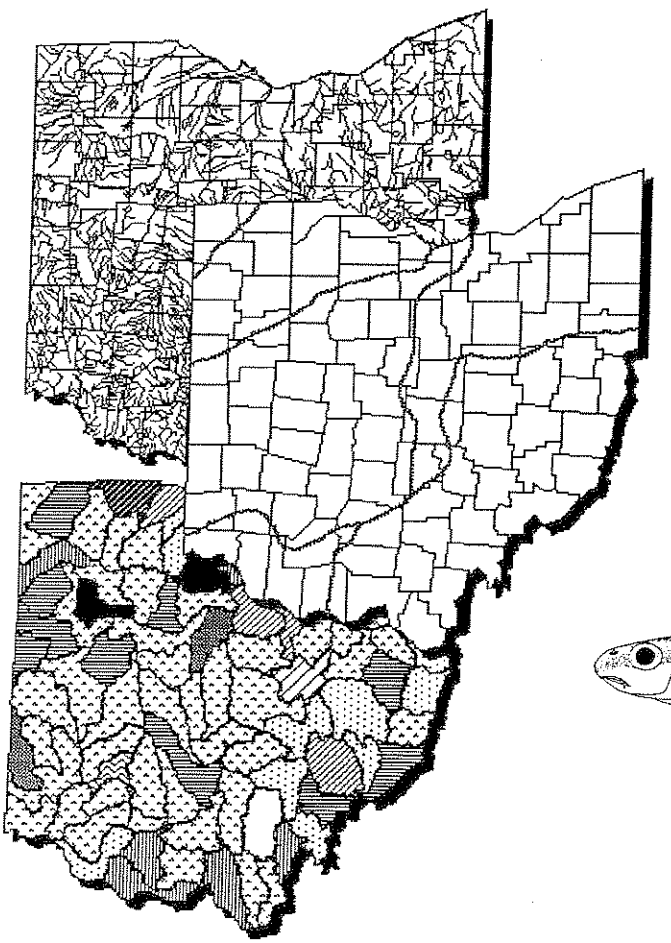
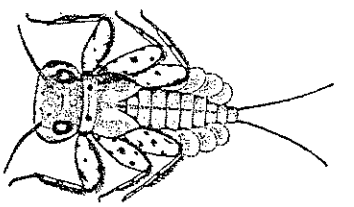
State of Ohio
Environmental Protection Agency

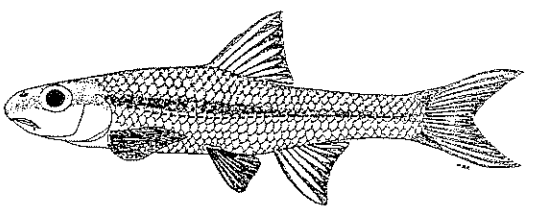
Ecological Assessment Section
Division of Water Quality
Planning & Assessment

Biological and Water Quality Study of the Auglaize River and Selected Tributaries

Auglaize, Allen, Putnam, and Paulding Counties (Ohio)







November 25, 1992

P.O. Box 1049, 1800 WaterMark Dr., Columbus, Ohio 43266-0149

Biological and Water Quality Study of the Auglaize River and Selected Tributaries

Auglaize, Allen, Putnam and Paulding Counties, Ohio

November 25, 1992

OEPA Technical Report EAS/1992-11-8

prepared by

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NOTICE TO USERS

Ohio EPA adopted 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, and the Invertebrate Community Index (ICI), which is based on macroinvertebrates. Criteria for each index are specified for each of Ohio's five ecoregions, and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the chemical and whole effluent toxicity evaluation methods, figure prominently in the assessment of Ohio's surface water resources.

Several documents support the adoption of the biological criteria by outlining the rationale for using biological information, the specific methods by which the biocriteria were derived and calculated, the field methods by which sampling must be conducted, and the process for evaluating results. These documents are:

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

Ohio Environmental Protection Agency. 1989a. Addendum to Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1990c. The use of biological criteria in the Ohio EPA surface water monitoring and assessment program. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale,methods, and application. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

These documents and this document can be obtained by writing to:

Ohio EPA - WQP&A
Ecological Assessment Section
1685 Westbelt Drive
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(614) 777-6264

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Reviewer(s) - Chris Yoder,Jeff DeShon

This evaluation and report would not have been possible without the additional assistance of the study team, numerous full and part time staff in the field, and the chemistry analyses provided by the Ohio EPA Division of Environmental Services.

Biological and Water Quality Survey of the Auglaize River and Selected Tributaries (Auglaize, Allen, Putnam, and Paulding Counties, Ohio)

Ohio Environmental Protection Agency
Division of Water Quality Planning and Assessment
1800 WaterMark Drive
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Introduction

The Auglaize River study area included the Auglaize River mainstem above Wapakoneta, Ohio (RM 87.8) to downstream from the confluence of the Ottawa River (RM 28.5);.a single site on Pusheta Creek (RM 0.3); Six Mile Creek from the headwaters in Spencerville, Ohio (RM 4.2) to near the mouth (RM 0.1); and Flatrock Creek upstream from Payne, Ohio (RM 28.9) to near the mouth (RM 2.7).

Specific objectives of this evaluation were to:

1) monitor and assess chemical/physical water quality and biological communities in the Auglaize River study area to determine the degree to which the streams are impacted by point and nonpoint sources of pollution and by habitat alterations,

2) evaluate impacts from combined sewer overflows (CSOs) and municipal WWTPs of the city of Wapakoneta and the villages of Payne and Paulding on their respective receiving streams,

3) evaluate the impact of discharges from Trim Trends, Ohio Decorative Products, the Farm Service Center and the Spencerville WWTP on Sixmile Creek,

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

5) conduct a water resource trend assessment where historical data exists for a portion of the Auglaize River mainstem Flatrock Creek and Sixmile Creek.

The findings of this evaluation 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 eventually be incorporated into the State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Water Resource Inventory (305[b] report).

Summary

Auglaize River
Based on the analysis of available macrohabitat attributes and biological performance a Warmwater Habitat (WWH) aquatic life use is appropriate for the Auglaize River mainstem from RM 87.8 to RM 28.5. The WWH use is recommended to replace the current Exceptional Warmwater Habitat (EWH) use for the stream segment between RM 67.0 and 28.5. This change should not be interpreted as a downgrading of the use; rather, it represents a more detailed analysis of habitat and

biological performance using new assessment tools and criteria that were not available when the current EWH use was assigned in 1985. Based on the performance of the biological communities and the ecoregional biocriteria, a total of 14.6 miles of the Auglaize River were in FULL attainment of the WWH aquatic life use (25% of the study area); 43.9 miles demonstrated PARTIAL attainment (75%); and 0.6 miles were **NON** attaining (1%). Identified impacts contributing to the **NON** and PARTIAL attainment included: 1) inordinately low flow conditions during the summer sampling period upstream from Wapakoneta, 2) organic enrichment as reflected in the macroinvertebrate community downstream from the Wapakoneta urban area and downstream from the Wapakoneta WWTP, and 3) siltation that affected the fish and, to a lesser degree, macroinvertebrate assemblages throughout the study area, and particularly between RM 63.1 and RM 52.7 which is a segment of low stream gradient.

The Wapakoneta WWTP discharges to the Auglaize River at RM 85.1. Results of this survey indicated considerable improvement in chemical water quality downstream from the WWTP, when compared to 1975 and 1985 Ohio EPA data. Nevertheless, a severely enriched condition was reflected in the performance of the macroinvertebrate community downstream from the WWTP discharge. The impact was evident for approximately five miles downstream. Fish assemblages were less affected by the WWTP discharge. Chemical sampling downstream from the WWTP in 1991 did not reflect major water quality degradation, at least in terms of WQS violations. However, an increase in nutrient concentrations was noted downstream from the plant, and sludge deposits were observed.

Biological community health appeared to have improved somewhat in the vicinity of the Geokke tributary (RM 63.1) and Sixmile Creek since 1985. The improvement appears to be a consequence of the cessation of the land application of nitrogenous materials on lands that border the Geokke tributary. However, a water quality impact related to the input of Sixmile Creek was indicated by a depression in mean dissolved oxygen at RM 60.4 and a slight increase in phosphorus and ammonia-N levels. No major chemical contamination of the sediment was noted in the Auglaize River in 1991. Siltation negatively affected the fish assemblage most obviously at approximately RM 63.1 and continued to the downstream limit of the study at RM 28.8. The macroinvertebrate community was also most affected by siltation primarily at RMs 63.4 and 61.6.

Sixmile Creek

The 1991 sampling effort on Sixmile Creek extended from upstream from the city of Spencerville (RM 4.2) to near the mouth (RM 0.1). The creek has undergone considerable habitat modification as recently as 1976. This was reflected in a predominance of modified macrohabitat attributes that were available to the biota of the stream. In addition to habitat factors, urban runoff, acute toxicity attributed to industrial dischargers in the village of Spencerville, and organic degradation from the Spencerville WWTP resulted in a severely impaired water resource. Partial recovery from the influences of the point sources was documented in the biological sampling conducted near the mouth (RM 0.1), however, the entire stream segment was in **NON** attainment of the current WWH use.

The combined discharge from Ohio Decorative Products and Trim Trends enters Sixmile Creek at RM 4.0. The response of the biota downstream from the discharge was one of acute toxicity. The stream supported a limited tolerant benthic fauna and was nearly devoid of fish at all sampling sites except RM 0.1 where only slight recovery was in evidence. Impacts were obvious in both the water and sediment chemistry results. Significant problems with nutrient input and dissolved oxygen depletion were noted in 1991, as were increases in metals and priority pollutant levels in

the sediments. Extremely to highly elevated metals and PCBs in excess of 6 mg/kg were documented downstream from the Ohio Decorative Products /Trim Trends discharge. Bioassays conducted by Ohio EPA in 1991 indicated that the effluents from both entities were acutely toxic. The cessation of regular discharges from the Farm Service Center has probably resulted in a reduction in the overall contaminant load of Sixmile Creek since 1985. However, Sixmile Creek likely continued to receive overflows from an on-site collection system. Enrichment downstream from the Spencerville WWTP was reflected in an increases in the density of the few tolerant benthic taxa that were present upstream and in biochemical oxygen demand (BOD_5) and ammonia levels. The elevated occurrence of anomalies recorded on fishes found in the Auglaize River downstream from the confluence of Sixmile Creek indicated a continued sublethal impact from Sixmile Creek.

Flatrock Creek

The 1991 survey of Flatrock Creek extended from RM 28.9, upstream from the village of Payne to RM 2.8, downstream from Paulding, Ohio. Habitat was atypical compared to similarly sized Huron Erie Lake Plain (HELP) streams in that a relatively contiguous wooded riparian corridor was present. The wooded riparian zone should aid in the eventual attainment of the biological criteria if measures are put in place to minimize the anthropomorphic impacts within the basin. No change in the current WWH aquatic life use is indicated at this time as the stream appeared to be recovering from the effects of past channelization. Based on the analysis of fish and macroinvertebrate community performance, a total of 19.7 miles of Flatrock Creek were **NON** attaining the biological criteria as stipulated for a warmwater habitat (WWH)use designation(75% of the study area). PARTIAL attainment was indicated for 4.3 miles (16% of the study area). Causes and sources for the predominance of partial and nonattainment included habitat factors (*i.e.* siltation, embeddedness) and organic loadings due to raw sewage that entered the stream within the village of Payne via a malfunctioning sewer and organic enrichment from the Paulding WWTP lagoon discharge. A 2.1 mile segment of the stream downstream from the Paulding water treatment plant dam (RM 13.8) achieved FULL attainment of the biological criteria (8% of the study area). This stream segment was less impacted by siltation and substrate embeddedness.

Pusheta Creek

Results of biological sampling at a single location at RM 0.3 demonstrated FULL attainment of the WWH criteria despite evidence of recent localized channelization. However, there is historical data suggesting that Pusheta Creek once supported a greater diversity of fish species than were collected in 1991 (Clark 1942). Instream chemical sampling reflected no significant water quality problems.

Conclusions

Auglaize River

- Low flow conditions experienced during the 1991 sampling period upstream from the city of Wapakoneta was apparently preventing attainment of the designated WWH use upstream from Wapakoneta. Much of the watershed upstream from RM 87.8 has undergone extensive channelization and tiling that in turn has made the mainstem more susceptible to extremes in both high and low flow conditions. These anthropomorphic changes to the upper Auglaize River almost certainly contributed to the inability of the stream to attain a WWH use at RM 87.8.

- Moderate impact was indicated in the macroinvertebrate sampling results downstream from CSOs within the city of Wapakoneta; however, the fish community was unaffected.

- A significant impact to the macroinvertebrate community occurred downstream from the Wapakoneta WWTP (RM 85.1) that was indicative of the introduction of a significant nutrient and organic load. Pollution tolerant midges predominated on the natural substrates and relatively sensitive caddisfly taxa were rare despite adequate habitat. The fish community did not appear to be as affected by the discharge as both of the fish community indices exceeded the WWH biocriteria. Water chemistry results suggested no major surface water quality degradation.

- A depression in fish community performance was evident beginning at RM 63.1 and extending to the downstream limit of the study area (RM 28.8). The apparent cause was extensive siltation along with some type of subchronic impact from Sixmile Creek or possibly the Geokke tributary. Elevated frequencies of DELT anomalies (deformities, eroded fins/barbels, lesions and tumors) suggested the negative influence that the tributaries were having. A sharp decline in the percent of fish species that require clean coarse substrates for spawning (simple lithophils) compared to sites upstream from RM 63.1 was a strong indication that siltation was impacting the resource. The suspected influence of the Sixmile Creek on water quality was evident particularly in depression of dissolved oxygen levels. The macroinvertebrate community in this stretch was adversely affected primarily where slow current velocities allowed for the deposition of a thick silt layer.

Sixmile Creek

- The upstream site at RM 4.2 was intermittent or nearly intermittent during the 1991 sampling season and supported a low diversity of facultative and tolerant macroinvertebrate taxa. No fish were collected. Factors that were apparently limiting to the biota included low flow conditions, a highly modified habitat, urban runoff, and acute toxicity downstream which may serve as a barrier for fish recolonization.

- The fish community downstream from Spencerville was so depauperate that individual impacts from the Ohio Decorative Products/Trim Trends discharge, the Farm Service Center and the Spencerville WWTP could not be discerned. With the exception of RM 0.1, electrofishing yielded a total of 15 individual fish at four sampling locations. Macroinvertebrate assemblages reflected acute toxicity downstream from the Ohio Decorative Products /Trim Trends discharge. No additional impact was attributed to the Farm Service Center. Organic enrichment downstream from the Spencerville WWTP was reflected in an increase in total numbers of the few tolerant benthic taxa that were present upstream. Partial recovery was apparent in the macroinvertebrate community at RM 1.3 and in both the fish and macroinvertebrates collected near the mouth. Chemical sampling results indicated that, although overall quality has improved since 1985, water quality is still extremely degraded.

Flatrock Creek

- Biological communities in Flatrock Creek were to varying degrees depressed throughout the study area apparently due to low water levels experienced during the sampling period, and by past habitat alterations. However, a feature unique to Flatrock Creek was the presence of an extensive permanently wooded riparian corridor at the majority of locations evaluated. The types of instream cover present were directly a result of the wooded riparian corridor. It is also likely that the riparian vegetation limited the severity and extent of erosion occurring during periods of high flow.

- Locally severe organic degradation was apparent in the response of the fish and macroinvertebrate communities and in field observations downstream from a dry weather

combined sewer overflow (CSO) in the village of Payne and downstream from the Paulding WWTP. The Payne CSO discharge was the result of a malfunctioning sewage delivery system. The poor quality of the Paulding WWTP effluent was apparently due to an overloaded treatment system that is in need of rehabilitation.

Pusheta Creek

- Although the sampling site at RM 0.3 had been recently modified on a local scale, fish and macroinvertebrate communities were attaining the designated Warmwater Habitat (WWH) aquatic life use. Instream chemical sampling indicated no major water quality problems and general attainment of Warmwater Habitat criteria.

Recommendations

Status of Aquatic Life Uses (Table 1)

Several of the streams evaluated during this study were originally designated for aquatic life uses in the 1978 Ohio WQS. The techniques used then did not include standardized approaches to the collection of instream biological data or numerical biological criteria. Therefore, because this study represents a first use of this type of biological data to evaluate and establish aquatic life use designations, several revisions are recommended. While some of the changes may appear to constitute "downgrades" (*i.e.* EWH to WWH, WWH to MWH, etc.) or "upgrades" (*i.e.* LWH to WWH, WWH to EWH, etc.), any changes should not be construed as such because this constitutes the first use of an objective and robust use evaluation system and database. Ohio EPA is under obligation by a 1981 public notice to review and evaluate all aquatic life use designations outside of the WWH use prior to basing any permitting actions on the existing, unverified use designations. Thus some of the following aquatic life use recommendations constitute a fulfillment of that obligation.

Auglaize River

The Auglaize River between RM 87.8 and RM 67.0 is currently designated as Warmwater Habitat. Fish sampling sites within this reach had a mean Qualitative Habitat Evaluation Index (QHEI) score of 72.2. Several sites either were in FULL or PARTIAL attainment of the WWH use criteria. Based on macrohabitat attributes and biological performance, this use is appropriate.

Downstream from RM 67.0 to RM 28.8 the river is presently designated as EWH. However, the biological communities failed to demonstrate FULL EWH attainment at any of the sampling locations within this reach. A prevalence of modified habitat attributes, limited habitat diversity and subsequent biological performance provides strong evidence for the redesignation of this area as a Warmwater Habitat (WWH). The fish community, in particular, was negatively affected by habitat factors (*e.g.* siltation). The stream segment between RM 67.3 and 52.7 is in the Eastern Corn Belt Plain ecoregion and had a mean QHEI score was 46.8. The two most downstream sites (RM 39.7 and RM 28.8) are in the Huron Erie Lake Plain ecoregion and had a mean QHEI score of 69.3. Protection and remediation of the riparian zone and implementation of management practices to minimize upland soil loss and bank erosion particularly between RM 67.0 and 52.7 are needed to protect the water resource from further declines.

The State Resource Water designation (SRW) is appropriate for the Auglaize River. This designation is based on the existence of a viable population of greater redhorse (*Moxostoma valenciennesi*), a state endangered species. The Auglaize River is one of only two rivers in Ohio that support good populations of this species.

Flatrock Creek
The current Warmwater Habitat (WWH) aquatic life use is appropriate. Fish and macroinvertebrates tended toward attainment of the WWH use at those sites that were not directly impacted by point sources (*i.e.* Payne CSO and Paulding WWTP). Narrative macroinvertebrate evaluations of good and IBI scores that were nonsignificant departures from the biological criteria were recorded at six of the nine sites sampled. One site, RM 7.4, was in FULL attainment of the biological criteria. The presence of a predominately wooded riparian corridor and an average QHEI score of 52.2 also support the appropriateness of the current Warmwater Habitat aquatic life use (WWH). Siltation and substrate embeddedness were the most pervasive modified habitat attributes in the study area and appeared to be related primarily to bank erosion. The headwaters and tributaries of Flatrock Creek have been extensively channelized to enable intensive row crop agriculture. One consequence of channelizing agricultural lands to promote drainage is that runoff reaches the stream sooner and over a shorter period of time. This in turn increases the frequency of bank full flows and the erosive force of the water on the stream bank. Any measures are taken to correct the aforementioned problems and preserve and enhance the wooded riparian corridor would increase the potential for the stream to support WWH aquatic communities.

Sixmile Creek
Channelization of Sixmile Creek is documented beginning before 1900 and as recently as 1976. Given this history of habitat modification and the likelihood that it will continue, a change in aquatic life use from Warmwater Habitat (WWH) to Modified Warmwater Habitat is appropriate upstream from RM 1.2. The mean QHEI was 33.6 and the majority of sites had poor channel development, sparse instream cover and extensive substrate embeddedness, all modified habitat attributes. Beginning at approximately RM 1.3 the stream was in the process of recovery from past channelization; QHEI scores were 56.4 and 44.0, respectively. The existing WWH use designation is appropriate for this brief segment.

Pusheta Creek
The sampling site at RM 0.3 had been recently modified which was reflected in a QHEI score of 41.0. The modification appeared to be a localized occurrence and did not significantly impact the biota. Based on the biological performance, the current Warmwater Habitat use is appropriate.

Status of Non-Aquatic Life Uses
- No changes are recommended for the designated non-aquatic life uses as a result of this survey. All four streams are currently designated for Primary Contact Recreation (PCR), and for Industrial Water Supply (IWS) and Agricultural Water Supply (AWS) uses.

Other Recommendations
- Ohio EPA Northwest District Office (NWDO) staff have indicated that the Wapakoneta WWTP has been operated using only a portion the plant which results in overloads during rain events. Instream results demonstrate a need for changes in plant operation to eliminate the overloading by fully utilizing the existing WWTP treatment capacity.

- Operation and maintenance procedures need to be evaluated at both the Payne WWTP and the Paulding WWTP. The Payne WWTP had a failure of the sewer system during the 1991 sampling period that resulted in the discharge of untreated waste via a CSO into Flatrock Creek and the Paulding WWTP has periodically experienced plant overloading.

- Despite the efforts of Ohio EPA and the various entities that discharge to Sixmile Creek, the toxic conditions recorded in a 1981 survey have not been appreciably abated. If it is not already, Sixmile Creek should be given priority status to rectify the complicated set of issues that affect

the stream and continue to impact the Auglaize River mainstem. Removal of contaminated sediments may be nessasary to protect against the bioaccumualtion of PCBs if, and when, a viable fish community is reestablished in the stream.

Future Monitoring Needs

- Additional sampling and a follow-up investigation of the Miami-Erie Canal is needed to identify the source of zinc that resulted in observed violations of WQS.

- Field reconnaissance of the Geokke tributary should be conducted to determine what influence, if any, this stream is having on conditions in the Auglaize River. An effort should be made to inventory and identify any previously unknown inputs.

- Additional sediment sampling in Sixmile Creek is needed to precisely define the nature and extent of contamination that was indicated by the 1991 sampling effort.

- Questions remain concerning the fate of runoff/leachate from the Farm Service Center property. Wet weather monitoring of nearby stormsewers needs to be conducted to determine if pollutants are entering Sixmile Creek from the Farm Service Center.

- This survey should be redone in 1996 in accordance with the Five Year Basin Approach monitoring strategy to document the changes in the quality of the water resource and provide updated information for the reissuance of NPDES permits.

Study Area (Figure 1; Tables 2 and 3)

The Auglaize River basin covers 2,342 square miles in northwest Ohio and 107 square miles in northeast Indiana and includes parts of Allen, Auglaize, Defiance, Paulding, Putnam and Van Wert counties. The basin headwaters are in Allen and Auglaize counties. The mainstem flows in a northerly direction through glaciated, flat topography and joins Maumee River at Defiance. The Auglaize River and its many tributaries, including the Blanchard, the Ottawa and the Little Auglaize rivers, drain much of the southern portion of the Maumee River basin. The principal municipal point source dischargers in the Auglaize River study area include Wapakoneta, Spencerville, Payne and Paulding.

The Auglaize River basin is situated in two ecoregions: the Huron/Erie Lake Plain (HELP) and the Eastern Corn Belt Plains (ECBP). The HELP ecoregion comprises approximately 75 percent of the Auglaize River study area. The HELP ecoregion is characterized by a broad, almost level, lake plain with some low moraines and beach ridges. There is very little local relief. Streams in the HELP ecoregion have very low gradients. The soils are high in organic matter and provide some of the richest farm land in the state. The soils are poorly to very poorly drained. Corn and soybean farming is the predominant land use and requires an extensive drainage ditch system to make row crop farming possible.

The ECBP ecoregion is occupied by in the Auglaize River headwaters portion of the study area and is characterized by a gently rolling glacial till plain with moraines, kames and outwash plains. Local relief is usually less than 50 feet. The ECBP ecoregion is a rich agricultural plain which stretches south and east of the HELP ecoregion to occupy much of western and central Ohio. Soils are derived from glacial till materials and soil drainage is poor. Many of the small streams in the

Table 1. Aquatic life use attainment status for the existing or recommended Warmwater Habitat (WWH) stream segments in the Auglaize River and tributaries based on data collected during June - September 1991.

RIVER MILE Fish/Invert.	IBI	Modified Iwb	ICI[a]	QHEI[b]	Attainment Status[c]	Comment
Auglaize River (1991)						
	Eastern Corn Belt Plain - WWH Use Designation (Existing)					
87.7/87.8	35*	6.6*	16/G	56.0	PARTIAL	Ust. Wapakoneta
85.5/85.2	45	9.3	22/MG	74.5	FULL	Dst. CSOs; Ust.WWTP
85.1/85.1	38	7.7	4/P	N/A	N/A	Wapak.WWTP Mix Zone
85.0/85.0	45	9.8	12*	81.0	**NON**	Dst. Wapak. WWTP
80.4/80.4	43	9.3	36	75.5	FULL	
	Eastern Corn Belt Plain - WWH Use Designation (Recommended)					
67.3/67.0	46	9.5	46	74.5	FULL	Regional reference Site
65.0/ -	43	8.4[ns]	-	47.0	(FULL)	Impounded
63.1/63.4	37*	8.1[ns]	20/MG	33.5	PARTIAL	Ust. Sixmile Creek
61.8/61.6	38[ns]	8.7	20/MG	48.5	FULL	Dst. Sixmile Creek
58.4/ -	36*	8.8	-	55.0	(PARTIAL)	
58.0/58.0	29*	8.2[ns]	50	57.0	PARTIAL	
52.7/ -	31*	8.3[ns]	-	39.5	(PARTIAL)	
	Huron Erie Lake Plain - WWH Use Designation (Recommended)					
39.7/39.4	33[ns]	10.0	26/G	66.5	FULL	
28.8/28.8	30[ns]	8.8	48	72.0	FULL	
Pusheta Creek (1991)						
	Eastern Corn Belt Plain - WWH Use Designation (Existing)					
0.3/0.3	42	9.6	34[ns]	41.0	FULL	Near Mouth
Sixmile Creek (1991)						
	Huron Erie Lake Plain - MWH Use Designation (Recommended)					
4.2/4.2	12*	N/A	P*	43.0	**NON**	Ust. OD/ TT
3.8/3.8	12*	N/A	0*	29.0	**NON**	Dst. OD/ TT
3.7/3.6	13*	N/A	0*	26.5	**NON**	Dst. Farm Services
3.5/3.5	12*	N/A	2*	35.8	**NON**	Dst. WWTP trib.
	Huron Erie Lake Plain - WWH Use Designation (Existingf					
1.2/1.3	12*	N/A	P*	56.5	**NON**	Habitat recovery
0.1/0.2	23*	N/A	18*	44	**NON**	Near mouth

Table 1. (continued)

RIVER MILE Fish/Invert.	IBI	Modified Iwb	ICI[a]	QHEI[b]	Attainment Status[c]	Comment
Flatrock Creek (1991)						
Huron Erie Lake Plain - WWH Use Designation (Existing)						
28.9/28.8	30ns	5.2*	10/G	53.5	**NON**	Ust. Payne
26.1/26.1	27*	6.0*	0/VP*	45.0	**NON**	Dst. CSOs
24.4/23.7	28ns	5.8*	16/G	76.0	**NON**	Dst. Payne WWTP
18.1/18.0	28ns	5.1*	4/G	60.5	**NON**	
13.8/13.8	31ns	7.4	16/G	55.5	FULL	Dst. Paulding WTP dam
9.6/9.6	29ns	6.5*	2/G	52.5	PARTIAL	Ust. Paulding WWTP
9.0/8.1	25*	6.7*	2/P*	55.0	**NON**	Dst. Paulding WWTP
6.0/6.0	28ns	6.6*	18/F*	65.0	PARTIAL	
2.8/2.9	26*	6.6*	20/G	59.0	PARTIAL	Near mouth

Ecoregion Biocriteria:

Eastern Corn Belt Plains (ECBP)

INDEX - Site Type	WWH	EWH	MWH[d]
IBI - Headwaters/Wading	40	50	24
IBI - Boat	42	48	24
Mod. Iwb - Wading	8.3	9.4	5.8
Mod. Iwb - Boat	8.5	9.6	5.8
ICI	36	46	22

Huron Erie Lake Plain (HELP)

INDEX - Site Type	WWH	EWH	MWH[d]
IBI - Headwaters/Wading	28	50	20
IBI - Wading	32	50	22
IBI - Boat	34	48	20
Mod. Iwb - Wading	7.3	9.4	5.6
Mod. Iwb - Boat	8.6	9.6	5.7
ICI	34	46	22

[d] - Modified Warmwater Habitat for channel modified areas.

* - significant departure from biocriteria; poor and very poor results are underlined.

ns - nonsignificant departure from biocriteria for WWH or EWH (4 IBI or ICI units; 0.5 Iwb units).

a - Narrative evaluation used in lieu of ICI where quantitative sampling was not done or where artificial substrates were influenced by slow (< 0.3 ft/sec) current velocity (E=Exceptional; G=good; MG=Marginally good; F=Fair; P=Poor; VP=Very Poor).

b - Qualitative Habitat Evaluation Index (QHEI) values based on the new version (Rankin 1989).

