effort, the near and instream macrohabitats of Tuby Run were evaluated at two fish sampling stations located within the industrial and suburban portions of the City of Shelby. Habitat evaluations at RMs 0.7 (upstream Copperweld) and 0.1 (downstream Copperweld) yielded QHEI scores of 49.5 and 41.0, respectively. This segment of Tuby Run appeared highly artificial, the result of excessive urban encroachment and direct channel modifications. Both stations contained a predominance of high and moderate influence modified habitat features, which were reflected in the deficient QHEI scores. Limiting habitat or the possibility of habitat derived impairment must be given due consideration regarding ambient biological performance.

Rocky Fork Mohican River

As part of the 1998 fish sampling effort, the quality of near and instream macrohabitats of the Rocky Fork Mohican River were evaluated at six locations. QHEI values ranged between 34.0 (RM 15.8, Old Bowman Rd.-adj. Omnisource) and 77.0 (RM 0.6, Applegate Rd.), with a mean reach score of 59.3 (±16.7 SD). A matrix of habitat features and QHEI values for each fish sampling station is presented in Table 18.

The mainstem of the Rocky Fork was found to contain a diversity of habitat types. Two segments possessed the requisite complement of positive habitat attributes. The first included the extreme headwaters of the study area and extended downstream to approximately Old Bowman Rd. Macrohabitat quality of this segment was evaluated at RM 16.4 (Wilging Rd.). Although much evidence of physical encroachment (e.g., direct channel modification, removal of riparian vegetation, and bank stabilization efforts) was apparent, the station did maintain a minimum of positive habitat features (QHEI = 58.0). Although the condition of near and instream habitat within this segment was not optimal, significant habitat derived impairment did not appear likely.

The second segment of functional habitat included the lower portion of the Rocky Fork mainstem, extending from RM 11.6 (Illinois Ave.) to the mouth at RM 0.6 (Applegate Rd.). Macrohabitat quality was markedly improved throughout this segment, as all stations within this reach maintained QHEI values well above the WWH threshold. Positive habitat attributes commonly encountered included abundant coarse substrates, good to excellent channel development (recovered or natural), and abundant instream cover. Overall, the macrohabitat quality of this reach appeared fully capable of supporting WWH aquatic communities.

The intervening segment of the Rocky Fork, between RM 15.8 (Old Bowman Rd.) and RM 11.6 (Illinois Ave.), contained the most degraded stream habitats encountered within the 1998 study area. This reach was evaluated at RMs 15.8 and 14.3, and scored a QHEIs of 34 and 46.0, respectively. This segment contained a predominance of high influence modified habitat attributes. The channel configuration was highly artificial, mainly trapezoidal in cross section, and deeply incised. Much of the habitat deficit was attributable to the intensely urban and/or industrial nature of the adjacent land use. The simplified and artificial conditions of this portion of the Rocky Fork undoubtedly limit the ambient biological potential.

Clear Fork Mohican River

As part of the 1998 fish sampling effort, the quality of near and instream macrohabitats of the Clear Fork Mohican River were evaluated at ten free flowing locations. QHEI values ranged between 54.0 (RM 27.6, upstream Lexington WWTP) and 92.0 (RM 11.7, Butler Newville Rd.), with a mean reach score of 70.3 (±12.8 SD). A matrix of habitat features and QHEI values for each fish sampling station is presented in Table 18.

By and large, the condition of the macrohabitats within the free flowing portions of the Clear Fork Mohican River were found fully capable of supporting WWH aquatic communities. Fully half of the stations exhibited nearly exceptional habitat characteristics (QHEI≥74). The majority of the sampling stations contained a full complement of positive habitat features. The channel configuration was typically in a natural or recovered state, possessing good-excellent channel development and adequate sinuosity. Substrates were typically coarse, derived mainly from glacial till and native bedrock, and were not excessively burdened with fine sediment. Most stations were well structured with a variety of instream cover types that included woody debris, boulders, deep pools, and backwater areas.

Deficient macrohabitat was indicated at three sampling stations contained within the segment of the Clear Fork that flows through the city of Lexington, extending downstream to I-71. This reach has been subjected to extensive channelization, with varying degrees of recovery evident. The stations bracketing the Lexington WWTP (RMs 27.6 and 27.4) were by far the in the worst condition. The channel configuration was monotonous and largely trapezoidal in cross section. Substrates were predominately fine, composed mainly of sand, clays, and silt. The presence of a fairly mature wooded riparian corridor through this area suggests that a considerable amount of time has elapsed since the initial channel modifications. The apparent lack of recovery or natural reestablishment of positive habitat features, despite a sufficient period time, appeared a result of the low gradient of the segment (mean 3.9 ft./mile^2). Compared to the Clear Fork average of 10.3 ft/mile^2, with values as high as 35.7 ft./mile^2, this segment possessed the lowest stream fall observed within the study area. This lack of stream energy has greatly limited the physical recovery of this segment as well as creating ideal conditions for the deposition of fine embedding sediments. The degraded and highly simplified habitat undoubtedly exerted a negative influence on the ability of this portion of the Clear Fork to support and maintain an assemblage of fishes fully consistent with the WWH biological criteria.

Progressing further downstream from Lexington, modified channel characteristic persisted, but the level of recovery was significantly greater. Specifically, at RM 23.5 (Kings Corner Rd.), owing to increased gradient, many natural habitat features were reestablished Particularly, through substrate redistribution, several riffle-run-pool complexes were present in contrast with the monotony observed upstream. Substrates quality also reflected improved gradient, as the composition was predominately coarse, consisting mainly of glacial gravel and cobble.

In summary, the majority of the Clear Fork appeared fully capable of supporting an assemblage of aquatic organisms fully consistent with the WWH biological criteria. The potential of habitat derived impairment was indicated only for the 4.1 mile segment flowing through, and downstream from Lexington.

Selected Clear Fork Mohican Tributaries

The quality of near and instream macrohabitats of selected Clear Fork tributaries were evaluated as part of the 1998 effort in the following streams: Cedar Fork, Possum Run, and Pine Run. As measured by the QHEI, macrohabitat quality at or near the WWH threshold was observed at all stations. Furthermore, very good to fully exceptional habitat quality was indicated at three of the five sampling stations. Habitat derived impairment of the WWH aquatic life use did not appear likely for any of the Clear Fork tributaries evaluated in 1998.

Biological Assessment: Macroinvertebrate Community

Black Fork Mohican River

Quantitative (artificial substrate) and/or qualitative samples were collected from ten locations on the Black Fork Mohican River from RM 54.7, downstream from Stiving Ave. to RM 38.5, upstream from Geisinger Rd during the summer of 1998. Qualitative sampling was conducted twice in the Shelby WWTP mixing zone (RM 50.0). The 1998 macroinvertebrate sampling results are summarized in Table 19. A very good macroinvertebrate assemblage was present at the uppermost site (RM 54.7) despite less than optimal habitat afforded by a predominance of gravel substrate and riffle embeddedness. The biological criterion was met at RM 53.4 (ICI=36) but was significantly lower than that achieved at RM 54.7. The decline in the ICI was primarily due to a large proportion of tolerant organisms in the quantitative sample. The result reflected the effects of channelization and reduced water quality associated with urban runoff. The ICI declined into the fair range (ICI = 28) at the two sites downstream from Tuby Run (RMs 53.2 and 52.7). A high percentage of tolerant organisms were once again collected from the artificial substrates. Reductions in the density and diversity of relatively pollution sensitive mayfly and caddisfly taxa at these sites compared to RM 53.4 suggested that polluted water from Tuby Run may be contributing a toxic impact in addition to degradation associated with the surrounding urban land use. The macroinvertebrate community improved at RM 50.7 resulting in an ICI score in the exceptional range (ICI = 46), 2.6 miles downstream from Tuby Run. Sampling of the Shelby WWTP indicated that the discharge was not acutely toxic; however, tolerant taxa were predominate. A four point decrease in the ICI at RM 49.5 compared with RM 50.7, in part due to a relatively high number of the pollution tolerant limpet *Ferrissia*, indicated that the WWTP discharge was having a small but identifiable impact on the macroinvertebrate community. An imprint from the discharge was evident again at RM 46.5 in the relatively high number of blackflies (*Simulium* sp.) observed on the natural substrates. Blackflies can become numerous below WWTPs when nutrients in the effluent stimulate algal production on which the blackflies feed. Nevertheless, ICI scores were in the very good to exceptional range at all four sampling locations downstream from the Shelby WWTP (RM 49.5 to RM 38.5).

Compared to results of a similar survey conducted in 1989, the health of the macroinvertebrate community was significantly improved in 1998 (Figure 20). The greatest improvement was observed downstream from Tuby Run. Overall improvement since 1994 is reflected in the ICI ADV/mile statistic which declined from 60.3 in 1984 to 0.7 in 1998 (Table 20).

Table 19. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Clear Fork, Jerome Fork, Black Fork, and Rocky Fork Mohican River basin, July - October, 1998 and Cedar Fork of the Clear Fork, June 1999. Aquatic life uses listed are those currently designated in the Ohio Water Quality Standards or are proposed use designation changes.

Stream River Mile	Rel. Density (#/ft.^{2})	No. Quant. Taxa	No. Qual. Taxa	Qual. EPT[a]	Predominate Organisms	QCTV[c]	ICI	Narrative Evaluation[b]
					Clear Fork Mohican River (WWH proposed)			
35.7	192	34	47	11	Isopods, midges	39.5	44	Very good
29.6	1150	37	55	7	Hydropsychid caddisflies, midges	34.9	38	Good
27.7	1187	39	39	8	Hydropsychid caddisflies	38.7	40	Good
27.2	814	38	25	2	Aquatic worms, red midges	32.4	18	Fair
24.3	734	44	55	8	Hydropsychid caddisflies	37.9	48	Exceptional
23.5	560	44	45	7	Hydropsychid caddisflies	36.0	46	Exceptional
21.1	3165	31	75	23	Midges, hydropsychid caddisflies	39.5	48	Exceptional
16.8	2802	42	53	18	Tanytarsini midges	40.9	52	Exceptional
11.8	4375	33	61	21	Tanytarsini midges	40.9	48	Exceptional
4.0	-	-	43	13	Midges	40.9	-	Very good
0.3	-	-	63	24	Midges	42.7	-	Exceptional
					Cedar Fork (WWH proposed)			
8.2	-	-	59	19	Caddisflies, midges	41.3	-	Exceptional
3.2	-	-	43	13	Hydropsychid caddisflies, midges	39.9	-	Very good
0.8	-	-	31	12	Hydropsychid caddisflies, midges	41.2	-	Very good
					Black Fork Mohican River (existing WWH)			
54.7	543	47	55	10	Caddisflies, water pennies	38.4	44	Very Good
53.4	2012	48	45	11	Midges, aquatic worms	36.0	36	Good
53.2	487	43	28	9	Midges, aquatic worms	39.3	28	Fair
52.7	271	43	43	11	Midges, aquatic worms, riffle beetles	35.3	28	Fair
50.7	298	47	41	11	Hydropsychid caddisflies, midges	34.5	46	Exceptional
50.0A	-	-	30	4	Midges	26.7	-	Fair
50.0B	-	-	23	2	Midges	28.1	-	Fair

Table 19. Continued.

Stream River Mile	Rel. Density (#/ft.2)	No. Quant. Taxa	No. Qual. Taxa	Qual. EPT[a]	Predominate Organisms	QCTV[c]	ICI	Narrative Evaluation[b]
49.5	594	45	45	11	Mayflies, midges	35.7	42	Very Good
46.5	860	44	39	8	Hydropsychid caddisflies, mayflies	38.1	44	Very Good
43.5	353	43	36	10	Hydropsychid caddis, mayflies, midges	39.3	46	Exceptional
38.5	215	40	26	5	Heptageniid mayflies	38.7	46	Exceptional
Tuby Run (existing WWH)								
0.7	-	-	22	2	Midges	27.1	-	Poor
0.6	-	-	21	2	Midges	27.1	-	Poor
0.2	-	-	12	0	Midges, pond snails	22.7	-	Very Poor
Rocky Fork Mohican River (existing WWH)								
16.3	274	40	41	9	Mayflies, midges	39.1	46	Very Good
15.8	432	29	31	4	Midges	32.5	22	Fair
14.5A	-	-	22	3	Midges	34.5	-	Fair
14.5B	-	-	25	3	Midges	33.4	-	Fair
14.2	657	34	31	7	Midges	37.3	26	Fair
11.6	-	-	30	2	Midges	32.2	-	Fair
11.2A	-	-	19	2	Midges	33.5	-	Poor
11.2B	-	-	24	3	Blackflies	32.0	-	Poor
10.2	-	-	37	2	Midges, blackflies	33.5	-	Fair
0.6	1225	22	27	7	Hydropsychid caddis, blackflies, midges	38.8	36	Good
Town Run (existing WWH)								
0.1	-	-	30	5	Midges, blackflies, riffle beetles	35.1	-	Marginally good
Jamison Creek (existing WWH)								
1.2	-	-	59	11	Riffle beetles, caddisflies, mayflies	38.1	-	Very Good
0.3	-	-	45	10	Mayflies, riffle beetles, blackflies, midges	35.7	-	Good
0.1	-	-	36	8	Riffle beetles, midges	38.4	-	Good
Lang Creek (existing WWH)								
3.2	540	53	56	15	Baetid mayflies, hydropsychid caddisflies	38.1	58	Exceptional
0.4	-	-	47	13	Baetid mayflies, hydropsychid caddisflies	37.4	-	Good

Table 19. Continued.

Stream River Mile	Rel. Density (#/ft.2)	No. Quant. Taxa	No. Qual. Taxa	Qual. EPT[a]	Predominate Organisms	QCTV[c]	ICI	Narrative Evaluation[b]
0.34	-	-	45	12	Baetid mayflies, midges	37.3	-	Good
0.3	-	-	41	9	Riffle beetles, mayflies, midges	34.9	-	Good
					Jerome Fork (existing WWH)			
13.8	-	-	40	9	Mayflies, caddisflies, damselflies	39.1	-	Good
12.1	282	58	46	10	Mayflies, midges	37.3	48	Exceptional
10.5	156	34	38	11	Mayflies, damselflies, midges	38.4	[26]	Exceptional
5.7	634	38	44	12	Hydropsychid caddisflies	39.1	52	Exceptional
2.5	-	-	30	8	Mayflies, caddisflies, damselflies	39.3	-	Good
					Muddy Fork Mohican River (existing WWH)			
18.4	329	33	41	9	Mayflies, midges	39.1	44	Very good
13.4	266	53	34	10	Mayflies, midges	39.1	44	Very good
					Red Haw Creek (existing WWH)			
2.1	219	44	42	13	Mayflies, tanytarsini midges	40.8	58	Exceptional

Ecoregion Biocriteria: Erie-0ntario Lake Plain (EOLP)

INDEX	WWH	EWH
ICI	34	46

a- EPT=total Ephemeroptera (mayflies), Plecoptera (stoneflies), & Trichoptera (caddisflies) taxa richness.
b- Qualitative narrative evaluation is based on best professional judgment utilizing sample attributes such as taxa richness, EPT richness, and QCTV score and is used when quantitative data are not available to calculate an Invertebrate Community Index (ICI) score.
c- Qualitative Community Tolerance Value (QCTV) is derived as the median of the tolerance values calculated for each qualitative taxon present (see discussion in Methods Section).
d- Qualitative assessment used in lieu of quantitative score due to lack of flow and/or vandalism of H.-D.'s.
*- Significant departure from ecoregion biocriterion (>4 ICI units); poor and very poor results are underlined.
ns- Nonsignificant departure from ecoregion biocriterion (≤4 ICI units).