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

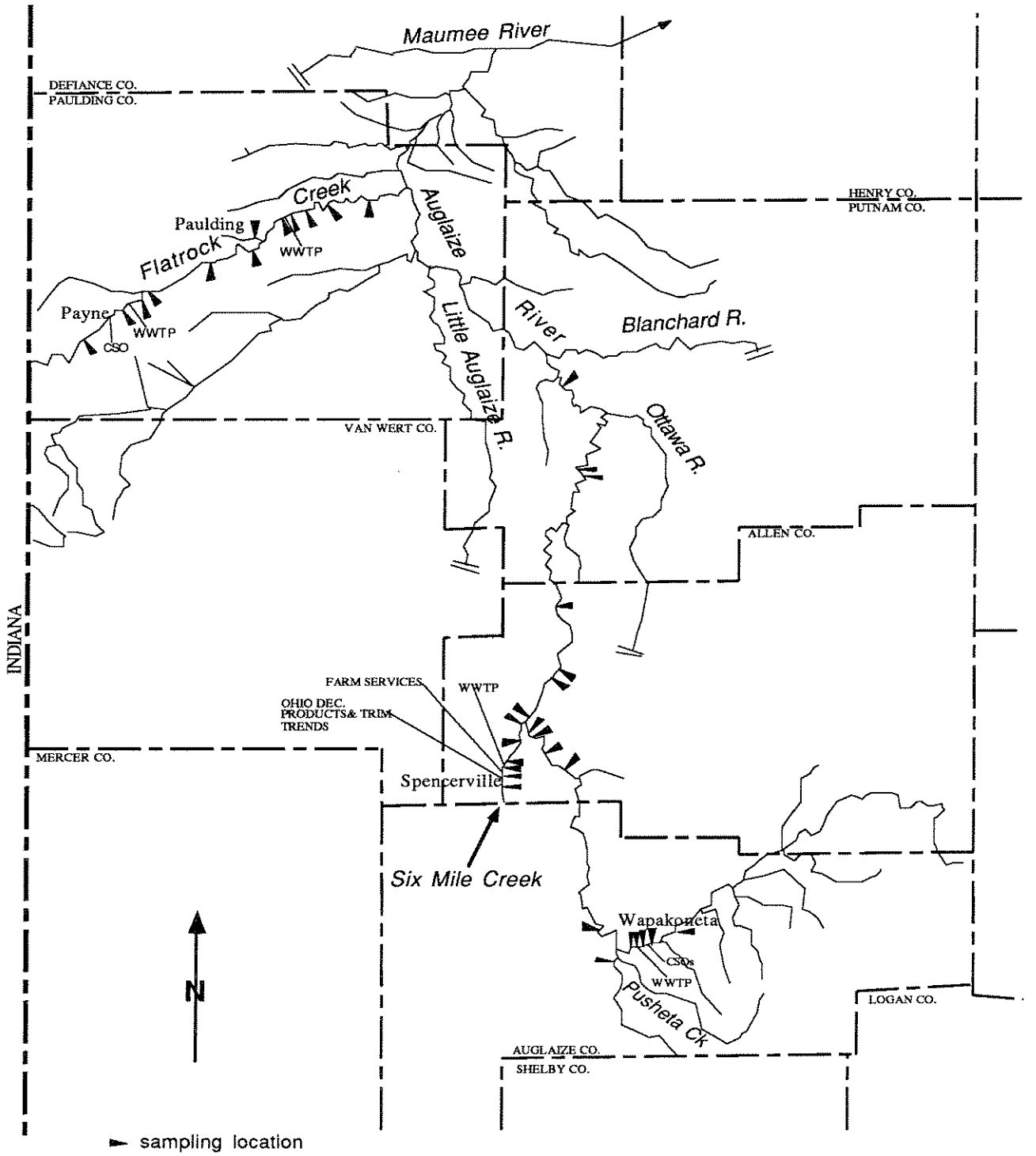

Figure 1. The Auglaize River study area showing principal streams and tributaries, population centers, pollution sources, and sampling locations.

upper Auglaize River basin have been channelized to improve the drainage for farming. Seventy - five percent of the area of this ecoregion is used for farming.

Agriculture and channelization are the predominant types of nonpoint source (NPS) pollution in the watershed. Other types of NPS pollution known or suspected in the watershed include urban runoff, on-site septic systems, in-place pollutants and stream bank modification (Ohio EPA 1990).

Table 2. Stream characteristics and significant identified pollution sources in the Auglaize River study area.

Stream Name	Length (Miles)	Average Fall (Feet/Mile)	Drainage Area (Square Miles)	Nonpoint Source Pollution Categories	Point Sources Evaluated
Auglaize River	101.9	3.2	2448.2 (106.6 in Ind.)	Agriculture Hydromodification Urban runoff	Wapakoneta WWTP and CSOs
Sixmile Creek	12.0	3.4	19.95	Agriculture Channelization Storm & San. Sewers On-site septic systems In-place pollutants	Spencerville WWTP Trim Trends Ohio Decor. Prods. Farm Services
Flatrock Creek	34 (in Ohio)	2.1	214.6 (106.6 in Ind.)	Agriculture Channelization	Payne WWTP and CSOs Paulding WWTP and CSOs
Pusheta Creek	13.7	11.7	35.9	Agriculture Hydromodification Sanitary Sewers	

Methods

All chemical, physical, and biological field, laboratory, data processing, and data analysis methods and procedures adhere to those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 1989c) and Biological Criteria for the Protection of Aquatic Life, Volumes II-III (Ohio Environmental Protection Agency 1987b, 1989a, 1989b), and The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application (Rankin 1989) for aquatic habitat assessment.

Attainment/nonattainment of aquatic life uses is determined by using biological criteria codified in Ohio Administrative Code (OAC) 3745-1-07, Table 7-17. The biological community performance measures that are used include the Index of Biotic Integrity (IBI) and the Modified Index of Well-being (MIwb), both of which are based on fish community characteristics, and the

Table 3. Sampling locations (effluent sample - E, water chemistry - C sediment chemistry - S, benthos - B, fish - F, fish tissue - FT) in the Auglaize River study area, 1991.

Stream/ River Mile	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad. Map
Auglaize River				
87.8	B	40 34 57 /84 10 16	Ust. Dixie Hwy.	Wapakoneta
87.7	F,S	40 34 53 /84 10 25	Ust. Dixie Hwy.	Wapakoneta
87.5	C	40 34 52 /84 10 29	Dixie Hwy.	Wapakoneta
85.6	S	40 34 16 /84 12 11	Ust. lowhead dam	Wapakoneta
85.5	F,C	40 34 14 /84 12 19	Dst. CSO	Wapakoneta
85.2	B	40 34 13 /84 12 38	Dst. CSO	Wapakoneta
85.1	B,F,C,E	40 34 13 /84 12 33	Wapak.WWTP	Wapakoneta
85.0	B,F	40 34 13 /84 12 37	Dst. Wapak. WWTP	Wapakoneta
84.3	C,S	40 33 54 /84 13 05	Adj. Greenlawn Cem.	Wapakoneta
80.5	C,S	40 34 56 /84 14 36	Glynwood Rd.	Wapakoneta
80.4	B,F	40 35 05 /84 14 32	Ust. Glynwood Rd.	Wapakoneta
67.3	F	40 42 32 /84 16 31	Dst. SR 117	Spencerville
67.0	B,C	40 42 02 /84 16 24	Conant Rd.	Spencerville
65.0	F	40 43 40 /84 18 09	Ust Spencerville dam	Spencerville
63.4	B	40 44 18 /84 18 51	Ust. Sixmile Creek	Spencerville
63.1	F,C,S	40 44 29 /84 18 55	Ust. Sixmile Creek	Spencerville
61.8	F	40 45 10 /84 18 48	Dst. Sixmile Creek	Delphos
61.6	B	40 45 17 /84 18 47	Dst. Sixmile Creek	Delphos
60.4	C,S	40 45 54 /84 18 18	Zion Church Rd.	Delphos
58.4	F	40 47 02 /84 17 36	Ust. Piquad Rd.	Delphos
58.2	C	40 47 13 /84 17 31	Piquad Rd.	Delphos
58.0	B,F	40 47 20 /84 17 26	Dst. Piquad Rd.	Delphos
52.7	F	40 50 41 /84 17 13	Dst. Lincoln Hwy	Delphos
39.7	F	40 56 50 /84 15 45	Ust. US 224	Ottoville
39.6	C	41 56 56 /8415 57	US 224	Ottoville
39.4	B	40 57 01 /84 16 07	Adj. SR 190	Ottoville
28.8	B,F	41 01 04 /84 17 10	Adj. SR 114	Continental
28.5	C	41 01 16 /84 17 20	SR 114	Continental
Pusheta Creek				
0.3	B,F,C	40 34 01 /84 13 38	Dst. Auglaize St.	Wapakoneta
Sixmile Creek				
4.2	B,F,C,S	40 42 52 /84 21 14	Dst. Baily St.	Spencerville
3.9	C,S	40 43 00 /84 20 57	SR 66	Spencerville
3.8	B,F	40 43 02 /84 20 50	Dst. OD/ TT	Spencerville
3.7	F	40 43 02 /84 20 45	Dst. Farm Services	Spencerville
3.6	B,C,S	40 43 07 /84 20 45	Dst. Farm Services	Spencerville
3.5	B	40 43 10 /84 20 38	Dst. WWTP trib.	Spencerville

Table 3. (continued)

Stream/ River Mile	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad. Map
Sixmile Creek				
1.2	F,C	40 44 07 /84 14 24	Dst. SR 81	Spencerville
0.2	B,C,S	40 44 49 /84 19 17	Near mouth	Spencerville
0.1	F	40 44 56 /84 19 14	Dst. Defiance Trail	Spencerville
Miami-Erie Canal				
10.2	C	40 42 57 /84 21 02	At Spencerville	Spencerville
Flatrock Creek				
28.9	F,C,S	42 03 25 /84 44 18	Ust.TR 33	Payne
28.8	B	41 03 26 /84 44 45	Ust. Payne	Payne
26.1	C,S	41 04 42 /84 43 04	Dst. CSOs	Payne
26.2	B,F	41 04 41 /84 43 01	Dst. CSOs	Payne
24.4	F	42 05 04 /84 42 00	Dst. Payne WWTP	Payne
23.7	B,C,S	41 05 27 /84 51 35	Dst. Payne WWTP	Payne
18.3	C	40 06 54 /84 37 53	Hazelet Rd.	Payne
18.1	F	42 06 56 /84 37 49	Dst Hazelet Rd.	Payne
18.0	B	41 07 00 /84 37 48	Hazelet Rd.	Payne
13.8	B,F,C,S	41 07 39 /84 35 12	Dst.WTP dam	Paulding
9.6	B,F,C,S	41 09 24 /84 33 15	Ust. Paulding WWTP	Paulding
8.1	B,C,S	41 09 27 /84 32 14	Dst. Paulding WWTP	Paulding
6.0	B,F,C,S	41 09 47 /84 31 02	C.R. 111	Paulding
2.9	B	41 10 06 /84 28 49	Upstream SR 637	Junction
2.8	F	41 10 04 /84 28 39	Upstream SR 637	Junction
2.7	C	41 10 04 /84 28 35	SR 637	Junction
Opposum Run				
0.4	C	41 08 55 /84 34 26	Dst. CR 115	Paulding

Invertebrate Community Index (ICI) which is based on macroinvertebrate community characteristics. IBI and ICI are multi-metric indices patterned after an original IBI described by Karr (1981) and Fausch et al. (1984). The MIwb is a measure of fish community abundance and diversity using numbers and weight information; it is a modification of the original Index of Well-Being applied to fish community information from the Wabash River (Gammon 1976, Gammon *et al.* 1981).

Performance expectations for the basic aquatic life uses (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 an aquatic life use is FULL if all three indices (or those available) meet the applicable criteria, PARTIAL if at least one of the indexes does not attain and performance does not fall below the fair category, and **NON** if all indices either fail to attain or any index indicates poor or very poor performance.

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989). Various attributes of the available habitat are scored based on their overall importance to the establishment of viable, diverse aquatic faunas. Evaluations of type and quality of substrate, amount of instream cover, channel morphology, extent of riparian canopy, pool and riffle development and quality, and stream gradient are among the metrics used to determine the QHEI score which generally ranges from 20 to 100. The QHEI is used to evaluate the characteristics of a stream segment, not just the characteristics of a single sampling site. As such, individual sites may have much 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 higher than 60 are generally conducive to the establishment of warmwater faunas while those scores in excess of 75-80 often typify habitat conditions which have the ability to support exceptional faunas.

During this survey, macroinvertebrates were sampled using modified Hester/Dendy multiple-plate artificial substrate samplers supplemented with a qualitative assessment of the available natural substrates. Exceptions included the upstream control site on Sixmile Creek (RM 4.2) and those locations where the artificial substrate samplers were affected by a lack of sufficient current velocity (qualitative sampling only). A current velocity of 0.3 ft/sec across the artificial substrates is generally required for direct application of the resultant ICI score in determining aquatic life use attainment.

Macroinvertebrate sites in the study area were also evaluated using an assessment tool currently in the developmental phase. This method utilizes the qualitative, natural substrate collections available from each site and relies on tolerance values derived for each macroinvertebrate taxon collected. These tolerance values, unlike other tolerance values used in common indices (e.g., the Hilsenhoff Biotic Index), utilizes the abundance data for a given taxon collected with artificial substrates at sites around Ohio. To determine the tolerance value of a given taxon, ICI scores at all locations where the taxon has been collected with artificial substrates are weighted by the abundance data of that taxon at those sites. The mean of the weighted ICI scores for the taxon results in the tolerance value of that taxon. Thus, a taxon's tolerance value represents its relative level of tolerance on the ICI's 0 to 60 scale. High tolerance values are calculated for the more intolerant taxa which tend to reach their greatest abundance at undisturbed sites (i.e., sites with highest ICI scores). Conversely, the more pollution tolerant taxa attain their greatest abundances at highly disturbed sites with low ICI scores, which results in a lower tolerance value. For the qualitative macroinvertebrate collections in the Auglaize River study area, the median tolerance value, based on all tolerance values of the organisms collected at a site, resulted in what has been termed the Qualitative Community Tolerance Value (QCTV). Though only in the developmental stage, the QCTV shows potential as a method to supplement existing assessment methods using the qualitatively collected macroinvertebrate information. Its use in evaluating sites in the Auglaize River study area was restricted to relative comparisons between sites with no attempt to interpret quality of the sites or aquatic life use attainment status.

Fish were sampled 2-3 times using pulsed DC electrofishing gear using either the wading method (150 meter zones) or boat method (500 meter zones). Chemical/physical and biological sampling locations are listed in Table 3.

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

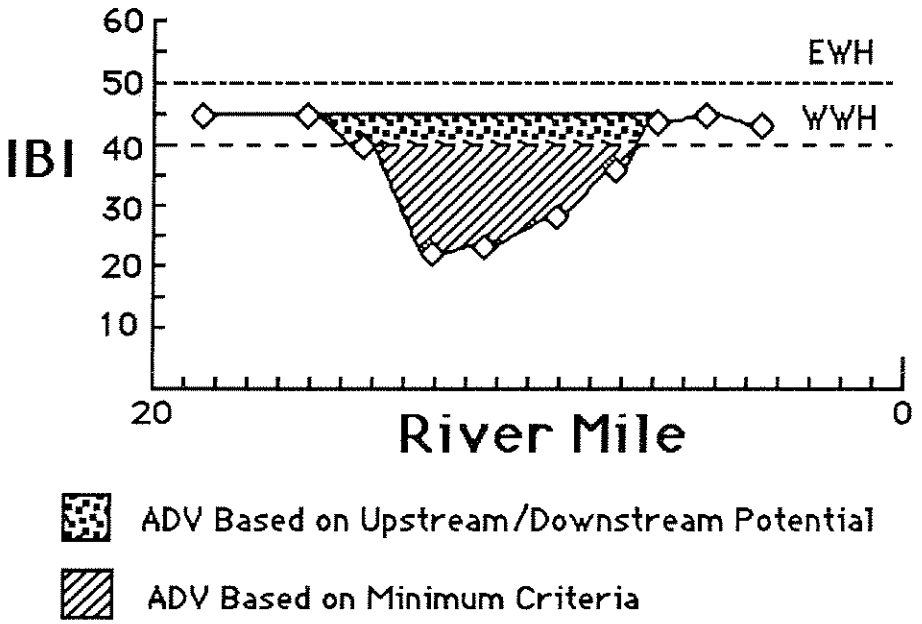

Figure 2. Graphic illustration of the calculation of Area of Degradation Values (ADV) based on upstream potential and the ecoregion warmwater habitat use or minimum criteria (WWH). Criteria for exceptional warmwater habitat use (EWH) is provided for reference.

Results and Discussion

Auglaize River

Pollutant Loadings: 1976- 1991

- The City of Wapakoneta operates an advanced secondary wastewater treatment system (Ohio EPA permit number 2PD00019) which treats an average of 2.27 million gallons per day. This system can be operated in either conventional activated sludge or contact stabilization modes. According to Ohio EPA NWDO staff the WWTP has in the past been operated using only one half of the facility. This operating scheme has apparently resulted in a lack of capacity and subsequent bypassing following rain events. Final effluent from the plant is discharged to the Auglaize River at RM 85.1. The plant was originally constructed in 1936 with the last major modification occurring in 1983. The city has an industrial pretreatment program with two metal finishing entities which contribute approximately 15% of the total inflow. The collection system is approximately 35% combined sewers Three CSOs and an influent bypass are monitored when discharging.

- Phosphorus concentrations in the Wapakoneta WWTP effluent reflects plant upgrades, which greatly reduced annual loadings after 1983 (Figure 3). The loadings for ammonia-N also decreased considerably beginning in 1983. Concurrent with the decrease in ammonia-N is an increase in nitrate-N, indicating increased WWTP nitrification. There also seems to be an overall trend of decreasing BOD_5 in the effluent since 1982. However, beginning in 1983 there was four year long cycle of increasing BOD_5 followed by a decrease and another four year cycle of annual increases. The aforementioned information concerning plant operation may explain this pattern in the BOD_5 loadings

- Monthly self monitoring reports indicate no discharges from the plant influent bypass in 1991. CSOs discharged, on the average, 1.8 times per month for 8.3 hours, with an average annual flow of 40,000 gallons per day (0.040 MGD). Mean annual loadings for $CBOD_5$ and total nonfilterable residue (total suspended solids, TSS) from CSOs were calculated at 9.6 and 40.2 kg/day, respectively. Expressed as a percent of the total pollutant load to the Auglaize River for these parameters, CSOs contributed 20% of the $CBOD_5$ load and 26.2% of the TSS load.

- Effluent samples from the Wapakoneta WWTP were tested for acute toxicity by Ohio EPA in June and July of 1984 (Bioassay Report Numbers 84-306-NW and 84-322-NW). Results of both tests indicated no acute toxicity to fathead minnows, but did indicate acute toxicity to Ceriodaphina.

Chemical Water Quality

- Very few exceedences of Warmwater Habitat water quality criteria were detected in the samples for this survey (Table 4). A single D.O. exceedence was measured at RM 87.5, the upstream control site. The most heavily impacted site in the Wapakoneta area was at RM 84.3 with one D.O. measurement and one ammonia-N concentration in violation of Warmwater Habitat criteria. A single nitrate-N Public Water Supply criterion exceedence was also recorded at RM 84.3.

- The sampling site at RM 87.5 was a relatively wide, shallow, and silty section of the Auglaize River. Mean D.O. concentrations from grab samples indicated that the D.O. level at this site was one of the lowest in the Auglaize River (Figure 4). This probably reflected nonpoint source influence from the upper drainage basin combined with a nearly intermittent flow condition. The mean D.O. increased at the next site downstream (RM 85.5), which was located below the CSOs, indicating a lack of significant input from these sources during the sampling period. This site was also downstream from a lowhead dam, which may affect dissolved oxygen concentrations due to photosynthesis of algae and macrophytes in the impounded area. The mean D.O. concentration continued to increase at the next site (RM 85.1), which was located in the WWTP mixing zone. Impacts from the WWTP effluent were reflected in a drop in mean D.O. at RM 84.3, adjacent to Greenlawn Cemetery. Field personnel noted the presence of minor sludge deposits at this site (the sludge had the appearance of a brownish floc). The mean D.O. increased dramatically at RM 80.5 and leveled off somewhat at RM 67.0 at a considerably higher level than at the upstream control site. D.O. measurements using continuous monitors reflected a similar pattern of downstream change in concentrations, with an increase downstream from the WWTP (RM 83.27), followed by a D.O. sag at RM 82.40 (Figure 6). This was followed by an increase in D.O. at RM 80.50, and a leveling-off at RM 77.52.

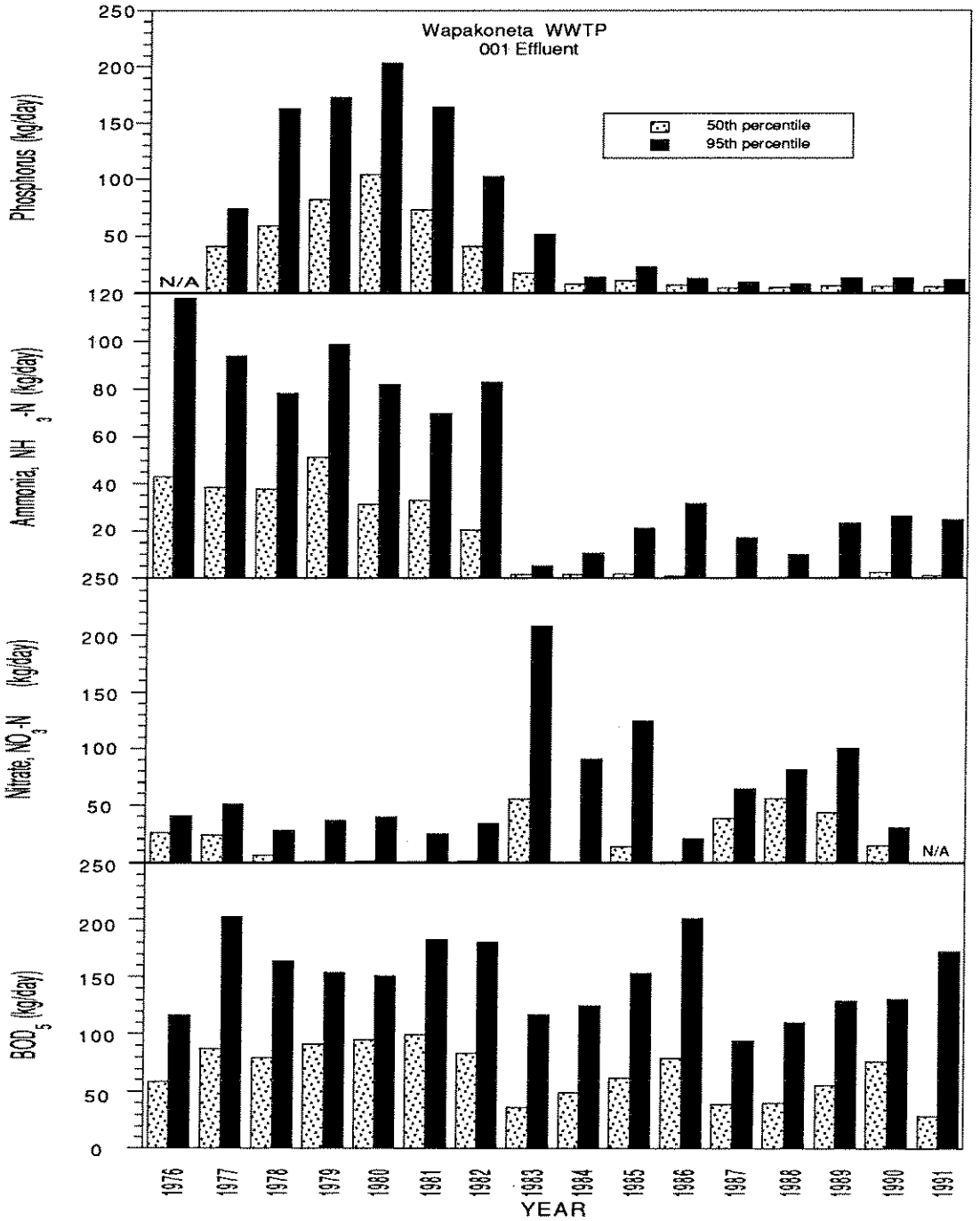

Figure 3. Annual loadings (kg/day) of phosphorus, ammonia-N, nitrate and biochemical oxygen demand (BOD_5) from the Wapakoneta WWTP to the Auglaize River, 1976 to 1991. BOD_5 loading for 1991 is calculated based on reported five-day carbonaceous biochemical oxygen demand ($CBOD_5$) values.

Table 4. Exceedences of Ohio EPA Warmwater Habitat criteria (OAC 3745-1) for chemical/physical parameters measured in the Auglaize River and Sixmile Creek study areas, 1991 (units are µg/l for metals, #/100 ml for fecal coliform, and mg/l for all other parameters).

Stream Name	River Mile	Violation: Parameter (value)
Auglaize R	87.5	D.O. (3.90‡‡)
	84.3	D.O. (4.0‡); NH_3-N (1.99*); NO_3-N (10.9∞)
	63.1	D.O. (3.6‡‡)
	60.4	D.O. (4.2‡, 3.7‡‡, 4.0‡, 2.6‡‡)
	39.6	D.O. (4.3‡, 4.2‡); Zn (1220 ***)
	28.5	D.O. (4.7‡); Zn (315 *)
Sixmile Cr	4.2	D.O. (4.5‡); Cu (30*); Fecal coliform (4700◊)
	3.9	D.O. (3.8‡‡, 3.1‡‡, 0.3‡‡‡); NH3-N (0.44*) Fecal coliform (11000◊◊, 2300◊, >2000◊)
	3.5	D.O. (3.2‡‡, 4.9‡, 3.9‡‡); NH3-N (6.68*); Fecal coliform (>2000◊)
	1.2	D.O. (4.8‡, 4.3‡‡); NH_3-N (5.89*)
	0.2	Zn (160*); NH_3-N (6.25*)
Miami-Erie Canal		Zn (260 **, 640***)
Pusheta Creek	0.3	Fecal coliform (3750◊)
		73 of 108 iron samples (67.5%) exceeded 1.0 mg/l in the study area.

* indicates an exceedence of numerical criteria for prevention of chronic toxicity (CAC).
** indicates an exceedence of numerical criteria for prevention of acute toxicity (AAC).
*** indicates an exceedence of numerical criteria for prevention of lethality (FAV).
‡ violation of the average dissolved oxygen (D.O.) criterion.
‡‡ violation of the minimum dissolved oxygen (D.O.) criterion.
‡‡‡ violation of the "nuisance prevention" minimum dissolved oxygen (D.O.) criterion.
◊ exceedence of the Primary Contact Recreation criterion.
◊◊ exceedence of the Secondary Contact Recreation criterion.
∞ exceedence of the Public Drinking Water criterion.

- Mean BOD_5 concentrations ranged between 3-6 mg/l (Figure 4), with indications of slight increases downstream from both the Wapakoneta CSOs and WWTP. Nonpoint source influences probably contribute to further slight increases downstream. The increase in BOD_5 at RM 58.2 is a likely result of nutrient stimulus from Sixmile Creek and the peak at RM 39.6 may be a result of inputs from Jennings Creek. The only pattern noted in the graph for ammonia-N was a slight increase at RM 84.3, which coincided with the D.O. sag at that site. The graph for total phosphorus indicated some input from the WWTP and at RM 67.0, an increase which may be accounted for by nonpoint source inputs.

- The site on the Auglaize River at RM 63.1 was upstream from the confluence of Sixmile Creek. One violation of the daily average D.O.criterion was noted at this site during the 1991 survey. The graph of continuous monitor D.O. concentrations for RM 63.1 indicated a relatively wide range of measurements, which suggests that the violations at this site were the result of algal blooms, influenced by nonpoint source nutrient input. The next downstream site on the Auglaize River was at RM 60.4, which is 1.91 river miles downstream from the point where Sixmile Creek joins the Auglaize. Three of six D.O. concentrations at RM 60.4 were less than the daily average criterion of 5.0 mg/l, suggesting that Sixmile Creek was contributing to water quality degradation. The remaining sites on the Auglaize River showed recovery of the average concentration with the influence of algal productivity evident in three samples less than the 5 mg/l daily average.

- An exceedence for zinc was noted for RM 39.6 and also for RM 28.5. Given the observed high zinc concentrations in the Miami-Erie canal in Spencerville, these results may be related albeit being more than 20 miles downstream, and may be indicative of episodic discharges originating from the Spencerville area.

- The Village of Ft. Jennings is located on the Auglaize River, in the vicinity of RM 46.4. Ft. Jennings is an unsewered community with both on-site sewage discharges and combined sewer overflows that discharge directly into the Auglaize River from several discharge points. Jennings Creek is a tributary to the Auglaize River at RM 47.02 and is the receiving stream for the Delphos WWTP, as well as combined sewer overflows from Delphos. The combined inputs from Ft.Jennings and Jennings Creek may have had some influence on the following observations: 1)decrease in mean D.O. at RM 39.6, (2) the increase in total nonfilterable residue at RM 39.6, and (3) the increase in BOD_5 at RM 39.6. There may be other factors involved at RM 39.6, such as the hydrology and physical structure of the river in this section.

- A flow hydrograph depicting daily discharge in the Auglaize River at Ft. Jennings indicated a declining flow volume during the survey period (Figure 5). This site is located well downstream from Wapakoneta, but accurately represents the low flow conditions experienced during the 1991 study period.

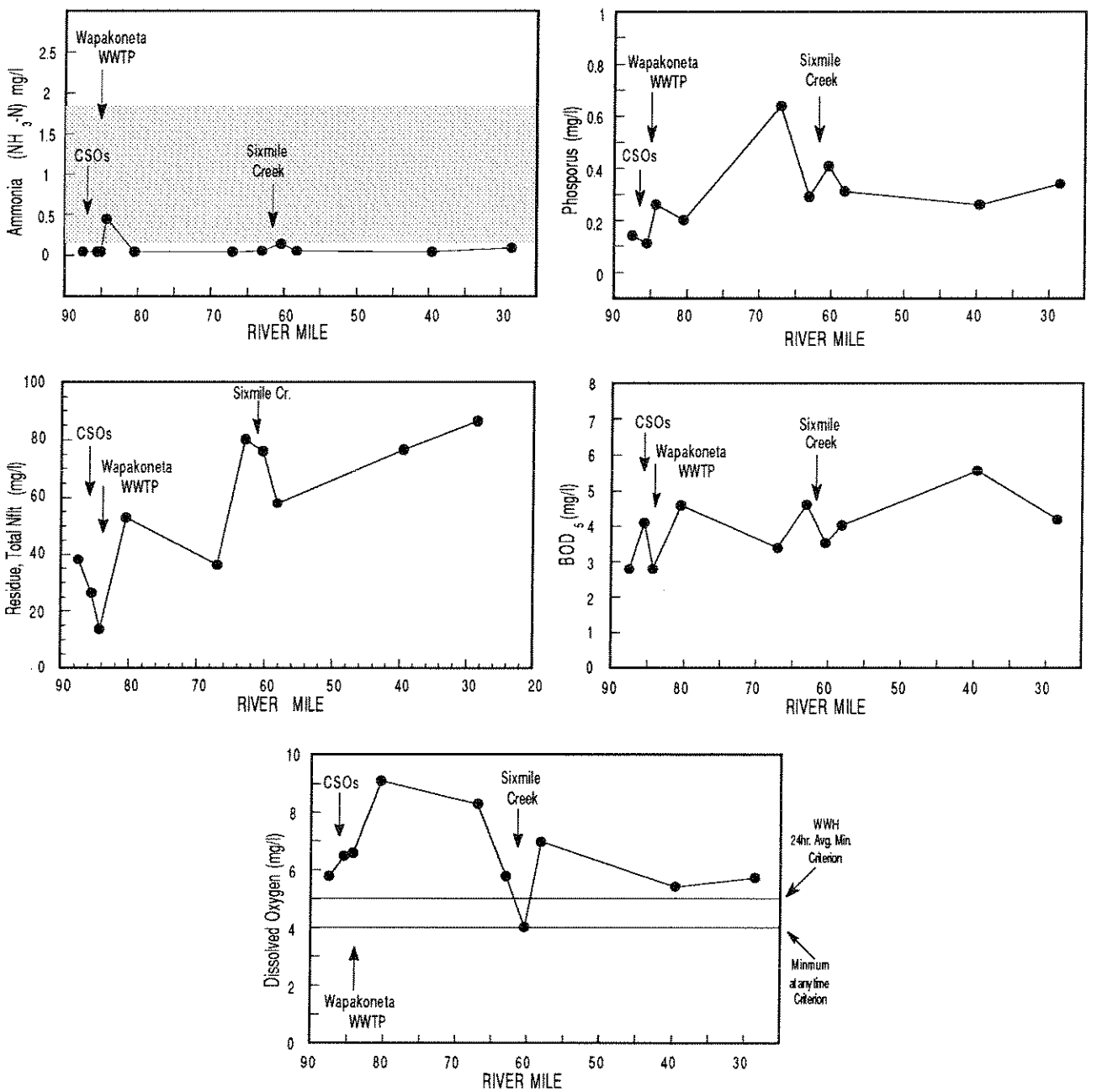

Figure 4. Longitudinal trends of mean phosphorus, dissolved oxygen, biochemical oxygen demand (BOD_5),and ammonia-N in the Auglaize River, 1991. Shaded area in the ammonia-N plot represents the range of WQS criteria based on 90th and 25th percentile pH and temperature values from study data.

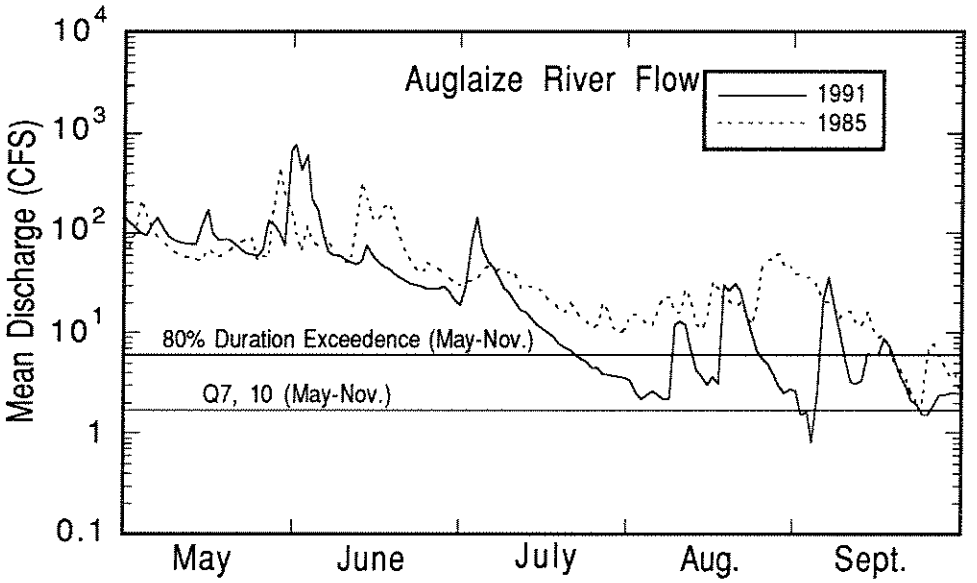

Figure 5. Flow hydrograph for the Auglaize River at Ft. Jennings, Ohio (RM 39.7) May through September, 1985 and, 1991 (USGS 1991). May through November low-flow conditions (Q710 [1.7 cfs] and 80% duration flow [6.0 cfs]; period of record 1915 to 1978) calculated from historical flow records of the Auglaize River at Defiance are indicated (USGS 1981).

- Continuously recorded D.O. concentration changes in the Auglaize River (Figure 6) suggests that, while the D.O. levels upstream from Sixmile Creek (RM 63.1) are somewhat depressed, the impact of Sixmile Creek was evident in the D.O. levels observed at RM 60.4. Recovery can be seen in the generally higher levels at RM 58.2 and increases at RM 39.6.

- The graph of mean grab sample concentrations for ammonia-N (Figure 4) indicates that Sixmile Creek continues to be a detectable input source for this parameter in the Auglaize River.

- Mean nonfilterable residue (suspended solids) results (Figure 4) suggest that agricultural runoff is the major source in the Auglaize River upstream from Sixmile Creek. The increase in suspended solids between RM 58.2 and RM 28.5 may also be nonpoint source in origin, but may originate from Jennings Creek.

Sediment Chemistry

- Highly elevated and elevated concentrations of arsenic were detected at four sediment sample sites and are probably the result of the widespread use of arsenic containing compounds for pest control on agricultural lands in the 1940s and 50s (Table 5). The elevated level of lead at RM 85.5 is probably due to an urban nonpoint source input. The heavy metals concentrations in the Auglaize River sediment samples indicate that Sixmile Creek is not a major contributor of metals to the river. Only in the case of lead is the concentration higher downstream from the confluence of Sixmile Creek than upstream. The results of sediment chemistry analysis do not indicate any major problems with the priority organic content (Table 6).

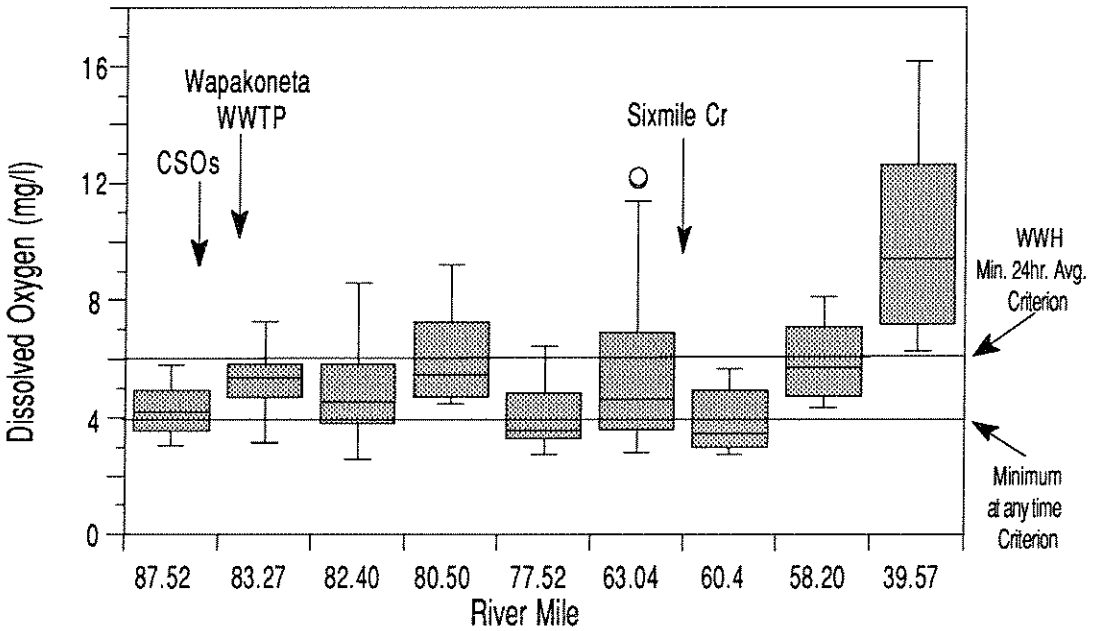

Figure 6. Boxplots of dissolved oxygen data recorded with continuous monitors at selected locations in the Auglaize River during the summer of 1991.

Physical Habitat for Aquatic Life

- Macrohabitats of the Auglaize River were evaluated at a total of 13 fish sample locations.The QHEI in the Auglaize River ranged from 33.5 at RM 63.1 to 81.0 at RM 85.0 (Table 7). The mean QHEI score for the Auglaize was 60.0. This score demonstrates that the habitat quality throughout the study area is sufficient to support an aquatic community capable of attaining the WWH use. In order to elucidate distinct, relatively homogenous segments of habitat types throughout the study area, the Auglaize River mainstem was divided into three segments based upon QHEI scores. The segments are defined as: **Segment 1)** RM 87.7 to RM 67.3; **Segment 2)** RM 65.0 to RM 52.7; **Segment 3)** RM 39.7 to RM 28.8 (Table 8).

- The highest quality habitats of the Auglaize River were found between RMs 87.7 and 67.3. Generally the upper reach consisted of numerous pool/run/riffle complexes, mixed substrates of glacial and native origin, abundant instream cover, and good to fair channel development. A noted exception to the high quality habitat of this segment was RM 87.7, where moderate influence modified habitat attributes predominated (QHEI=56.0). The reach between RMs 87.7 and 67.3 had a mean QHEI score of 72.2, demonstrating the abundance and quality of warmwater macrohabitat types generally found within this segment. Instream habitats of this reach were more than capable of supporting and maintaining a biological community consistent with the WWH use.

Table 5. Concentrations of heavy metals in sediments of the Auglaize River study area, 1991. All parameter concentrations, excluding nickel, were ranked based on a stream sediment classification system described by Kelly and Hite (1984).

River Mile	Sediment Concentration (mg/kg dry weight) As	Cd	Cr	Cu	Fe	Pb	Ni	Zn
Auglaize River								
87.7	**22.8**[d]	0.605[b]	16.0[b]	21.3[a]	22800[b]	30.8[b]	22.4	81.1[b]
85.6	15.8[c]	0.562[b]	15.6[a]	26.8[a]	17200[a]	51.2[c]	24.1	82.0[b]
84.3	**20.1**[d]	0.578[b]	22.6[b]	20.9[a]	20300[b]	39.2[b]	33.1	88.7[b]
80.5	**21.2**[d]	0.557[b]	21.7[b]	25.2[a]	20800[b]	38.5[c]	30.8	89.0[b]
63.1	**26.3**[d]	0.493[a]	23.5[c]	29.7[a]	**33300**[d]	39.8[c]	30.9	115.0[c]
60.4	14.1[c]	0.297[a]	17.9[b]	18.9[a]	18700[b]	44.5[c]	26.8	61.9[a]
Sixmile Creek								
4.2	**29.1**[e]	0.379[a]	15.1[a]	37.4[a]	**41400**[d]	32.8[b]	34.5	104.0[c]
3.9	**23.0**[d]	0.619[b]	**72.8**[e]	88.4[c]	29100[c]	56.7[c]	98.5	**187.0**[d]
3.5	**17.6**[d]	0.491[a]	**42.3**[d]	98.5[c]	27100[c]	37.8[b]	47.3	166.0[c]
1.3	10.4[b]	0.371[a]	**38.4**[d]	43.6[b]	16300[a]	21.8[a]	32.8	68.4[a]
0.2	14.6[c]	0.241[a]	**41.2**[d]	38.5[b]	24400[c]	22.6[a]	36.6	66.8[a]
Flatrock Creek								
28.9	**18.3**[d]	0.339[a]	16.3[b]	23.1[a]	30400[c]	24.4[a]	23.9	72.6[a]
26.2	7.76[a]	0.765[b]	15.8[a]	31.7[a]	20100[b]	42.8[c]	20.2	125.0[c]
23.7	10.8[b]	0.528[b]	16.6[b]	26.4[a]	22900[b]	28.1[b]	22.0	84.9[b]
13.8	18.8[d]	0.506[b]	14.2[a]	34.5[a]	23000[c]	44.9[c]	20.3	90.6[b]
9.6	12.0[c]	0.524[b]	21.4[b]	28.8[a]	27600[c]	38.6[c]	31.5	90.4[b]
8.1	7.70[a]	0.259[a]	8.96[a]	20.3[a]	17100[a]	23.6[a]	19.3	47.6[a]
6.0	6.29[a]	0.292[a]	9.76[a]	15.0[a]	16400[a]	20.4[a]	16.3	54.4[a]

[a] Non-elevated; [b] Slightly elevated; [c] Elevated; [d] **Highly elevated**; [e] **Extremely elevated**
Note: The Kelly and Hite classification system addresses relative concentrations but does not directly assess toxicity.

- QHEI values dropped significantly in the reach extending from RM 65.0 to RM 52.7. Currently this segment is designated as Exceptional Warmwater Habitat (EWH). However, the majority of sites exhibited characteristics associated with modified habitats and/or areas that naturally lacked a high degree of habitat heterogeneity (Table 7). Habitat modification included: impoundment, past channel/bank modifications, and the increased deposition of clayey silts.The most pervasive disturbance was siltation, which resulted from the intensive agricultural land use in the Auglaize River basin.This problem was particularly deleterious in the segment between RM 63.1 to RM 52.7. This reach has a significantly lower average stream gradient, which encourages the deposition of fine sediments. The deposition of sediments in

Table 6. Auglaize River near Wapakoneta sediment priority pollutant scan detections (µg/kg), 1991

RIVER MILE	84.3
PARAMETER (µg/kg)	
GC/MS LIBRARY COMPUTER MATCH [1] (non - priority pollutants)	
1, 1, 2, 2 - Tetrachloro - Ethane	5.4
3 - Methoxy - 3, Methyl - 2 - Butanone	24.2
2 - Methyl 2 - Hexanol	2.3
Nonacosane	1.6

1. Library matched chemical concentrations indicated are estimates within one order of magnitude reported.

Note:Samples for analysis of PCB's/Pesticides were not submitted for the Auglaize River near Wapakoneta.

this area significantly limited the functional attributes of various instream habitats. The mean QHEI values of the reach between RM 65.0 and RM 52.7 was 46.8 (Table 8).This value reflected the predominance of high and moderate influence modified habitat attributes, and indicated that this reach is unable to support a biological community achieving the current EWH aquatic life use criteria.

- QHEI values improved in the lower reach, between RM 39.7 and RM 28.8, with Warmwater Habitat attributes more prevalent than moderate influence modified habitat attributes. The mean QHEI score of this reach was 69.3 (Table 8). This segment demonstrated fair channel development, mixed current velocities, and mixed instream cover. However, siltation and the predominance of bedrock substrate seemed to limit fish community performance. Based on existing habitat conditions, it is unlikely that the fish community could achieve the applicable EWH biocriteria.

Biological Assessment: Macroinvertebrate Community **(Figure 7, Table 9.)**

- Six of the eleven macroinvertebrate sampling locations on the Auglaize River lacked sufficient current velocity to permit locating the artificial substrates in the prescribed minimum flow of greater than 0.3 feet/second. This was due to a lack of depth in areas where current velocity exceeded 0.3 feet/second or because the site was located in a sluggish, low gradient portions of the stream. For this reason, final evaluation of the macroinvertebrate community performance in these cases relied less on the ICI score and more on qualitative sampling results such as the Qualitative Community Tolerance Values (QCTV) and field observations of organism predominance and density.

- The upstream control site (RM 87.8) was nearly intermittent when sampling was conducted on 3 September, 1991. The artificial substrates were collected from an area with no current and produced an ICI score in the fair range. Conversely, qualitative sampling from available natural habitats yielded a relatively diverse and pollution sensitive assemblage. The overall impression of the sampling was that the water resource was affected by the nearly intermittent conditions but that the Warmwater Habitat use designation was appropriate. Based on qualitative sampling results, the macroinvertebrate community was attaining this use.

Table 7. Qualitative Habitat Evaluation Index (QHEI) matrix showing modified and warmwater habitat characteristics for the Auglaize River , July - September, 1991.

Key QHEI Components			WWH Attributes										MWH Attributes																					
													High Influence										*Moderate Influence*												
River Mile	QHEI	Gradient (ft/mile)	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Mod/High Sinuosity	Extensive/Moderate Cover	Fast Current/ Eddies	Low/Normal Embeddedness	Max Depth >40 cm	Low/No Riffle Embeddedness	**Total WWH Attributes**	Channelized or No Recovery	Silt/Muck Substrates	Low Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD,HW)	**Total (High Influence) MWH Attributes**	Recovering Channel	Heavy/Mod. Silt Cover	Sand Substrates (BT)	Hardpan Origin	Fair/Poor Development	Low/No Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Embeddedness	Ext./Mod. Riffle Embeddedness	No Riffle	**Total (Moderate Influence) MWH Attributes**	**MWH (High)/WWH Attributes**	**MWH (Mod.)/WWH Attributes**
(04-100) – AUGLAIZE RIVER																																		
Year: 91																																		
87.7	56.0	1.55	■				■				■		3						0	▲▲			▲▲			▲▲			▲		7	.25	2.00
85.5	74.5	6.10	■				■				■		3						0	▲			▲▲			▲▲▲					6	.25	1.75
85.0	81.0	6.10	■■		■		■■			■	■		8						0				▲▲			▲		▲			4	.11	.56
80.4	75.5	1.53	■		■		■■				■		7						0	▲			▲			▲▲					4	.13	.63
67.3	74.5	.73	■■		■		■■			■	■	■	9						0	▲											1	.10	.20
65.0	47.0	.73					■■				■		3	●					1	▲▲			▲▲			▲▲			▲		7	.50	2.25
63.1	33.5	.73					■				■		2	●●			●		3		▲		▲▲			▲▲			▲		6	1.33	3.33
61.8	48.5	.73					■				■		2	●					1	▲▲			▲▲			▲▲			▲		7	.67	3.00
58.4	55.0	2.53	■				■				■		3	●					1	▲▲			▲▲			▲▲			▲		7	.50	2.25
58.0	57.0	2.53	■■				■				■		5				●		1	▲▲			▲▲			▲▲▲					7	.33	1.50
52.7	39.5	2.30	■										1	●			●●		3		▲		▲▲			▲▲			▲		6	2.00	5.00
39.7	66.5	1.40	■		■		■■				■		5						0	▲▲			▲			▲▲▲					6	.17	1.17
28.8	72.0	5.00	■		■		■■				■	■	7						0	▲▲			▲			▲					4	.13	.63
(04-109) – FLATROCK CREEK																																		
Year: 91																																		
28.9	53.5	1.82	■■				■				■		4						0	▲▲			▲▲			▲▲			▲		7	.20	1.60
26.1	45.0	1.94	■								■		2				●		1	▲			▲▲			▲▲			▲		6	.67	2.67
24.4	76.0	2.39	■■		■		■■				■		6						0	▲						▲▲▲					4	.14	.71
23.6	71.0	2.39	■■		■		■■			■	■	■	8						0				▲			▲					2	.11	.33
18.1	60.5	1.79	■		■		■■			■	■		6						0	▲▲			▲			▲▲			▲		6	.14	1.00
13.8	55.5	2.00	■							■	■	■	4	●			●		2	▲			▲▲			▲					4	.60	1.40
9.6	52.5	1.77	■■				■				■		4				●		1	▲			▲▲			▲▲			▲		6	.40	1.60
9.0	55.0	1.77	■		■		■■				■		5						0	▲			▲			▲▲			▲		5	.17	1.00
6.0	65.0	2.43	■■				■■				■		5				●		1				▲▲			▲▲▲					5	.33	1.17
2.8	59.0	.95	■■				■				■		4				●		1	▲			▲▲			▲▲▲					6	.40	1.60
(04-235) – PUSHETA CREEK																																		
Year: 91																																		
0.3	41.0	8.62	■								■		2	●			●		2	▲			▲▲▲			▲▲▲▲					8	1.00	3.67
(04-128) – SIXMILE CREEK																																		
Year: 91																																		
4.2	43.0	13.51	■		■		■						3				●●●		3	▲▲			▲▲			▲▲▲			▲		8	1.00	3.00
3.8	29.0	14.29									■		1	●●●●					4	▲			▲▲			▲▲			▲		6	2.50	5.50
3.7	26.5	6.02									■		1	●●●●					4	▲			▲▲			▲▲			▲		6	2.50	5.50
3.5	38.5	6.02						■			■		2	●●●●					4	▲			▲▲			▲▲▲					6	1.67	3.67
1.2	56.5	9.80	■		■		■■				■		5	●●					2	▲▲			▲▲			▲▲			▲		7	.50	1.67
0.1	44.0	5.68									■		1	●			●●		3	▲			▲▲			▲▲▲▲					7	2.00	5.50

Table 8. Average QHEI scores for three relatively homogenous segments of the Auglaize River mainstem based on sampling conducted during July - October, 1991.

Sample Location: Segment Description			Sample	Segment
Upstream River Mile	Downstream River Mile	River Mile	Location QHEI	Average QHEI
Segment 1: Ust. Wapakoneta to SR 117				
87.7	67.3	87.7	56.0	72.2
		85.5	74.5	
		85.0	81.0	
		80.4	75.5	
		67.3	74.5	
Segment 2: Ust. Spencerville Dam to Lincoln Hwy.				
65.0	52.7	65.0	47.0	46.8
		63.1	33.5	
		61.8	48.5	
		58.4	55.0	
		58.0	57.0	
		52.7	39.5	
Segment 3: Cascade Cemetery to Cloverdale				
39.7	28.8	39.7	66.5	69.3
		28.8	72.0	

- Immediately upstream from the Wapakoneta WWTP (RM 85.2) the macroinvertebrate community appeared to be moderately impacted by urban runoff, CSO and/or stormwater discharges. The artificial substrates were again in current of less than the minimum 0.3 ft/sec. requirement and scored in the fair range (ICI= 22). A number of relatively pollution sensitive caddisfly taxa were collected but the increased predominance of pollution tolerant taxa on the artificial substrates and observed on the natural substrates indicated a decline in water quality compared to RM87.8. The benthic community was reflective of marginally good water quality.

- The sites within the Wapakoneta WWTP mixing zone and immediately downstream (RMs 85.1 and 85.0) supported macroinvertebrate communities reflective of a grossly enriched condition. The artificial substrates in the mixing zone were collected from a pool. Current velocity was adequate at RM 85.0 The ICI scores at both sites were in the poor range (ICI= 4 and 12, respectively). On the natural substrates, pollution tolerant midges predominated and caddisfly taxa were rare despite suitable habitat.

- Significant, though incomplete recovery was evident in the benthos at RM 80.4. Quantitative sampling demonstrated achievement of the WWH criterion (ICI= 36); however, a predominance of facultative organisms, particularly filter feeding taxa, on both the artificial and natural substrates indicated continued organic enrichment.

Table 9. Summary of macroinvertebrate data collected from artificial substrate samplers (quantitative) and natural substrates (qualitative sampling) in the Auglaize River, July - September , 1991.

Quantitative Evaluation Stream River Mile	Relative Density	Quant. Taxa	Qual. Taxa	Qual. EPT[b]	QCTV[c]	ICI	Narrative Evaluation
Auglaize River							
87.8	105	30	36	9	37.1	16*	Good[d]
85.2	1023	30	42	6	32.6	22*	Marg. Good[d]
85.1	831	11	21	1	25.8	4*	(Mix Zone)
85.0	1051	22	30	3	31.2	12*	Poor
80.4	1494	39	19	2	31.9	36	Good
67.0	538	47	32	7	34.9	46	Exceptional
63.4	1051	28	21	4	28.7	20*	Marg. Good[d]
61.6	932	32	28	3	28.7	20*	Marg. Good[d]
58.0	707	41	41	13	38.4	50	Exceptional
39.4	1221	32	34	10	40.1	26*	Marg. Good[d]
28.8	2061	37	43	12	35.8	48	Exceptional
Pusheta Creek							
0.3	798	35	34	11	37.3	34[ns]	Good
Six Mile Creek							
4.2		Qual. Only	21	0	14.4	-	Marg. Fair
3.8	96	6	8	0	12.6	0*	Very Poor
3.6	72	4	6	0	12.6	0*	Very Poor
3.5	86	11	11	0	12.6	2*	Very Poor
1.3		Qual. Only	21	0	22.0	-	Poor
0.2	544	29	17	2	34.9	18*	Fair
Flatrock Creek							
28.8	527	25	22	2	28.9	10*	Good[d]
26.1	33	6	22	0	22.5	0*	Poor[d]
23.7	261	25	33	7	31.2	16*	Good[d]
18.0	404	17	21	0	27.4	4*	Good[d]
13.8	1613	25	27	1	28.9	16*	Good[d]
9.6	141	12	25	2	30.3	2*	Good[d]
8.1	2352	12	21	0	22.9	2*	Poor[d]
6.0	970	33	46	4	29.7	18*	Fair[d]
2.9	832	26	43	5	29.8	20*	Good[d]

Table 9 continued.

Stream River Mile	No. Qual. Taxa	*Qualitative Evaluation* Average Tol. Value[c]	Qual. EPT[b]	Relative Density	Predominant Organisms	Narrative Evaluation[a]
Six Mile Creek						
4.2	21	14.4	0	Mod.	Isopods, Beetles	Marg. Fair
1.3	21	22.0	0	Mod.	Midges	Poor

Ecoregion Biocriteria:

E. Corn Belt Plains (ECBP)

INDEX	WWH	EWH	MWH[e]
ICI	36	46	22

Huron Erie Lake Plain (HELP)

INDEX	WWH	EWH	MWH[e]
ICI	34	46	22

[e] - Modified Warmwater Habitat for channel modified areas.

[a] A qualitative narrative evaluation is based on best professional judgement is used when quantitative data is not available to calculate the Invertebrate Community Index (ICI) scores.
[b] EPT= total Ephemeroptera (mayflies), Plectoptera (stoneflies) and Tricoptera (caddisflies).
[c] Qualitative Community Tolerance Value (QCTV) calculated as the average of the weighted ICI for each taxa.
[d] Narrative evaluation used if needed for final evaluation of attainment status in lieu of ICI where current velocity over the artificial substrates was less than the prescribed minimum of 0.3 ft/s; narrative evaluation is based on best professional judgment.
* Significant departure from ecoregion biocriterion (>4 ICI units); poor and very poor results are underlined.
ns Nonsignificant departure from biocriterion (≤4 ICI units).

- The macroinvertebrate communities at the remaining six sites form RM 67.0 to RM 28.8 were greatly influenced by the presence or absence of riffle/run habitats. Sites at RMs 67.0, 58.0 and 28.8 all had riffle/run habitats and adequate current velocity over the artificial substrates. ICI scores at these three sites achieved the criterion for the existing Exceptional Warmwater Habitat aquatic life use (EWH) with values of 46, 50 and 48, respectively. The sites which bracketed Sixmile Creek at RMs 63.4 and 61.6 were in sluggish pooled areas that lacked any riffle/run habitat. The streambed was composed primarily of sand and silt, therefore most of the organisms collected in the qualitative sample were from logs and other allochthonous material in the stream. Although no chemical water quality problems were detected at these two sites, the benthic fauna was not reflective of the EWH use due to limiting habitat characteristics. The site at RM 39.4 had a short riffle comprised of rip rap which acted to slow the current upstream and allowed for the deposition of significant amounts of silt. The quantitative sample was collected from non-discernible current and scored in the fair range.

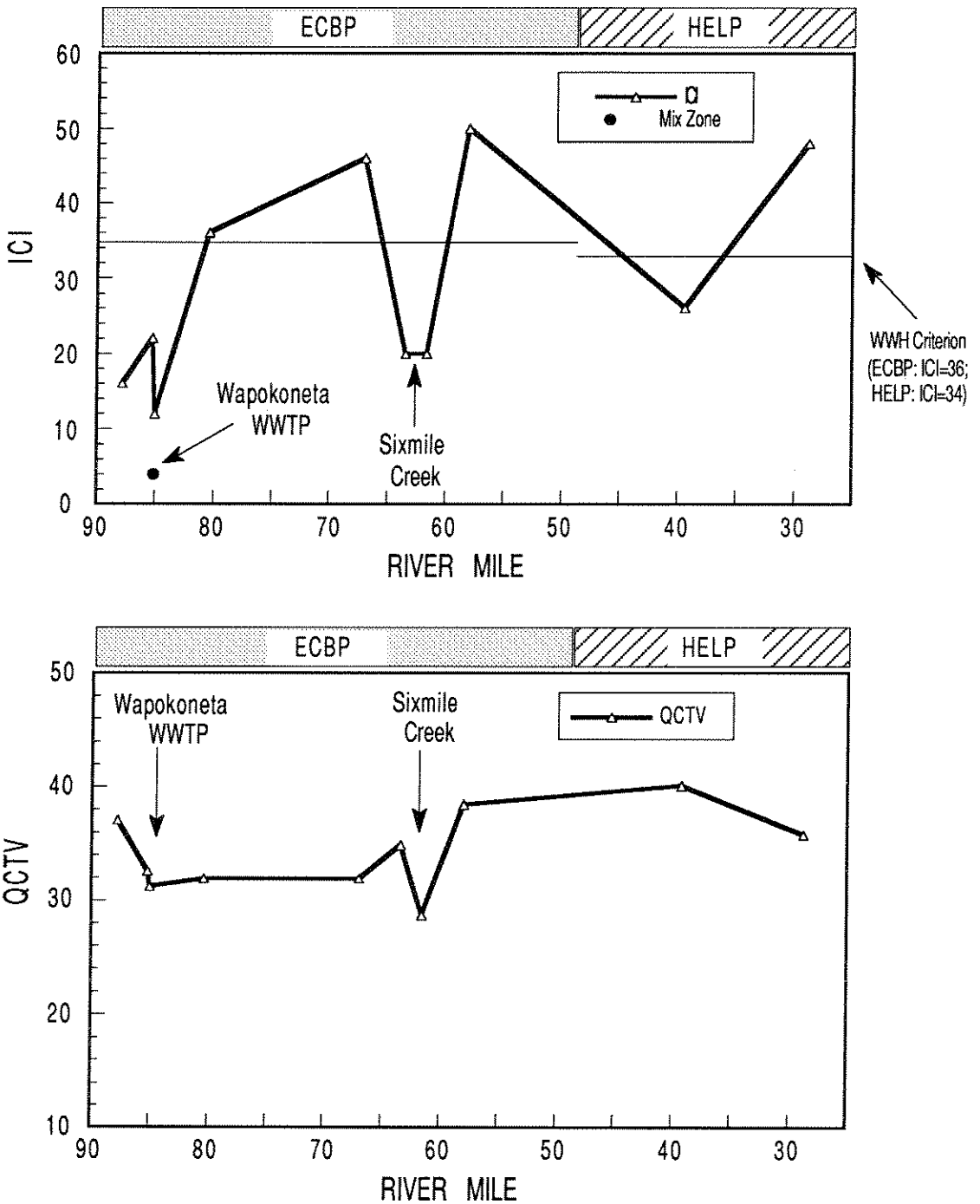

Figure 7. Longitudinal trend of the Invertebrate Community Index (ICI) in the Auglaize River, 1991.

Qualitative sampling yielded good numbers of mayfly and caddisfly taxa (N=13). These results point out the importance of current velocities in the determination and interpretation of ICI scores throughout this segment of the Auglaize River.

- In a previous survey of Auglaize River and Sixmile Creek (Ohio EPA 1986), the Geokke tributary, which enters the Auglaize River at RM 63.6 appeared to have a significant impact on the Auglaize River at RM 63.1. The suspected source of the degradation was the land application of whey and fertilizer waste which entered the Geokke tributary as runoff. This degradation extended downstream to RM 61.1 and apparently masked any impact from Sixmile Creek. The 1991 macroinvertebrate sampling indicated that the Geokke tributary was no longer impacting the Auglaize River and that Sixmile Creek, though still impacted, was not a significant factor affecting the macroinvertebrate community in the mainstem.

Biological Assessment: Fish Community

- A total of 17,974 fish comprised of 51 species and 5 hybrids were collected from the Auglaize River mainstem from June 25 through September 18, 1991. The sampling effort included a cumulative total of 94.8 km at 14 locations between RM 87.7, upstream from Wapakoneta, and RM 28.8 downstream from the Ottawa River.

- The fish community was predominated by number by bluntnose minnow (20.9%), green sunfish (15.6%), spotted sucker (8.0%), longear sunfish (6.8%), greenside darter (6.4%), spotfin shiner (5.4%), and suckermouth minnow (4.6%). Species that predominated in terms of biomass were common carp (31.9%), spotted sucker (16.8%), golden redhorse (9.2%), green sunfish (6.5%), and fresh water drum (4.7%). Species classified as endangered (ODNR 1992), included only the greater redhorse. A total of 57 greater redhorse, both adult and juvenile, were collected during the survey.