Tuby Run

Tuby Run is a small channelized stream that flows adjacent to and receives runoff and effluent from the Copperweld Inc. facility in Shelby, Ohio. Samples collected upstream from the Copperweld 005 discharge (RM 0.7) and within the mixing zone (RM 0.6) yielded similar results. Twenty-one taxa were collected at each site. While there did not appear to be an acutely toxic impact from the 005 discharge, the macroinvertebrate community at both sites was in poor condition. Channelization, runoff from Copperweld and nutrient enrichment from agriculture in the headwaters were possible sources of the degradation. The community at RM 0.2 was composed of a limited number of taxa and overall density was low. The pollution tolerant midge, *Cricotopus bicinctus*, and pond snails (*Physella* sp.) were numerically predominant and were reflective of a severe toxic impact. Operations at Copperweld and contaminated sediments were possible sources of toxicity.

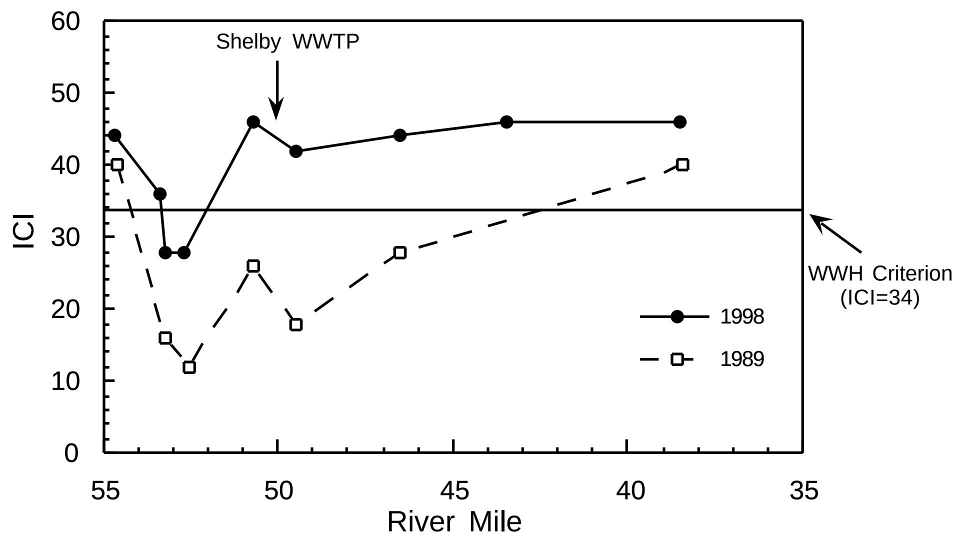

Figure 20. Longitudinal trend of the Invertebrate Community Index (ICI) in the Black Fork Mohican River, 1989 and 1998.

Rocky Fork Mohican River

Quantitative (artificial substrate) and/or qualitative samples were collected from seven locations on the Rocky Fork Mohican River from RM 16.3, at Wilging Rd. to RM 0.6, upstream from Applegate Rd. Qualitative sampling was conducted twice in the Armco 002 (RM 14.5) and the Mansfield WWTP mixing zones (RM 11.2) during the summer of 1998. A similar survey was conducted in 1993. A very good macroinvertebrate community (ICI = 46) was present at Wilging Rd. but a decline was evident in the highly modified industrial area at RM 15.8 (Figure 21). The community was in fair condition as a result of the suboptimal channelized habitat and polluted runoff. Qualitative sampling of the Armco 002 mixing zone demonstrated that the acute toxic condition present in 1993 had been corrected. Pollution tolerant taxa were predominant but a number of comparatively sensitive taxa were also collected. The community was impaired downstream from the Armco 002 discharge (RM 14.2) and upstream from the Mansfield WWTP (RM 11.6), but was substantially improved compared to the severely

Table 20. Area of Degradation Values (ADV) statistics for the Clear Fork, Jerome Fork, Black Fork, and Rocky Fork Mohican River basins. Values were calculated using Erie/Ontario Lake Plain (EOLP) WWH biocriteria as the baseline for community performance.

Stream (Year)	Reach		Biological Index Values		ADV Statistics Positive		ADV Statistics Negative		Attainment Status (miles)		
Index	Upper RM	Lower RM	Mini-mum	Maxi-mum	ADV	**ADV/ Mile**	ADV	**ADV/ Mile**	Full	Partial	**Non**
Clear Fork Mohican River (1998)											
IBI			35	46	2942	83.0	0	**0.0**			
MIwb	35.7	0.3	7.0	9.3	1793	61.1	4	**0.1**	33.5	1.9	**0.0**
ICI			18	52	4637	130.9	85	**2.4**			
Rocky Fork Mohican River (1998)											
IBI			24	41	198	**12.5**	414	**26.2**			
MIwb	16.4	0.6	5.7	6.5	0	**0.0**	764	**69.4**	0.2	5.9	**9.7**
ICI			22	46	176	**11.2**	461	**29.3**			
Rocky Fork Mohican River (1993)											
IBI			12	41	91	**5.7**	1614	**102.1**			
MIwb	16.4	0.6	1.6	9.1	160	**12.4**	950	**74.2**	2.7	2.9	**10.2**
ICI			0.0	50	1141	**72.6**	1175	**74.8**			
Muddy Fork Mohican River (1998)											
IBI			42	43	425	**84.9**	0	**0.0**			
MIwb	18.4	13.4	8.3	8.6	253	**50.6**	0	**0.0**	5.0	0.0	**0.0**
ICI			44	44	700	**140.0**	0	**0.0**			
Muddy Fork Mohican River (1984)											
IBI			45	45	0	**0.0**	90	**90.0**			
MIwb	19.0	18.0							1.0	0.0	**0.0**
ICI											
Jamison Creek (1998)											
IBI			52	54	170	**170.0**	0	**0.0**			
MIwb	1.2	0.1							1.1	0.0	**0.0**
ICI			34	42	84	**76.3**	0	**0.0**			

Table 20 Continued.

Stream (Year)	Reach		Biological Index Values		ADV Statistics				Attainment Status (miles)		
					Positive		Negative				
Index	Upper RM	Lower RM	Mini-mum	Maxi-mum	ADV	**ADV/ Mile**	ADV	**ADV/ Mile**	Full	Partial	**Non**
Jamison Creek (1984)											
IBI			32	37	0	**0.4**	16	**18.2**			
MIwb	1.2	0.3							0.1	0.8	**0.0**
ICI			30	34	20	**22.2**	0	**0.0**			
Lang Creek (1998)											
IBI			44	46	332	**114.4**	0	**0.0**			
MIwb	3.2	0.3	8.5	9.0	6	**55.0**	0	**0.0**	2.9	0.0	**0.0**
ICI			34	58	464	**159.9**	0	**0.0**			
Lang Creek (1984)											
IBI			33	47	133	**53.2**	1	**0.5**			
MIwb	3.2	0.3	5.8	5.8	0	**0.0**	83	**82.5**	1.9	0.0	**0.6**
ICI			34	34	96	**40.0**	0	**0.0**			
Jerome Fork Mohican River (1998)											
IBI			32	46	617	**58.7**	6	**0.5**			
MIwb	13.8	2.5	6.7	9.2	389	**37.0**	39	**3.7**	8.8	2.5	**0.0**
ICI			34	52	1787	**158.1**	0	**0.0**			
Jerome Fork Mohican River (1984)											
IBI			14	35	10	**1.1**	748	**89.0**			
MIwb	13.9	0.9	3.1	8.2	15	**1.7**	723	**86.0**	0.7	0.6	**11.7**
ICI			2	50	48	**3.9**	2096	**173.2**			
Black Fork Mohican River (1998)											
IBI			12	48	803	**49.5**	315	**19.4**			
MIwb	54.7	38.4	0.2	9.4	184	**11.3**	798	**49.2**	2.9	9.3	**4.1**
ICI			28	46	1086	**127.9**	13	**0.8**			
Black Fork Mohican River (1984)											
IBI			17	32	0	**0.0**	1194	**104.7**			
MIwb	54.6	43.2	2.5	7.6	0	**0.0**	1240	**108.7**	0.0.	0.0	**11.4**
ICI			12	34	128	**18.7**	393	**57.7**			

degraded conditions present in 1993. These sites were rated as very poor in 1993 versus a fair rating in 1998. A high percentage of tolerant organisms within this reach demonstrated that toxicity remained a factor despite improved treatment processes at Armco. Sources may include effluent outfalls,

contaminated sediments and/or runoff from the urban/industrial area. The Mansfield WWTP effluent (RM 11.2) was not acutely toxic; however, it appeared to contribute a significant nutrient load to the stream. The mixing zone yielded high numbers of tolerant midges and blackflies. The macroinvertebrate community was in fair condition at SR 39 (RM 10.2) based on qualitative sampling and appeared to be marginally improved compared to results of the 1993 sampling. Tolerant midges of the genus *Cricotopus* and blackflies predominated the natural substrates. Filter feeding caddisflies (Hydropsycidae) were present in low numbers but no mayflies were collected. It appeared that a high level of nutrient enrichment along with some lingering toxicity were impacting the macroinvertebrate community. The biocriterion was exceeded at RM 0.6 (ICI = 36); however, an enrichment affect was still evidenced by the large number of filter feeding caddisflies and blackflies. This site scored in the exceptional range (ICI = 46) in 1993. Overall improvement since 1993 is reflected in the ICI ADV/mile statistic which declined from 70.7 in 1993 to 27.5 in 1998 (Table 20).

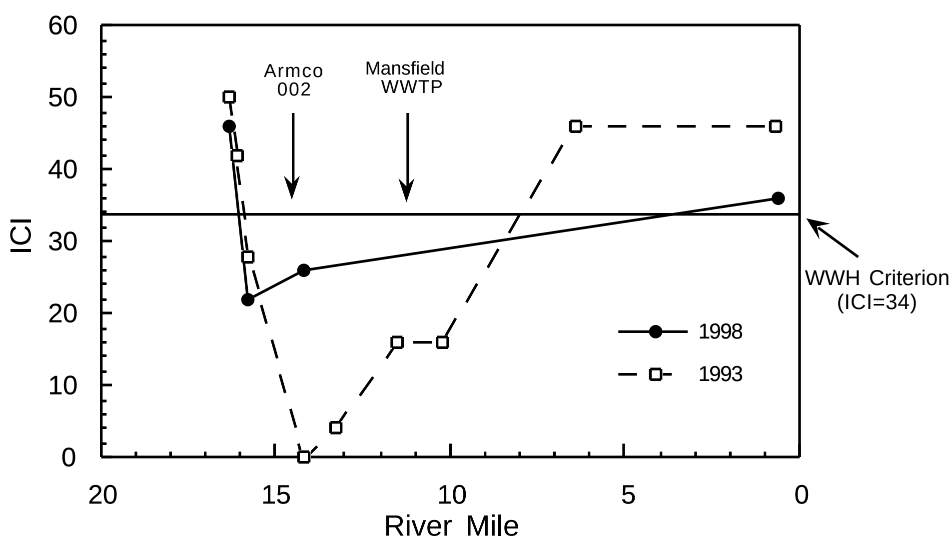

Figure 21. Longitudinal trend of the Invertebrate Community Index (ICI) in the Rocky Fork Mohican River, 1993 and 1998.

Town Run

Qualitative sampling of Town Run at RM 0.1 produced 30 taxa in low density. The macroinvertebrate community included five relatively pollution sensitive EPT taxa (Ephemeroptera, Plecoptera and Trichoptera) as well as a number of tolerant taxa including blackflies and *Cricotopus* spp. midges. It appeared that recent high stream flows had scoured the stream prior to sampling. It was likely that the effect was aggravated by the large percentage of urban land use in the watershed.

Jamison Creek

Qualitative sampling was conducted at three locations on Jamison Creek. The macroinvertebrate community was in very good condition at RM 1.2. The natural substrate was less affected by scouring than the sites downstream, and, as a result, supported a diverse macroinvertebrate assemblage including eleven EPT taxa. The two downstream sites (RMs 0.3 and 0.1) yielded fewer taxa, fewer EPT taxa and supported lower densities of organisms than the upstream sampling location. The decline appeared to be due to recent scouring by high flow rather than an impact from Town Run. The macroinvertebrate communities were in good condition at RM 0.3 and RM 0.1. The macroinvertebrate community at RM 0.1 was in much better condition in 1998 versus when the stream was last surveyed in 1984. This site had been severely impacted by a toxic metals discharge to an upstream unnamed tributary that has since been eliminated. The impact extended to downstream segments of Lang Creek and Jerome Fork in 1984.

Lang Creek

The ICI score of 58 from RM 3.2 demonstrated the exceptional nature of the macroinvertebrate community. In addition, qualitative sampling produced a high diversity of taxa including numerous sensitive taxa. This result was somewhat unexpected because the stream flowed through an area of extensive row crop agriculture with a narrow shrubbed riparian zone. Qualitative sampling upstream, within, and downstream from the Ashland WWTP mixing zone (RMs 0.4, 0.34 and 0.3, respectively) produced good macroinvertebrate assemblages but not as diverse as the upstream site; each supported low overall densities. The Ashland WWTP discharge was not acutely toxic nor was there any significant enrichment attributable to the WWTP or impact from Jamison Creek. There was evidence of substrate scouring due to high stream flow at all four sites on Lang Creek.

Jerome Fork

Jerome Fork sampling results were severely affected by redistribution of the sand due to high water. Qualitative sampling produced good to exceptional assemblages, however, most of the organisms were limited to stable pieces of wood, rubble or root mats. In two cases (RMs 13.8 and 2.5) the artificial substrates were buried by up to several feet of sand. Sites where the artificial substrates were unaffected (RMs 12.1 and 5.7) produced ICI scores in the exceptional range (ICI = 48 and 52, respectively) (Figure 22). The artificial substrates were collected and analyzed from RM 10.5 even through the majority of the samplers were filled with sand. The quantitative sample contained relatively high numbers of aquatic worms and midges of the *Polypedilum (Tripodura)* nr. *Scalaenum* group and low diversity and numbers of mayfly and caddisfly taxa. The resultant ICI score of 26 was not reflective of the exceptional community health demonstrated by the assemblage collected from the available natural substrates. The sites that supported exceptional macroinvertebrate assemblages had more large substrate material than those which received a good rating. In 1984, the macroinvertebrate community in Jerome Fork was severely impacted downstream from Lang Creek. The 1998 sampling demonstrated significant improvement in water quality due to improved operation of the Ashland WWTP and elimination of toxic discharges to Jamison Creek which also affected Lang Creek and Jerome Fork.

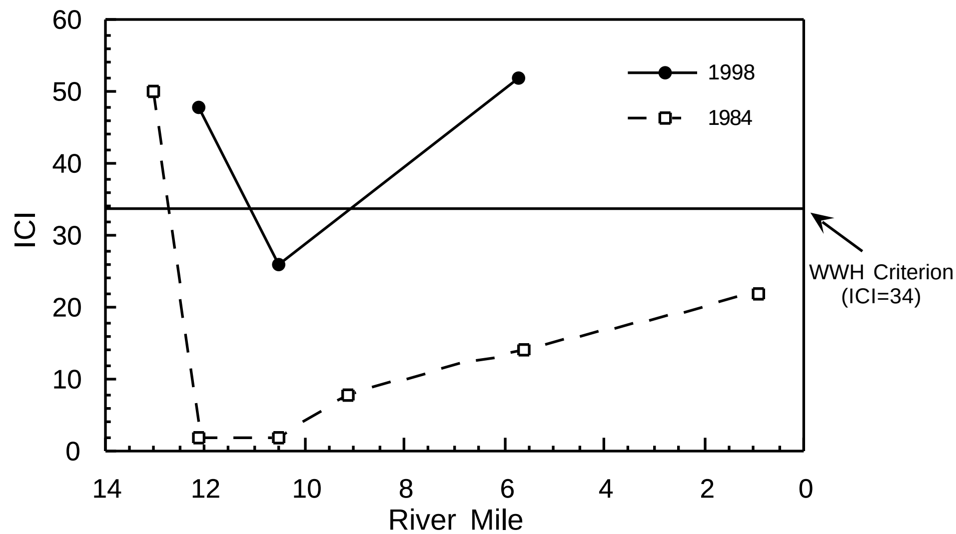

Figure 22. Longitudinal trend of the Invertebrate Community Index (ICI) in the Jerome Fork Mohican River, 1993 and 1998.