- Based on IBI and MIwb scores and the accompanying narrative evaluation, overall fish community performance ranged from exceptional/good to fair. No sites performed at fully exceptional or poor levels (Table 10, Figure 8). Generally, fish community performance in the Auglaize River can be characterized as marginally good, with the majority of sites containing the usual association of expected species; intolerant species were absent or in low abundance.

- IBI and MIwb values in the very good to good range were observed at RM 85.5, downstream from the CSOs in Wapakoneta, and from RM 85.0, downstream from the Wapakoneta WWTP, to RM 65.0, upstream from the Spencerville dam. IBI and MIwb values in the good to fair range were observed upstream from Wapakoneta (RM 87.7), the Wapakoneta WWTP mixing zone (RM 85.1), and between RM 63.1, and from upstream from Sixmile Creek (RM 63.1) to the most downstream site (RM 28.8).

- No impact to the fish community was detectable downstream from the CSOs in Wapakoneta at RM 85.5, with fish community performance exceeding WWH biological criteria (IBI=45, MIwb=9.3). At RM 85.1, moderate near field impact was detected immediately downstream from the Wapakoneta's WWTP but at RM 85.0, community performance again exceeded WWH biological criteria (IBI=45, MIwb=9.8). The fish community continued to meet or exceed biological criteria downstream to RM 67.3 (Figure 8).

- Non-achievement of biological criteria, attributed in part to poor habitat quality, was evident in the reach extending from RM 63.1 upstream from Sixmile Creek to RM 52.7. Currently this

Table 10. Fish community indices based on pulsed D.C. electrofishing samples at 30 locations sampled by Ohio EPA in the Auglaize River study area during July - September, 1991.

Stream River Mile	Mean Number of Species	Cumulative Species	Mean Rel. No. (No./Km)	Mean Rel. Wt. (Kg/Km)	QHEI	Mean Modified Index of Well-Being	Mean Index of Biotic Integrity	Narrative Evaluation
Auglaize River								
		Eastern Corn Belt Plain - WWH Use designation (Existing)						
87.7	18.5	24	435	8.7	56.0	6.6*	35*	Fair
85.5	29.0	33	1128	17.3	74.5	9.3	45	Good
85.1 (mz)	17.0	23	713	12.8	N/A	7.7*	38_{ns}	Good/Fair
85.0	29.5	34	1743	44.8	81.0	9.8	45	Ex./Good
80.4	25.5	30	1035	38.2	75.5	9.3	43	Good
		Eastern Corn Belt Plain - WWH Use designation (Recommended))						
67.3	25.0	30	1148	26.4	74.5	9.5	46	Very Good
65.0	18.0	26	394	91.0	47.0	8.4*	43	Good
63.1	20.7	30	549	88.4	33.5	8.1*	37*	Fair
61.8	21.3	26	612	70.2	48.5	8.7*	38^{ns}	Good/Fair
58.4	24.3	32	729	57.4	55.0	8.8*	36*	Good/Fair
58.0	23.7	33	1633	41.5	57.0	8.2*	29*	Fair
52.7	26.0	26	1222	42.9	39.5	8.3*	31*	Good/Fair
		Huron Erie Lake Plain - WWH Use designation (Recommended)						
39.7	30.3	37	816	119.9	66.5	10.0	33^{ns}	Ex./Fair
28.8	22.0	31	950	46.5	72.0	8.8	30^{ns}	Good/Fair
Pusheta Creek								
		Eastern Corn Belt Plain - WWH Use designation (Existing)						
0.3	23.0	27	2592	12	41.0	9.6	42	Ex./Good
Sixmile Creek								
		Huron Erie Lake Plain - MWH Use designation (Recommended)						
4.2	0.0	0	0	N/A	43.0	N/A	12*	Very Poor
3.8	1.5	2	3	N/A	29.0	N/A	12*	Very Poor
3.7	2.0	4	7	N/A	26.5	N/A	13*	Very Poor
3.5	0.0	0	0	N/A	38.5	N/A	12*	Very Poor
		Huron Erie Lake Plain - WWH Use designation (Existing)						
1.2	0.5	1	1	N/A	56.5	N/A	12*	Very Poor
0.1	9.5	14	14	N/A	44.0	N/A	23*	Poor

Table 10. Continued.

Stream River Mile	Mean Number of Species	Cumulative Species	Mean Rel. No. (No./Km)	Mean Rel. Wt. (Kg/Km)	QHEI	Mean Modified Index of Well-Being	Mean Index of Biotic Integrity	Narrative Evaluation
Flatrock Creek								
			Huron Erie Lake Plain - WWH Use designation (Existing)					
28.9	12.5	15	342	21.0	53.5	5.2*	30ns	Fair/Poor
26.1	15.5	17	675	15.6	45.0	6.0*	27*	Poor
24.4	19.0	23	983	68.4	76.0	5.8*	28ns	Fair/Poor
18.1	15.5	18	374	7.8	60.5	5.1*	28ns	Fair/Poor
13.8	26.0	29	843	31.1	55.5	7.4	31ns	Good/Fair
9.6	18.0	23	750	9.5	52.5	6.5*	29ns	Fair
9.0	20.0	22	1160	52.0	55.0	6.7*	25*	Fair/Poor
6.0	22.5	26	802	14.8	65.0	6.6*	28ns	Fair
2.8	18.5	23	392	14.6	59.0	6.6*	26*	Fair/Poor

Ecoregion Biocriteria: E. Corn Belt Plains (ECBP)

INDEX - Site Type	WWH	EWH	MWHd
IBI - Headwaters	40	50	24
IBI - Boat	42	48	24
Mod. Iwb - Wading	8.3	9.4	5.8
Mod. Iwb - Boat	8.5	9.6	5.8

Huron Erie Lake Plain (HELP)

INDEX - Site Type	WWH	EWH	MWHd
IBI - Headwaters/Wading	28	50	20
IBI - Wading	32	50	22
IBI - Boat	34	48	20
Mod. Iwb - Wading	8.3	9.4	5.6
Mod. Iwb - Boat	8.5	9.6	5.7

d - Modified Warmwater Habitat for channel modified areas.

* - Significant departure from applicable biological criterion (>4 IBI units or >0.5 Iwb units); underlined values are in the poor and very poor range.

ns - Nonsignificant departure from biocriterion (≤4 IBI units or < 0.5 MIwb units)

a - Narrative evaluation is based on both MIwb and IBI scores.

NA - Headwater site; MIwb is not applicable.

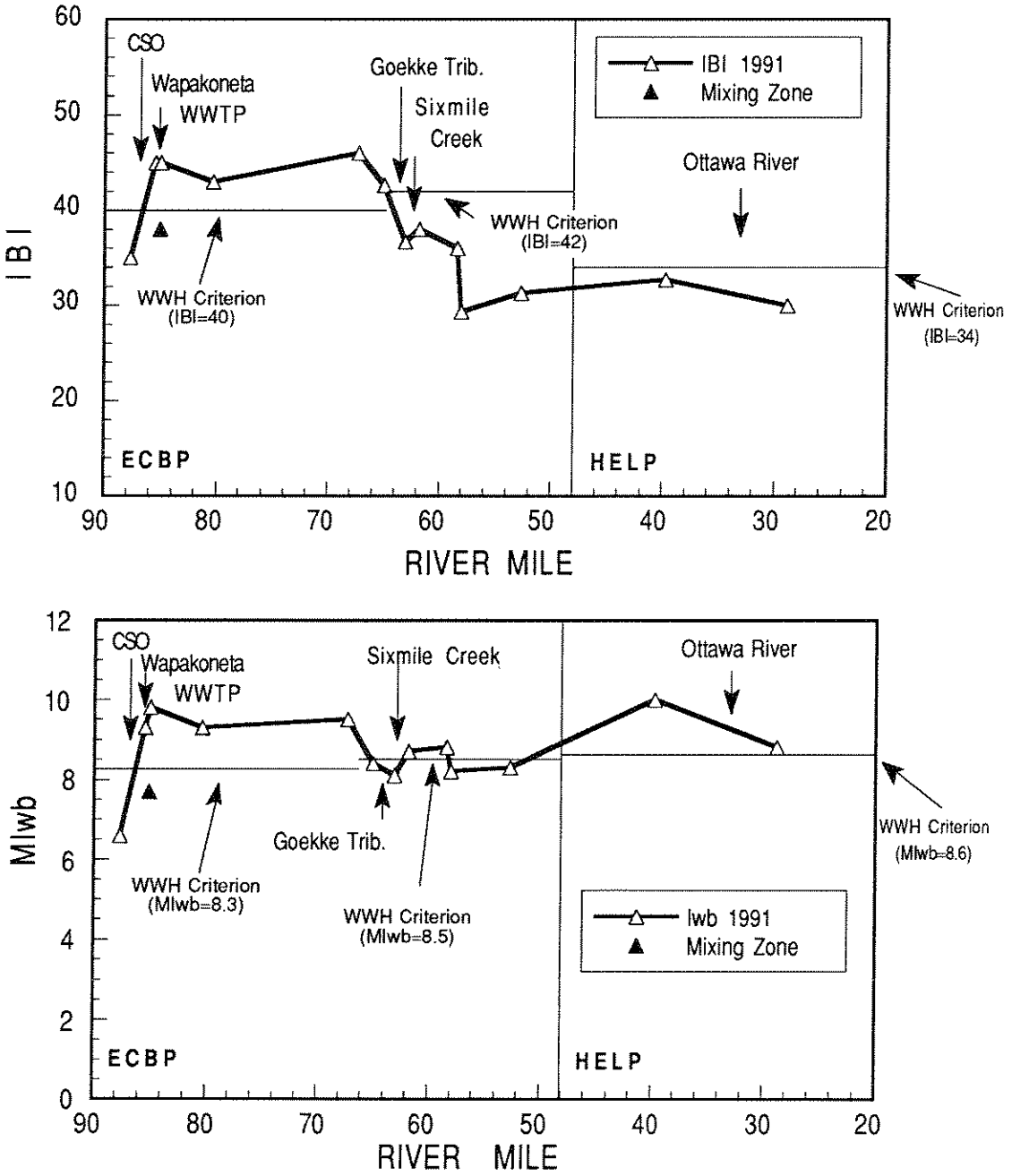

Figure 8. Longitudinal trend of the Index of Biotic Integrity (IBI; upper) and the Modified Index of Well-Being (MIwb; lower) in the Auglaize River, 1991.

segment is designated EWH, but QHEI values and fish community performance within this reach demonstrated that a WWH designation may be more appropriate.

- Downstream from the Goekke tributary (RM 63.1) and Sixmile Creek (RM 61.8), there was a discernible impact to the fish community in the Auglaize River mainstem (Figure 8). It is difficult to attribute the decline in community performance solely to the influence of Goekke tributary and Sixmile Creek, due to limited habitat associated with this reach. However, all subsequent downstream fish community samples demonstrated significantly lower community performance and all failed to achieve WWH biological criteria. Stresses to the community were reflected in elevated incidence of deformities, eroded fins/barbels, lesions and tumors (the DELT anomalies metric of the IBI). The occurrence of DELT anomalies demonstrated a marked increase between RM 63.1 and RM 61.8, reaching a maximum of 3.1% downstream from Sixmile Creek. All subsequent downstream sampling stations exceeded 0.5% frequency in the incidence of DELT anomalies. The observed frequency of DELT anomalies most likely reflects a community response to water quality impacts to the Auglaize River from the Goekke tributary and/or Sixmile Creek. Elevated incidence of DELT anomalies is indicative of stresses to the community associated with chemical water quality degradation (OEPA 1987b).

- The sharp decline in the community percentage of simple lithophils observed between RM 63.1 and RM 28.8 demonstrated the impact of habitat disturbance on functional components of the fish community. Simple lithophils represent the most environmentally sensitive spawning guild, requiring relatively clean coarse substrates; thus, this group is particularly intolerant of habitat disturbances (Ohio EPA 1987b). Additionally, the percent of round bodied sucker species sharply declined at RM 58.0 and was depressed throughout the remainder of the study area. Due to specialized spawning and feeding requirements, this component of the fish community is generally intolerant of water quality impacts as well as habitat modifications and siltation. As lithophils and round bodied sucker species declined, the percent omnivores greatly increased. Omnivores tend to predominate in disturbed areas, where water quality and/or habitat heterogeneity has been greatly reduced.

- The suppressed community performance recorded downstream from the Goekke tributary and Sixmile Creek most likely reflected a combination of poor habitat and impacts to water quality. Given the low QHEI values and the predominance of significant and moderate influence modified habitat attributes from RM 65.0 to RM 52.7, it is doubtful that this segment is capable of achieving the existing EWH use designation.

- The reach between RM 39.7, upstream from the Ottawa River and RM 28.8 downstream demonstrated some improvement, but full recovery was not achieved. Structural components of the fish community improved, reflected in an increase in the MIwb values. However, functional components were still suppressed, as illustrated by low IBI scores. Although the quality of the instream habitats significantly improved in the lower reach, the community did not achieve EWH biocriteria, and is unable to support and maintain an exceptional assemblage of fish species.

Pusheta Creek

Chemical Water Quality

- One fecal coliform bacteria violation was recorded at the site on Pusheta Creek (RM 0.3). Otherwise, WQS were met and chemical sampling indicated no significant water quality concerns.

Physical Habitat for Aquatic Life

- Only one site was evaluated for biological community performance in Pusheta Creek at RM 0.3. It was apparent that the stream had recently been physically modified including the placement of rip-rap on a portion of the banks. There was no significant riparian canopy and moderate to severe bank erosion was evident on outside bends. The substrate primarily consisted of sand and pea gravel which resulted in unstable riffle/run development. Moderate influence modified habitat attributes predominated this site, resulting in a QHEI score of 41 (Table 7).

Biological Assessment: Macroinvertebrate Community

- An ICI score of 34 at RM 0.3 was a non-significant departure from the WWH aquatic life use designation. Qualitative sampling produced a relatively diverse assemblage and included eleven mayfly and caddisfly taxa. No significant water quality impacts were indicated, however, the benthic assemblage was quite likely depressed somewhat by the constraints of fairly recent channelization.

Biological Assessment: Fish Community

- One fish community sample was collected from Pusheta Creek at RM 0.3. Although habitat at this site was modified, the fish community performance exceeded WWH biological criteria (IBI=42; MIwb=9.6), with a narrative evaluation of good/exceptional.

- Community performance at this level, despite habitat of marginal quality, is apparently either due to the proximity of the site to the confluence of the Auglaize River and/or the presence of higher quality habitat in the upper portion of Pusheta Creek. Both situations would tend to buffer the effects of localized habitat disturbances on community performance, by supporting good fish communities in areas adjacent to RM 0.3.

Sixmile Creek

Pollutant Loadings: 1976-1991

- Trim Trends, Inc., a subsidiary of Harvard Industries, (Ohio EPA permit number 2IC00020) manufactures anodized aluminum trim and window assemblies for the automotive industry. Treated process wastewater is discharged to Sixmile Creek at RM 3.95 via a stormsewer. Mean annual discharge from the system is 60,000 gallons per day (0.060 MGD).

- Trim Trends BOD_5 loadings indicate a slight increasing trend while phosphorus loadings show a definite decreasing trend following higher levels in the early 80s. Chromium, nickel and aluminum loadings follow a pattern similar to phosphorus over the same time span (Figure 9).

- Ohio EPA conducted two acute bioassays of Trim Trends effluent in 1991 to assess toxicity. Results of the first test (Bioassay Report Number 91-907-NW) indicated that Trim Trends

effluent is acutely toxic to both fathead minnows (*Pimephales promelas*) and *Ceriodaphina dubia*. Magnitude of acute toxicity was expressed as a *P.promelas* 96-hr EC50 of 67.1% effluent and a *C.dubia* 48-hr EC50 of 62.0% effluent. This test also indicated the possibility of chronic toxicity where instream effluent concentrations exceed 6%. Results of the second test (Bioassay Report Number 91-923-NW) indicated variable toxicity to the test organisms. Magnitude of toxicity was expressed as a P.promelas 96-hr EC50 of 25.4% effluent. This test also indicated the possibility of chronic toxicity where instream effluent concentrations exceed 2.5%.

- Ohio Decorative Products (Ohio EPA permit number 2IC00018) finishes zinc die cast parts for use in appliance and automobile manufacturing. Treated process wastewater is discharged to Sixmile Creek at RM 3.95 via a stormsewer. Mean annual discharge from the system is 30,000 gallons per day.

- Ohio Decorative Products ammonia-N loadings remained relatively low from 1981 through 1987, but show a slight increasing trend from 1988 through 1991 (Figure 10). The loadings for phosphorus in 1990 and 1991 suggest a decreasing trend when compared to loadings from previous years. The loadings for cyanide are of some concern due to the higher loadings after 1984 when compared to those from 1976 through 1980. The chromium and copper loadings indicates decreasing trends in the last several years, but earlier annual loadings suggests that this might be only a temporary phenomenon (Figure 11). However, it can be seen that both parameters are much lower when compared to the levels of 1976/1977. There is a suggestion of a decreasing trend in nickel, particularly when compared to the levels of 1976-1981, but it should be noted that there was an increase after the lower loadings seen from 1982 to 1985. Finally, there seems to be a more definite decreasing trend in zinc loadings.

- Ohio Decorative Products effluent was tested for acute toxicity in October and November, 1991 (Bioassay Report Numbers 91-908-NW and 91-922-NW). In the first screening test, all effluents tested caused 100% mortality to Pimephales promelas and Ceriodaphina dubia within 24 hours. The 48 hour P. promelas LC50 was 2.8 % effluent. Results of the second screening test were similar to the first. The 48 hour P. promelas LC50 was <0.5 % effluent. These results indicate a highly toxic discharge.

- Farm Service Center of Spencerville operated an agricultural supply business which ceased operations in May 1988. A Permit to Install (#03-3320) was issued in August 1988, for stormwater containment and collection facilities. The facility consists of a collection pit which receives contaminated stormwater and a pump which transfers it into a storage lagoon prior to disposal. Since this PTI was issued, the collection pit has been documented on several occasions to be overflowing into an adjacent stormsewer which discharges to Sixmile Creek at RM 3.85. Analysis of samples collected from the pit on March 15, 1990 revealed concentrations of 243 mg/l ammonia-N and 146 mg/l phosphorus.

- The Village of Spencerville operates an extended aeration wastewater treatment system with a tertiary polishing lagoon (Ohio EPA permit number 2PC00000) which treats an average of 332,000 gallons per day (0.332 MGD). Final effluent from the system discharges to a small unnamed tributary which flows into Sixmile Creek at RM 3.6. The plant was originally constructed in 1956 with the last major modification occurring in 1971. The collection system is 100% separate sewers with no overflows and a post settling plant bypass. Reported BOD_5 and ammonia-N loadings declined in the late 80's and the 90's, while total phosphorus appears

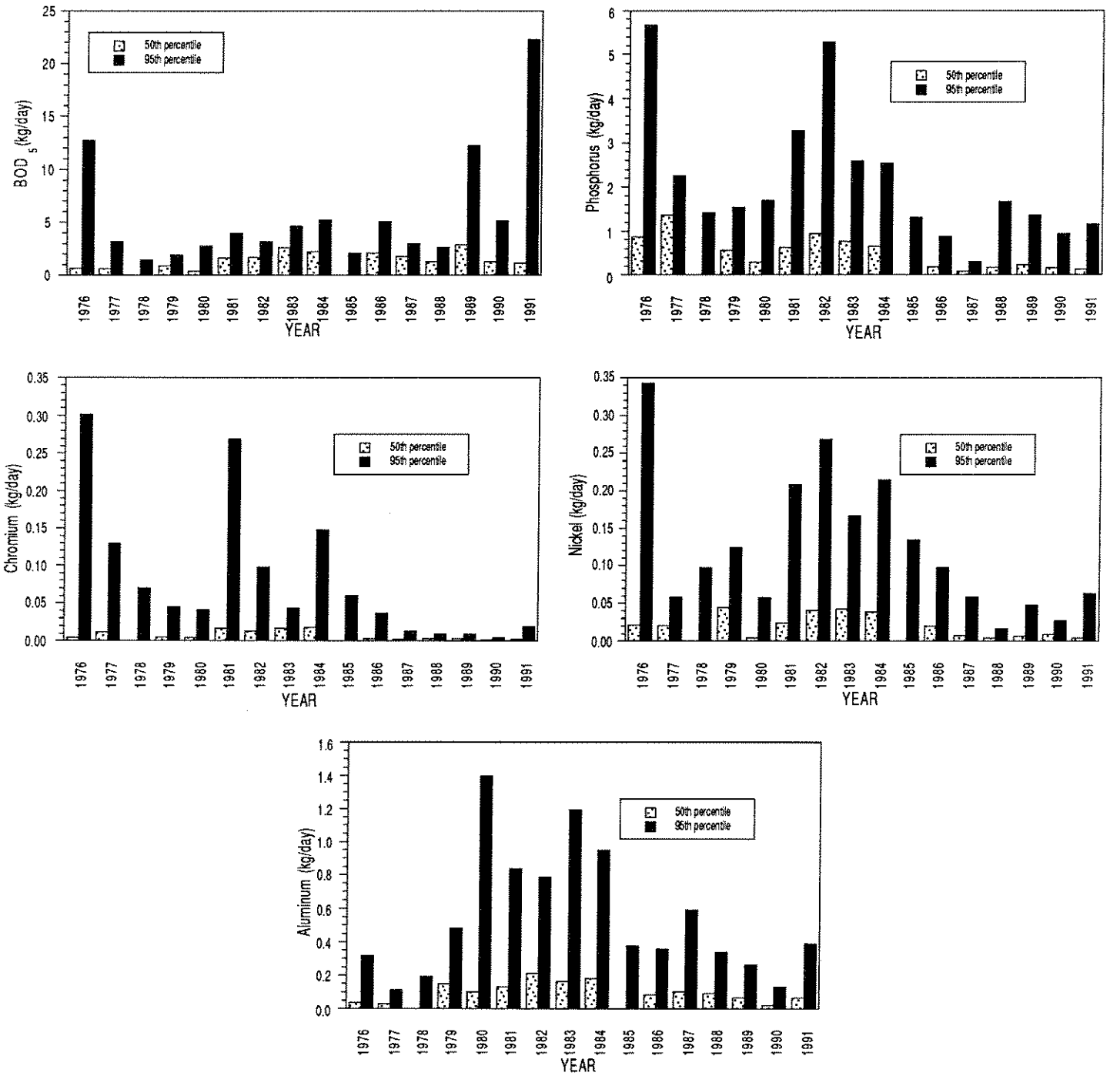

Figure 9. Annual loadings (kg/day) from Trim Trends of BOD_5, phosphorus and chromium, nickel and aluminum to Sixmile Creek, 1976-1991.

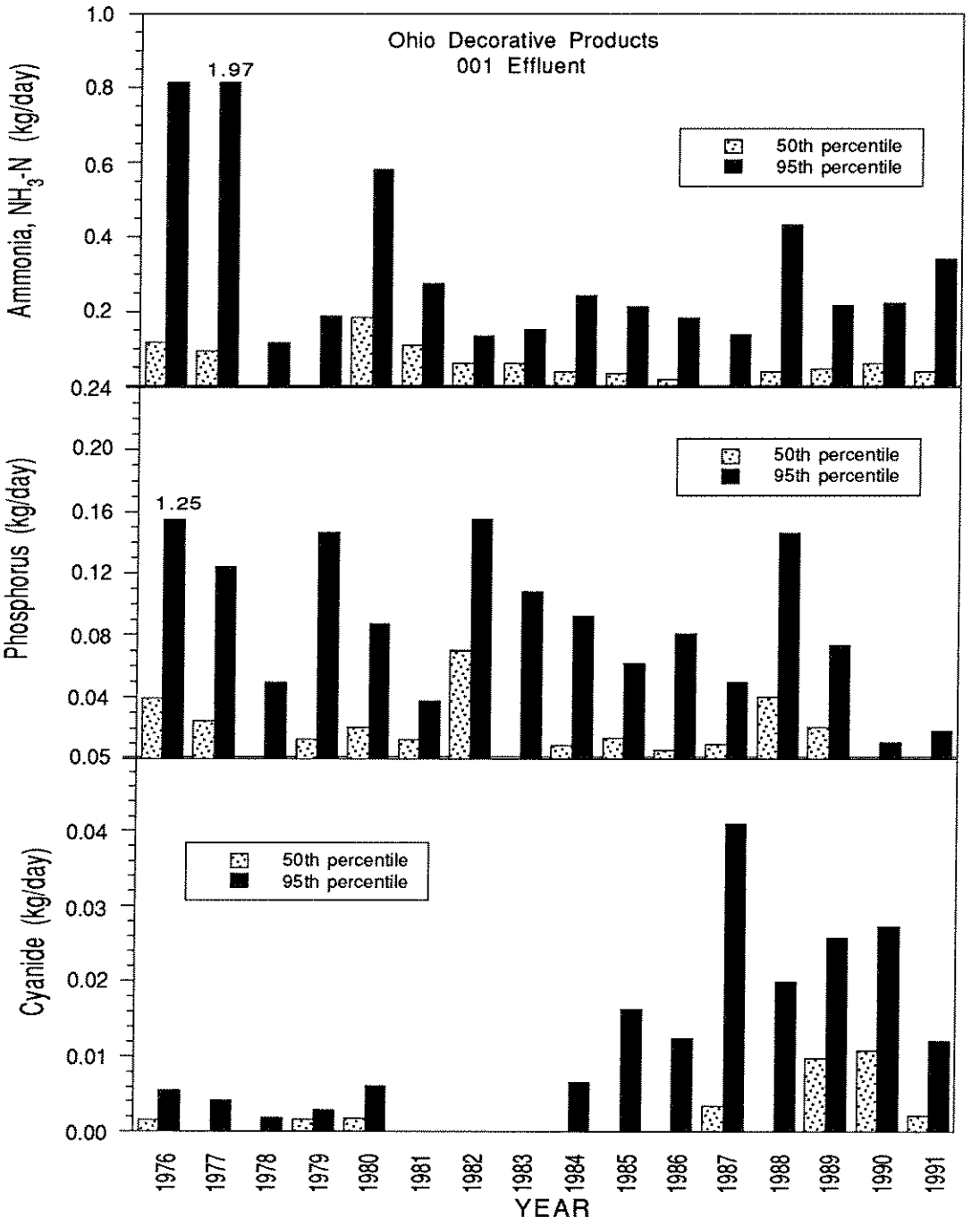

Figure 10. Annual loadings (kg/day) from Ohio Decorative Products of ammonia, phosphorus and cyanide to Sixmile Creek, 1976-1991.

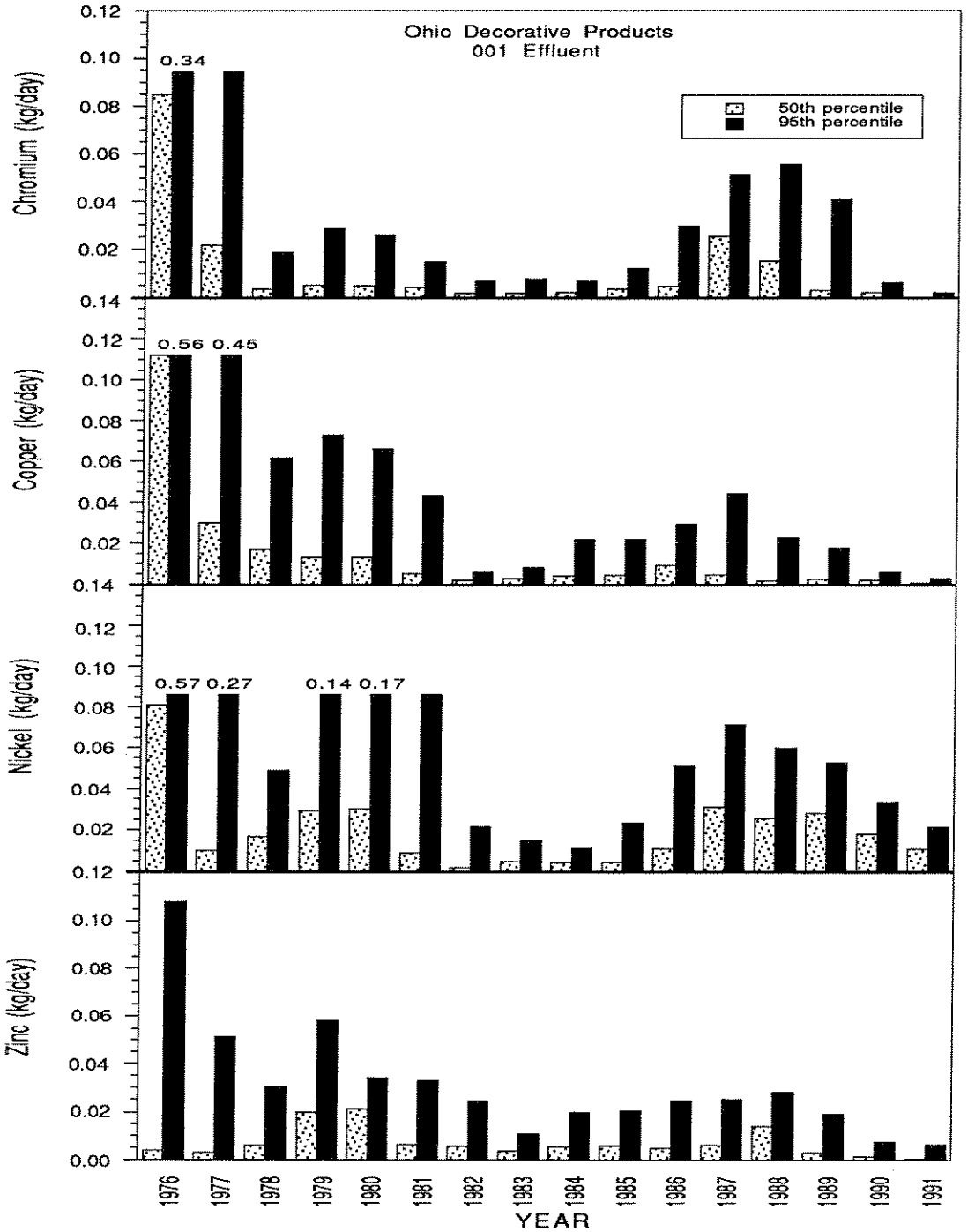

Figure 11. Annual loadings (kg/day) from Ohio Decorative Products of chromium, copper, nickel and zinc to Sixmile Creek, 1976-1991.

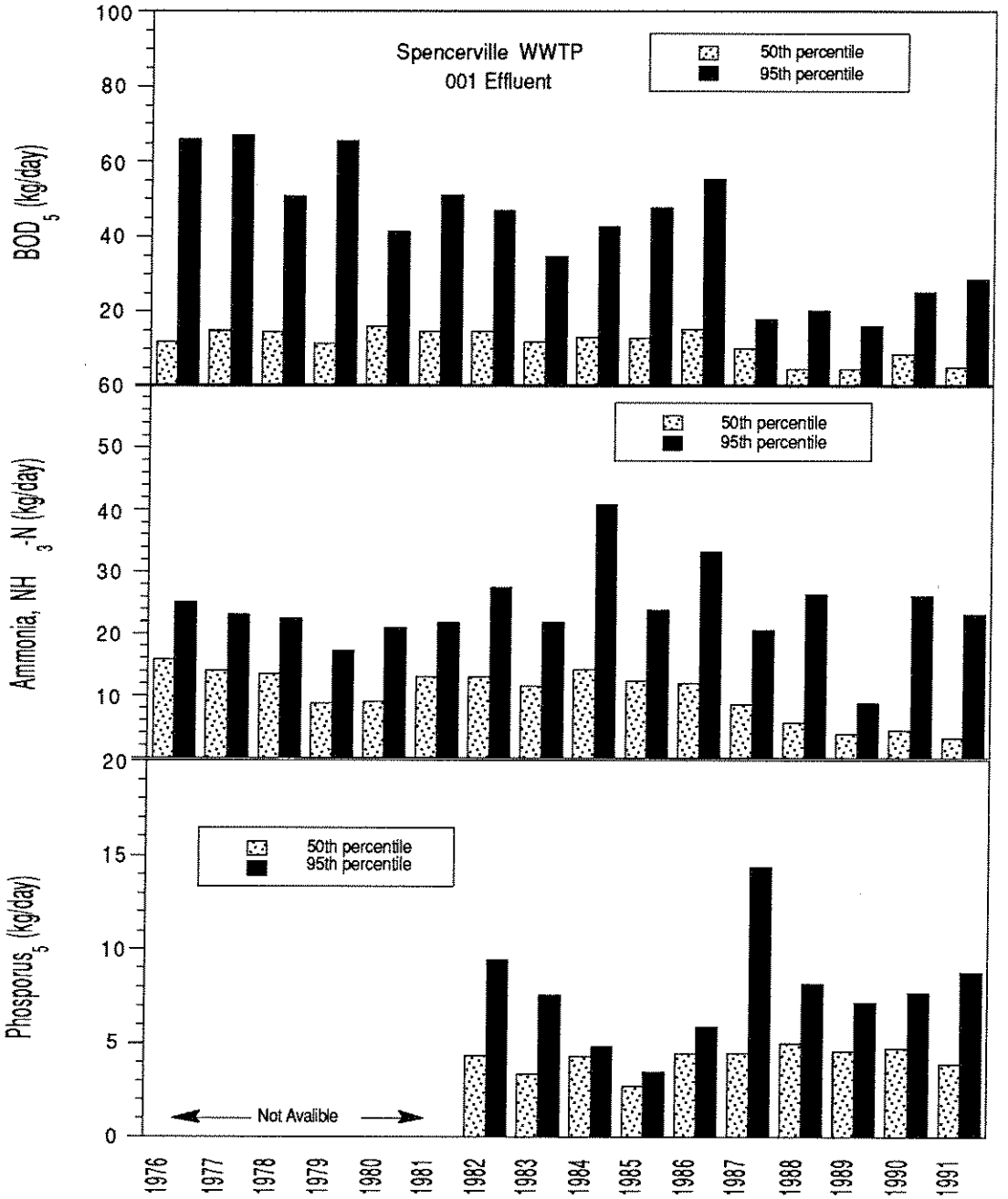

Figure 12. Annual loadings (kg/day) from the Spencerville WWTP of BOD_5, ammonia and phosphorus to Sixmile Creek, 1976-1991. BOD_5 loadings for 1988-1991 are calculated based on reported five-day carbonaceous biochemical oxygen demand ($CBOD_5$) values.

to have remained fairly stable (Figure 12). The Village of Spencerville is required to monitor its post-settling bypass for flow and duration when discharging. No occurrences were reported in self monitoring records for 1991.

Chemical Water Quality

- The graph for continuous monitor D.O. results in Sixmile Creek clearly indicates a major impact from the industrial and WWTP effluents in Spencerville, with the sag point at RM 1.2 and only marginal recovery at RM 0.2 (Figure 13). The longitudinal D.O. trend (Figure 14) suggests that the combined discharges from Trim Trends and Ohio Decorative Products and the Spencerville WWTP were the major contributors to D.O. depletion, with an increase in mean D.O. for the remaining sites. It should be noted that the mean D.O. values in Figure 14 were calculated from discrete measurements taken during mid-morning sample runs, and reflect only a portion of the daily D.O. flux. The greatest increase in mean BOD_5 occurred downstream from the combined industrial discharge, with additional input from the Spencerville WWTP; this parameter decreased considerably prior to discharge to the Auglaize River. The mean ammonia-N concentration at all downstream sites was elevated over that at the most upstream site; the Spencerville WWTP appeared to be the major contributor, followed by the industries and the Farm Service Center. Slight increases in mean concentrations of phosphorus were noted downstream from both the combined industrial discharges and the Spencerville WWTP.

- Discrete dissolved oxygen values were frequently less than the WWH minimum allowable criterion of 4.0 mg/l downstream from the combined Trim Trends/Ohio Decorative Products discharge and the Spencerville WWTP; however only one value was less than the recommended Modified Warmwater Habitat (MWH) criterion of 3.0 mg/l (Table 4). The single MWH dissolved oxygen violation was at RM 3.9, immediately downstream from the combined industrial discharge. Fecal coliform levels were in excess of the PCR criterion at least once at the three most upstream sites Exceedences occurred most frequently immediately downstream from the Trim Trends/ Ohio Decorative Products discharge. Apparently runoff at the upstream site from the surrounding urban area was one contributor with the primary source of fecal coliform bacteria being the combined industrial discharge. The importance of the Spencerville WWTP as another potential source of excessive fecal coliform bacteria could not be determined due to the elevated levels upstream, however, one PCR exceedence was recorded downstream from the WWTP (RM 3.5). Ammonia-N exceedences was recorded at all but the upstream control site. These elevated ammonia-N levels indicated that incomplete nitrification was occurring in Sixmile Creek and suggest that the stream is a source of ammonia - N in the Auglaize River. In fact, a small increase in ammonia-N concentration was observed in the Auglaize River downstream from Sixmile Creek.

- Two exceedences of instream WQS metals criteria were recorded. A copper exceedence at the upstream site (RM 4.2) was probably the result urban runoff. The only known source of the zinc exceedence recorded at RM 0.2 was from the Miami-Erie canal which enters Sixmile Creek immediately upstream from the Trim Trends/ Ohio Decorative Products discharge at RM 3.9.

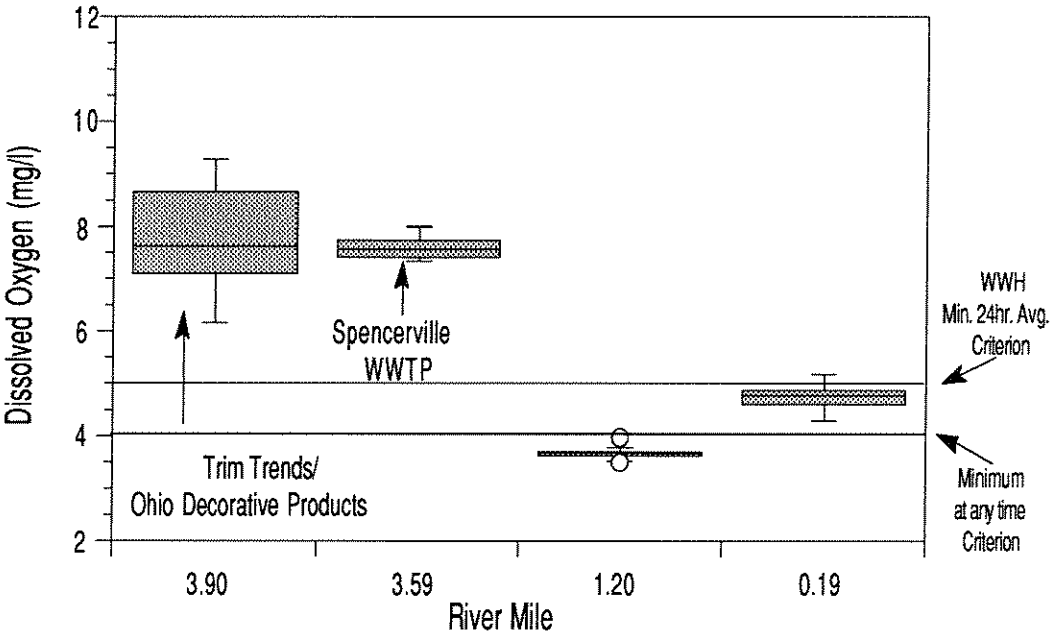

Figure 13. Boxplots of dissolved oxygen data recorded with continuous monitors at selected locations in Sixmile Creek during the summer of 1991.

Sediment Chemistry

- Metals concentrations within the sediments of Sixmile Creek are a significant concern (Table 5). Arsenic was extremely elevated at RM 4.2 and highly elevated at RMs 3.9 and 3.5. Although arsenic is present in geologic parent material, it is suspected that the historical use of arsenic based herbicides and insecticides is the source of these elevated concentrations. Generally, the remaining metals concentrations were highest below the Trim Trends and Ohio Decorative Products combined discharge at RM 3.9 and decreased downstream. The concentration of cadmium was slightly elevated and zinc was highly elevated at RM 3.9 downstream from the combined industrial discharge. The concentration of chromium was extremely elevated at this same site and, although the level decreased somewhat at the remaining sites, the chromium concentation was still highly elevated at RM 0.2. Additionally, lead and nickel concentations also increased at RM 3.9 compared to the levels recorded at RM 4.2.

- An extremely elevated concentration of Heptachlor Epoxide and a highly elevated concentration of DDT were detected at RM 3.9 (Table 11). These compounds were histroically used in the agricultural industry as insecticides. Although their use in this application has been discontinued, they continue to persist in the environment.

- Another concern with the sediments in Sixmile Creek is the presence of polycyclic aromatic hydrocabons (PAHs) and polychlorinated biphenyls (PCBs). Many of these compounds are suspected human carcinogens and tend to accumulate in the food chain. They are commonly

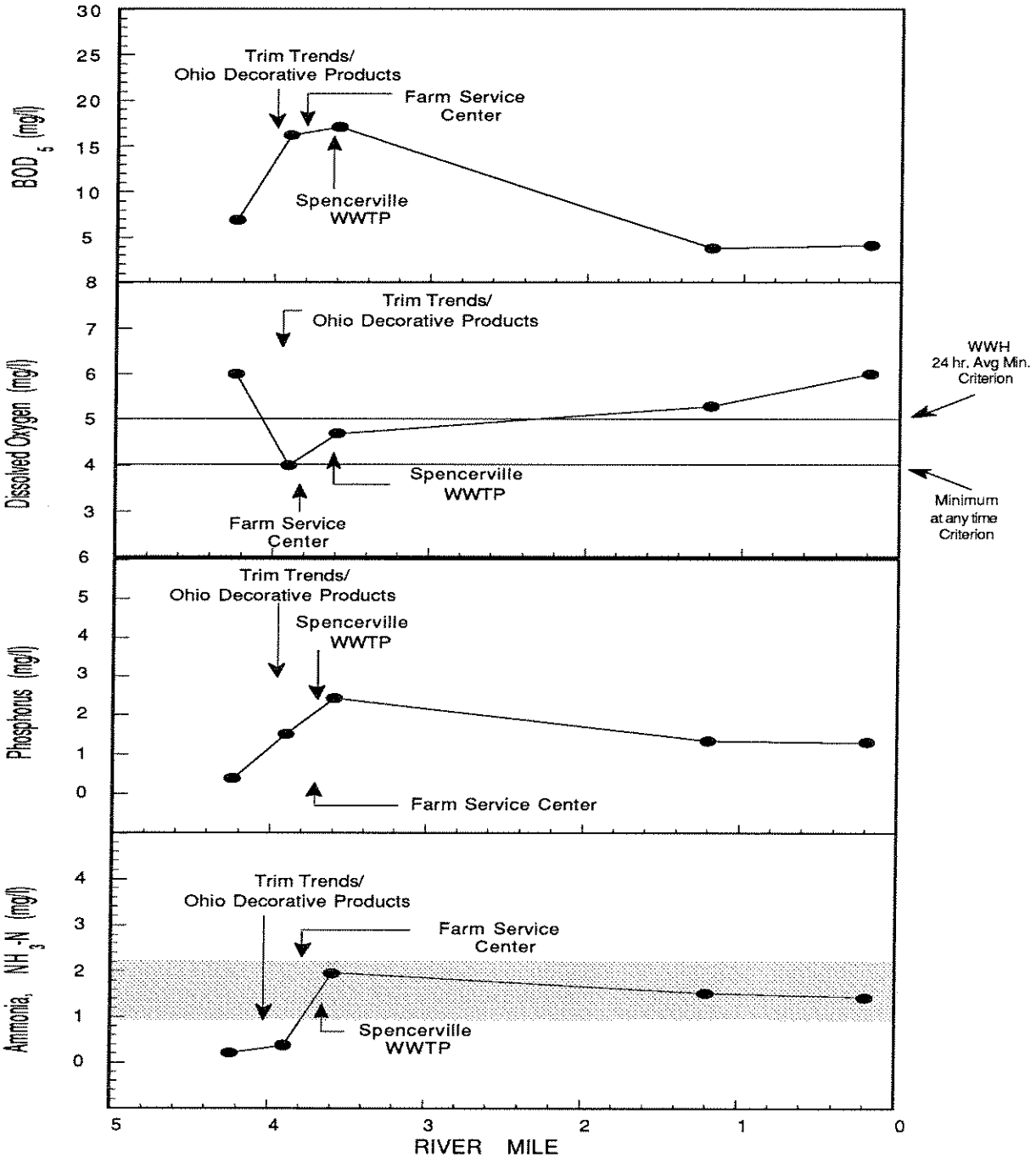

Figure 14. Longitudinal trends of mean 5-day biochemical oxygen demand, dissolved oxygen, phosphorus and ammonia-N in the Sixmile Creek, 1991. Shaded area represents the ammonia-N WQS criteria range for 90th and 25th percentile pH and temperature values.

Table 11. Organic pollutants detected in sediment from Sixmile Creek, 1991.

RIVER MILE	4.2	3.9	0.2
PARAMETER			
POLYCYCLIC AROMATIC HYDROCARBONS (mg/kg)			
Phenanthrene	ND[1]	1.9	ND
Fluoranthene	ND	2.2	ND
Pyrene	ND	1.6	ND
Benzo (K) Fluoranthene	ND	1.5	ND
PESTICIDES (µg/kg) [2]			
y - BHC	ND	8.82[f]	ND
d - BHC	7.57[f]	13.11[f]	3.64[f]
Heptachlor Epoxide[3]	ND	**141.91**[e]	ND
Dieldrin	1.35[a]	ND	3.44[a]
Eldrin[3]	ND	ND	0.72[f]
Endosulfan II[3]	ND	ND	2.22[f]
Methoxychlor[3]	8.70[f]	37.20[f]	ND
DDT (sum)[4]	ND	**132.48**[d]	ND
PCBs (µg/kg)	ND	**6377.19**[e]	**246.72**[d]
GC/MS LIBRARY COMPUTER MATCH [5] (non - priority pollutants, mg/kg)			
2-Propanone	2.35	ND	ND
1, 3, 4, 5 - Tetrachloro - 2, 3, 4, 5 - tetrafluoro 1 - Cyclopentene	ND	0.18	ND
2, 4, 4 - trimethyl - 1 - Pentene	ND	0.21	ND
2, 3 - dihydro - 1, 4, 7 -trimethyl 1H - Indene	ND	0.11	ND
2, 6, 10 - trimethyl - Dodecane	ND	0.14	ND
1, 1, 2, 2 - Tetrachloro - Ethane	5.5	4.4	3.7
2, 3, 7 - Trimethyl - Octane	ND	2.1	ND
Pentadecane	ND	4.3	ND
2, 6 - Dimethyl - Heptadecane	ND	3.3	ND
Hexadecane	ND	6.4	ND
Pentadecane	ND	2.4	ND
Nonacosane	1.6	2.2	8.5
Triacontane	ND	1.9	1.0

Table 11. (cont.)

RIVER MILE	4.2	3.9	0.2
PARAMETER (mg/kg)			
Hexadecane	ND	6.4	ND
Pentadecane	ND	2.4	ND
Nonacosane	1.6	2.2	8.5
Triacontane	ND	1.9	1.0

1. ND = not detected
2. Pesticide and PCB concentrations, unless indicated, were ranked with the following stream sediment classification system described by Kelly and Hite (1984). NOTE: The Kelly and Hite classification system addresses relative concentrations, but does not directly assess toxicity. [a] Non-elevated; [b] Slightly elevated; [c] Elevated; [d] **Highly elevated**; [e] **Extremely elevated**; [f] Not evaluated by Kelly and Hite
3. Interference may be present due to PCBs.
4. Sum DDT is the total of 4, 4' - DDE, 4, 4' - DDD, and 4, 4' - DDT. reported.
5. Library matched chemical concentrations indicated are estimates within one order of magnitude

are commonly associated with pretrolem products as additives for lubricants. According to the ranges provided by Kelly and Hite (1984), the concentation of PCBs was extremely elevated at RM 3.9 and highly elevated at RM 0.2 (Table 11). A review of past sampling results revealed that low levels of PCB-1260 was detected in the Trim Trends treated wastewater in 1987 and in a 1985 fish tissue sample.

- Concentrations of volatile organic and acid and base neutral extractable compounds were primarily detected at RM 3.9, downstream from the combined industrial discharge (Table 11). The majority of compounds detected at RM 3.9 were below instrument detection limits at RM 0.2.

Physical Habitat for Aquatic Life

- The QHEI in Sixmile Creek ranged from 56.5 at RM 1.2 to 26.5 at RM 3.7, with a mean score of 39.6 (Table 7). This value reflected the physically degraded condition of Sixmile Creek. Reviewing specific components of instream habitats, it was apparent that Sixmile Creek has been subject to severe alterations. The most significant modifications were channelization, heavy siltation resulting from agricultural runoff and the introduction of solids from point source discharges. The majority of sites evaluated demonstrated poor channel development, sparse instream cover and substrates extensively embedded by introduced sediments/solids. QHEI scores improved in the segment from RM 1.2 to RM 0.1, however, high and moderate influence modified habitat attributes were still predominant.

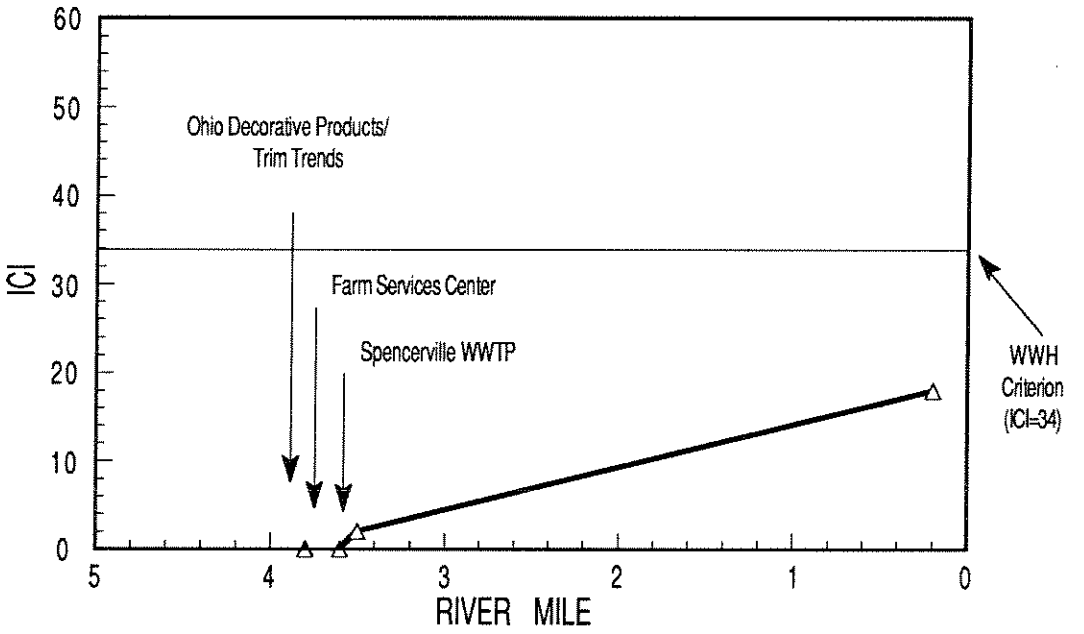

Figure 15. Longitudinal trend of the Invertebrate Community Index (ICI) in Sixmile Creek, 1991.

- Conditions were similar at RM 3.6; the ICI again scored 0 and oligochaetes predominated. Overall density appeared even lower on the natural substrates, but whether this was due to an additional impact from the discharge of wastes from the the Farm Service Center lagoon could not be ascertained.

- The effluent from the Spencerville WWTP (RM 3.5) added an enrichment component to the toxicity that was already impacting the biota of Sixmile Creek. The net result was a significant increase in density of an exclusively tolerant macroinvertebrate assemblage. The ICI score was 2 at this site.

- The beginnings of a recovery in the macroinvertebrate community was indicated at RM 1.3. The artificial substrates were covered by sand and not collected but the number of taxa collected in the qualitative sample increased from 11 at RM 3.5 to 21 at RM 1.3. The community was still overwhelmingly predominated by tolerant organisms however and continued to reflect a poor water resource condition.

- The quantitative sample from RM 0.2 scored in the fair range (ICI=18) and reflected continued, although incomplete, improvement in the macroinvertebrate community with increased distance downstream from Spencerville. The pollution tolerant midge species, Dicrotendipes simpsoni predominated on the artificial substrates but an improvement in the ICI score resulted from an increased diversity of midge taxa and the collection of the caddisfly genus Cheumatopsyche.

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Biological Assessment: Fish Community

- Fish community samples were collected from Sixmile Creek during the period between July 1 and August 15, 1991. The sampling effort included a total of 6.5 km at six sampling locations between RM 4.2, upstream from Ohio Decorative Products/Trim-Trend Inc, and RM 0.1, near the mouth.

- IBI and MIwb values ranged from 23 at RM 0.1 to 12 at RM 4.2; no sites achieved the WWH criteria. Based on the narrative evaluation, the fish community performance ranged from poor to very poor and over all performance can be characterized as very poor (Table 10, Figure 16). With the exception of RM 0.1, Sixmile Creek was nearly devoid of fish. Two of the six sites failed to support any fish and the remainder harbored a few individuals of the most tolerant species. The total catch for all samples collected upstream of RM 0.1 was 15 individuals.

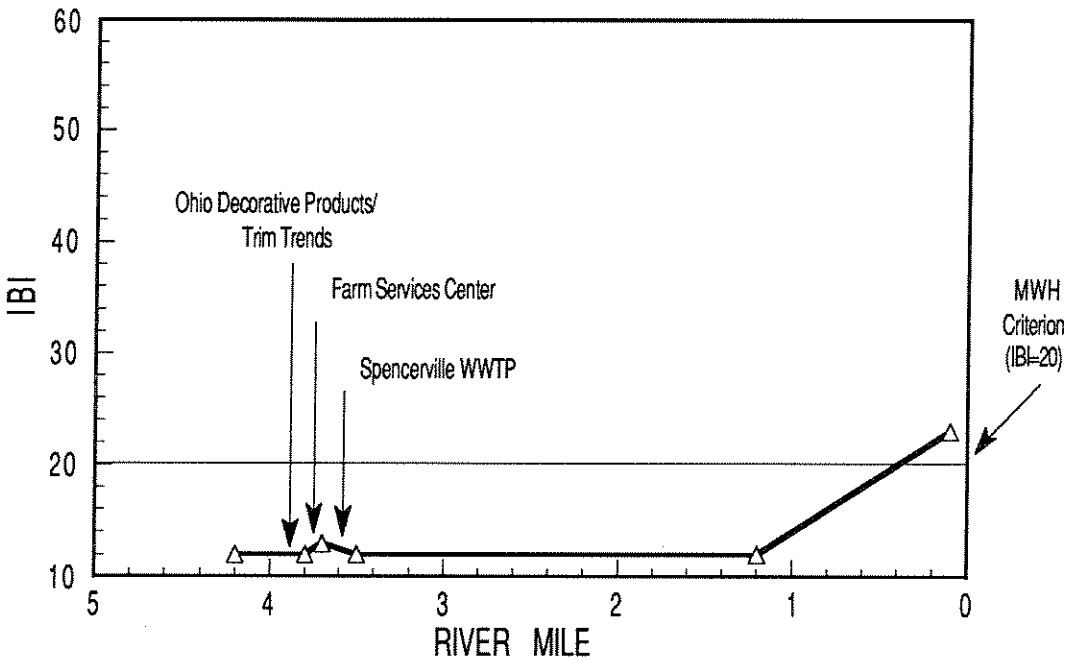

Figure 16. Longitudinal trend of the Index of Biotic Integrity (IBI) in Sixmile Creek; 1991.

- At RM 4.2 no fish were collected. Habitats were sufficient at this site to support a limited fauna. The site appeared impacted by urban runoff and there was evidence of enrichment. The reach between RM 3.8 and RM 1.2 was so thoroughly impaired by the combined influences of Farm Service Center., Ohio Decorative Products Inc., Trim Trend Inc., the Spencerville WWTP, and poor habitat quality that each sampling location can be characterized as having no community organization, few or no species and extremely low numbers of only the most tolerant species (Figure 16).

- Near the mouth (RM 0.1), community performance did increase but was still considered poor (IBI=23). The community at this sampling station consisted primarily of tolerant and pioneering species which probably entered the lower reach of Sixmile Creek from the Auglaize River mainstem.
- It is difficult to attribute the very poor community performance observed in the upper and middle segments Sixmile Creek to a discrete point source, given the proximity of the outfalls which were all within a 0.3 mile segment. However, very poor performance was indicative of acutely toxic chemical conditions.

Flatrock Creek

Pollutant Loadings: 1976 - 1991

- The Village of Payne operates a series of facultative waste stabilization lagoons (Ohio EPA permit number 2PA00019) which treats an average of 150,000 gallons per day. The system was originally constructed in 1969. Final effluent from the system discharges to Flatrock Creek at RM 25.1. The village collection system is approximately 95% combined sewers, with two combined sewer overflows (CSOs). One of these CSOs is located on Flatrock Creek at RM 25.96 and was observed to have dry weather flow during the survey period due to a malfunctioning lift station.

- Monthly self-monitoring records submitted by the Village of Payne are incomplete; therefore, reliable information on pollutant loadings (kg/day) could not be calculated or presented.

- Stokely U.S.A. operates a tomato processing plant in the Village of Paulding (Ohio EPA permit number 2IH00044) and has a seasonal discharge of treated process wastewater to Opossum Run, which flows into Flatrock Creek at RM 11.3. The wastewater treatment system is a series of aerated lagoons and, when operating, discharges an average of 350,000 gallons per day (0.35 MGD). According to self-monitoring records for 1991, discharges from the lagoon system occurred daily from August 14 through September 26. In the future, Stokely intends to upgrade the treatment system by adding additional lagoons and aeration.

- In the past, the Village of Paulding has accepted wastewater from Stokely into their lagoon system. This has at times created septic conditions because of excessive nutrient loads and, as a result, the village no longer accepts this wastewater. Stokely wastewater discharged to Opossum Run often indirectly reaches the Paulding lagoon system because of a deteriorated sewer line which runs under the stream bed. The village currently has plans to replace this sewer to alleviate this problem.

- The Village of Paulding operates a series of facultative waste stabilization lagoons (Ohio EPA permit number 2PD00027) which treat an average of 650,000 gallons per day (0.65 MGD). Final effluent from the system enters Flatrock Creek at RM 9.4. The village collection system

is approximately 75% combined sewers; with eighteen CSOs which are authorized to discharge during wet weather periods. Dry weather discharges to Opossum Run were observed from several CSOs during the survey period. The system was originally constructed in 1963, and the village is currently under Findings and Orders to complete improvements to the facility and eliminate bypasses and overflows. A four phase plan is scheduled to begin in the summer of 1992, with the addition of aeration and removal of accumulated sludge in the lagoons. The elimination of CSOs in Opossum Run and Flatrock Creek is scheduled to be completed in December 2000.

- The loading data for the Paulding WWTP are somewhat complex to interpret, since they reflect the seasonal changes in the lagoon system, as well as the wastewater inputs to the lagoons (Figure 17). The BOD_5 loadings were relatively low, but after 1986, there is an indication of higher BOD_5 loadings . Total phosphorus loadings appear to remain relatively stable, but with a suggestion of a decreasing trend throughout. There appears to be a fairly stable pattern in the fluctuations of nitrate-N and ammonia-N, which probably reflects seasonal trends of nutrient output typical of a lagoon system.

- The Village of Paulding does not monitor CSOs, therefore the pollutant loadings from these sources is unknown.

Chemical Water Quality

- During the 1991 sampling season, a malfunctioning lift station in the Village of Payne discharged raw sewage to Flatrock Creek, just upstream from the sampling site at RM 26.07. This discharge was the source of sludge deposits in a pool on the upstream side of the bridge. The Payne lagoon system discharge was green, due to algal content, but there was no buildup of lagoon algae noted in Flatrock Creek. The site at RM 9.6 was impacted by CSOs from the Village of Paulding. The majority of these overflows enter Opossum Run, a direct tributary to Flatrock Creek. Dry weather flow was noted from several of these overflows.

- Impact from the Village of Paulding lagoon system on Flatrock Creek was noted in the green algal coloration of the creek water, as well as sludge deposits, at RM 8.13. Opossum Run had intermittent flow upstream from the sampling site at RM 0.4. The flow at this site was apparently composed of inputs from CSOs and Grasser Ditch, a small tributary which enters Opossum Run just upstream from the sampling station. The Stokely Company effluent was apparently entering a sewer under the stream bed, which carried the effluent to the Paulding lagoon system.