Muddy Fork Mohican River

Two sites on the Muddy Fork supported very good macroinvertebrate communities (Figure 23). ICI scores of 44 were recorded, however, recent high flow had scoured and redistributed the predominantly sand and fine gravel substrates and woody debris. Consequently, organism density was reduced on the natural substrates at RM 13.4. The habitat at RM 18.4 which included significant amounts of rubble and boulders was much less affected by high water.

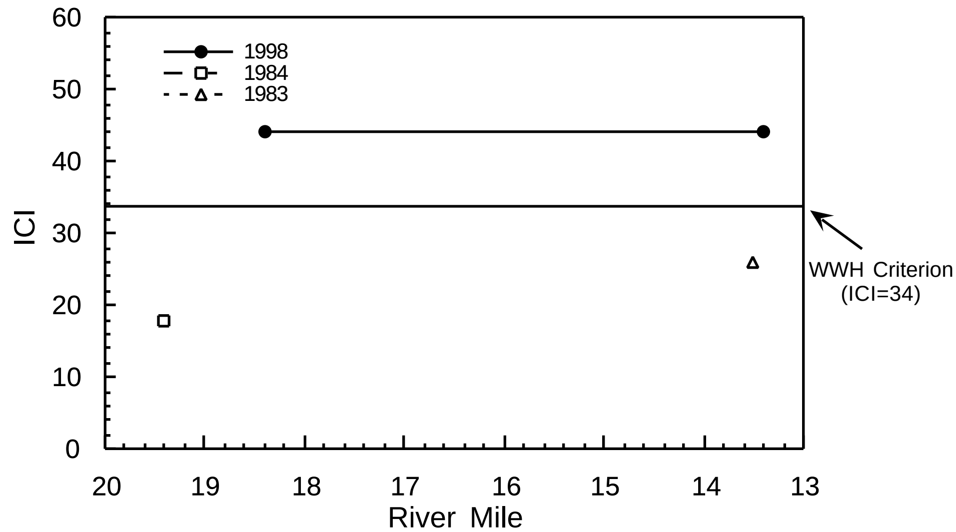

Figure 23. Longitudinal trend of the Invertebrate Community Index (ICI) in the Muddy Fork Mohican River, 1983, 1984 and 1998.

Redhaw Creek

The macroinvertebrate community of Redhaw Creek at RM 2.1 was in exceptional condition owing, in part, to an abundance of coarse stable substrates that resisted recent scouring that affected many sampling locations in the Jerome Fork basin. Sampling yielded an ICI score of 58 and a diverse assemblage of sensitive taxa including three stonefly taxa.

Clear Fork

Macroinvertebrate sampling was conducted at eleven locations from upstream from Clear Fork Reservoir (RM 35.7) to near the mouth of the stream (RM 0.3). Upstream from Clear Fork Reservoir the community was in very good condition but individual septic systems and sedimentation were considered threats to water quality at the site. Sedimentation was also evident downstream from Clear Fork Reservoir and within the city of Lexington (RMs 29.6 and 27.7). The macroinvertebrate community was in good condition within this reach but urban runoff and the addition of suspended organic material in the discharge from Clear Fork Reservoir along with sedimentation may have been limiting community diversity. The only sampling location that did not attain the WWH bicriterion was downstream from the Lexington WWTP (RM 27.2) where an ICI score of 18 was recorded (Figure 24). This site was channelized and heavily silted which can inhibit the establishment of a typical warmwater macroinvertebrate community. However, the predominance of tolerant organisms in the quantitative sample, an absence of mayfly taxa, and limited diversity and numbers of caddisfly taxa indicated that the stream was degraded by the WWTP discharge. The physical condition of the stream may have worsened the impact by limiting reaeration and accumulating organic material. Invertebrate Community Index scores were in the exceptional range at the five sites from Kocheiser Rd (RM 24.3) to Butler Newville Rd., upstream from Pleasant Hill Lake (RM 11.8). Filter feeding hydropsychid caddisflies and tanytarsini midges predominated and indicated an abundance of suspended organic material. The number of EPT taxa collected from the natural substrates within this reach was variable and positively associated with large substrate size and reduced sedimentation. Macroinvertebrate community health declined slightly immediately downstream from Pleasant Hill Lake (RM 4.0) but was again considered exceptional near the mouth of the Clear Fork where a total of 24 EPT taxa were collected.

Currently the Clear Fork is designated with the Coldwater Habitat (CWH) aquatic life use. Only two coolwater taxa, the caddisfly *Ceratopsyche slossonae* and the midge *Parmetriocnemus,* were collected sporadically throughout the study area. A CWH use based on native fauna was not merited based on this result.

Cedar Fork

Qualitative sampling was conducted at three locations during June, 1999. Exceptional to very good communities were documented. The upstream sampling location (RM 8.2) yielded 59 taxa including four coolwater taxa. Downstream from RM 8.2, the stream was affected by

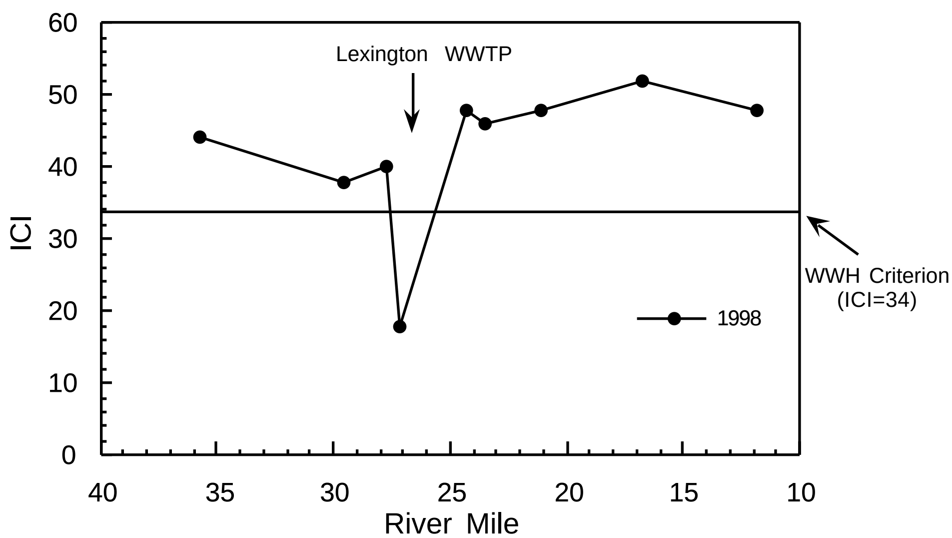

Figure 24. Longitudinal trend of the Invertebrate Community Index (ICI) in the Clear Fork Mohican River, 1998.

channelization and reduced canopy. As a result, community diversity at RMs 3.2 and 0.8 was decreased and only one coolwater taxon (*Ceratopsyche slossonae*) was collected.

Biological Assessment: Fish Community

Jerome Fork Mohican River

A total of 6,963 fish comprising 35 species were collected from Jerome Fork between July and October, 1998. The fish sampling effort included five stations along the mainstem from RM 13.9 (SR 58) to RM 2.6 (CR 175). The entire length of Jerome Fork is currently designated WWH (OAC 3745-1). As the drainage area at each 1998 station exceeded 20 mile^2, the condition of the fish community was evaluated against wading biocriteria, which includes the use of both the IBI and MIwb (Ohio EPA 1989).

Numerically, the predominant species included bluntnose minnow (24.0%), creek chub (23.0%), striped shiner (10.5%), central stoneroller (8.9%), and sand shiner (6.8%). In terms of biomass, dominant species were white sucker (26.0%), common carp (24.6%), creek chub (21.5%), striped shiner (7.4%), and bluntnose minnow (3.6%). No species classified as endangered, threatened or special status (Ohio DNR 1997) were observed during the 1998 Jerome Fork survey .

Community indices and accompanying narrative evaluations ranged between very good/good (IBI=46, MIwb=9.0) at RM 13.0 (SR 58) and fair (IBI=32, MIwb=6.7) at RM 2.6 (CR175). Overall, the fish assemblage of Jerome Fork was characterized as good. Longitudinal performance of the IBI and MIwb are presented in Figure 25. Summarized index scores and community statistics by station are presented in Table 21.

The performance of the IBI and MIwb exhibited considerable parity throughout the length of Jerome Fork, as both indices displayed nearly identical longitudinal patterns. Community performance was generally depressed at two points, RM 10.5 (SR 20) and RM 2.6 (CR 125A), as one or both of the community measures deviated from the WWH biocriteria at each site. Fish communities fully consistent with the WWH biocriteria were found at the upper two sampling sites (RM 13.0 and RM 12.1), immediately bracketing the Ashland WWTP (via Lang Creek), and at RM 5.7 (CR 30A).

The sampling stations at RM 10.5 and RM 2.6 were found to contain deficient instream habitat, achieving QHEI scores of 51.0 and 45.0, respectively; the lower site was by far the most impacted. Degraded stream habitat can exert a strong negative influence on ambient biological performance, and cannot be discounted in explaining the subpar performance of the fish assemblages at these sites. However, multiple point stressors are also present throughout the Jerome Fork subbasin and impacted water quality appeared culpable. Departure from the WWH

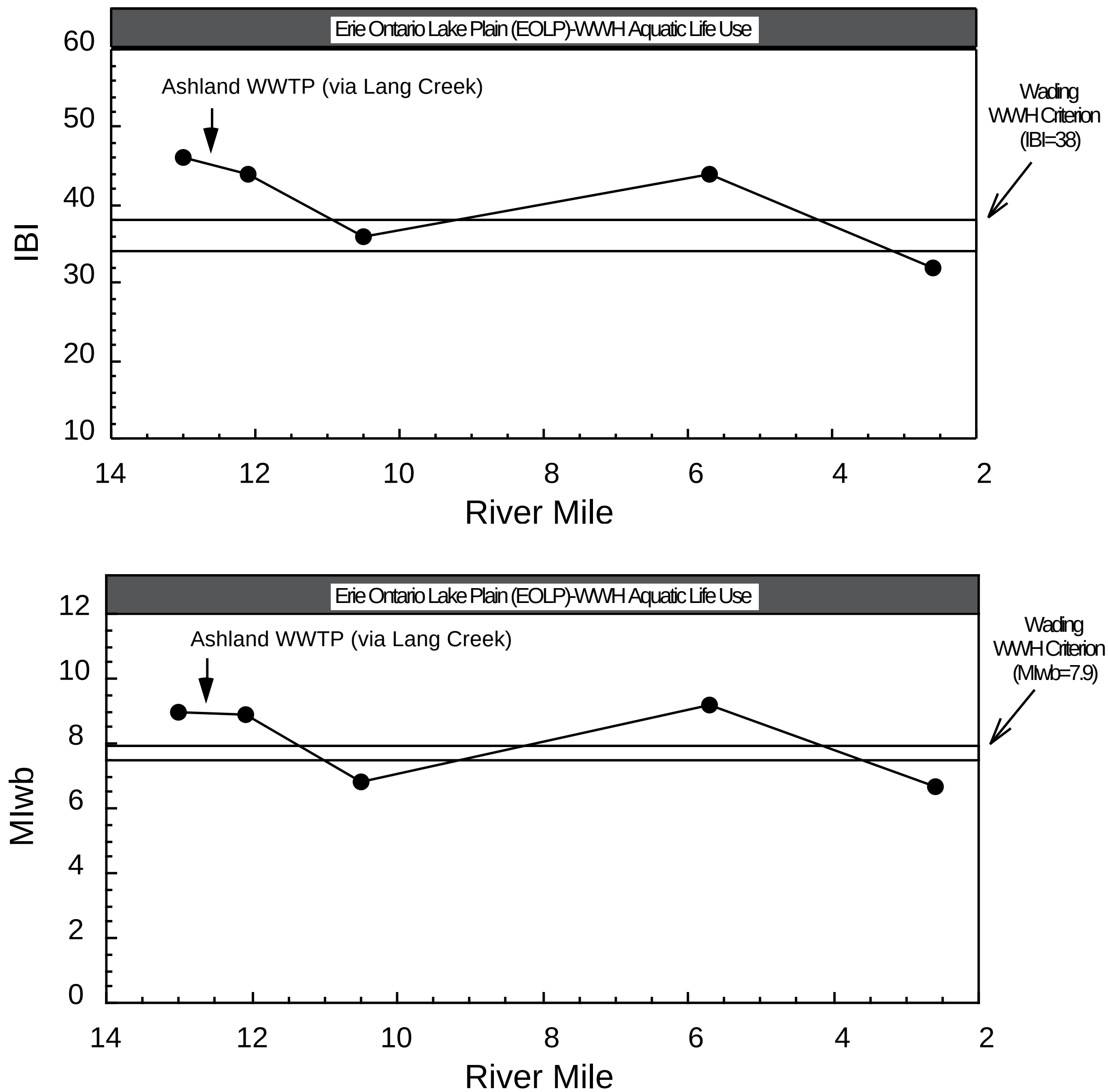

Figure 25. Longitudinal performance of the Index of Biotic Integrity (IBI) and the Modified Index of well-being (MIwb) through Jerome Fork, 1998. The solid lines represent numerical biological criteria and the area of nonsignificant departure in support of the existing WWH aquatic life use designations-Erie Ontario Lake Plain (EOLP) ecoregion.

Table 21. Fish community indices and descriptive statistics based on samples collected by Ohio EPA from the Mohican River basin, 1982-1998.

Stream River Mile	Mean Number Species	Cumulative Species	Mean Rel. No. (No./0.3km)	Mean Rel. Wt. (Wt./0.3km)	QHEI	Mean IBI	Mean MIwb	Narrative Evaluation
Jerome Fork (1998) *Erie Ontario Lake Plain - WWH Use Designation*								
13.0(W)	28.0	31	1449.8	16.5	53.0	46	9.0	V. Good/Good
12.1(W)	24.0	24	1938.0	24.9	65.0	44	8.9	Good/V.Good
10.5(W)	18.0	18	361.3	10.3	51.0	36[ns]	6.8*	M.Good/Fair
5.7(W)	22.0	22	1506.0	37.5	71.5	44	9.2	Good/V.Good
2.6(W)	23.0	23	279.0	51.2	45.0	32*	6.7*	Fair
Jerome Fork (1984) *Erie Ontario Lake Plain - WWH Use Designation*								
13.9(W)	20.3	26	697.0	10.7	-	35[ns]	7.2*	M.Good/Fair
13.0(W)	23.7	30	1848.0	25.5	62.0	35[ns]	8.2	M.Good/Good
12.1(W)	4.0	5	38.0	0.5	70.0	15*	3.4*	Very Poor
10.6(W)	6.0	8	39.0	0.2	50.0	14*	3.4*	Very Poor
9.1(W)	12.0	14	818.0	1.8	59.0	26*	5.9*	Poor/Fair
5.6(W)	17.5	22	599.0	11.1	70.0	32*	7.1*	Fair
Lang Creek (1998) *Erie Ontario Lake Plain - WWH Use Designation*								
3.2(H)	23.0	26	1533.0	20.4	56.0	46	N/A	V.Good
0.4(W)	25.0	25	2702.0	36.9	56.5	46	8.5	V.Good/Good
*0.34(W)**MZ***	*22.0*	*22*	*3738.0*	*41.2*	*N/A*	*52*	*9.4*	*Exceptional*
0.3(W)	24.0	24	2623.5	17.4	82.5	44	9.0	Good
Lang Creek(1984) *Erie Ontario Lake Plain - WWH Use Designation*								
3.2(W)	17.3	20	5227.0	N/A	71.0	47	N/A	Very Good
0.8(W)	17.5	19	456.0	26.8	71.0	33*	5.7*	Fair/Poor
Jamison Creek (1998) *Erie Ontario Lake Plain - WWH Use Designation*								
1.2(H)	18.0	18	4090.0	27.1	-	54	N/A	Exceptional
0.3(H)	20.0	20	6406.0	32.0	64.0	52	N/A	Exceptional
Jamison Creek (1984) *Erie Ontario Lake Plain - WWH Use Designation*								
1.2(H)	8.5	10	561.0	N/A	68.0	32*	N/A	Fair
0.3(H)	14.3	18	2050.0	N/A	75.0	37[ns]	N/A	M.Good
Town Run (1998) *Erie Ontario Lake Plain - WWH Use Designation*								
0.3(H)	16.0	16	2293.5	11.9	65.5	46	N/A	Very Good
Town Run (1984) *Erie Ontario Lake Plain - WWH Use Designation*								
0.3(H)	11.5	13	1701.0	N/A	59.0	59	N/A	Exceptional

Table 21. Continued.

Stream River Mile	Mean Number Species	Cumulative Species	Mean Rel. No. (No./0.3km)	Mean Rel. Wt. (Wt./0.3km)	QHEI	Mean IBI	Mean MIwb	Narrative Evaluation
Muddy Fork (1998) *Erie-Ontario Lake Plain - WWH Use Designation*								
18.4$^{(W)}$	21.5	23	1811.3	7.9	61.5	42	8.3	Good
13.4$^{(W)}$	25.0	30	1656.0	13.2	56.0	43	8.6	Good
Muddy Fork (1984) *Erie-Ontario Lake Plain - WWH Use Designation*								
18.5(H)	21.7		2124	-	51.0	45	N/A	Good
Muddy Fork (1983) *Erie-Ontario Lake Plain - WWH Use Designation*								
12.8 (W)	27.0		1781		65	40	9.2	Good
Black Fork Mohican River(1998) *Erie-Ontario Lake Plain - WWH Use Designation*								
54.6$^{(W)}$	18.0	20	1031.5	14.0	73.0	41	8.8	Good
53.4$^{(W)}$	23.0	23	2433.5	20.8	45.0	44	9.4	Good/V.Good
53.2$^{(W)}$	23.0	23	559.4	11.0	43.0	48	8.5	V.Good/Good
52.6$^{(W)}$	24.0	24	1546.5	24.6	59.0	42	8.6	Good
50.7$^{(W)}$	23.0	23	613.5	25.5	55.5	36^{ns}	6.2*	M.Good/Fair
50.0$^{(W)MZ}$	*11.0*	*11*	*372.0*	*10.2*	-	*40*	*7.4^{ns}*	*Good/M.Good*
49.6$^{(W)}$	25.0	25	409.5	27.5	59.5	40	6.5*	Good/Fair
46.5$^{(W)}$	19.0	19	558.0	7.1	50.5	44	7.5^{ns}	Good/M.Good
43.3$^{(W)}$	15.0	15	147.0	13.5	51.0	38	6.4*	Good/Fair
38.4$^{(W)}$	10.0	10	97.5	43.5	40.0	22*	5.1*	Poor
Black Fork Mohican River (1989) *Erie-Ontario Lake Plain - WWH Use Designation*								
54.7$^{(W)}$	19.5	21	1217.0	14.1	86.0	41	8.5	Good
53.4$^{(W)}$	22.5	27	1456.0	23.6	42.0	40	8.9	Good
53.3$^{(W)}$	14.0	18	760.0	10.1	38.0	31*	6.8*	Fair
52.7$^{(W)}$	16.0	21	372.0	5.6	61.0	34*	6.6*	Fair
50.4$^{(W)}$	14.5	20	253.0	35.2	46.0	25*	4.3*	Poor/V.Poor
50.0$^{(W)MZ}$	*7.5*	*10*	*185.0*	*25.8*	*49.0*	*23**	*5.3**	*Poor*
49.9$^{(W)}$	12.5	16	317.0	158.4	-	23*	6.6*	Poor/Fair
49.8$^{(W)}$	13.5	17	367.0	10.1	50.0	24*	5.5*	Poor
46.4$^{(W)}$	11.0	16	161.0	22.8	57.0	22*	4.4*	Poor/V.Poor
43.0$^{(W)}$	10.0	15	121.0	33.1	53.0	24*	4.0*	Poor/V.Poor

Table 21. Continued.

Stream River Mile	Mean Number Species	Cumulative Species	Mean Rel. No. (No./0.3km)	Mean Rel. Wt. (Wt./0.3km)	QHEI	Mean IBI	Mean MIwb	Narrative Evaluation
Black Fork Mohican River (1984) *Erie-Ontario Lake Plain - WWH Use Designation*								
54.6(W)	17.0	20	1578.0	9.9	67.0	32*	7.6[ns]	Fair/M.Good
53.3(W)	15.5	19	823.0	14.5	50.0	27*	7.4[ns]	Fair/Good
52.6(W)	15.0	17	542.0	8.8	68.0	23*	6.2*	Poor/Fair
50.2(W)	16.0	22	459.0	31.7	48.0	20*	4.3*	Poor/V.Poor
49.6(W)	7.0	9	120.0	5.7	60.0	17*	2.5*	Very Poor
46.5(W)	17.0	21	567.0	11.3	66.0	24*	5.8*	Poor
43.2(W)	14.0	17	333.0	8.8	70.0	28*	5.9*	Fair/Poor
36.6(W)	7.0	11	41	14.3	50.0	14*	3.7*	Very Poor
Tuby Run (1998) *Erie-Ontario Lake Plain - WWH Use Designation*								
0.7(H)	11.0	11	2138.0	17.5	49.5	40	N/A	Good
*0.6(H)**MZ***	*15.0*	*15*	*1104.0*	*6.4*	*N/A*	*42*	*N/A*	*Good*
0.1(H)	12.0	12	369.4	3.4	41.0	40	N/A	Good
Tuby Run (1989) *Erie-Ontario Lake Plain - WWH Use Designation*								
1.0(H)	3.0	3	72.0	N/A	46.0	18*	N/A	Poor
0.8(H)	5.0	8	609.0	N/A	48.0	18*	N/A	Poor
0.6(H)	6.5	10	62.0	N/A	41.0	22*	N/A	Poor
Rocky Fork Mohican River (1998) *Erie-Ontario Lake Plain - WWH Use Designation*								
16.4(H)	16.5	19	1657.5	12.8	58.0	40	N/A	Good
15.8(H)	15.5	18	639.0	28.4	34.0	24*	N/A	Poor
14.3(H)	15.0	16	1223.3	6.7	46.0	33*	N/A	Fair
11.6(W)	16.0	18	690.0	31.7	68.0	28*	5.9*	Fair
*11.2(W)**MZ***	*11.5*	*14*	*1965.0*	*55.8*	*N/A*	*26**	*5.0**	*Poor*
10.2(W)	18.0	21	884.3	44.0	73.0	29*	5.7*	Fair/Poor
0.6(W)	19.0	24	198.8	26.3	77.0	41	6.5*	Good/Fair
Rocky Fork Mohican (1993) *Erie-Ontario Lake Plain - WWH Use Designation*								
16.4(H)	14.0	14	1035.0	22.9	56.5	31*	N/A	Fair
15.8(H)	11.5	14	598.5	32.5	38.0	18*	N/A	Poor
14.6(H)	7.0	9	90.9	14.6	47.5	14*	N/A	Very Poor
*14.47(H)**MZ***	*1.0*	*2*	*6.0*	*0.08*	*N/A*	*12**	*N/A*	*Very Poor*
14.2(H)	0.0	0	0.0	0.0	56.5	12*	N/A	Very Poor
13.4(W)	3.5	6	6.36	0.13	48.5	12*	2.5*	Very Poor

Table 21. Continued.

Stream River Mile	Mean Number Species	Cumulative Species	Mean Rel. No. (No./0.3km)	Mean Rel. Wt. (Wt./0.3km)	QHEI	Mean IBI	Mean MIwb	Narrative Evaluation
Rocky Fork Mohican (1993) *Erie-Ontario Lake Plain - WWH Use Designation*								
11.7(W)	9.5	15	202.5	12.5	67.0	19*	3.9*	V.Poor/Poor
*11.1(W)**MZ***	*11.5*	*14*	*3456.0*	*34.3*	*N/A*	23*	*6.7**	*Fair/Poor*
10.2(W)	11.0	13	703.5	38.9	81.5	21*	5.2*	Poor
6.4(W)	17.5	19	1119.8	34.3	76.5	26*	6.6*	Fair/Poor
0.6(W)	23.5	26	2676.0	82.5	82.5	41	9.1	Good
Rocky Fork Mohican River (1982) *Erie-Ontario Lake Plain - WWH Use Designation*								
18.4(H)	8.5	10	198.8	N/A	-	34^{ns}	N/A	M.Good
16.4(H)	9.0	10	217.5	N/A	-	34^{ns}	N/A	M.Good
14.2(H)	3.8	7	73.2	N/A	-	16*	N/A	Very Poor
12.5(W)	5.5	8	195.4	N/A	-	19*	N/A	Poor
4.4(W)	4.8	8	50.6	N/A	-	18*	N/A	Poor
Rocky Fork Mohican River (1979) *Erie-Ontario Lake Plain - WWH Use Designation*								
11.6(W)	7.0	11	291.7	N/A	-	21*	N/A	Very Poor
10.2(W)	5.0	5	69.3	N/A	-	18*	N/A	Very Poor
4.4(W)	6.0	7	147.8	N/A	-	20*	N/A	Poor
0.6(W)	6.0	6	114.0	N/A	-	20*	N/A	Very Poor
Clear Fork Mohican River (1998) *Erie-Ontario Lake Plain - WWH Use Designation*								
35.7(H)	16.5	19	2110.0	11.9	72.0	46	N/A	Very Good
Erie-Ontario Lake Plain - CWH/WWH Use Designation Existing/Recommended								
29.6(W)	23.0	26	504.0	20.7	60.0	45	8.4	Good
27.6(W)	21.5	27	601.5	41.2	54.0	36^{ns}	7.0*	M.Good/Fair
27.4(W)	24.0	27	790.8	53.0	54.5	35^{ns}	7.6^{ns}	M.Good
23.5(W)	21.0	24	937.5	35.0	58.5	35^{ns}	7.5^{ns}	M.Good
21.0(W)	28.5	31	760.5	25.5	78.5	43	9.3	Good/V.Good
16.8(W)	22.0	24	1104.0	48.8	76.0	42	9.1	Good
Erie-Ontario Lake Plain - WWH Use Designation								
11.7(W)	26.5	33	799.5	46.6	92.0	44	9.2	Good
Erie-Ontario Lake Plain - CWH/WWH Use Designation Existing/Recommended								
4.0(W)	25.0	25	523.2	35.2	80.5	46	8.7	V.Good/Good
0.4(W)	24.5	30	661.5	26.2	77.0	40	8.0	Good

Table 21. Continued.

Stream River Mile	Mean Number Species	Cumulative Species	Mean Rel. No. (No./0.3km)	Mean Rel. Wt. (Wt./0.3km)	QHEI	Mean IBI	Mean MIwb	Narrative Evaluation
Clear Fork Mohican River (1993) *Erie-Ontario Lake Plain - WWH Use Designation*								
35.7(H)	14.5	17	2065.8	9.9	68.5	43	N/A	Good
Clear Fork Mohican River (1982) *Erie-Ontario Lake Plain - WWH Use Designation*								
36.7(H)	11.0		456.0	N/A	-	46	N/A	V.Good
Cedar Fork (1998) *Erie-Ontario Lake Plain - WWH Use Designation*								
8.0(H)	23.0	23	2460.0	15.3	76.0	60	N/A	Exceptional
3.2(W)	25.0	25	2680.0	40.0	72.0	46	9.6	V.Good
0.8(W)	22.0	22	772.5	13.9	66.5	44	8.3	Good
Possum Run (1998) *Erie-Ontario Lake Plain - WWH Use Designation*								
1.4(H)	16.0	16	1326.0	13.3	55.5	46	N/A	V.Good
Pine Run (1998) *Erie-Ontario Lake Plain - WWH Use Designation*								
0.1(H)	20.0	20	1130.6	4.64	70.5	44	N/A	Good

*-Significant departure from ecoregion biocriterion; poor and very poor results are underlined.
ns-Nonsignificant departure from biocriterion (≤4 IBI or ≤0.5 MIwb units).
H-Headwater station
W-Wadable station.
MZ-Samples collected with the 001 mixing zone.

Ecoregion Biocriteria: Erie-Ontario Lake Plain (EOLP)
(OAC 3745-1-07, Table 7-14)

INDEX - Site Type	WWH	EWH	MWH[d]
IBI - Headwater	40	50	24
IBI - Wading	38	50	24
MIwb - Wading	7.9	9.4	6.2

[d] - Modified Warmwater Habitat for channelized habitats/impounded habitats.

criteria at these sites appeared a result of the combined effects of both poor physical habitat and point sources of pollution.at RM 5.7 (CR 30A).

The sampling stations at RM 10.5 and RM 2.6 were found to contain deficient instream habitat, achieving QHEI scores of 51.0 and 45.0, respectively; the lower site being by far the most impacted. Degraded stream habitat can exert a strong negative influence on ambient biological performance, and cannot be discounted in explaining the subpar performance of the fish assemblages at these sites. However, multiple point stressors are also present throughout the Jerome Fork subbasin and impacted water quality appeared culpable. Departure from the WWH criteria at these sites appeared a result of the combined effects of both poor physical habitat and point sources of pollution.

The stream reach evaluated at RM 10.5 was obviously modified in the past, as channel development was monotonous, with little to no functional sinuosity. In keeping with this trapezoidal and highly artificial channel, substrates were typically fine, shifting and unstable sand and gravel. In terms of permitted discharges, this station was so placed as to evaluate the release of storm water from an intermittent discharge operated by BP Oil Co. (Ashland Pipeline), as well as the far field effects of wastewater released by the Ashland WWTP (via Lang Creek), located approximately two miles upstream. Field observations by Ohio EPA staff included a pronounced petroleum odor at this station, and a modest release of an oily substance into the water column upon substrate disturbance. Although anecdotal, these observations would suggest some level of petroleum contamination from the BP storm water discharge. These conditions were not observed elsewhere in the study area.

The MIwb failed to achieve the WWH criterion at RM 10.5 but the IBI met the minimum criterion (nonsignificant departure). The performance of both indices was uniformly depressed, however, in comparison with the relatively unimpacted stations upstream. Specifically, the IBI was negatively influenced by reduced species richness and a skewed trophic structure. The performance of the MIwb was most affected by overall low fish abundance (relative number and relative biomass), a common result of limited physical habitat. Moreover, the departure of the MIwb was not severe and was consistent with the MWH criterion, a performance benchmark established to evaluate permanently modified/physically degraded water bodies. In light of this it appears as though habitat quality is a significant factor in explaining the WWH departure.

The influence of the intermittent release from the BP storm water discharge and pollutant loads from Lang Creek (Ashland WWTP and multiple industrial entities within the Lang Creek subbasin) must also be considered. The fish community did provide evidence of chronic sublethal stress not typically associated with a strictly habitat derived impact. Deformities, eroded fins/barbels, lesions, and tumors (DELT) anomalies were elevated at nearly all stations beginning at RM 12.1 (downstream from the Ashland WWTP) and extending to the lower limits of the study area. Within this segment, the percentage of fish possessing these anomalies ranged between 0.1% and 1.2%. Based upon ecoregional reference conditions 0.3% and 1.3% are considered elevated and highly elevated, respectively (Ohio EPA 1987). Elevated DELT anomalies within an assemblage of fishes have been found to be a reliable indicator of degraded water/sediment quality (Leonard and Orth 1986).

Departure from the WWH biocriteria at RM 2.6 was similar to that found at RM 10.5. Habitat conditions were severely degraded, representing the worst encountered in the Jerome Fork subbasin.