- Three violations of the WWH dissolved oxygen (D.O.) criterion were measured at the upstream site on Flatrock Creek, at RM 28.9 (Table 12). A single exceedence fecal coliform bacteria was also noted. These violations may have been due to nonpoint source inputs or a source upstream from the state line. A possible source of nonpoint source inputs was an auto scrap yard that was adjacent to this site. The site at RM 26.1 had four exceedences for D.O. and one for fecal coliform bacteria, likely a result of the malfunctioning lift station. Only a single fecal coliform bacteria exceedence was detected at RM 23.7, downstream from the Payne lagoons. Dissolved oxygen problems were evident at RM 18.3; five of the six samples collected were in violation of the Warmwater Habitat criterion. D.O. continued to be degraded at RM 13.8, on the downstream side of the dam in Paulding, but upstream from the Paulding WWTP. The site at RM 9.6 was impacted by the CSOs from Paulding with five of the six D.O. concentrations below the 4.0 mg/l criterion. The next downstream site, RM 8.1, was located downstream from the Paulding wastewater treatment lagoons and was subject to low D.O.and elevated

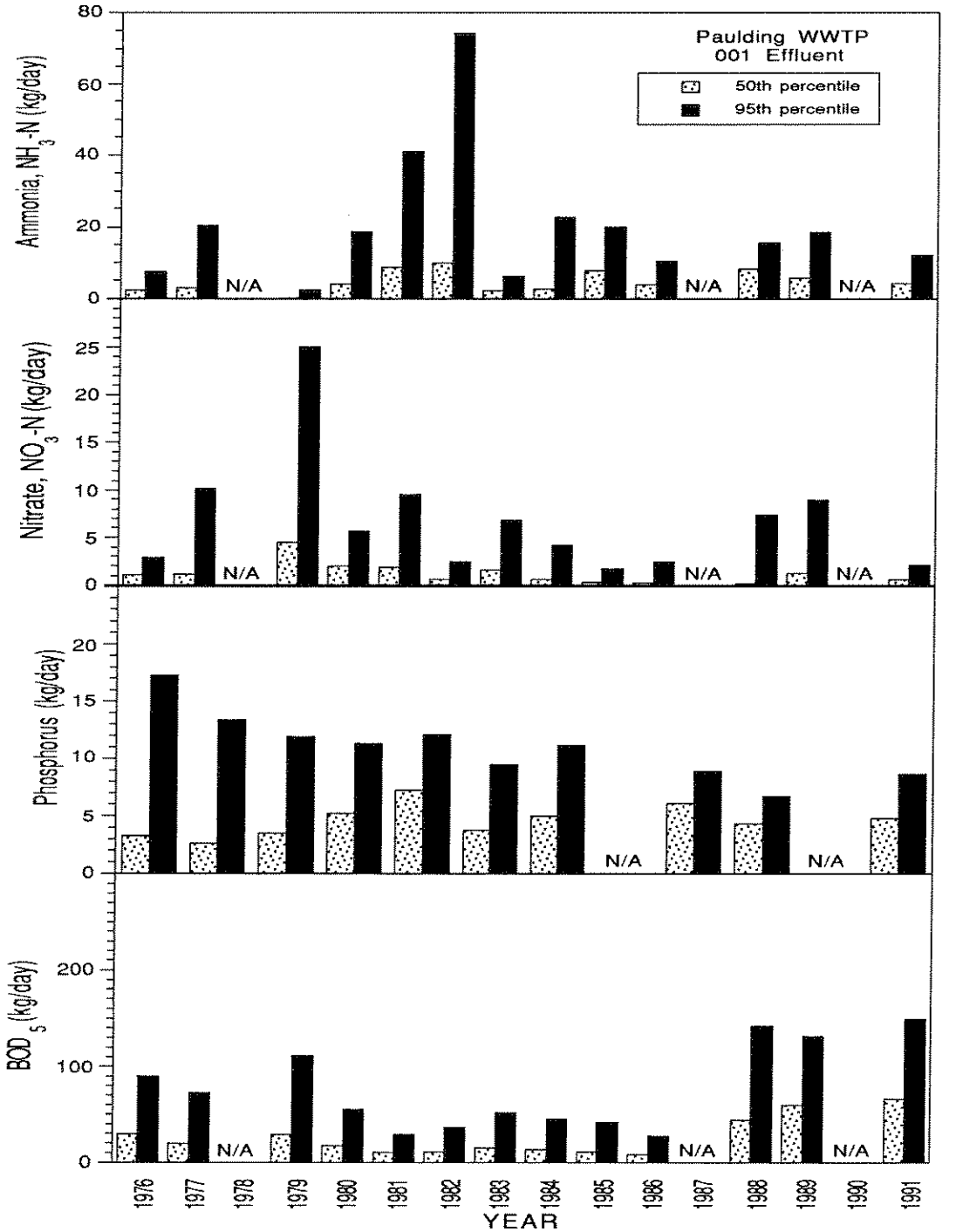

Figure 17. Annual loadings (kg/day) of Ammonia, Nitrate, Phosphorus and Biochemical Oxygen Demand (BOD_5) from the Paulding WWTP to Flatrock Creek, 1991.

ammonia-N levels The site at RM 6.0 continued to be affected by the lagoon discharge, with two D.O.minimum violations and three ammonia-N exceedences. There was also a considerable D.O. flux at this site, with one pH violation associated with a D.O. value of 14 mg/l. D.O. violations were also recorded at the last downstream site, at RM 2.7. Exceedences for ammonia-N and very elevated fecal coliform numbers were recorded at the Opossum Run site at RM 0.4.

Table 12. Exceedences of Ohio EPA Warmwater Habitat criteria (OAC 3745-1) for chemical/physical parameters measured in the Flatrock Creek study area, 1991 (units are S.U. for pH, #/100 ml for fecal coliform, and mg/l for all other parameters).

Stream Name	River Mile	Violation: Parameter (value)
Flatrock Creek	28.9	D.O. (3.3‡‡, 3.7 ‡‡, 3.3 ‡‡); Fecal coliform (2650)
	26.2	D.O. (2.4 ‡‡, 3.5 ‡‡, 4.5 ‡, 2.5 ‡‡); Fecal coliform (5800 ◊◊)
	23.7	Fecal coliform (4900 ◊)
	18.3	D.O. (4.7 ‡, 4.0 ‡, 4.2 ‡, 3.3 ‡‡, 3.2 ‡‡)
	13.8	D.O. (1.5 ‡‡‡, 2.5 ‡‡, 4.9 ‡); Fecal coliform (3500 ◊)
	9.6	D.O. (4.7 ‡, 3.7 ‡‡, 4.1 ‡, 1.9 ‡‡‡, 2.6 ‡‡); Fecal coliform (3600 ◊)
	8.1	D.O. (4.4 ‡, 2.4 ‡‡, 1.8 ‡‡‡, 2.6‡‡); NH_3-N (0.88 *, 0.79 *, 2.07 *); Fecal coliform (3600 ◊)
	6.0	D.O. (3.9 ‡‡, 2.0 ‡‡); NH_3-N (1.82 *, 1.38 **, 2.90 *); pH (9.3 **)
	2.7	D.O. (4.7 ‡, 3.6 ‡‡, 4.3 ‡)
Opossum Run	0.4	NH_3-N (0.25 *, 2.08 *); Fecal coliform (380000 ◊◊ 13000 ◊◊, 6200 ◊◊)
		44 iron of 60 samples (73.3%) exceeded 1.0 mg/l in the study area.

* indicates an exceedence of numerical criteria for prevention of chronic toxicity (CAC).
** indicates an exceedence of numerical criteria for prevention of acute toxicity (AAC).
*** indicates an exceedence of numerical criteria for prevention of lethality (FAV).
‡ violation of the average dissolved oxygen (D.O.) criterion.
‡‡ violation of the minimum dissolved oxygen (D.O.) criterion.
‡‡‡ violation of the "nuisance prevention" minimum dissolved oxygen (D.O.) criterion.
◊ exceedence of the Primary Contact Recreation criterion.
◊◊ exceedence of the Secondary Contact Recreation criterion.
† exceedence of the Human Health Public Water Supply criterion.

•Continuous monitor data (Figure 18) clearly demonstrated the effects on diel D.O. fluctuations caused by the WWTP discharges from both Payne and Paulding, as well as the CSOs in Paulding. The pattern of decrease at the three sites downstream from Payne may reflect oxygen demand from sediments, rather than planktonic algae, since the diurnal fluctuations are limited. The addition of raw sewage from the lift station in Payne certainly contributed to this demand, but it would be difficult to separate this effect from that of the WWTP lagoon. Dissolved oxygen was further impacted at RM 9.6 by the CSO discharges in Paulding. The lowest continuous monitor D.O. concentrations were recorded at RM 8.0, below the Paulding lagoon discharge in response to the introduced organic load from the WWTP. D.O. levels improved marginally at the next site, but were still heavily impacted. The final site (RM 2.7) had extensive D.O. flux, however, the average concentration of D.O.increased considerably indicating substantial recovery in water quality.

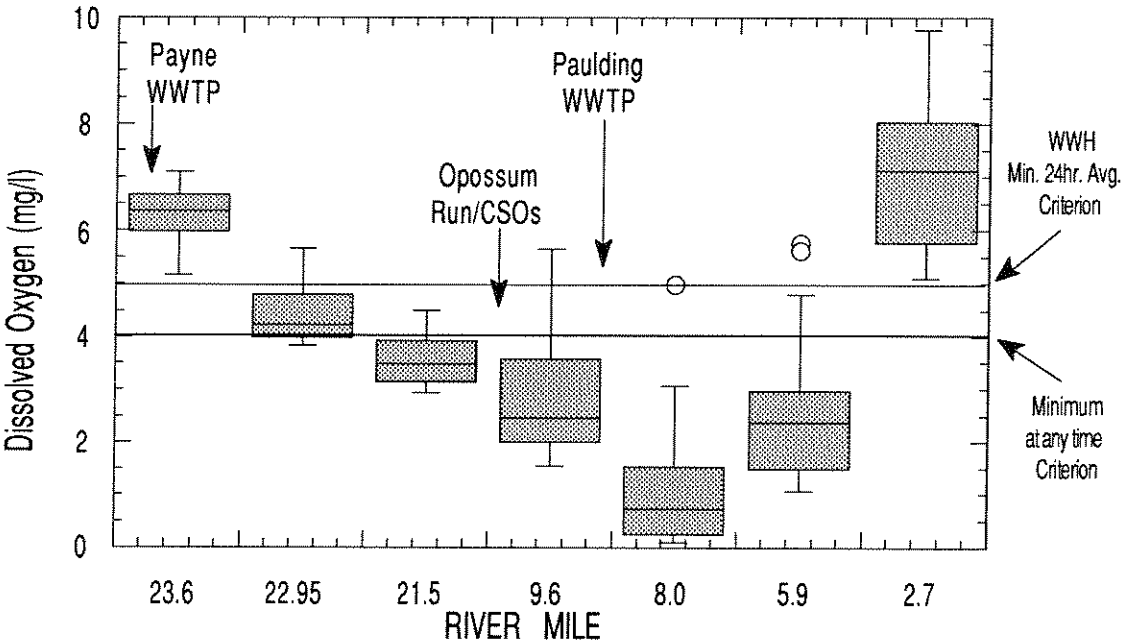

Figure 18. Boxplots of dissolved oxygen recorded with continuous monitors at selected locations in Flatrock Creek during the summer of 1991

- Mean data for grab samples of D.O., BOD_5, total phosphorus, ammonia-N, and nitrate-N reflect general water quality conditions in the sampled area of Flatrock Creek (Figure 19). The effect of the lift station input in Payne was seen in the D.O. decrease from RM 28.9 to RM 26.1. The D.O. levels increased at RM 23.7, downstream from the Payne WWTP but again decreased at RM 18.3, probably due to a combination of lagoon and lift station input. Recovery can be detected at RM 13.8, but D.O. was again impacted by the Paulding CSOs.The D.O. increased at RM 8.0 and RM 5.9, suggest algal related D.O. flux at the times of day when the samples were collected. The D.O. mean at RM 2.7 may represent a more realistic recovery point from the effects of the Paulding discharges. BOD_5 was elevated upstream from the Payne lagoon outfall apparently due to the malfunctioning lift station in Payne. The mean BOD_5 increased somewhat downstream from the CSO in Payne but quickly recovered. A

much bigger increase in BOD_5 was recorded downstream from the Paulding WWTP discharge at RMs 8.1 and 6.0. The mean BOD_5 decreased at the last site (RM 2.7), but was still higher than the upstream control site. The total phosphorus graph indicates that the lift station in Payne, the Payne WWTP, the Paulding CSOs, and the Paulding WWTP are all sources of phosphorus, with the Paulding WWTP the greatest contributor. There is some ammonia-N input from the Payne lift station, and a suggestion of some increase downstream from the Payne WWTP, but the major addition is clearly from the Paulding WWTP. The major sources of nitrate-N, an important algal nutrient, were the Payne WWTP, the Paulding CSOs, and the Paulding WWTP.

Sediment Chemistry

- The elevated zinc concentration at RM 26.1 may be related to the input from the malfunctioning lift station in Payne (Table 5). The elevated iron levels reflect natural background iron sources. The two highly elevated concentrations of arsenic appear to be related to past agricultural use of arsenic containing compounds for pest control. No priority organic pollutants were detected from a sample collected at RM 6.0 (Table 13).

Table 13. Flatrock Creek sediment priority pollutant scan detections (mg/kg), 1991.[1]

RIVER MILE **PARAMETER** (mg/kg)	6.0
GC/MS LIBRARY COMPUTER MATCH [2] (non - priority pollutants)	
1, 1, 2, 2 - Tetrachloro - Ethane	2.1
3 - Methoxy - 3, Methyl - 2 - Butanone	11.9
Octacosane	1.4
2, 6 - Dimethyl Heptadecane	1.1
Nonacosane	3.4
Triacontane	1.4

1.ND = not detected
2.Library matched chemical concentrations indicated are estimates within one order of magnitude reported.

Note: Samples for analysis of PCBs/Pesticides were not submitted for Flatrock Creek.

Physical Habitat for Aquatic Life

- Flatrock Creek is located within the Huron Erie Lake Plain ecoregion (HELP). The extensive nearly flat lake plain dominates this area and is responsible for the poorly drained landscape of this region (Omernik 1989). Originally covered mostly by forested wetland, the conversion of this area to intensive row crop agriculture required extensive ditching, field tiling and channelization to expedite surface and subsurface drainage. These activities coupled with large

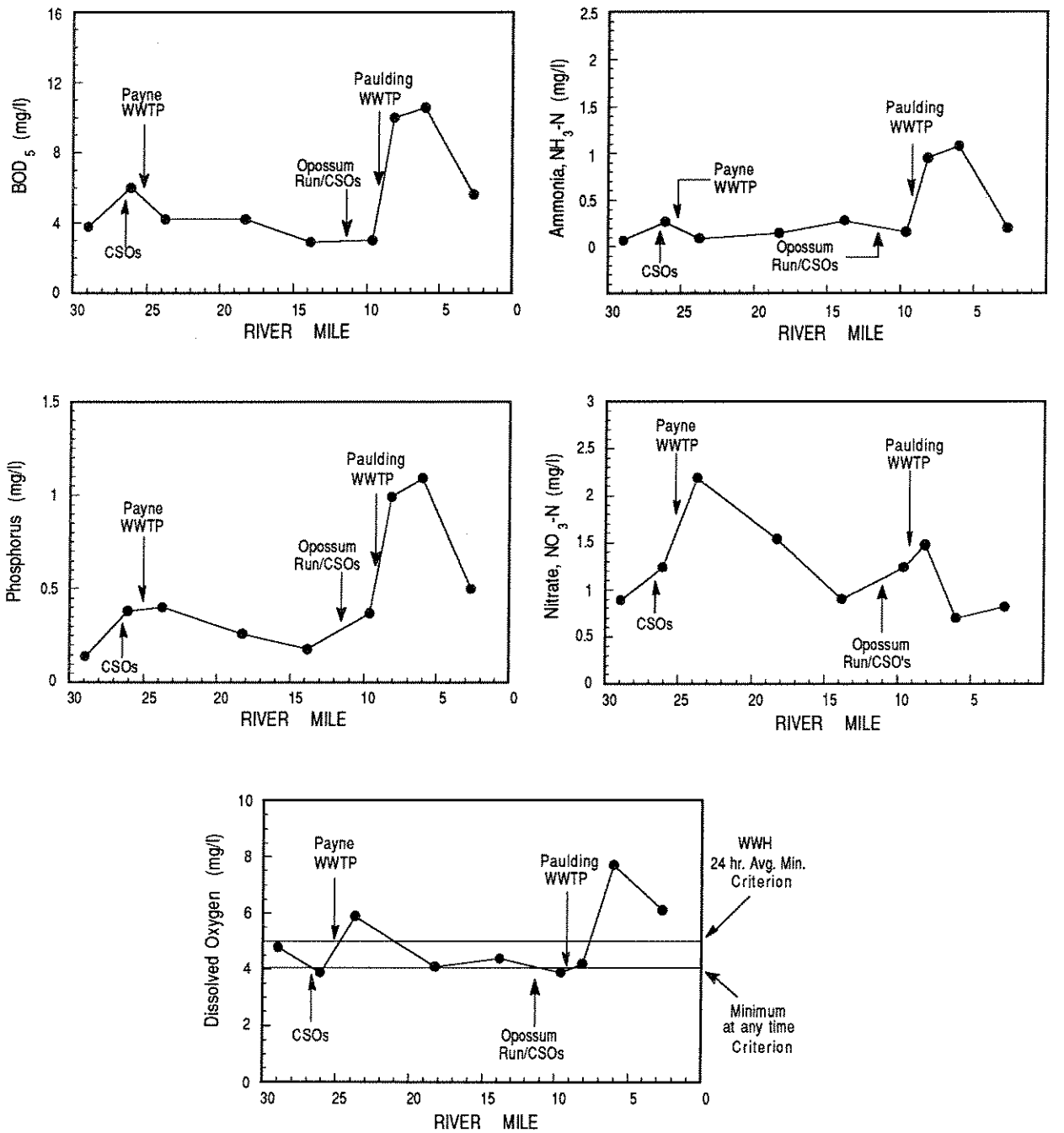

Figure 19. Longitudinal trends of mean Biochemical Oxygen Demand, Ammonia, Phosphorus, Nitrate and Dissolved Oxygen in the Flatrock Creek, 1991.

scale deforestation have resulted in significant modifications to stream channel development, the introduction of sediments, and significant alteration to seasonal runoff patterns (Omernik and Gallant 1989; Whittier *et al* 1987).

- Macrohabitats of the Flatrock Creek study area were evaluated at a total of nine fish sample locations. The QHEI ranged from 76.0 at RM 24.4 to 45.0 at RM 26.1, with a mean score of 52.2. Moderate influence modified habitat attributes were slightly more prevalent than warmwater habitat attributes; high influence modified habitat attributes occurred at a much lower frequency (Table 7). Apparently, Flatrock Creek is either in the process of recovery from past modification or it has been subject to less overall modification than other streams of this region. The most frequently encountered warmwater habitat attributes were pools greater than 40 cm in depth, extensive to moderate instream cover, and the lack of channel modifications or the recovery of past modifications. These attributes are usually lacking from other similarly sized streams in the HELP ecoregion. Moderate influence modified habitat attributes present were heavy to moderate siltation, moderately embedded substrates, low gradient, and fair to poor channel development.

- Considering the history of the HELP ecoregion, a feature unique to Flatrock Creek is the presence of an extensive permanently wooded riparian corridor, extending at least 40 meters from each bank at the majority of locations evaluated. The riparian and near stream vegetation consisted of mature floodplain species in the segment between RM 24.4 to RM 2.8, and younger floodplain species in the upper reach (RM 28.9 to RM 26.1). The positive effects of the wooded riparian are manifested in various components of the QHEI. The vast majority of instream cover types recorded were directly a result of permanent riparian vegetation. Cover types included: logs and woody debris, rootwads, over-hanging vegetation and undercut banks. In the lower reach the mature riparian canopy generally offered 70% to 90% coverage of the stream an added to bank stability. Although bank scouring was evident at most sites, it is likely that the riparian vegetation limited the severity and extent of erosion occurring during periods of high flow. The extent and relative quality of the wooded riparian and nearstream vegetation is by far the most critical component of habitat within the Flatrock Creek basin.

Biological Assessment: Macroinvertebrate Community **(Figure 20, Table 9)**

- The ICI scores from Flatrock Creek could not be directly applied in the evaluation of the macroinvertebrate community performance and use attainment because none of the site locations had sufficient current combined with water depth to allow for the placement of the artificial substrates in flow that exceeded 0.3 ft/sec. As a result, more emphasis was placed on the qualitative and field observations in assessment of attainment status and identifying impacts on the macroinvertebrate community.

- The flow at the upstream control site at RM 28.8 was intermittent. An additional negative factor affecting the benthos at this site was that silt comprised a large component of the streambed. Twenty-five taxa were collected on the artificial substrates and scored an ICI value of 10; 22 taxa were collected in the qualitative sample. The mayfly genera Stenacron and Caenis were collected using both sampling methods. The macroinvertebrate community was considered to be in relatively good condition.

- The site at RM 26.2 was heavily impacted by sewage from the village of Payne which flowed into the stream via a CSO located a short distance upstream. The raw wastewater was being diverted into the CSO due to a malfunctioning valve in the sewer system. A thick layer of sludge, sewage fungus and blue-green algae coated the streambed. Not surprisingly, the

benthic community was predominated by tolerant midges and the ICI score was 0 (very poor). Although this particular situation has been corrected overflows are likely following rain events and there is potential for breakdowns of the sewage delivery system in the future.

- Conditions improved at RM 23.7. An ICI score of 16 resulted in part, due to increases in diversity of midge taxa and mayfly density compared to the upstream control site. A small volume of water was flowing between the pools at this site which provided a habitat type that was not present upstream and yielded three caddisfly taxa in the qualitative sample. No observable impact was noted from the Payne WWTP or the malfunctioning CSO.

- The three sites upstream from the Paulding WWTP, RMs 18.0, 13.8 and 9.6, produced ICI scores of 4, 16 and 2, respectively. Water quality at these sites did not appear to be significantly different. The variability of the ICI scores apparently is a reflection of the instability of the macroinvertebrate community given the nearly intermittent conditions, predominance of fine gravel, sand and silt, and substrate embeddedness found at these sites. Bank erosion was noted as being moderate to heavy at each of these sites and may be one factor which if lessened could result in an improvement of the macroinvertebrate community. No impact was detected from CSOs in Paulding.

- The Paulding WWTP discharge grossly enriched Flatrock Creek. The water at RM 8.1 was a deep green color and large amounts of sewage fungus and bluegreen algae were observed. Both the artificial and natural substrates were predominated by midge taxa tolerant of organic wastes, primarily individuals of the genus Glyptotendipes and the Chironomus decorus group. The WWTP discharge comprised the great majority of the flow within this reach during the 1991 sampling period and a significant improvement in the quality of the effluent will be needed to correct the severe degradation that exists.

- Tolerant midge taxa continued to predominate on the artificial substrates at RM 6.0, however, midge diversity increased and a total of 5 species of mayflies and caddisflies were collected. Cheumatopsyche, a moderately pollution tolerant caddisfly, and riffle beetles were the predominate organisms collected from natural substrates that were in current. These results reflect a partial recovery of the benthos with increased distance downstream from the Paulding WWTP. The macroinvertebrate community was in fair condition.

- The enrichment impact was not evident at RM 2.9 as tolerant midge taxa no longer predominated on the artificial substrates. Habitat conditions were again the primary determinant of the macroinvertebrate assemblage present at this site. The presence of rubble substrates at this site and at RM 6.0 seemed to be, in part, responsible for the collection of 43 and 46 taxa in the qualitative sample, respectively. The macroinvertebrate community appeared to be in good condition at RM 2.9.

- The median qualitative community tolerance value (QCTV) at each site were not as affected by the lack of current as the ICI and provided a relative measure of the impacts of the Payne CSO and the Paulding WWTP. The two lowest values were downstream from the Payne CSO (RM 26.1) and the Paulding WWTP (RM 8.1); scores were 22.5 and 22.9, respectively. The sites which were not severely organically degraded had median QCTV scores that ranged from 31.2 to 27.4 (Figure 20).

- The macroinvertebrate fauna in areas that were not organically degraded were typical enough of a HELP ecoregion warmwater habitat to warrant maintaining the current aquatic life use.

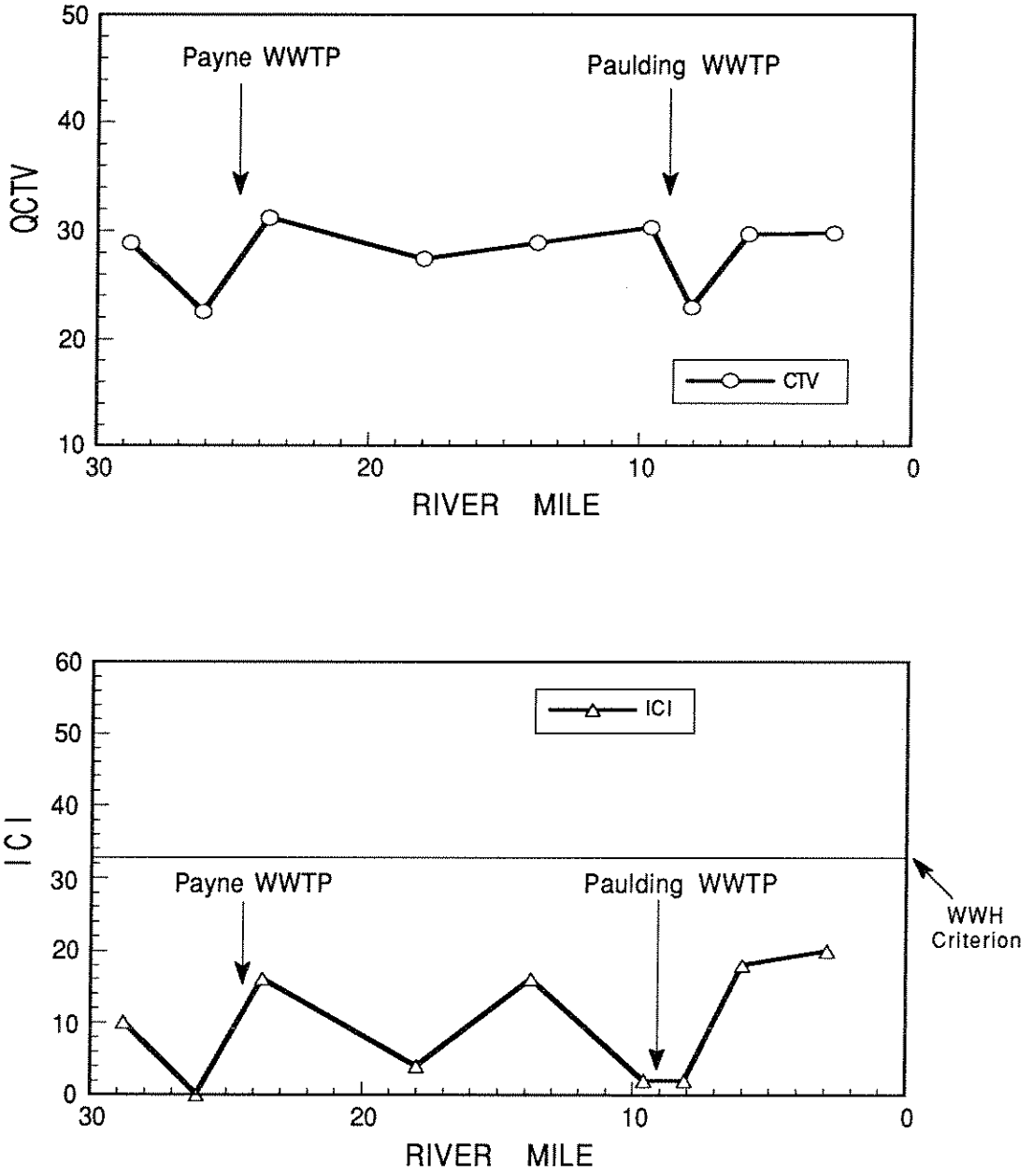

Figure 20. Longitudinal trend of the Invertebrate Community Index (ICI) and the Qualitative Community Tolerance Value (QCTV) in the Flatrock Creek, 1991.

Siltation and the low flow characteristics of the stream were the primary negative habitat attributes affecting the benthos. It will be important that the riparian buffer is maintained and improved where necessary in order to provide bank stability to minimize erosion and sedimentation.

Biological Assessment: Fish Community

- A total of 8,811 fish comprised of 32 species and 5 hybrids were collected from Flatrock Creek during the period between July 15 through September 18, 1991. The sampling effort included a total of 42 km at 9 sampling locations between RM 28.9, upstream from the village of Payne, and RM 2.8, downstream from the city of Paulding.

- The fish community was numerically predominated by green sunfish (24%), bluntnose minnow (23%), gizzard shad (16%), and yellow bullhead (9%). Species that predominated in terms of biomass were common carp (15%), yellow bullhead (4%), and green sunfish (3%).

- Based on IBI and MIwb scores and the accompanying narrative evaluation, fish community performance ranged from Good/Fair at RM 13.8 to Poor at RM 26.1. Generally the fish community of Flatrock Creek was characterized as Fair and was predominated by omnivores, tolerant species, and habitat generalists. Only RM 13.8 fully achieved the WWH biocriteria and no sites reached exceptional levels or declined to very poor levels (Table.10).

- No impact to the fish community was detected at RM 24.4, immediately downstream from the Payne WWTP. However, impacts were detected at RM 26.2, downstream from the Payne CSO (IBI=27; MIwb=6.0) and RM 9.0, downstream from the Paulding WWTP (IBI=25; MIwb=6.7) (Figure 21).

- At RM 26.2 an observed impact was attributed to a malfunctioning lift station which resulted in the discharge of untreated municipal waste into Flatrock Creek. The worst of the organic enrichment appeared to be relatively localized, but suppressed community performance was observed for approximately two miles downstream from the outfall. At RM 13.8 the fish community appeared to recover and achieved the WWH biological criteria. However, this site was situated immediately downstream from a lowhead dam. The impoundment formed upstream from the dam permitted suspended sediments to settle and resulted in considerably less silt deposition downstream and improved the available habitat. This fact may have contributed to an increase in community performance observed at RM 13.8.

- Immediately downstream from the Paulding WWTP, RM 9.0, the fish community performance declined and failed to recover downstream (Figure 21). The impact observed at RM 9.0 most likely a result of organic enrichment. The treatment lagoons support and subsequently discharge a quantity of algae sufficient to color the receiving stream a bright green.

- The community response to the impacts observed at RM 26.1 and RM 9.0 were manifest in shifts of structural and functional components of the fish community. Downstream from the discharging stormsewer in Payne both relative abundance (No./0.3 km) and the percent of omnivorous species demonstrated a marked increase. Downstream from Paulding WWTP, relative abundance, percent omnivores, and percent tolerant species all demonstrated a significant increase. Additionally, the occurrence of DELT anomalies reached a maximum of 3.0% at RM 24.4. DELT anomalies greater than 0.1% were persistent at the majority of downstream sampling locations. A frequency of DELT anomalies greater than 0.1% is an indication of stress to the fish community associated with degraded water quality.