In addition to deficient physical habitat, this reach was subjected to diffuse sources of pollution, mainly wastes emanating from the unsewered area of Jeromesville and storm water from the Ashland Co. Landfill. Community performance as measured by the IBI and MIwb was characterized as fair, below the WWH, but exceeding the MWH criteria. The highly artificial and simplified habitats undoubtedly suppressed biological performance, but the incidence of DELT anomalies was elevated (1.2%), suggesting a potent nonlethal stress unrelated to the quality of physical habitat.

Selected Jerome Fork Tributaries

The fish assemblages of Lang Creek and its principal tributaries were surveyed and assessed at seven sampling sites during the summer of 1998. The Lang Creek effort extended from RM 3.2 (TR 1104) to RM 0.3 (downstream from the Ashland WWTP), and included one mixing zone and three ambient stations. Jamison Creek was sampled at two ambient locations: RM 1.2 (US 42, upstream Town from Run) and RM 0.3 (CR 1302, downstream from Town Run). A single sampling station was located on Town Run, at RM 0.3 (SR 42).

As measured by the IBI and MIwb (where applicable), all nonmixing zone stations within the Lang Creek subbasins were found to support a WWH fish community of fish fully consistent with the WWH biocriteria. Ambient community performance in Lang Creek ranged from good at RM 0.3 (IBI=44 and MIwb=9.0) to very Good, at RM 3.2 (IBI=46). Acute toxicity or avoidance was not indicated within the zone of initial mixing immediately downstream from the Ashland WWTP. Fully exceptional fish communities were collected at both Jamison Creek stations (IBIs=54 and 52), and very good conditions were found in Town Run (IBI=46). Longitudinal performance of the IBI for the Lang Creek subbasin is presented in Figure 26.

Despite these positive findings, elevated DELT anomalies were indicated in both Jamison Creek and Town Run. The highest incidence of gross anomalies (0.7%) was observed at RM 0.3 (Town Run) and Jamison Creek (RM 0.3, downstream from Town Run).

Muddy Fork Mohican River

A total of 4,623 fish comprising 31 species and one hybrid were collected from the Muddy Fork between August and September 1998. The fish sampling effort included two stations, evaluating the Muddy Fork mainstem at RM 18.4 (Flemming Rd.) and RM 13.4 (Martin Rd.). The entire length of the Muddy Fork is currently designated WWH (OAC 3745-1). Results from the fish sampling efforts were evaluated against the wading criteria which included the use of both the IBI and MIwb (Ohio EPA 1989).

Numerically, the predominant species included common shiner (16.9%), bluntnose minnow (16.6%), creek chub (12.8%), green sunfish (8.2%), and johnny darter (5.5%). In terms of biomass, dominant species were white sucker (31.2%), creek chub (24.6%), common shiner (11.6%), green sunfish

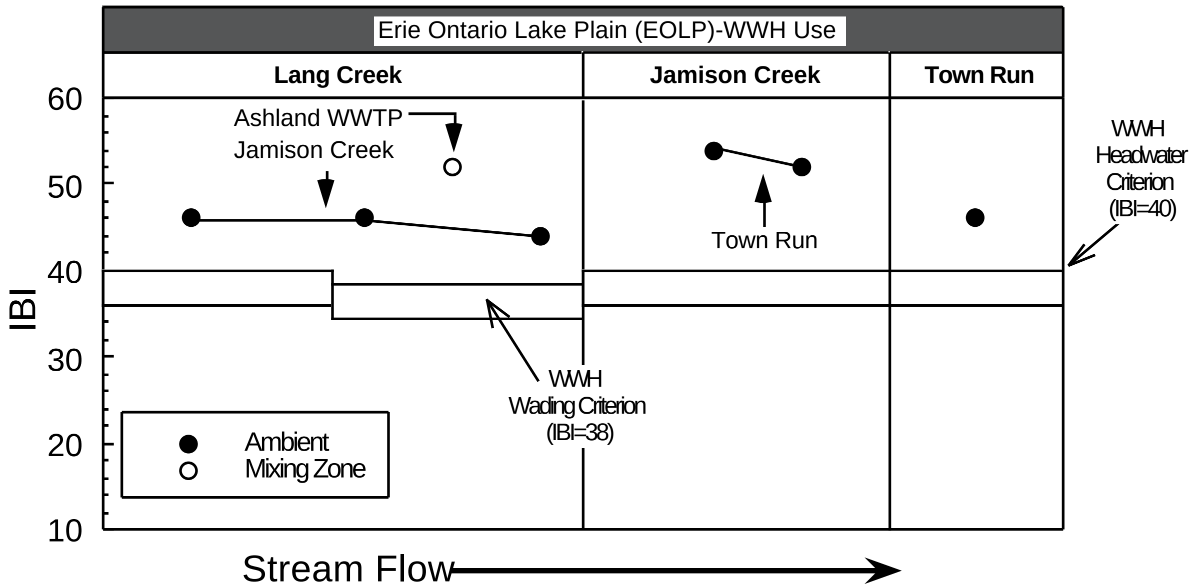

Figure 26. Longitudinal performance of the Index of Biotic Integrity (IBI) within the Lang Creek subbasin, 1998. The solid lines represent numerical biological criteria and the area of nonsignificant departure in support of the existing WWH aquatic life use designations - Erie-Ontario Lake Plain (EOLP) ecoregion.

(5.1%), and bluntnose minnow (4.5%). No species classified as endangered, threatened or special status (Ohio DNR 1997) were observed during the 1998 Rocky Fork survey. Community performance was remarkably similar between both sampling stations on the Muddy Fork. Each site was found to support a community of fishes. Summarized index scores and community statistics by station, are presented in Table 21.

Black Fork Mohican River

A total of 5,175 fish comprising 36 species and two hybrids were collected from the Black Fork between July and September, 1998. The fish sampling effort included ten stations along the mainstem between RM 54.6 (Stiving Rd.) and RM 38.4 (Geisinger Rd.). The entire length of the Black Fork is currently designated WWH (OAC 3745-1). Results from the fish sampling efforts were evaluated against the wading criteria, which includes the use of both the IBI and MIwb (Ohio EPA 1989).

Numerically, the predominant species included central stoneroller (16.0%), bluntnose minnow (15.5%), creek chub (10.1%), sand shiner (9.4%), and greenside darter (8.9%). In terms of biomass, dominant species were common carp (44.5%), white sucker (11.1%), creek chub (8.7%), central stoneroller (7.0%), and green sunfish (3.6%). No species classified as endangered, threatened or special status (Ohio DNR 1997) were observed during the 1998 Rocky Fork survey.

Community indices and their accompanying narrative evaluations ranged between poor (IBI=22, MIwb=5.1) at RM 38.4 (Geisinger Rd.) and very good/good (IBI=48, MIwb=8.5) at RM 53.2 (Main St.-downstream from Tuby Run). Overall, the fish assemblage of the Black Fork was characterized as good/marginally good. Longitudinal performance of the IBI and MIwb is presented in Figure 27. Summarized index scores and community statistics by station are presented in Table 21.

The performance of the IBI and MIwb displayed a similar longitudinal pattern throughout the length of the study area. However, the relative performance of each index against their respective WWH criterion was not nearly so correspondent. With the exception of the lower most station, the IBI typically met or exceeded the minimum WWH biocriterion throughout the Black Fork. In contrast, the MIwb was uniformly depressed throughout the middle and lower portions of the study area; over 50 % of the stations failed to meet the prescribed performance benchmark.

Only the four stations that constituted the upper limits of the study area supported fish communities meeting both criteria. These sampling locations were established primarily to assess the effects of wastewater released by Copperweld (via Tuby Run) on the overall environmental conditions of Black Fork mainstem. No significant impact was indicated downstream from the confluence of Tuby Run, as adequate species richness and functional and structural organization were maintained. Additionally, the incidence of DELT anomalies was well below regional norms.

Departure from the WWH criteria throughout the remaining downstream portion of the study area was driven, almost entirely, by subpar performance of the MIwb which remained uniformly depressed, displaying no particular pattern relative to pollution sources. A further and marked decline was indicated at the most downstream site (RM 38.4), where both the IBI and MIwb strongly deviated from the WWH benchmark. A highly elevated occcurance of DELT anomalies was an additional indication of chronic stress within the fish community at this station. This measure of fish community health has been found to be a reliable indicator of environmental degradation (Leonard and Orth 1986).

Nearly the entire length of the Black Fork mainstem has been subjected to extensive and systematic modification in the past. The highly artificial and greatly simplified channel features appeared the most influential factors in determining ambient biological performance; however, the effects of pollutant loads from permitted entities and runoff from adjacent urban and industrial areas could not be entirely discounted. Although no obvious near field effects were associated with Copperweld, the Shelby WWTP, and other minor sources, these stressors nonetheless may have contributed to the precipitous decline in community performance within the middle segment of the mainstem.

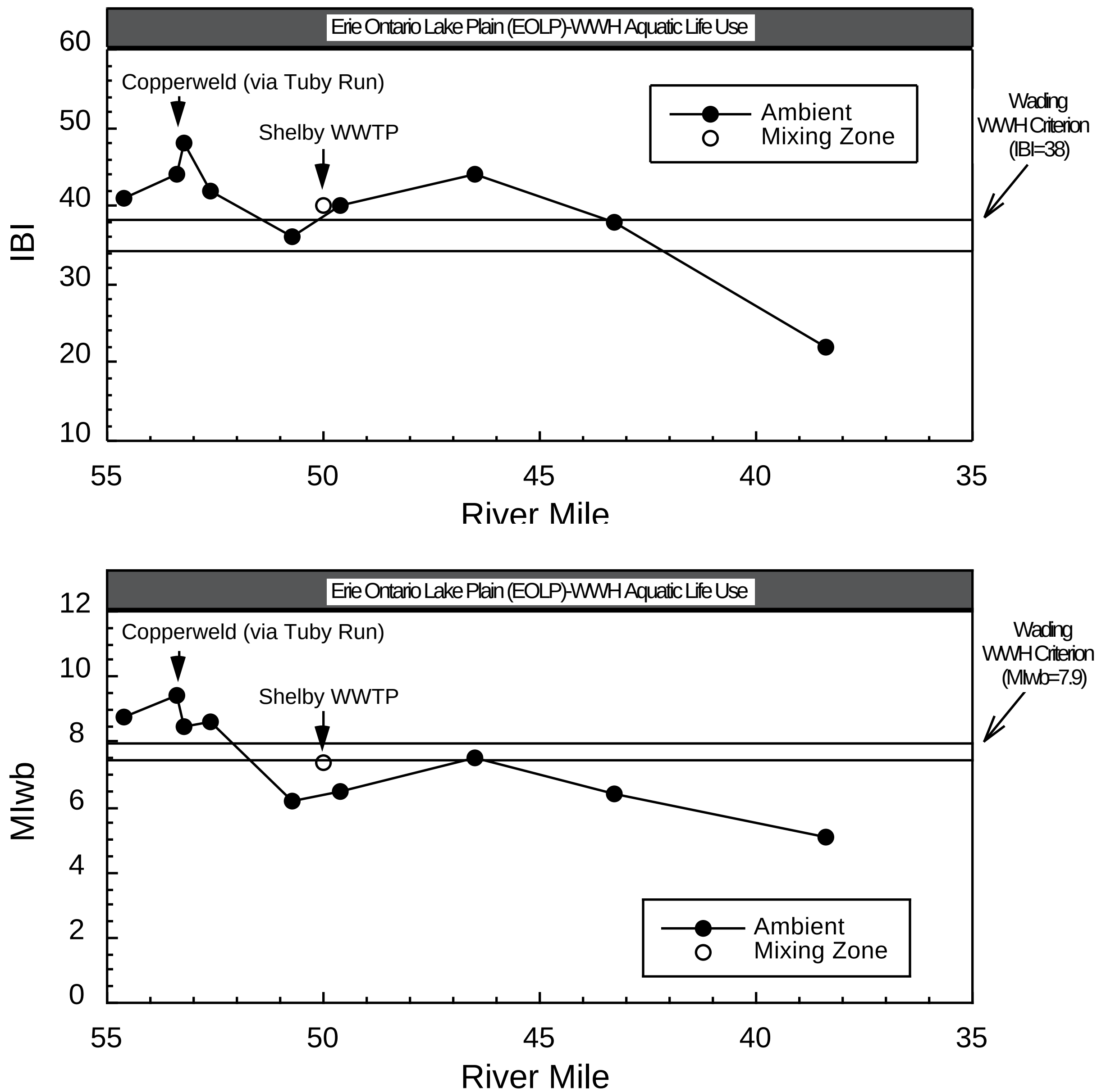

Figure 27. Longitudinal performance of the Index of Biotic Integrity (IBI) and the Modified Index of well-being (MIwb) through the Black Fork Mohican River, 1998. The solid lines represent numerical biological criteria and the area of nonsignificant departure in support of the existing WWH aquatic life use designations - Erie-Ontario Lake Plain (EOLP) ecoregion.

At this time, however, compelling habitat deficiencies appeared to be the most prominent and obvious cause of biocriteria departure.

The only exception to this observation involved the lowest station (RM 38.4). Here, poor IBI and MIwb scores were observed. Although this site possessed the worst habitat encountered within the study area (QHEI=40.0), the level of biological performance was far below that typically associated with an impact strictly derived from deficient physical habitat. In addition, highly elevated gross external anomalies were documented solely at this site. The combination of extremely low index values and elevated gross external anomalies was compelling, and suggested a complex, possibly toxic, impact compounding the stress associated with severely degraded habitat features.

Tuby Run

The fish assemblage of Tuby Run was sampled and evaluated at three locations between RM 0.7 (upstream from Copperweld) and RM 0.1 (near the mouth, downstream from Copperweld) during August 1998. This effort included two ambient sites(i.e., biocriteria applicable) and one site within the Copperweld mixing zone (i.e., biocriteria not applicable). Both ambient stations were found to support fish communities fully consistent with the WWH headwater biological criteria. Longitudinal community performance indicated comparable environmental conditions from the ambient stations bracketing Copperweld, as both sites achieved an IBI score of 40. Furthermore, toxicity or avoidance was not indicated, based upon the sampling results from the zone of initial effluent mixing at RM 0.6.

Rocky Fork Mohican River

A total of 7,491 fish comprising 37 species and three hybrids were collected from the Rocky Fork between July and August 1998. The fish sampling effort included seven stations, along the Rocky Fork mainstem from RM 16.4 (Wilging Rd.) to RM 0.6 (Applegate Rd.). The entire length of the Rocky Fork is currently designated WWH (OAC 3745-1). The stream reach between RM 16.4 and RM 14.2 represents the headwater segment of the mainstem [i.e., drainage area ≤ 20 miles^2 (Ohio EPA 1989)]. In these areas the headwater calibrated IBI is the only applicable fish community measure. The remainder of the mainstem was evaluated against the wading criteria, which includes the use of both the IBI and MIwb (Ohio EPA 1989).

Numerically, the predominant species included creek chub (28.1%), blacknose dace (18.8%), bluntnose minnow (12.5%), white sucker (11.3%), and green sunfish (8.4%). In terms of biomass, dominant species were white sucker (46.9%), northern hogsucker (20.2%), creek chub (18.3%), green sunfish (2.8%), and blacknose dace (2.5%). Excluding the northern hog sucker, all of the remaining dominant taxa are considered highly tolerant of poor water quality and degraded, modified or otherwise simplified riverine habitat. No species classified as endangered, threatened or special status (Ohio DNR 1997) were observed during the 1998 Rocky Fork survey.

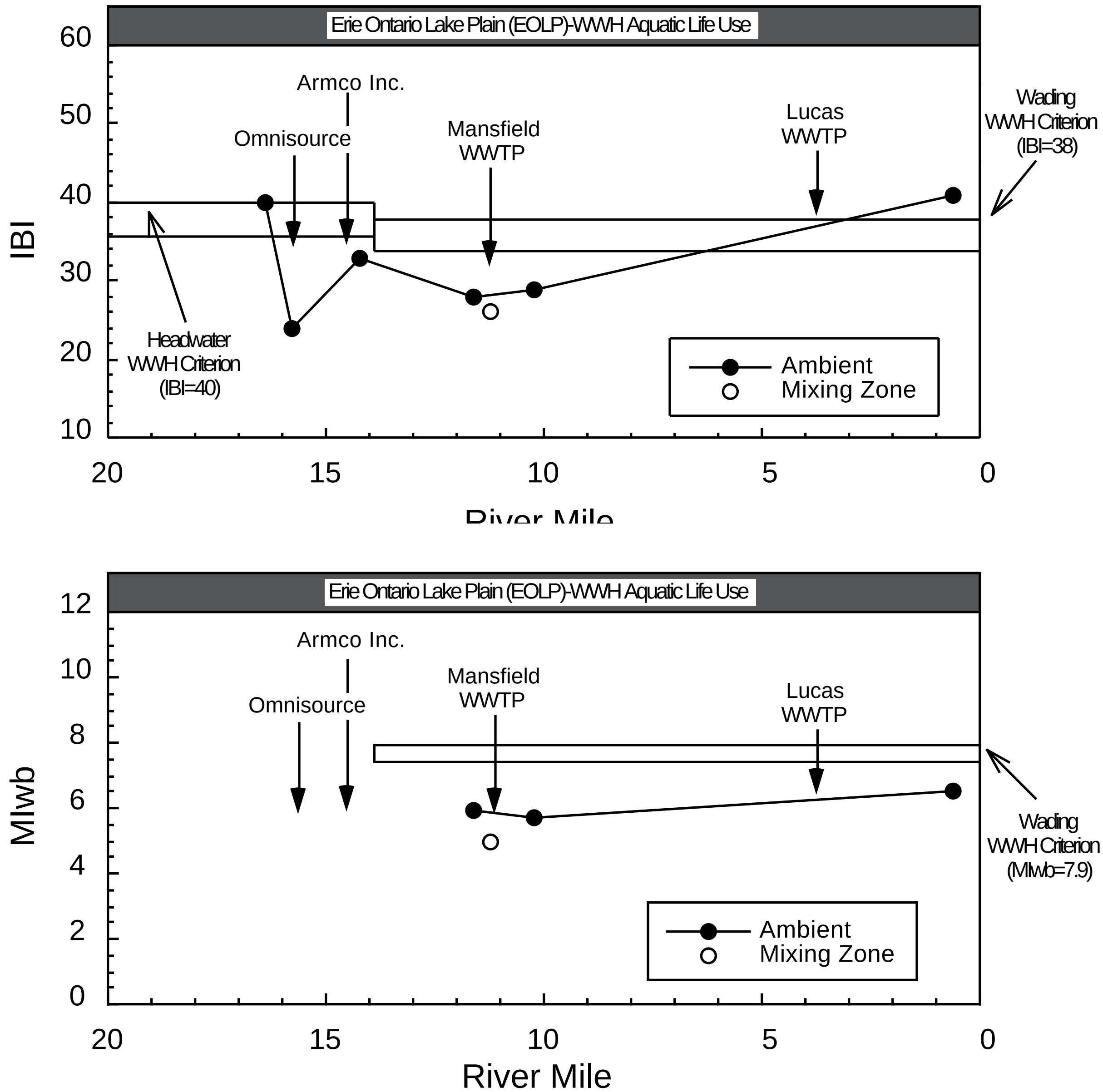

Figure 28. Longitudinal performance of the Index of Biotic Integrity (IBI) and the Modified Index of well-being (MIwb) through the Rocky Fork Mohican River, 1998. The solid lines represent numerical biological criteria and the area of nonsignificant departure in support of the existing WWH aquatic life use designations-Erie-Ontario Lake Plain (EOLP) ecoregion.

Community indices and their accompanying narrative evaluations ranged between good/fair (IBI=41, MIwb=6.5) at RM 0.6 (Applegate Rd.) to poor (IBI=24) at RM 15.8 (Old Bowman Rd. adj. Omnisource). Overall, the fish assemblage of the Rocky Fork was characterized as fair. Sampling efforts at most stations failed to yield results consistent with the WWH biological criteria. Longitudinal performance of the IBI and MIwb are presented in Figure 28. Summarized index scores and community statistics by station are presented in Table 21.

As measured by the IBI, WWH communities were indicated at the two stations that mark the upper and lower limits of the mainstem sampling effort. Features common to both of these sites included, adequate physical habitat and relatively unimpacted or recovered water quality (i.e., stations located either upstream from the greater Mansfield area or a sufficient distance downstream as to allow natural waste assimilation/recovery). All sites located within the intervening segment were found to support degraded communities. As the Rocky Fork flows through the greater Mansfield area, multiple chemical and physical stressors impinge upon the overall environmental quality of the segment. The combined effects of municipal and industrial dischargers, highly modified near and instream habitat, and contaminated urban/industrial runoff rendered most of the mainstem impaired. Community features observed throughout the impacted reach included lower than expected species richness, simplified trophic structure, and a predominance of environmentally tolerant taxa.

The lack of structural evenness and lower than expected relative abundance and relative weight estimates were reflected in uniformly depressed MIwb scores. The performance of this index remained well below the minimum WWH criterion at all stations.

Clear Fork Mohican River

A total of 10,653 fish comprising 50 species and four hybrids were collected from the Clear Fork River between July and September 1998. The fish sampling effort included ten stations, evaluating the Clear Fork mainstem from RM 35.7 (headwaters, Marion Ave.) to RM 0.4 (near mouth, SR 3). Two aquatic life use designations are currently in effect for the mainstem (OAC 3745-1). The CWH use was designated on two segments of the Clear Fork deemed suitable by the Ohio Department of Natural Resources, Division of Wildlife, to support a put-and-take trout fishery. These areas are demarcated by the free flowing stream reaches between RMs 30.5-13.0 and RMs 4.8-0.2. The remaining lotic segments are designated WWH. However, based upon the recommended use change, converting all CWH segments to WWH, biological performance and ultimately aquatic life use attainment will be evaluated against the WWH criteria.

Numerically, the predominant species were central stoneroller (16.0%), white sucker (12.2%), creek chub (10.6%), northern hog sucker (6.8%), and bluntnose minnow (6.2%). In terms of biomass, dominant species were: white sucker (26.9%), northern hogsucker (23.2%), common carp (17.6%), central stoneroller (5.3%), and creek chub (5.2%). No species classified as endangered, threatened or special status (Ohio DNR 1997) were observed during the 1998 Clear Fork survey. As the cold water fishery maintained on the Clear Fork is of high public value, brown trout relative abundance estimates from the 1998 fish sampling effort are presented in Figure 29.

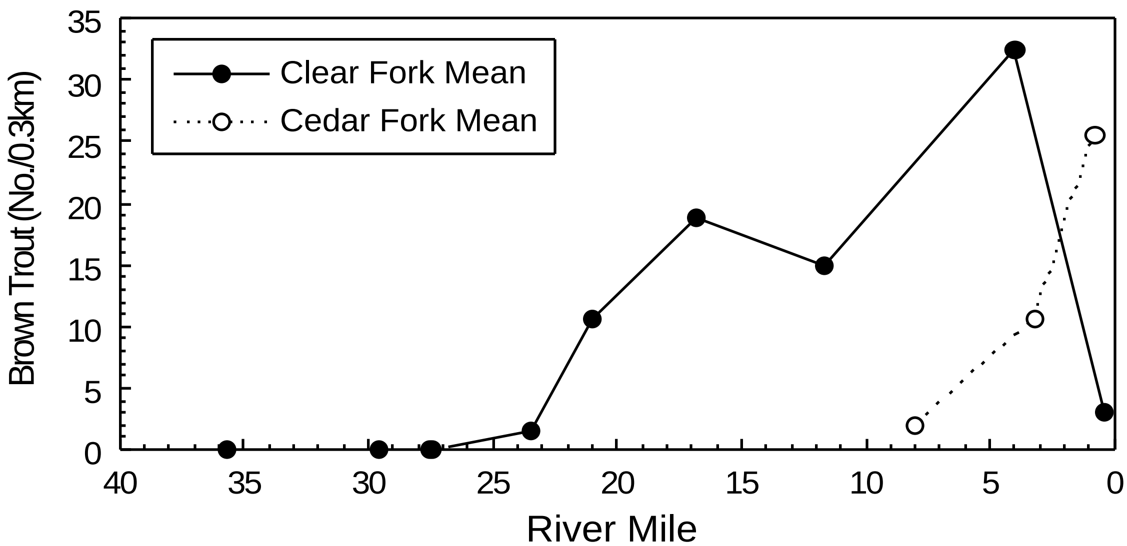

Figure 29. Brown trout relative abundance (No./0.3 km) throughout the Clear Fork Mohican River and Cedar Fork (a Clear Fork tributary), based on electrofishing surveys conducted during the summer of 1998.

Community performance as measured by the IBI and MIwb (where applicable), ranged from marginally good/fair (IBI=36, MIwb=7.0) at RM 27.6 (upstream from the Lexington WWTP) and very good/good (IBI=46, MIwb=8.7) at RM 4.0 (downstream from Pleasant Hill Lake). Overall, the fish assemblage of the Clear Fork was characterized as good. Nearly all non-mixing zone stations supported WWH biocriteria communities (Table 21). Longitudinal performance of the IBI and MIwb are presented in Figure 30.

Only one station, RM 27.6 (upstream from the Lexington WWTP), failed to meet the proposed WWH criteria. This site is situated within a highly modified segment of the Clear Fork that flows through the city of Lexington. This reach has been subjected to extensive channelization. The channel configuration was monotonous and largely trapezoidal in cross section. Substrates were predominately fine, composed mainly of sand, clays, and silt. The failure of the fish community to meet applicable biocriteria, was attributed to overall poor habitat quality. The level of departure was not severe. The MIwb was in the fair range and the IBI remained within nonsignificant departure of the WWH criterion. Furthermore, the adjacent station only 0.2 miles downstream (RM

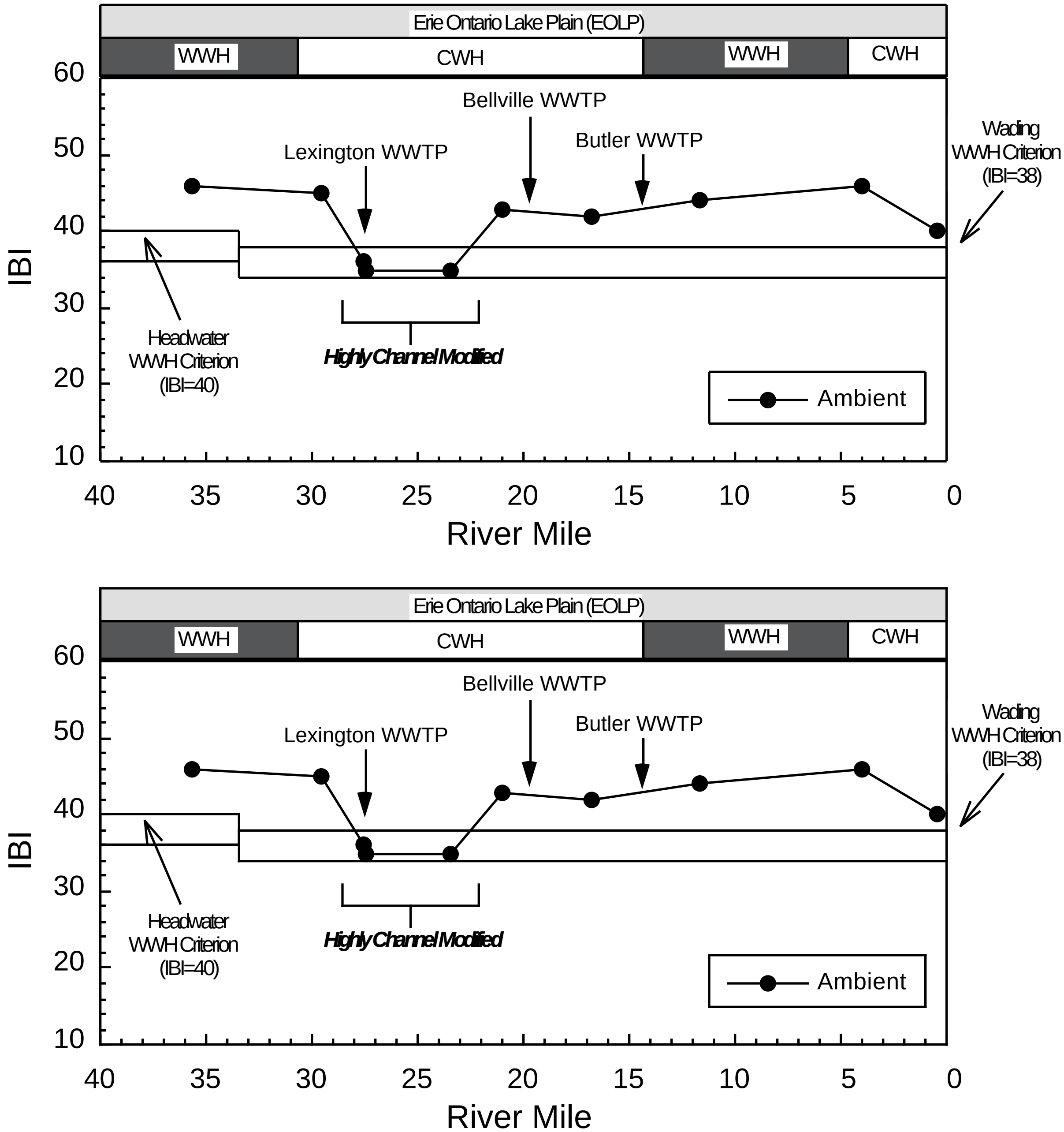

Figure 30. Longitudinal performance of the Index of Biotic Integrity (IBI) and the Modified Index of well-being (MIwb) along the Clear Fork Mohican River, 1998. The solid lines represent numerical biological criteria and the area of nonsignificant departure in support of the recommended WWH aquatic life use designations - Erie-Ontario Lake Plain (EOLP) ecoregion.

27.4, downstream from the Lexington WWTP) yielded a nearly identical IBI score and the MIwb was slightly improved (marginally good), achieving the minimum WWH criterion. In fact, all stations within this modified reach performed at a similar level though markedly depressed in comparison with other portions of the study area. Overall, longitudinal community performance throughout the Clear Fork appeared well correlated with habitat quality (Figure 31).

Selected Clear Fork Tributaries

As part of the 1998 effort, fish community samples were collected from three Clear Fork tributaries: Cedar Fork, Possum Run, and Pine Run. The entire length of Cedar Fork was evaluated by the placement of three stations between RM 8.0 (West Point Bellville Rd.) and RM 0.8 (Bellville Johnson Rd.). Possum Run and Pine Run were each sampled at one location at RM 1.4 (Wander Bridge) and RM 0.1 (near the mouth), respectively.

As measured by the IBI and MIwb, community performance throughout Cedar Fork ranged between exceptional (IBI=60), at RM 8.0 and good (IBI=44 and MIwb=8.3), at RM 0.8. All

stations supported a fish assemblage fully consistent with the WWH ambient biological criteria. Sampling in both Possum Run and Pine Run also yielded fish communities that fully met the WWH biological criteria. As the cold water fishery maintained on the Cedar Fork is of high public value, brown trout relative abundance estimates from the 1998 fish sampling effort are presented in Figure 29.

Fish Community Trend Assessment

Jerome Fork: 1984-98

Fish community data were collected from Jerome Fork in 1984 and 1998. The 1984 survey included six stations, assessing an 8.3 mile reach, between RM 13.9 (CR 1175) and RM 5.6 (CR 30A). The most recent sampling effort (1998), included approximately the same river segment, plus an additional sampling station further downstream at RM 2.6 (CR 175), expanding the assessment to 10.4 stream miles. Summarized index scores and community statistics, by station, are presented in Table 21.