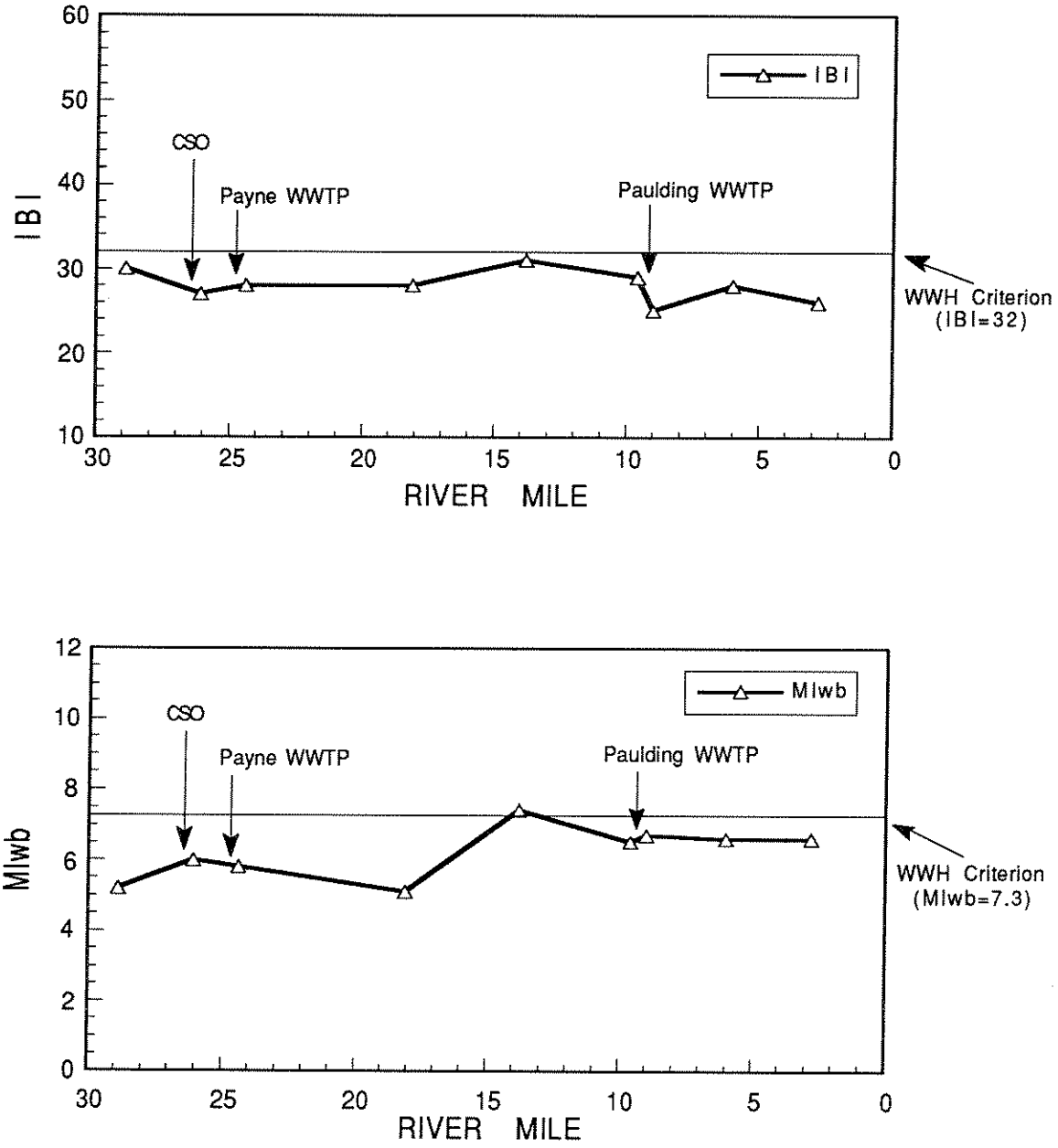

Figure 21. Longitudinal trend of the Index of Biotic Integrity (IBI; upper) and the Modified Index of Well-Being (MIwb; lower) in the Flatrock Creek, 1991.

•Generally the suppressed condition of the fish community inhabiting Flatrock Creek is a result of past and current land uses that have resulted in significant modification to physical habitat. This fact was recognized in the development of the biological criteria on an ecoregional basis (Ohio EPA 1989b). Reviewing IBI and MIwb values, it appeared that the fish community inhabiting Flatrock Creek achieved some degree of functional organization, but structural components were lacking. The lower innate potential of Flatrock Creek by no means excludes it from achieving the current use designation. Despite the lower biological expectation of the HELP ecoregion, significant impacts were detected downstream from the villages of Payne and Paulding. The community performance observed relative to these point source discharges was a typical biological response to organic enrichment, and appeared to inhibit the achievement of the WWH biological criteria.

Trend Assessment

Auglaize River

Chemical Water Quality Changes: 1975-1991.

- Water quality problems in 1975 downstream from the city of Wapakoneta, were reflected in the depressed D.O.and elevated nutrient and metals concentrations (Ohio EPA 1977). Based on chemical sampling results, conditions at the Wapakoneta WWTP have improved considerably since the 1975 survey and is reflected in the results discussed above.

- Chemical and biological sampling was conducted by Ohio EPA in 1985 on the Auglaize River from upstream from Sixmile Creek (RM 63.4) to near Cloverdale, Ohio (RM 28.6) (Ohio EPA, 1986) The flow hydrograph for the Auglaize River (Figure 6) was considerably higher during the June-September period in 1985 than in 1991, with a significant dip into the $Q_{7,10}$ range only in late September, 1985. The lower mean flows in 1991 should be kept in mind when looking at the other graphs comparing 1985/1991 mean concentration data for the Auglaize River. The flow differential seems evident in the D.O. graph for the two sampling periods. The two curves are very similar in shape, but the means for 1985 were higher throughout, apparently due to the higher flows. The curves for ammonia-N are also quite similar, but clearly the ammonia-N input to the Auglaize River was greater in 1985, due to Farm Service Center operations. Recovery from ammonia-N input to the Auglaize River from Sixmile Creek was definitely more rapid in 1991 than in 1985, although Sixmile Creek appears to remain the major source of ammonia-N in this section of the Auglaize River. Ammonia-N means were generally higher in 1985 than in 1991, particularly downstream from Sixmile Creek. Similarly, the phosphorus input to the Auglaize River from Sixmile Creek was less in 1991 than in 1985, with more rapid assimilation in 1991. The nitrate-N added to the Auglaize River by Sixmile Creek was much higher in 1985 than in 1991, with data from both surveys reflecting an additional increase at RM 39.6 and a higher peak at the last downstream site than downstream from Sixmile Creek, possibly due to impact from Ft. Jennings and Jennings Creek, which receives the Delphos WWTP effluent, as well as combined sewer overflows from Delphos. CSO inputs would have been less in 1991, due to the low rainfall conditions during that sample period.

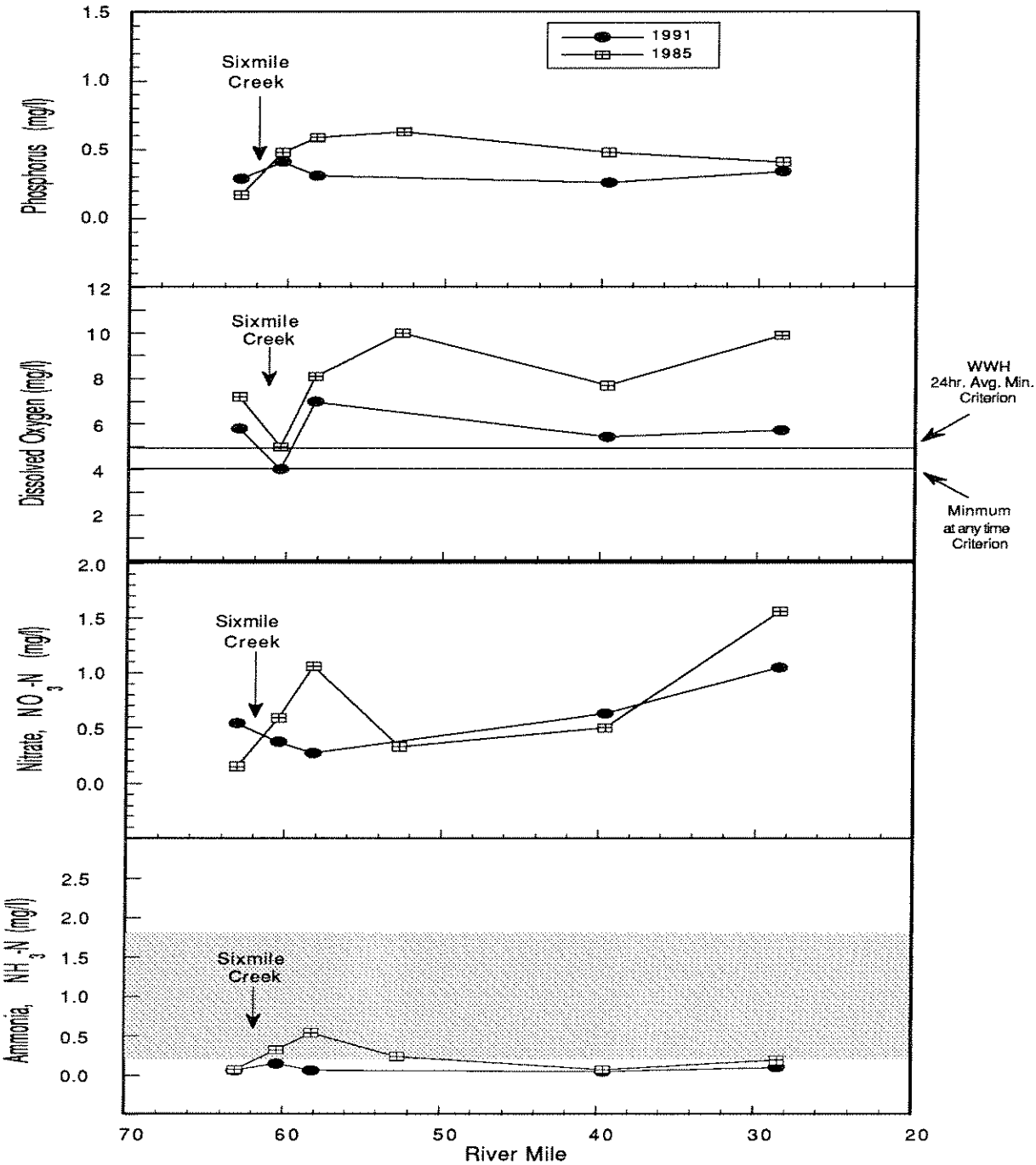

Figure 22. Longitudinal trend of phosphorus, dissolved oxygen, nitrate and ammonia in the Auglaize River, 1985 compared to 1991. Shaded area represents the Ammonia WQS range for 90th and 25th percentile pH and temperature values.

Changes in Biological Community Performance: 1985- 1991

- Limited sampling was conducted by the Ohio EPA in 1975 in the Auglaize River upstream and downstream from Wapakoneta(Ohio EPA, 1977). Interpretation of biological data suggested that the most severe water quality problem, at that time, was D.O. depletion from the CSOs in Wapakoneta. The macroinvertebrate community upstream from the WWTP was degraded and a large fish kill was noted in August 1975. The CSOs were not having as great an impact in 1991, however, the macroinvertebrate community appeared to be moderately impacted by a combination of CSOs, stormwater and urban runoff.

- Between RM 67.0 and 28.8 results from a 1985 Ohio EPA survey reported fish and macroinvertebrate communities in the Auglaize River that were impacted by degraded water quality inputs from the Geokke tributary that enters the mainstem at RM 63.6 and Sixmile Creek which enters the Auglaize River at RM 63.3 (Ohio EPA 1986). The biota in the vicinity of these two tributaries was also affected by a lack of suitable habitat. However, the predominance of tolerant macroinvertebrates in this segment and the incomplete recovery at RM 58.0 where habitat was much improved demonstrated that inputs from one or both of these streams was having a degrading impact over and above the influence of suboptimal habitat.

- Conditions were somewhat improved in 1991 (Figure 23). Although ICI scores at RMs 63.4 and 61.6 were only in the fair range (ICI=20), the depression of the macroinvertebrate community was attributed to habitat factors. The benthos scored in the exceptional range at RM 58.0, compared to the fair range in 1985, with many of the same sensitive organisms as were present at the site upstream from Sixmile Creek at RM 67.0. The ICI Area of Degradation Value (ADV) was reduced approximately 34% (from 613 to 402 ADV units) (Table 14). Qualitative sampling also reflected improved results in 1991 compared with 1985 as evidenced in higher numbers of caddisflies and mayflies and higher Qualitative Community Tolerance Values within the effected stream segment (Figure 23). It was suspected in 1985 that operations conducted by Farm Service Center was a significant source of degradation to the Auglaize River in the vicinity of Sixmile Creek. This was substantiated by the improved performance of the macroinvertebrate community in 1991 subsequent to the closure of the Farm Service Center.

- Historic changes in the fish community of the Auglaize River have been correlated with the degradation of water quality. Enrichment from municipal wastes, industrial wastes, agricultural runoff and byproducts of food processing facilities have resulted in fish kills too abundant to accurately enumerate in the context of this document (Clark 1942; Clark and Allison 1966; Trautman 1981). Historically, these problems were most evident in the lower reach, downstream from the confluence of the Ottawa River, where toxic loadings of ammonia - N resulted in the lower Auglaize being devoid fish. Ohio EPA data collected between 1985 and 1991 at RM 28.8, downstream of the Ottawa River, has reflected substantial recovery The fish community achieved the WWH biological criteria in 1991.

- Based on Ohio EPA survey results from 1985 to 1991, the Auglaize River fish community performance appears to have improved downstream of the confluence of the Goekke tributary and Sixmile Creek (RM 61.8 to RM 52.7) (Figure 24). Nevertheless, the elevated occurrence of DELT anomalies suggest that a sublethal impact is still present. The MIwb ADV was

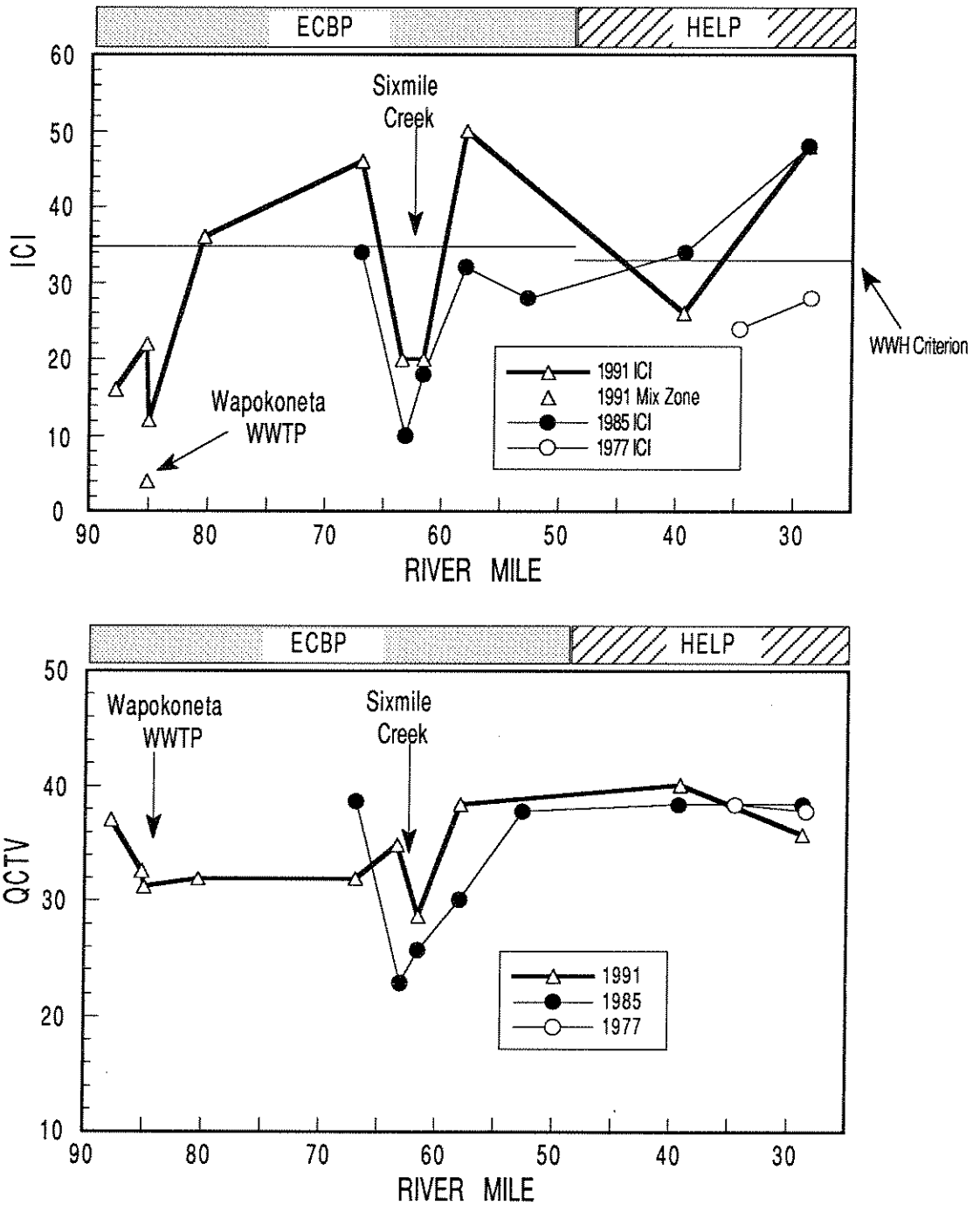

Figure 23. Longitudinal trend of the Invertebrate Community Index (ICI) and the Qualitative Community Tolerance Value (QCTV) in the Auglaize River, 1977,1985, and1991.

reduced from 350 in 1985 to zero in 1991 (Table 14). Conversely, the IBI ADV increased approximately 24% (1588 in 1985 versus 1973 in 1991). The net result in attainment status was a significant increase in miles PARTIAL attainment and reductions in the miles of FULL and NON attainment. As discussed previously, it appears that in 1991 toxicity was less of a factor than in 1985; however, siltation and negative habitat factors were impacting on community function (*i.e.*, limiting the number of simple lithophils and round bodied suckers).

Table 14. Area of Degradation (ADV) statistics for the Auglaize River study area, 1981 and 1991 (calculated using ecoregion criteria as the background community performance).

	Biological Index Scores				ADV Statistics			Attainment Status (miles)[a]			
Stream Index	Upper RM .	Lower RM .	Mini-mum	Maxi-mum	**ADV**	ADV/ Mile .	Poor/VP ADV	FULL	PARTIAL	**NON**	Poor/VP
Auglaize River (1985)											
IBI	67.0	28.8	24	42	**1588**	41.6	0	18.0	11.8	8.5	3.3
MIwb			6.4	11.3	**350**	9.2	0				
ICI			18	48	**613**	18.7	0				
Auglaize River (1991)											
IBI	67.0	28.8	29	46	**1973**	54.5	0	5.4	32.9	0.0	0.0
MIwb			8.1	10.0	0	0	0				
ICI			20	50	0	0	0				
Auglaize River (1991)											
IBI	87.8	28.8	29	46	**1976**	33.5	0	14.6	43.9	0.6	0.3
MIwb			6.6	10.0	**40**	0.6	0				
ICI			12	50	**1077**	17.1	0				
Sixmile Creek (1985)											
IBI	4.2	0.2	12	16	**293**	73.3	251	(0.0)	(0.0)	(4.2)	(4.2)
Sixmile Creek (1991)											
IBI	4.2	0.1	12	23	**274**	66.8	236	(0.4)	(0.0)	(3.8)	(3.8)
Flatrock Creek (1991)											
IBI	2.8	28.9	25	31	**160**	6.1	45	(4.3)	(4.8)	(17.1)	(11.5)
MIwb			5.1	7.4	**875**	33.5	30				
Pusheta Creek (1991)											
IBI	0.3	0.3	42	42	**0**	0	0	0.1	0.0	0.0	0.0
MIwb			9.6	9.6	**0**	0	0				
ICI			34	34	**0**	0	0				

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

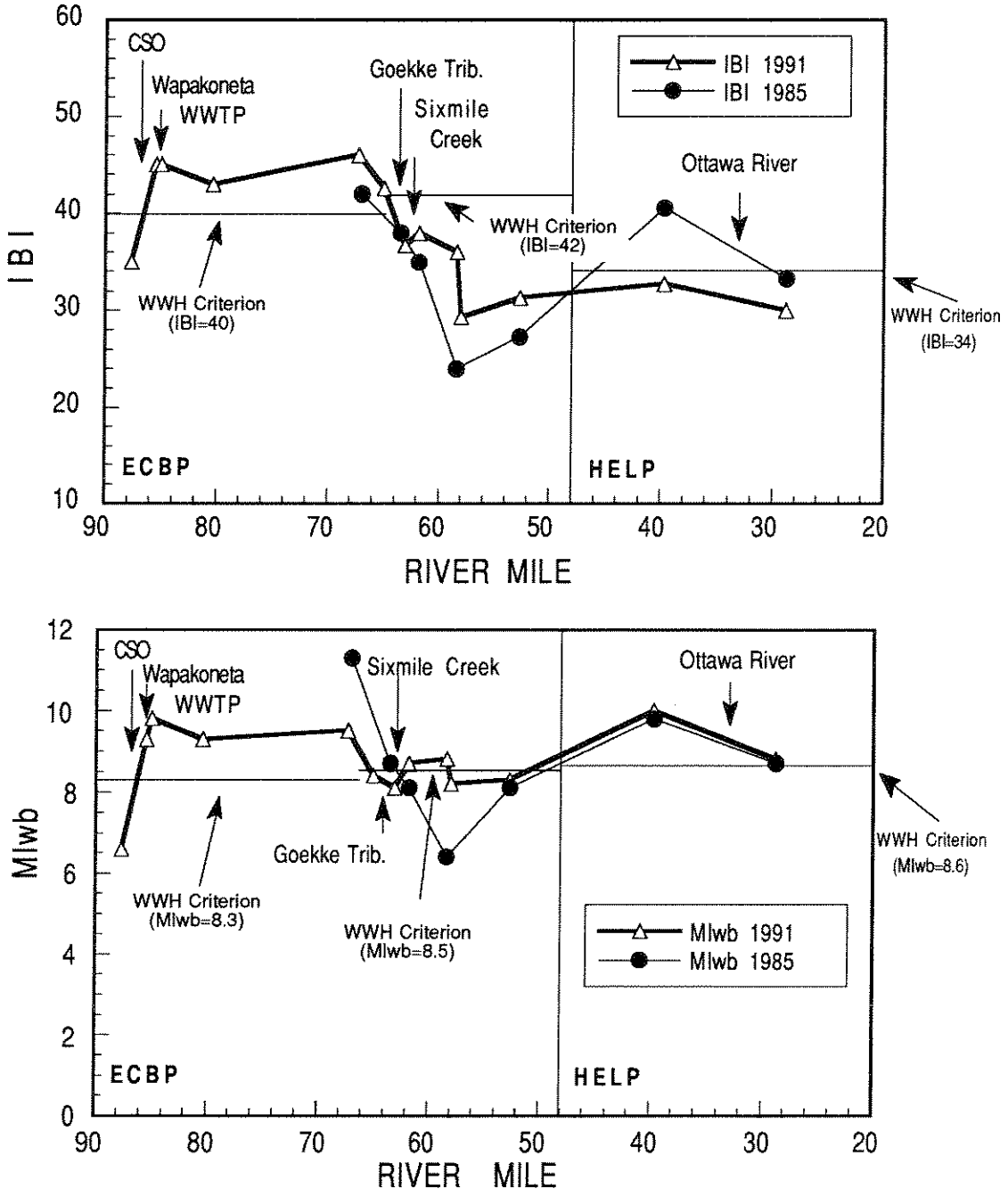

Figure 24. Longitudinal trend of the Index of Biotic Integrity (IBI), and the Modified Index of Well-Being (MIwb)in the Auglaize River, 1985 and 1991.

Sixmile Creek

Chemical Water Quality Changes: 1985-1991.

- Trend analysis of D.O. indicates a slight increase in mean concentrations downstream from the combined industrial discharges in 1985, which may have reflected higher stream flow levels and associated reaeration. The most significant difference in the two years is the obvious influence of the Farm Service Center input in 1985. The Farm Service Center was also the main contributor of ammonia-N and phosphorus loading in 1985, while the WWTP discharge had a diluting influence on the concentrations of these parameters.

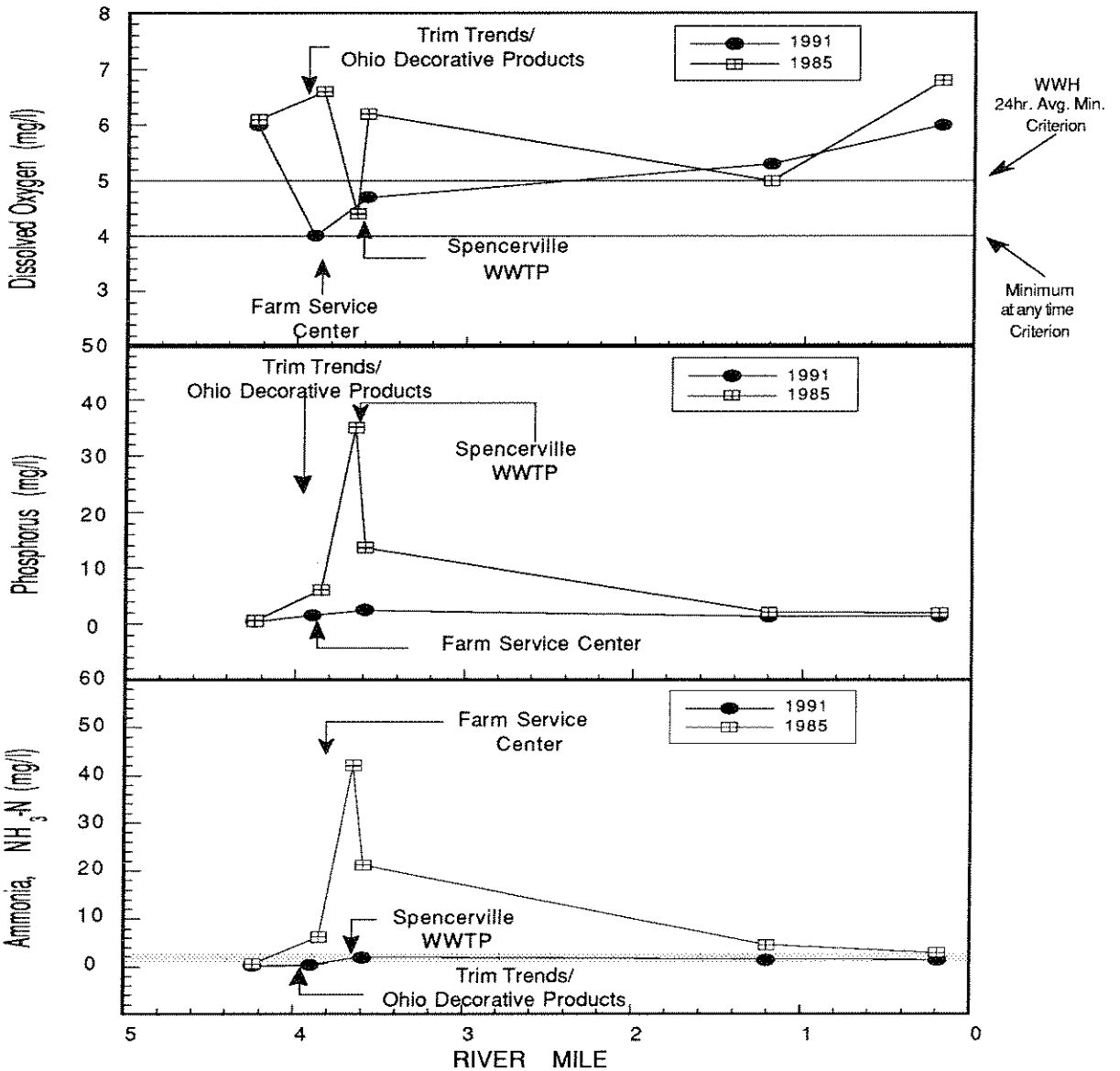

Figure 25. Longitudinal trend of D.O., phosphorus and ammonia-N in the Sixmile Creek study area, 1985 compared to 1991. Shaded area represents the Ammonia WQS range between the 90th and 25th percentile pH and temperatures.

Changes in Biological Community Performance: 1985-1991

- Results from the 1991 survey of Sixmile Creek indicated continued severe impairment that was documented in 1985. With the exception of RM 0.1/.02 which demonstrated a moderate increase in community performance from very poor to poor, it appears that Sixmile Creek does not support a resident fish community (Figure 26). The IBI ADV statistics for 1985 and 1991 demonstrated a small improvement in the interim. The IBI ADV/mile decreased from 73.3 in 1985 to 66.8 in 1991. It is important to note, however, that these values were significantly higher than those of other streams evaluated in 1991.

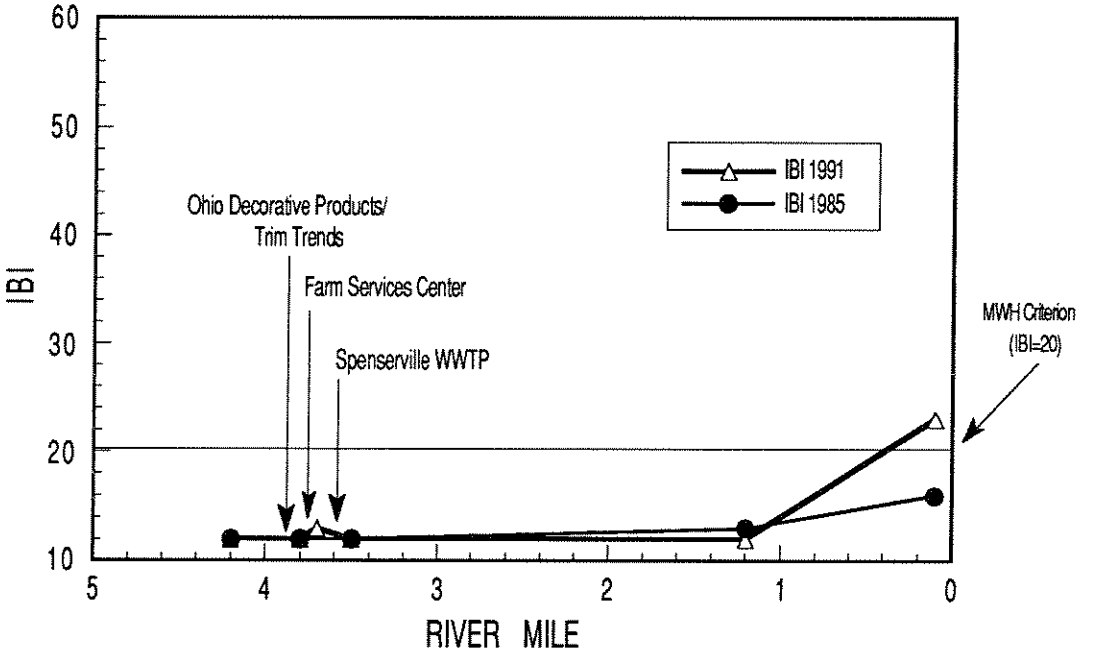

Figure 26. Longitudinal trend of the Index of Biotic Integrity (IBI) in the Sixmile Creek study area, 1985 and 1991.

Flatrock Creek

Changes in Biological Community Performance: 1985- 1991

- Ohio EPA evaluated one site, RM 2.8, to determine fish community performance during a 1984 survey of the upper Maumee River watershed. In comparison to the 1991 survey results, this site demonstrated little change in biological community performance. The discharge of municipal, industrial and agricultural wastes has resulted in numerous episodic fish kills over the past twenty years (ODNR1969-90; Clark and Allison 1966). Reported fish kills as a result of discharges from the Payne and Paulding WWTPs have decreased in frequency and severity, but still persist on an annual basis and demonstrate the inadequacies of the current treatment facilities.

- The MIwb ADV greatly exceeded the IBI ADV (MIwb ADV=875, IBI ADV=160). This result indicates that over the length of the study area the variety of fish species present were functionally relatively typical of a HELP fish community, however, the biomass and numbers of fish were depressed apparently due to the siltation that predominated at most of the sampling locations.

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Appendix Tables

Appendix Table 1. Results (mean/maximum-minimum)[a] of chemical/physical sampling in the Auglaize River study area during July-September, 1991. All conventional parameters are reported in mg/l; all metals and other substances are reported in ug/l, unless otherwise noted.

River Mile (n)	Dissolved Oxygen	Temperature (°C)	pH (S.U.)	Tot. Susp. Solids
AUGLAIZE RIVER				
87.5(6)	5.9(3.9- 7.2)	21.9(19.5-25.7)	8.1(7.5-8.5)	38(17- 77)
85.5(6)	6.5(5.3- 8.3)	24.1(22.5-27.2)	8.1(7.7-8.3)	27(8- 46)
Wapakoneta WWTP(6)	6.5(4.2- 7.7)	23.1(22.0-24.2)	7.6(7.3-8.0)	7(5- 12)
85.1(6)	8.0(7.2- 8.7)	23.5(22.5-25.0)	7.8(7.6-8.1)	8(5- 16)
84.3(6)	6.6(4.0- 8.3)	22.8(20.5-26.5)	7.9(7.6-8.1)	14(6- 25)
80.5(6)	9.1(6.3-12.1)	22.7(20.0-27.0)	8.4(7.9-8.7)	53(38- 85)
67.0(6)	8.3(6.4-10.0)	23.3(20.0-27.0)	8.4(8.1-8.7)	36(25- 62)
63.1(6)	5.8(3.6- 7.2)[b]	22.5(21.0-25.5)[b]	7.9(7.6-8.1)[b]	80(5-258)
60.4(6)	4.0(2.6- 5.6)[b]	21.7(19.8-24.5)[b]	7.8(7.6-8.0)[b]	76(45-134)
58.2(6)	7.0(5.1- 9.3)[b]	22.3(20.1-26.0)[b]	8.1(7.7-8.4)[b]	58(36- 78)
39.6(6)	5.4(4.2- 6.8)[b]	22.1(19.5-24.0)[b]	8.1(7.9-8.5)[b]	77(58- 95)
28.5(6)	5.7(4.7- 6.6)[b]	22.8(20.0-26.0)[b]	8.0(7.6-8.4)[b]	87(62-112)

River Mile (n)	Specific Conductance	BOD5	COD	Total Phosphorus
AUGLAIZE RIVER				
87.5(6)	648[e]	2.8(1.4- 4.6)	20(10-39)	0.14(0.12-0.16)
85.5(6)	1610[e]	4.1(3.5- 5.2)	20(12-29)	0.11(0.08-0.15)
Wapakoneta WWTP(6)	1560[e]	1.6(1.0- 2.9)	25(19-33)	0.40(0.22-0.67)
85.1(6)	1580[e]	2.2(1.4- 3.3)	26(15-35)	0.31(0.14-0.49)
84.3(6)	1570[e]	2.8(1.5- 3.8)	21(17-25)	0.26(0.09-0.57)
80.5(6)	1500[e]	4.6(3.0- 6.5)	24(11-32)	0.20(0.15-0.27)
67.0(6)	1510[e]	3.4(2.2- 4.8)	25(15-34)	0.64(0.12-3.02)
63.1(6)	1129(854-1340)[b]	4.6(3.0- 5.5)	25(12-35)	0.29(0.21-0.37)
60.4(6)	1246(1100-1390)[b]	3.5(2.0- 4.9)	21(14-40)	0.41(0.24-0.84)
58.2(6)	1278(1140-1370)[b]	4.0(2.2- 6.7)	24(15-29)	0.31(0.10-0.48)
39.6(6)	1126(921-1330)[b]	5.6(3.0-13.0)	23(15-31)	0.26(0.05-0.46)
28.5(6)	1225(876-1590)[b]	4.2(2.0- 6.7)	25(17-34)	0.34(0.05-0.61)

[a] Mean values are calculated using detection limits as the minimum value where reported minimum was less than detection limit.
[b] n<6 samples
[c] n=3 samples
[d] n=2 samples
[e] n=1 sample

Appendix Table 1 cont.

River Mile (n)	Nitrate-Nitrite (N)	Nitrite (N)	Ammonia-N	Tot. Kjeldahl Nitrogen
AUGLAIZE RIVER				
87.5(6)	0.70(0.10- 2.10)	0.03(0.02-0.05)	0.05(0.05-0.05)	0.5(0.4-0.7)
85.5(6)	0.71(0.10- 3.52)	0.02(0.02-0.03)	0.05(0.05-0.05)	0.6(0.4-0.7)
Wapakoneta WWTP(6)	8.21(4.91-16.00)[b]	0.04(0.02-0.09)	0.15(0.05-0.66)	1.2(0.9-1.6)
85.1(6)	5.46(2.69-12.10)	0.03(0.02-0.08)	0.05(0.05-0.05)[b]	0.8(0.2-1.2)
84.3(6)	4.07(1.12-10.90)	0.05(0.02-0.11)	0.45(0.05-1.99)	1.4(0.9-3.0)
80.5(6)	0.73(0.17- 1.35)	0.03(0.02-0.04)	0.05(0.05-0.05)	0.8(0.5-1.1)
67.0(6)	0.13(0.10- 0.26)	0.02(0.02-0.02)	0.05(0.05-0.05)	0.6(0.2-0.8)
63.1(6)	0.54(0.10- 2.50)	0.03(0.02-0.08)	0.06(0.05-0.11)	0.6(0.5-0.8)
60.4(6)	0.37(0.10- 1.34)	0.04(0.02-0.06)	0.15(0.05-0.38)	0.7(0.5-1.1)
58.2(6)	0.27(0.10- 0.66)	0.03(0.02-0.05)	0.06(0.05-0.11)	0.6(0.3-1.0)
39.6(6)	0.63(0.10- 1.88)	0.03(0.02-0.05)	0.05(0.05-0.07)	0.6(0.2-1.1)
28.5(6)	1.05(0.27- 2.60)	0.04(0.03-0.07)	0.10(0.05-0.17)	0.8(0.6-0.9)

River Mile (n)	Hardness (CaCO3)	Total Calcium	Total Magnesium	Lab pH (S.U.)
AUGLAIZE RIVER				
87.5(6)	325(290-342)	73(65- 76)	35(29-38)	7.99(7.25-8.24)
85.5(6)	563(384-705)	129(88-162)	59(40-73)	7.97(7.32-8.22)
Wapakoneta WWTP(6)	195(173-240)	48(43- 58)	19(16-23)	7.56(7.12-7.78)
85.1(6)	281(210-389)	66(51- 90)	28(20-40)	7.79(7.25-8.03)
84.3(6)	381(327-515)	87(75-117)	40(34-54)	7.84(7.22-8.08)
80.5(6)	351(339-365)	79(73- 82)	37(34-39)	8.15(7.43-8.53)
67.0(6)	355(290-421)	73(60- 85)	42(34-52)	8.11(7.56-8.45)
63.1(6)	321(239-383)	68(51- 81)	37(27-44)	7.97(7.73-8.22)[b]
60.4(6)	372(313-411)	81(66- 91)	41(36-47)	7.89(7.73-8.05)[b]
58.2(6)	359(331-422)	77(72- 90)	40(36-48)	8.14(7.89-8.47)[b]
39.6(6)	352(314-448)	79(69- 97)	38(32-50)	8.23(7.97-8.68)[b]
28.5(6)	348(302-425)	83(73-101)	34(29-42)	7.89(7.21-8.30)[b]

[a] Mean values are calculated using detection limits as the minimum value where reported minimum was less than detection limit.
[b] n<6 samples
[c] n=3 samples
[d] n=2 samples
[e] n=1 sample

Appendix Table 1 cont.

River Mile (n)	Total Aluminum	Total Cadmium	Total Chromium	Total Copper
AUGLAIZE RIVER				
87.5(6)		0.2(0.2-0.2)	30(30-30)	10(10-10)
85.5(6)		0.2(0.2-0.2)	30(30-30)	10(10-10)
Wapakoneta WWTP(6)		0.2(0.2-0.4)	30(30-30)	10(10-10)
85.1(6)		0.2(0.2-0.2)	30(30-30)	10(10-10)
84.3(6)		0.2(0.2-0.2)	30(30-30)	10(10-10)
80.5(6)		0.2(0.2-0.2)	30(30-30)	10(10-10)
67.0(6)		0.2(0.2-0.2)	30(30-30)	10(10-10)
63.1(6)	3568(760-12500)	0.2(0.2-0.2)	30(30-30)	11(10-15)
60.4(6)	2903(1640- 5080)	0.2(0.2-0.2)	30(30-30)	10(10-10)
58.2(6)	2423(1470- 3660)	0.2(0.2-0.2)	30(30-30)	10(10-10)
39.6(6)	2492(1940- 3040)	0.2(0.2-0.2)	30(30-30)	10(10-10)
28.5(6)	2935(1960- 3780)	0.2(0.2-0.2)	30(30-30)	10(10-10)

River Mile (n)	Total Iron	Total Lead	Total Nickel	Total Zinc
AUGLAIZE RIVER				
87.5(6)	1570(790-2260)	2(2-2)	40(40-40)	14(10-30)
85.5(6)	1157(780-1930)	2(2-2)	40(40-40)	14(10-25)
Wapakoneta WWTP(6)	1227(480-2480)	2(2-2)	40(40-40)	22(10-40)
85.1(6)	1002(440-1930)	2(2-4)	40(40-40)	18(10-45)
84.3(6)	537(350- 840)	2(2-2)	40(40-40)	17(10-30)
80.5(6)	1847(1360-2370)	2(2-2)	40(40-40)	13(10-15)
67.0(6)	1468(1040-2720)	2(2-2)	40(40-40)	12(10-15)
63.1(6)	4195(1760-13900)	3(2-6)	40(40-40)[b]	19(10-55)
60.4(6)	3477(1920- 6280)	2(2-3)	40(40-40)	18(10-30)
58.2(6)	2742(1590- 4180)	2(2-2)	42(40-50)	56(10- 270)
39.6(6)	2910(2260- 3630)	2(2-4)	40(40-40)	219(10-1220)
28.5(6)	3338(2290- 4240)	3(2-3)	40(40-40)	70(15- 315)

[a] Mean values are calculated using detection limits as the minimum value where reported minimum was less than detection limit.
[b] n<6 samples
[c] n=3 samples
[d] n=2 samples
[e] n=1 sample

Appendix Table 1 cont.

River Mile (n)	Fecal Coliform (#/100 ml)	Total Residual Chlorine
AUGLAIZE RIVER		
87.5(6)	273(170- 350)[c]	
85.5(6)	433(210- 590)[c]	
Wapakoneta WWTP(6)	307(250- 420)[c]	0.46(0.30-0.65)
85.1(6)	177(70- 260)[c]	
84.3(6)	780(340-1500)[c]	
80.5(6)	456(198- 590)[c]	
67.0(6)	706(126- 400)[c]	
63.1(6)	187(140- 260)[c]	
60.4(6)	367(160- 560)[c]	
58.2(6)	107(10- 180)[c]	
39.6(6)	310(220- 400)[d]	
28.5(6)	1015(330-1700)[d]	

River Mile (n)	Dissolved Oxygen	Temperature (°C)	pH (S.U.)	Tot. Susp. Solids
SIXMILE CREEK				
4.2(6)	6.0(4.5-9.5)[b]	20.0(18.0-21.5)[b]	7.8(7.5-8.1)[b]	63(16-192)
3.9(6)	4.0(0.3-6.6)[b]	21.1(20.0-22.0)[b]	8.0(7.4-8.7)[b]	38(8-100)
3.6(6)	4.7(3.2-5.9)[b]	20.9(20.0-22.0)[b]	7.6(7.2-7.8)[b]	21(7- 64)
1.2(6)	5.3(4.3-6.0)[b]	19.8(18.0-21.5)[b]	7.8(7.4-8.1)[b]	20(5- 56)
0.2(6)	6.0(5.6-6.5)[b]	19.6(17.5-21.0)[b]	7.7(7.3-7.9)[b]	23(8- 82)
MIAMI-ERIE CANAL (prior to mixing with Sixmile Cr)				
(6)	5.8(5.4-6.2)[b]	20.1(17.5-21.4)[b]	7.9(7.6-8.1)[b]	11(7- 17)
PUSHETA CREEK				
0.3(6)	7.6(6.5-8.9)[b]	22.3(19.5-26.0)[b]	8.0(7.7-8.3)[b]	31(8- 53)

[a] Mean values are calculated using detection limits as the minimum value where reported minimum was less than detection limit.
[b] n<6 samples
[c] n=3 samples
[d] n=2 samples
[e] n=1 sample

Appendix Table 1 cont.

River Mile (n)	Specific Conductance	Total BOD5	COD	Phosphorus
SIXMILE CREEK				
4.2(6)	1447(436-2220)[b]	6.9(1.2-30.0)	27(10- 40)	0.39(0.20-0.55)
3.9(6)	2284(609-3640)[b]	16.2(2.4-44.0)	67(14-164)	1.52(0.10-7.20)
3.6(6)	2140(781-2990)[b]	17.1(1.5-44.0)	70(23-182)	2.44(1.66-3.51)
1.2(6)	1777(533-2410)[b]	3.8(1.9- 5.5)	23(18- 28)	1.34(0.62-1.84)[b]
0.2(6)	1729(463-2420)[b]	4.1(1.6- 6.2)	26(14- 33)	1.31(0.67-1.90)
MIAMI-ERIE CANAL (prior to mixing with Sixmile Cr)				
(6)	510(438- 591)[b]	3.7(1.4- 7.8)	35(22- 50)	0.29(0.11-0.53)
PUSHETA CREEK				
0.3(6)	1640[e]	2.6(1.7- 5.0)	22(14- 27)	0.14(0.07-0.40)

River Mile (n)	Nitrate-Nitrite (N)	Nitrite (N)	Ammonia (N)	Tot. Kjeldahl Nitrogen
SIXMILE CREEK				
4.2(6)	1.59(0.16- 5.17)	0.09(0.03-0.15)	0.22(0.05-0.63)	1.2(0.4- 2.7)
3.9(6)	2.18(0.69- 5.03)	0.16(0.02-0.3)	0.38(0.08-0.62)	1.4(0.8- 2.0)
3.6(6)	4.53(0.33-13.00)	0.47(0.02-1.63)	1.96(0.08-6.68)	6.3(1.8-19.8)
1.2(6)	3.30(1.77- 5.05)	0.43(0.09-1.15)	1.52(0.13-5.89)	2.4(1.1- 7.0)
0.2(6)	3.29(1.22- 4.25)	0.27(0.07-0.64)	1.43(0.06-6.25)	2.2(0.8- 7.3)
MIAMI-ERIE CANAL (prior to mixing with Sixmile Creek)				
(6)	0.34(0.10- 1.16)	0.03(0.02-0.07)	0.12(0.05-0.38)	1.1(0.8- 1.6
PUSHETA CREEK				
0.3(6)	0.57(0.10- 2.68)	0.03(0.02-0.06)	0.05(0.05-0.05)	0.9(0.5- 1.1)

River Mile (n)	Hardness (CaCO3)	Total Calcium	Total Magnesium	Lab pH (S.U.)
SIXMILE CREEK				
4.2(6)	473(206- 682)	116(56-166)	45(16-67)	7.87(7.70-8.14)[b]
3.9(6)	797(271-1060)	218(69-350)	61(24-87)	7.83(7.63-8.09)[b]
3.6(6)	623(272- 841)	145(66-200)	63(26-83)	7.56(7.40-7.73)[b]
1.2(6)	570(181- 849)	133(46-195)	58(16-88)	7.80(7.59-7.99)[b]
0.2(6)	562(167- 836)	131(42-188)	57(15-89)	7.82(7.62-7.94)[b]
MIAMI-ERIE CANAL (prior to mixing with Sixmile Cr)				
(6)	176(142- 196)	38(24- 44)	20(15-22)7.87	(7.80-7.99)[b]
PUSHETA CREEK				
0.3(6)	356(335-373)	75(67- 85)	41(38-44)	7.80(7.31-8.10)

Appendix Table 1 cont.

River Mile (n)	Total Aluminum	Total Cadmium	Total Chromium	Total Copper
SIXMILE CREEK				
4.2(6)	4010(260-18200)	0.2(0.2-0.2)	30(30-30)	13(10-30)
3.9(6)	2227(380- 8760)	0.2(0.2-0.2)	30(30-30)	15(10-30)
3.6(6)	972(200- 4090)	0.5(0.2-2.0)	30(30-30)	11(10-15)
1.2(6)	935(210- 3130)	0.2(0.2-0.2)	32(30-40)	10(10-10
0.2(6)	1207(280- 4710)	0.2(0.2-0.2)	30(30-30)	10(10-10)
MIAMI-ERIE CANAL (prior to mixing with Sixmile Cr)				
(6)	498(310-690)	0.2(0.2-0.2)	32(30-40)	10(10-10)
PUSHETA CREEK				
0.3(6)	0.2(0.2-0.2)	30(30-30)	10(10-10)	

River Mile (n)	Total Iron	Total Lead	Total Nickel	Total Zinc
SIXMILE CREEK				
4.2(6)	6258(400-28600)	5(2-12)	42(40-50)	50(10-125)
3.9(6)	2978(380-12600)	4(2- 7)	45(40-70)	45(10- 95)
3.6(6)	1365(330- 5430)	3(2- 6)	40(40-40)	43(20- 80)
1.2(6)	1368(450- 3680)	2(2- 2)	40(40-40)	20(10- 45)
0.2(6)	1645(660- 5640)	2(2- 4)	40(40-40)	47(10-160)
MIAMI-ERIE CANAL (prior to mixing with Sixmile Cr)				
(6)	1047(820- 1400)	2(2- 2)	42(40-50)	161(10-640)
PUSHETA CREEK				
0.3(6)	2275(1200- 3990)	2(2- 2)	40(40-40)	25(10- 80)

River Mile (n)	Fecal Coliform (#/100 ml)
SIXMILE CREEK	
4.2(3)	2050(500- 4700)
3.9(3)	5100(2000-11000)
3.6(3)	673(10- 2000)
1.2(3)	1107(620- 1400)
0.2(3)	527(500-550)
MIAMI-ERIE CANAL (prior to mixing with Sixmile Cr)	
0.00(3)	330(250-410)
PUSHETA CREEK	
0.3(3)	1617(400- 3750)

Appendix Table 1 cont.

River Mile (n)	Dissolved Oxygen	Temperature (_C)	pH (S.U.)	Tot. Susp. Solids
FLATROCK CREEK				
28.94(6)	4.8(3.3- 7.4)	22.1(19.0-26.0)	7.9(7.7-8.3)	53(42- 62)[b]
26.07(6)	3.9(2.4- 5.5)	22.3(19.0-26.0)	7.7(7.1-7.9)	20(10- 30)[b]
23.72(6)	5.9(5.3- 7.2)	21.9(18.7-26.0)	7.8(7.5-8.4)	65(35- 85)[b]
18.25(6)	4.1(3.2- 5.4)	22.2(19.4-26.0)	7.7(7.2-8.1)	61(24-125)
13.80(6)	4.4(1.5- 6.3)	22.4(19.5-25.0)	7.6(7.2-7.9)	43(8-108)
9.60(6)	3.9(1.9- 6.5)	22.5(18.9-26.0)	7.7(7.4-8.2)	50(9-157)[b]
8.13(6)	4.2(1.8- 8.0)	22.5(19.7-26.0)	8.0(7.5-8.7)	39(9-126)
6.02(6)	7.7(2.0-14.8)	23.1(20.7-26.0)	8.4(7.9-9.3)	47(14- 97)
2.68(6)	6.1(3.6- 8.9)	22.6(19.9-25.5)	8.2(7.9-8.6)	80(29-244)
OPOSSUM RUN				
0.37(6)	10.8(8.2-15.6)	24.4(21.3-28.0)	8.5(8.1-9.0)	18(11- 30)

River Mile (n)	Specific Conductance	BOD5	COD	Total Phosphorus
FLATROCK CREEK				
28.94(6)	726(641- 790)	3.8(1.8- 5.2)[b]	24(16- 31)	0.14(0.10-0.24)
26.07(6)	683(590- 768)	6.0(2.1-12.0)[b]	26(13- 34)	0.38(0.08-0.93)
23.72(6)	944(486-1670)	4.2(1.8- 5.8)[b]	24(16- 34)	0.40(0.14-0.97)
18.25(6)	662(397- 801)	4.2(2.5- 6.6)[b]	28(19- 32)	0.26(0.14-0.39)
13.80(6)	928(533-2020)	2.9(1.3- 3.8)[b]	23(13- 30)	0.2(0.09-0.43)
9.60(6)	600(483- 740)	3.0(1.7- 4.5)[b]	26(18- 32)	0.37(0.17-1.13)
8.13(6)	744(547- 862)	10.0(4.0-18.0)[b]	40(19- 84)	0.99(0.51-1.60)
6.02(6)	822(550-1060)	10.6(4.0-18.0)[b]	38(18- 67)	1.09(0.22-1.68)
2.68(6)	757(559- 952)	5.6(3.7- 8.1)[b]	30(20- 37)	0.50(0.23-0.81)
OPOSSUM RUN				
0.37(6)	1413(1030-1700)	7.8(1.3-26.0)[b]	35(14-128)	0.23(0.06-0.62)

[a] Mean values are calculated using detection limits as the minimum value where reported minimum was less than detection limit.
[b] n<6 samples
[c] n=3 samples
[d] n=2 samples
[e] n=1 sample

Appendix Table 1 cont.

River Mile (n)	Nitrate-Nitrite (N)	Nitrite (N)	Ammonia-N	Tot. Kjeldahl Nitrogen
FLATROCK CREEK				
28.94(6)	0.89(0.10-4.39)	0.03(0.02-0.08)[b]	0.07(0.05-0.15)	0.7(0.6-0.8)
26.07(6)	1.24(0.10-4.29)	0.04(0.02-0.10)[b]	0.27(0.05-0.63)	1.2(0.6-1.8)
23.72(6)	2.19(0.10-4.26)	0.09(0.02-0.16)[b]	0.09(0.05-0.2)	1.0(0.6-1.3)
18.25(6)	1.54(0.10-7.65)	0.03(0.02-0.05)[b]	0.15(0.05-0.36)	0.8(0.6-1.0)
13.80(6)	0.90(0.10-4.04)	0.03(0.02-0.06)[b]	0.28(0.05-1.10)	0.9(0.5-1.6)
9.60(6)	1.24(0.10-5.45)	0.05(0.02-0.14)[b]	0.16(0.05-0.30)	0.8(0.6-1.1)
8.13(6)	1.48(0.10-4.65)	0.07(0.02-0.13)[b]	0.95(0.23-2.07)	3.0(0.8-5.4)
6.02(6)	0.70(0.10-3.50)	0.07(0.02-0.14)[b]	1.08(0.05-2.90)	2.9(0.7-5.2)
2.68(6)	0.82(0.10-2.76)	0.04(0.02-0.12)[b]	0.20(0.05-0.69)	1.3(0.6-1.9)
OPOSSUM RUN				
0.37(6)	0.76(0.10-3.92)	0.04(0.02-0.10)[b]	0.56(0.05-2.08)	1.2(0.5-2.6)

River Mile (n)	Hardness (CaCO3)	Total Calcium	Total Magnesium	Lab pH (S.U.)
FLATROCK CREEK				
28.94(6)	305(270-355)	83(75- 96)	24(20- 28)	8.00(7.80-8.32)[b]
26.07(6)	249(173-274)	68(48- 76)	20(13- 23)	7.82(7.68-8.00)[b]
23.72(6)	284(233-333)	76(67- 85)	23(16- 33)	8.09(7.76-8.41)[b]
18.25(6)	250(188-285)	68(54- 78)	19(13- 22)	7.93(7.69-8.11)[b]
13.80(6)	258(222-324)	68(61- 87)	21(17- 26)	7.81(7.68-7.96)[b]
9.60(6)	237(185-326)	64(51- 81)	19(14- 30)	7.81(7.65-8.10)[b]
8.13(6)	240(208-254)	62(57- 68)	21(16- 24)	8.07(7.82-8.39)[b]
6.02(6)	229(170-266)	59(45- 72)	20(14- 25)	8.20(7.93-8.57)[b]
2.68(6)	239(206-280)	62(53- 76)	20(18- 22)	8.17(7.90-8.42)[b]
OPOSSUM RUN				
0.37(6)	724(488-924)	147(108-172)	87(53-120)	8.24(8.16-8.75)[b]

[a] Mean values are calculated using detection limits as the minimum value where reported minimum was less than detection limit.
[b] n<6 samples
[c] n=3 samples
[d] n=2 samples
[e] n=1 sample

Appendix Table 1 cont.

River Mile (n)	Fecal Coliform (#/100 ml)	Total Cadmium	Total Chromium	Total Copper
FLATROCK CREEK				
28.94(6)	1090(50- 2650)[c]	0.2(0.2-0.2)	30(30-30)	10(10-10)
26.07(6)	3750(1700- 5800)[d]	0.2(0.2-0.2)	30(30-30)	11(10-15)
23.72(6)	1940(360- 4900)[c]	0.2(0.2-0.2)	30(30-30)	10(10-10)
18.25(6)	787(60- 1900)[c]	0.2(0.2-0.2)	30(30-30)	10(10-10)
13.80(6)	1276(98- 3500)[c]	0.2(0.2-0.2)	30(30-30)	10(10-10)
9.60(6)	1480(260- 3600)[c]	0.2(0.2-0.2)	30(30-30)	10(10-10)
8.13(6)	1607(420- 3600)[c]	0.2(0.2-0.2)	30(30-30)	10(10-10)
6.02(6)	290(171-360)[c]	0.2(0.2-0.2)	30(30-30)	10(10-10)
2.68(6)	933(370- 2000)[c]	0.2(0.2-0.2)	30(30-30)	10(10-10)
OPOSSUM RUN				
0.37(6)	133070(6200-380000)[c]	0.8(0.2-3.3)	30(30-30)	10(10-10)

River Mile (n)	Total Iron	Total Lead	Total Nickel	Total Zinc
FLATROCK CREEK				
28.94(6)	2463(2030-2980)	2(2-2)	40(40-40)	14(10-20)
26.07(6)	1375(740-2530)	2(2-2)	40(40-40)	20(10-65)
23.72(6)	3295(2350-5070)	2(2-2)	40(40-40)	17(10-30)
18.25(6)	3290(1260-8970)	3(2-6)	40(40-40)	18(10-50)
13.80(6)	2041(400-6810)	2(2-2)	40(40-40)	17(10-30)
9.60(6)	3068(520-8550)	3(2-7)	40(40-40)	20(10-35)
8.13(6)	1895(490-7280)	2(2-3)	40(40-40)	18(10-40)
6.02(6)	2317(660-6600)	3(2-5)	40(40-40)	18(10-40)
2.68(6)	2995(490-9270)	2(2-2)	40(40-40)	31(10-75)
OPOSSUM RUN				
0.37(6)	1082(410-2930)	2(2-4)	40(40-40)	38(10-85)

[a] Mean values are calculated using detection limits as the minimum value where reported minimum was less than detection limit.
[b] n<6 samples
[c] n=3 samples
[d] n=2 samples
[e] n=1 sample

Appendix Table 2. Summary of D.O.(mg/l) data recorded with continuous monitors at 6 locations in the Auglaize River in the Wapakoneta area, 17 July through 19 July, 1991.

River Mile	Total Hours	Mean (mg/l)	Median (mg/l)	Minimum (mg/l)	Maximum (mg/l)	25th %ile (mg/l)	75th %ile (mg/l)
Auglaize River							
87.5	45	4.27‡	4.21‡	3.07‡‡	5.82	3.56‡‡	4.95‡
83.3	43	5.15	5.36	3.15‡‡	7.27	4.69‡	5.84
82.4	43	4.77‡	4.55‡	2.60‡‡	8.60	3.80‡‡	5.85
80.5	44	5.96	5.48	4.48‡	9.22	4.74‡	7.15
77.5	40	4.09‡	3.6‡‡	2.74‡‡	6.42	3.28‡‡	4.81‡
Pusheta Creek							
0.3	43	8.96	9.04	5.11	12.84	6.82	10.38

Appendix Table 3. Summary of D.O.(mg/l) data recorded with continuous monitors at 9 locations in the Sixmile Creek area, 9 July through 11 July, 1991.

River Mile	Total Hours	Mean (mg/l)	Median (mg/l)	Minimum (mg/l)	Maximum (mg/l)	25th %ile (mg/l)	75th %ile (mg/l)
Auglaize River							
63.1	44	5.56‡‡	4.63‡‡	2.81‡‡	12.23	3.70‡‡	6.79
Sixmile Creek							
3.9	45	7.80	7.62	6.16	9.27	7.09	8.64
3.6	46	7.59	7.56	7.34	8.00	7.40	7.72
1.2	44	3.67‡‡	3.67‡‡	3.49‡‡	3.97‡‡	3.64‡‡	3.70‡‡
0.2	44	4.73‡	4.77‡	4.29‡	5.18	4.61‡	4.87‡
Auglaize River							
60.4	42	3.85‡‡	3.47‡‡	2.74‡‡	5.68‡‡	3.00‡‡	4.94‡‡
58.2	43	5.93‡‡	5.73‡‡	4.34‡‡	8.09	4.75‡‡	7.09
39.6	41	10.24	9.45	6.28	16.16	7.19	12.64
Miami-Erie Canal							
	46	6.91	4.87‡	2.23‡‡	16.59	2.98‡‡	11.21

‡ violation of the average dissolved oxygen (D.O.) criterion.
‡‡ violation of the minimum dissolved oxygen (D.O.) criterion.
‡‡violation of the "nuisance prevention" minimum dissolved oxygen (D.O.) criterion.

Appendix Table 4. Summary of D.O.(mg/l) data recorded with continuous monitors at 7 locations in Flatrock Creek, 4 September through 6 September, 1991.

River Mile	Total Hours	Mean (mg/l)	Median (mg/l)	Minimum (mg/l)	Maximum (mg/l)	25th %ile (mg/l)	75th %ile (mg/l)
Flatrock Creek							
23.60	43	6.32	6.36	5.17	7.09	5.97	6.67
22.95	31	4.42‡	4.22‡	3.82‡‡	5.66	3.98‡‡	4.80‡
21.50	47	3.53‡‡	3.47‡‡	2.93‡‡	4.51‡	3.14‡‡	3.92‡‡
9.60	44	2.83‡‡	2.46‡‡	1.55‡‡‡	5.65	2.00‡‡	3.52‡‡
8.00	44	1.03‡‡‡	0.73‡‡‡	0.10‡‡‡	4.98‡	0.26‡‡‡	1.51‡‡‡
5.90	42	2.52‡‡	2.38‡‡	1.06‡‡‡	5.75	1.49‡‡‡	2.97‡‡
2.70	41	7.16	7.11	5.10	9.76	5.77	8.03

‡ violation of the average dissolved oxygen (D.O.) criterion.
‡‡ violation of the minimum dissolved oxygen (D.O.) criterion.
‡‡‡violation of the "nuisance prevention" minimum dissolved oxygen (D.O.) criterion