The results from the 1984 survey indicated significant impairment of the WWH aquatic life use. Longitudinal performance of the IBI and MIwb displayed a precipitous and marked decline downstream from the Ashland WWTP (Figure 32). Although modest recovery was indicated several mile downstream, all remaining downstream stations failed to support WWH communities.

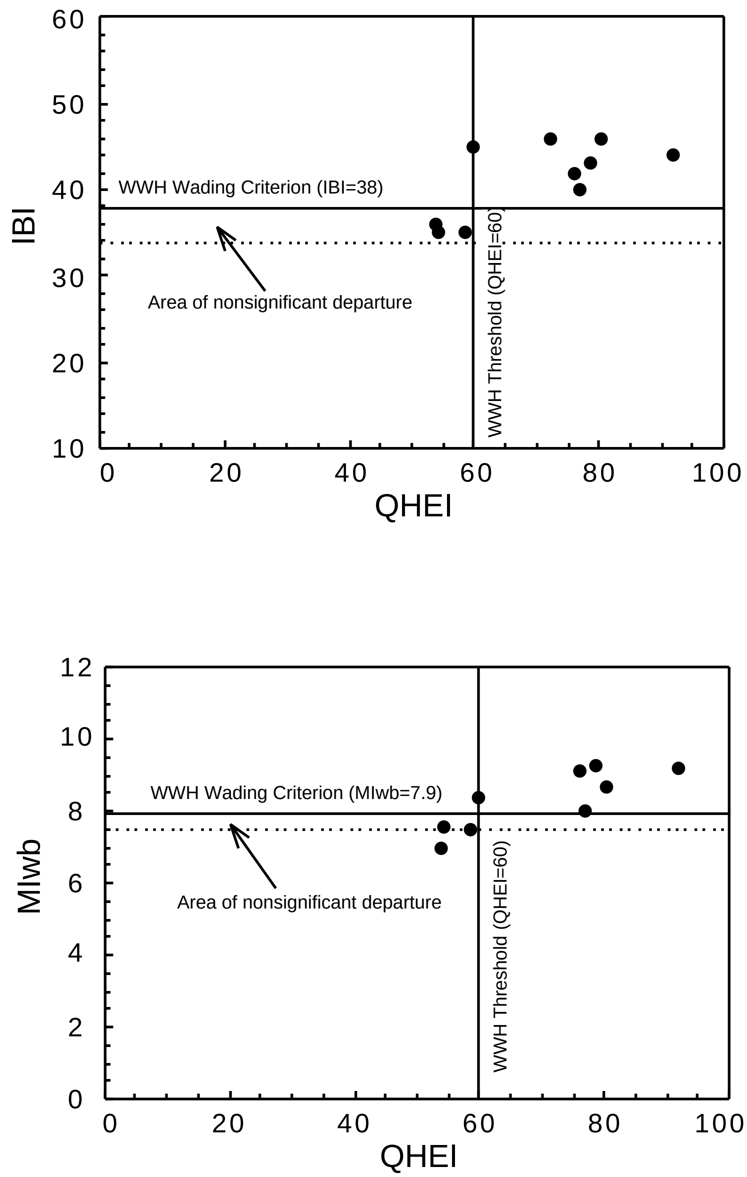

Figure 31. Scatter plots displaying the relationship between habitat quality (QHEI) and measures of ambient biological performance (IBI and MIwb) within the Clear Fork Mohican River subbasin, 1998.

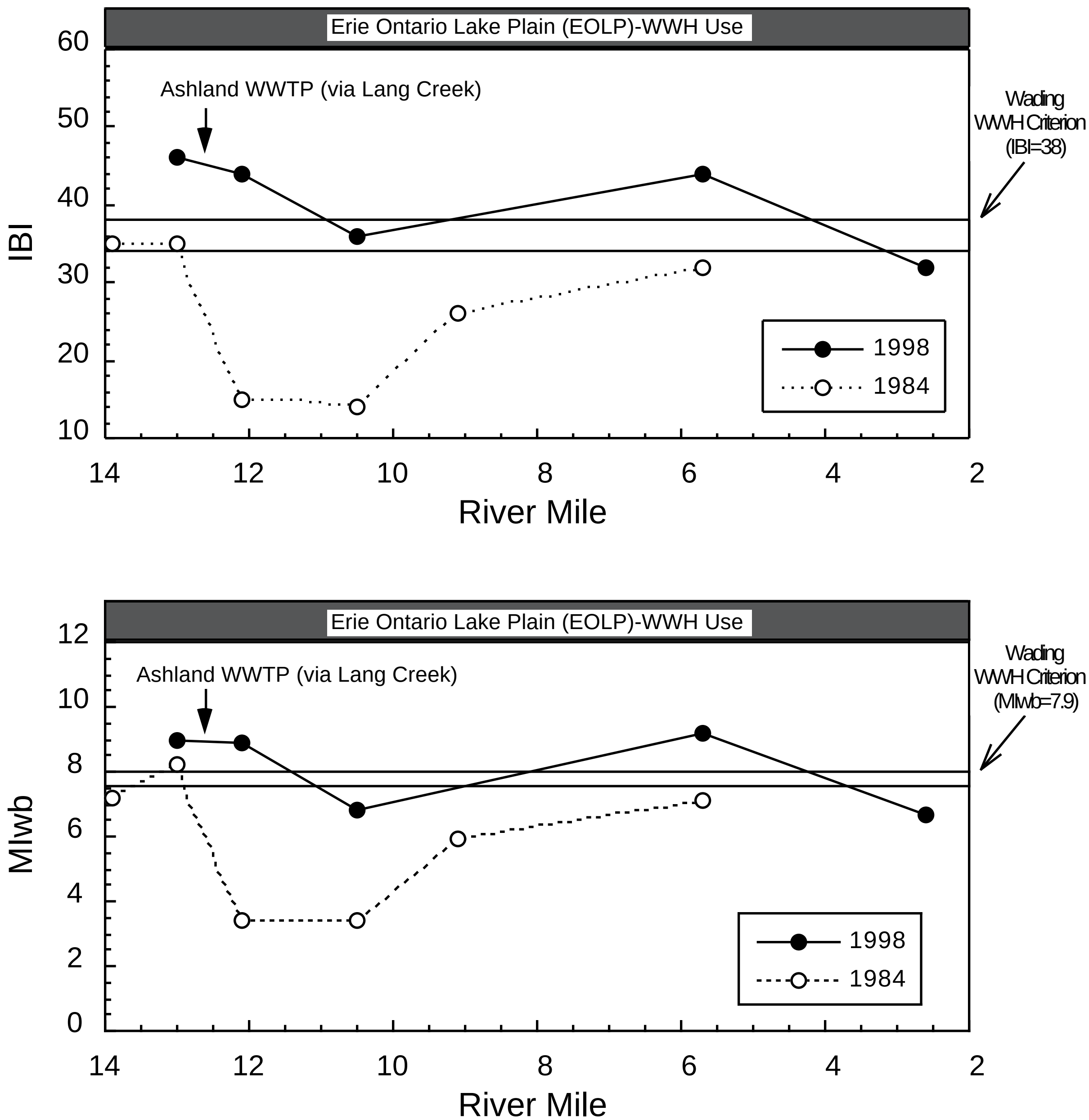

Figure 32. Longitudinal performance of the Index of Biotic Integrity (IBI) and the Modified Index of well-being (MIwb) through Jerome Fork for the years 1984 and 1998. The solid lines represent numerical biological criteria and area of nonsignificant departure in support of the existing WWH aquatic life use designations - Erie-Ontario Lake Plain (EOLP) ecoregion.

The results from the 1998 survey indicated stable conditions within the upper limits of Jerome Fork, as WWH communities were again observed. Substantial improvements were found throughout the area previously impacted. The highly degraded conditions observed in 1984 were largely ameliorated, as IBI and MIwb scores at or near the WWH biocriteria were observed throughout the remaining downstream segment.

Selected Jerome Fork Tributaries: 1984-98

The fish assemblages of Lang Creek and its principal tributaries were surveyed in 1984 and 1998. The efforts for both years were nearly identical, evaluating Lang Creek, Jamison Creek, and Town Run. Summarized index scores and community statistics by station are presented in Table 21.

Comparing the results from both sampling efforts, community performance remained stable, fully attaining the WWH biocriteria, at the uppermost site on Lang Creek (RM 3.2). All other stations on Lang Creek, Jamison Creek, and Town Run indicated considerable improvement through time (Figure 33). Recovery was evident at all sites, each supporting WWH fish communities.

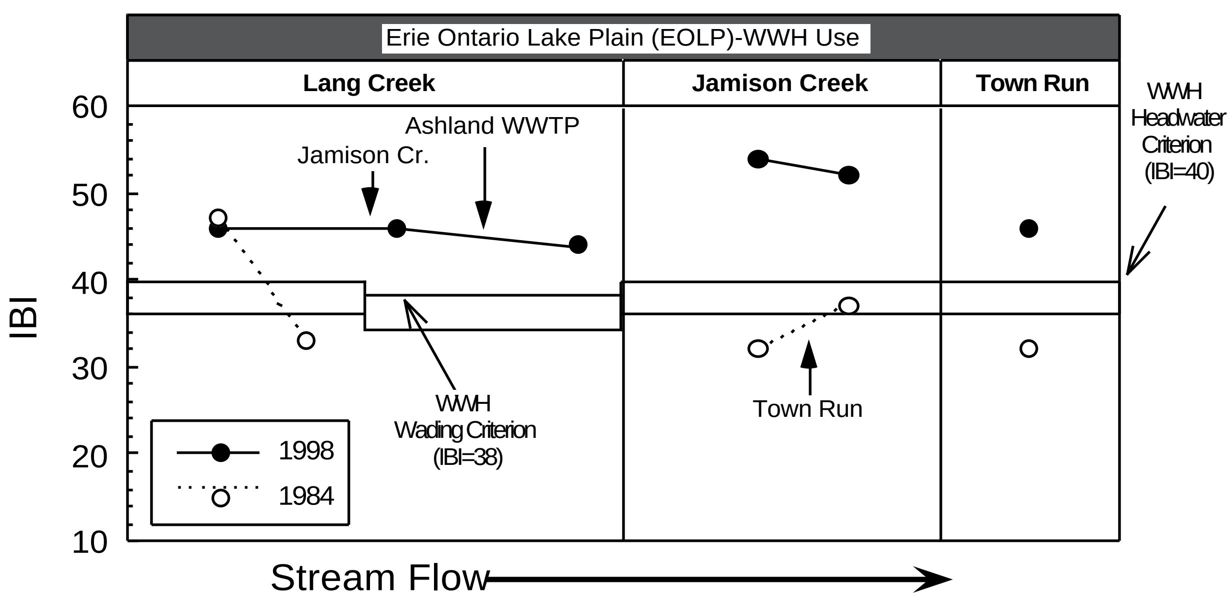

Figure 33. Longitudinal performance of the Index of Biotic Integrity (IBI) within the Lang Creek subbasin for the years 1984 and 1998. The solid lines represent numerical biological criteria and area of nonsignificant departure in support of the existing WWH aquatic life use designations - Erie-Ontario Lake Plain (EOLP) ecoregion.

Muddy Fork Mohican River: 1983-98

Fish community data were collected from the Muddy Fork in 1983, 1984, and 1998. The 1983 and 1984 sampling efforts were modest and included only two stations (RM 18.5 and RM 12.8). Both of these stations were reevaluated in 1998. Summarized index scores and community statistics by station, are presented in Table 21. The results from the 1998 survey indicated stable community performance at both sites. All stations, through time, consistently supported an assemblage of fishes fully consistent with the WWH biocriteria.

Black Fork Mohican River: 1984-98

Fish community data were collected for the years 1984, 1989, and 1998. The 1984 survey included eight stations, assessing an 18 mile reach, between RM 54.6 (Stiving Rd.) and RM 38.4 (Geisinger Rd.). The 1989 effort included ten stations evaluating an 11.7 mile segment between RM 54.7 (Geisinger Rd.) and RM 43.0 (Ganges-Five Point Rd.). The most recent sampling effort (1998) evaluated the same river segment as that assessed in 1984. Summarized index scores and community statistics, by station and sampling year, are presented in Table 21. Longitudinal performance of the IBI and MIwb, through time, are presented in Figure 34.

The results from the 1984 survey found most of the Black Fork seriously degraded. Marked and significant declines in community performance, as measured by the IBI and MIwb, were indicated downstream from both Copperweld (via Tuby Run) and the Shelby WWTP. Modest recovery was indicated further downstream, but all of the remaining stations failed to meet WWH criteria. The 1989 survey found similar conditions, with the exception of improvements indicated upstream from Tuby Run and within the vicinity of the Shelby WWTP.

In comparison with previous surveys, the 1998 results indicated considerable improvement in the environmental conditions of the Black Fork. Notably, improved species richness and functional organization of the fish assemblage were reflected in higher IBI scores at nearly every site. The IBI performance indicated near complete amelioration of the impacts previously documented downstream from both Tuby Run and the Shelby WWTP. The MIwb displayed a similar pattern of systematic improvement, although most stations failed to yield values consistent with the minimum criterion. Overall improvement since 1994 is reflected in the MIwb ADV/mile statistic which declined from 121.1 in 1984 to 49.7 in 1998 (Table 20).

Tuby Run: 1989-98

Fish community data were collected from Tuby Run in 1989 and 1998. The 1989 survey included three sampling sites: RM 1.0 (upstream from Copperweld), RM 0.8 (downstream from Copperweld), and RM 0.6 (near the Black Fork confluence). The 1998 sampling effort included three stations, two ambient sites (RM 0.7 and RM 0.1) and one in the Copperweld mixing zone (RM 0.6). Summarized index scores and community statistics are presented in Table 21.

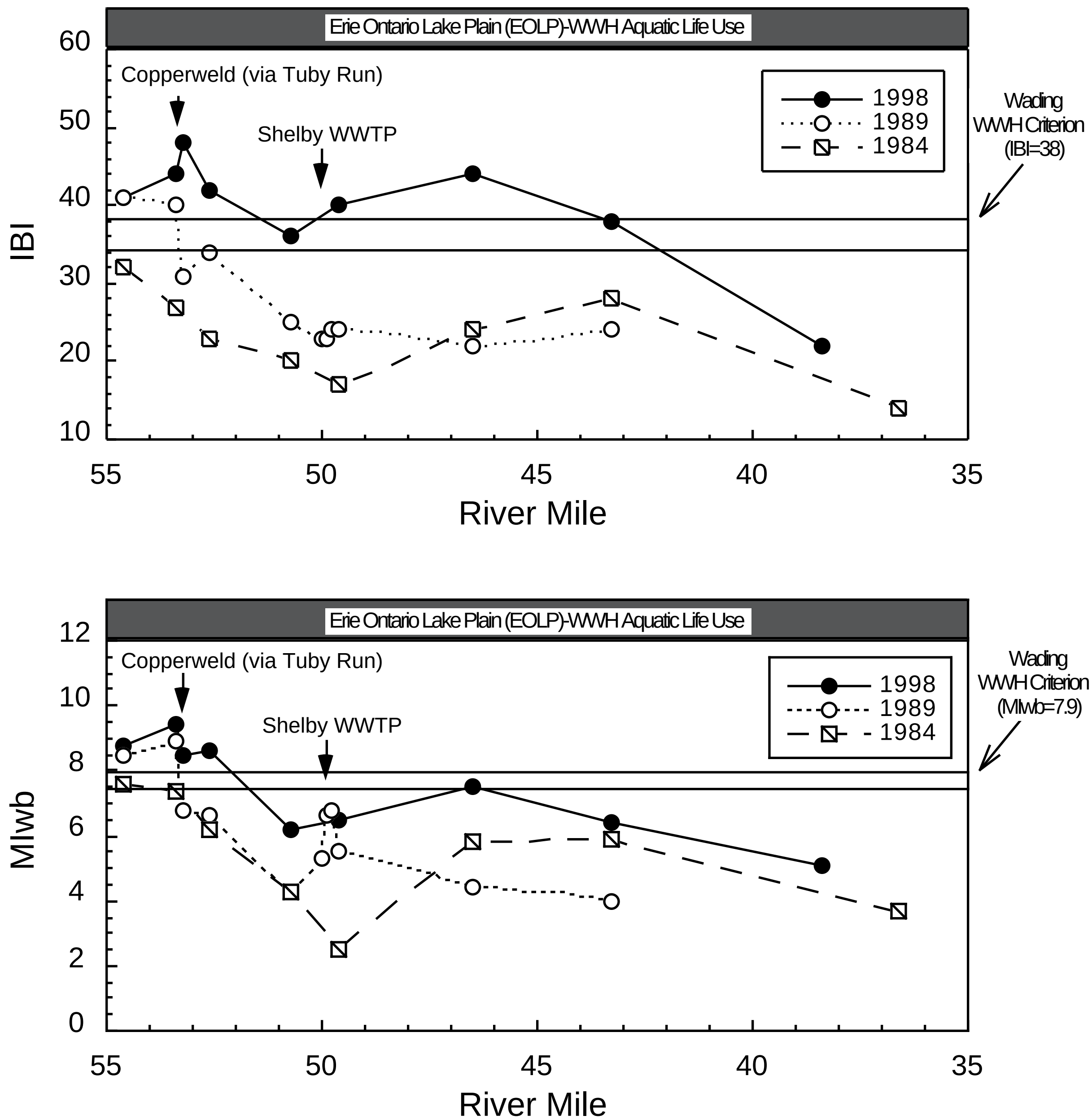

Figure 34. Longitudinal performance of the Index of Biotic Integrity (IBI) and the Modified Index of well-being (MIwb) through the Black Fork Mohican River for the years 1984, 1989, and 1998. The solid lines represent numerical biological criteria and the area of nonsignificant departure in support of the existing WWH aquatic life use designations - Erie-Ontario Lake Plain (EOLP) ecoregion.

The results from the 1989 survey found the entire evaluated segment highly degraded (Figure 35). Community performance at all stations strongly deviated from the WWH biocriterion and was uniformly poor. Complete recovery was indicated in 1998. Both ambient stations met WWH criterion. In addition, toxicity or avoidance was not indicated in the Copperweld mixing zone.

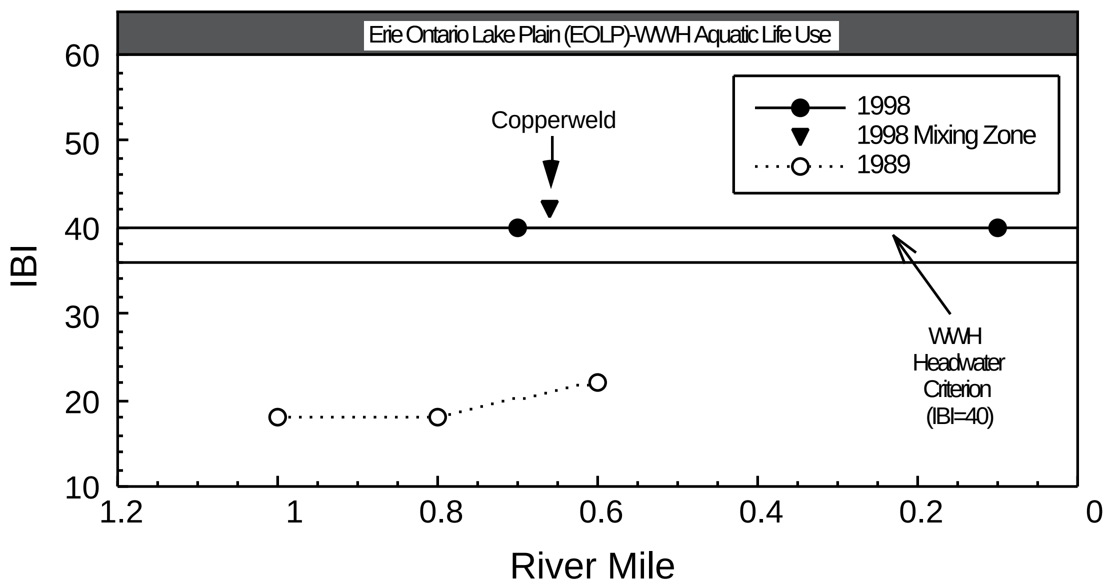

Figure 35. Longitudinal performance of the Index of Biotic Integrity (IBI) within Tuby Run for the years 1989 and 1998. The solid lines represent numerical biological criteria and the area of nonsignificant departure in support of the existing WWH aquatic life use designations - Erie-Ontario Lake Plain (EOLP) ecoregion.

Rocky Fork Mohican River: 1982-98

Ample community data are available to perform an assessment of trends throughout the Rocky Fork mainstem, as intensive fish surveys were performed for the years 1979, 1982, 1993, and 1998. The 1979 survey included four stations, assessing an eleven mile reach, between RM 11.6 (Illinois Rd.) and RM 0.6 (Applegate Rd.). The 1982 effort was conducted in support of graduate research at the Ohio State University (Reash and Berra 1986, 1987, and 1989) and evaluated a 14.0 mile segment between RM 18.4 (Leppo Rd.) and RM 4.4 (Smart Rd.) The more recent sampling efforts (1993 and 1998) evaluated the river segment between RM 16.4 (Wilging Rd.) and RM 0.6 (Applegate Rd.). Summarized index scores and community statistics, by station and sampling year, are presented in Table 21. Longitudinal performance of the IBI and MIwb, through time, are presented in Figure 36.

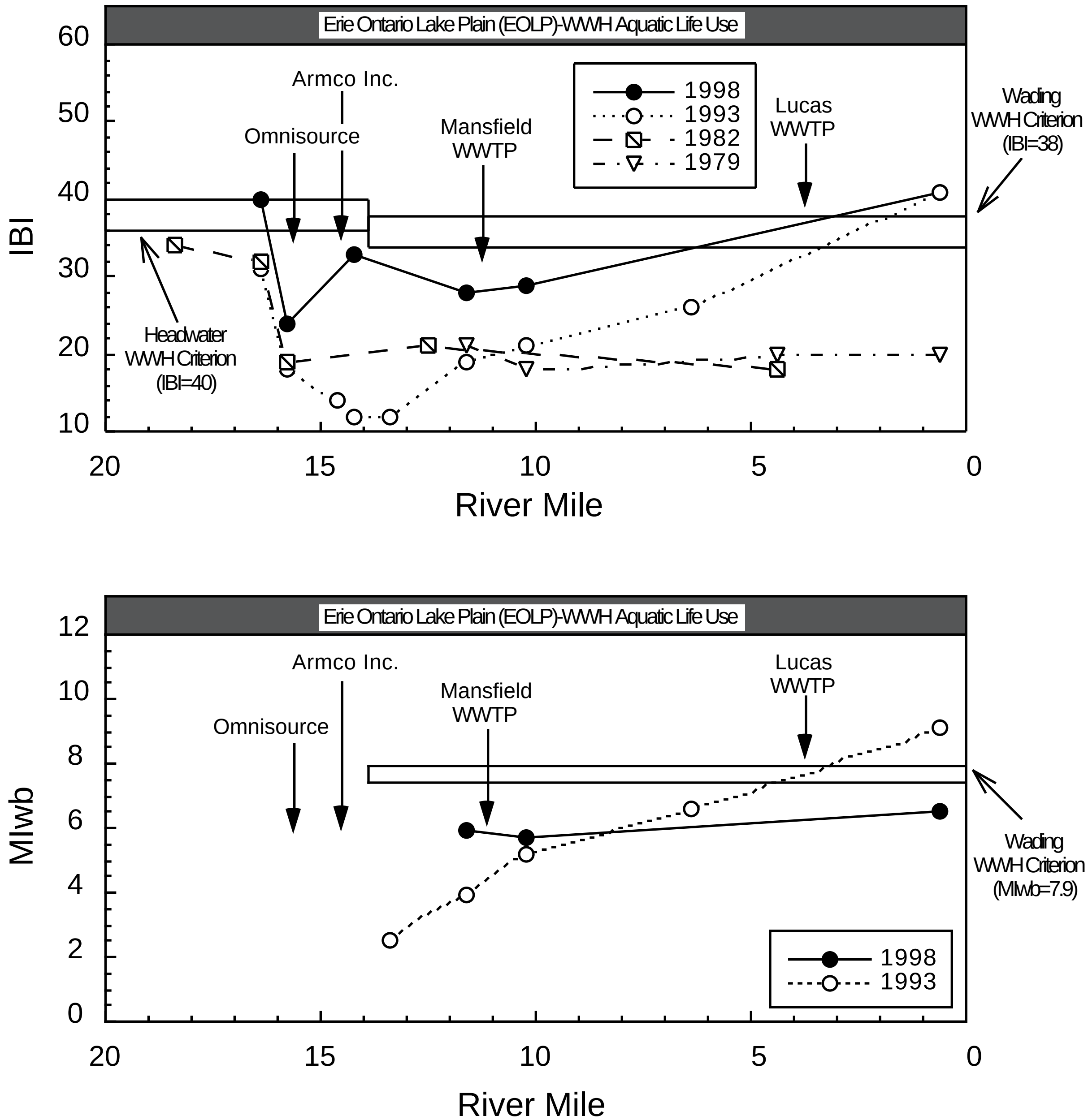

Figure 36. Longitudinal performance of the Index of Biotic Integrity (IBI) and the Modified Index of well-being (MIwb) through the Rocky Fork Mohican River for the years 1979, 1982, 1993, and 1998. The solid lines represent numerical biological criteria and area of nonsignificant departure in support of the existing WWH aquatic life use designations - Erie-Ontario Lake Plain (EOLP) ecoregion.

Where the sampling efforts were correspondent, the results from the 1979, 1982, and 1993 surveys typically yielded similar assessments. Longitudinally, conditions appeared stable within the headwaters upstream from Mansfield. Within this reach, fish community performance very near the WWH biocriterion was consistently observed between 1982 and 1993 (i.e., IBIs in the fair range). Progressing downstream, a precipitous decline was indicated in all years between 1982 and 1993. IBI scores were reduced to poor levels beginning at the site adjacent to the Omnisource scrape yard (a.k.a Luntz Corp.). Conditions worsened downstream from Armco Inc. in 1993, with the stations situated downstream from the facility nearly devoid of fish, indicative of a severe complex toxic impact. Community performance was slightly improved further downstream, as fish were again observed, but the simple and unstructured nature of the assemblage was still reflective of a highly degraded aquatic environment. Between 1979 and 1982 impacted fish communities were encountered throughout the remaining downstream portion of the study area. The only significant discrepancy between the 1979-82 and the 1993 survey results involved the lower eight miles. The earlier sutdies found communities uniformly depressed within the Rocky Fork downstream from Mansfield (and the various attendant municipal and industrial pollution sources). However, limited recovery was indicated within the remaining eight miles in 1993. The downstream most station (RM 0.6) supported a WWH fish community.

An additional indication of chronic environmental stress observed through the most degraded portions of the Rocky Fork included a striking rise in the incidence of gross external anomalies in 1993 (Figure 37). Beginning at RM 15.8 (Old Bowman Rd.-adjacent to Omnisource), DELT anomalies rose to 1.9%, a level that strongly deviated from natural background levels classified as highly elevated (Ohio EPA 1987). Through the following stations, the mean incidence of DELT anomalies continued to rise in a parabolic fashion reaching a maximum of 20% at RM 11.7 (Illinois Ave.). After that point the incidence of gross anomalies declined to 0.3% at RM 0.6. This observation corresponded with the recovery of other positive community attributes within the lower limits of the study area.

In comparison with these historical data, the results from the 1998 survey indicated substantial environmental improvement throughout the length of the Rocky Fork. Community indices (IBI and MIwb) and other community measures (*e.g.*, abundance, biomass, and cumulative species richness) were markedly higher at nearly every station. On the average, each site resampled in 1998 had increased species richness, relative abundance, and biomass when compared with past results. Perhaps the most compelling positive change observed within the fish assemblage of the Rocky Fork included the drastic reduction in the incidence of DELT anomalies with the average incidence not exceeding 0.2% at any site in 1998.

Although considerable progress has been achieved in reducing the severity of the impacts

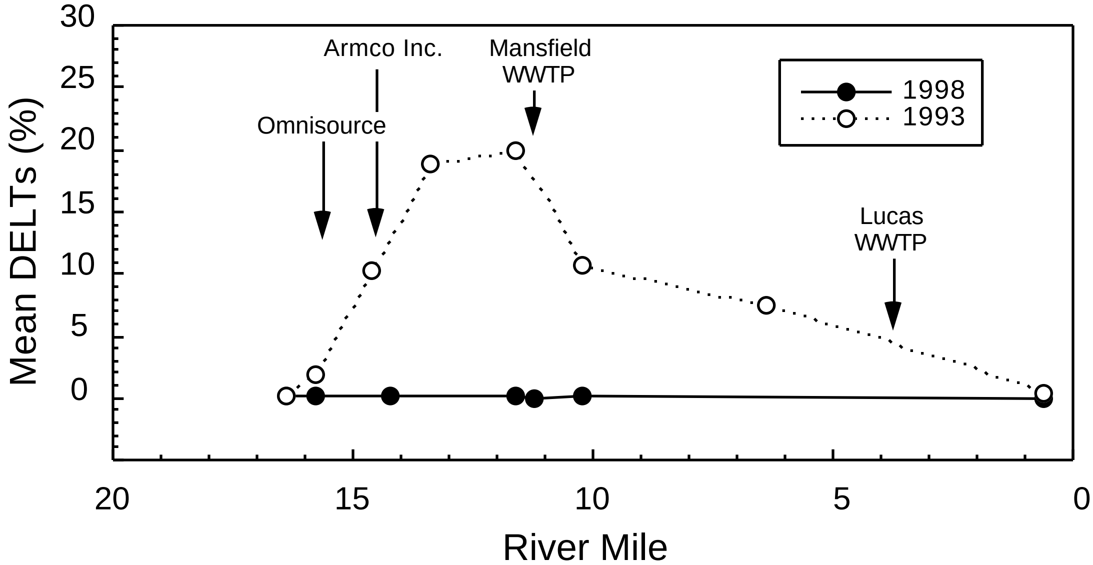

Figure 37. A comparison mean percent occurrence of gross Deformities, Eroded fins/barbels, Lesions, and Tumors (DELT) anomalies between 1993 and 1998, Rocky Fork Mohican River subbasin.

documented in previous investigations, the majority of the Rocky Fork still remains impaired. Additionally, one station (RM 0.6) did decline in comparison with the 1993 results. The IBI remained comparable between the sampling years, indicating acceptable species richness and functional organization, but reduced relative abundance and biomass resulted in an average MIwb value below the minimum WWH biocriterion. The cause for the recent decline at RM 0.6 is not clear at this time, as other community measures performed well. Reduced performance of the MIwb may reflect a protracted impact from the substantial release of treated wastewater from the Mansfield WWTP. These negative effects possibly were exacerbated by the relatively small flow from the minor Lucas WWTP. Overall improvement since 1993 is reflected in the MIwb ADV/mile statistic which declined from 79.2 in 1993 to 68.8 in 1998 (Table 20).

Clear Fork Mohican River: 1982-98

Fish community data were collected from the Clear Fork Mohican River in 1982, 1993, and 1998. The historical sampling efforts were limited to one station, located at RM 35.7 (Marion Ave.). The 1998 survey was much more robust and evaluated the entire mainstem including the site at RM 37.5. As such, an assessment of the environmental conditions of the Clear Fork, through time, is only possible at the uppermost station. Summarized index scores and community statistics, by station, are presented in Table 21.

Based upon the fish surveys conducted in 1982, 1993, and 1998, community performance at this station has remained remarkably stable over the past 16 years. Over this period, the IBI consistently met the WWH biocriterion, ranging between 43 and 46.

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