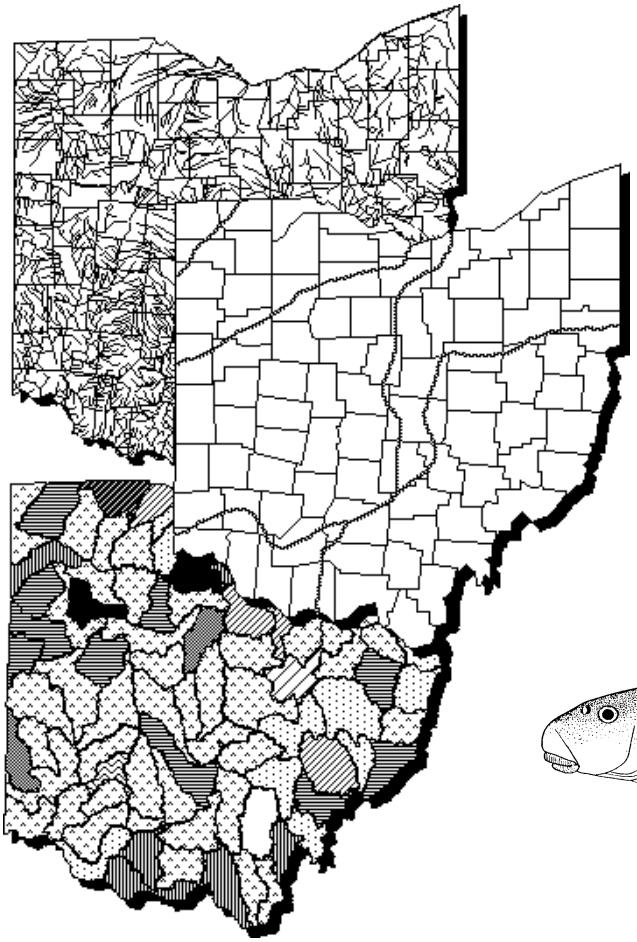
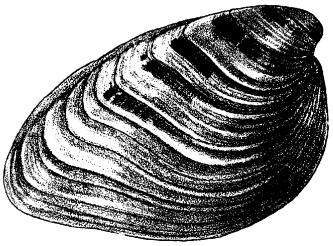
State of Ohio
Environmental Protection Agency

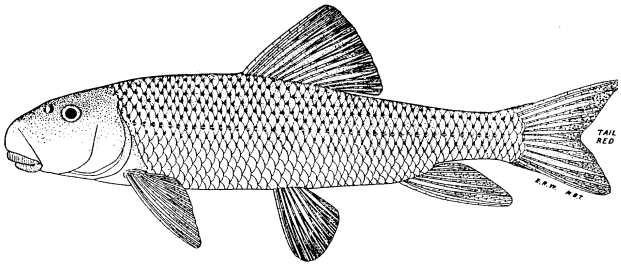
Ecological Assessment Section
Division of Surface Water

Biological and Water Quality Study of the St. Joseph River and Selected Tributaries

Williams and Defiance Counties, Ohio







January 13, 1994

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

Biological and Water Quality Study of the St. Joseph River and Selected Tributaries

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OEPA Technical Report EAS/1993-12-7

prepared by

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Division of Surface Water
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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. 1990a. 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 -DSW
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Acknowledgements

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Biological and Water Quality Survey of the St. Joseph River and selected tributaries (Williams and Defiance Counties, Ohio)

Ohio Environmental Protection Agency
Division of Surface Water
1800 WaterMark Drive
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Introduction

As part of the five year basin approach for National Pollution Discharge Elimination System (NPDES) permitting process, chemical, physical, and biological sampling was conducted within the St. Joseph River and selected tributaries. The 1992 St. Joseph River study area included the St. Joseph River mainstem, West Branch St. Joseph River, Fish Creek, Bear Creek, and Silver Creek. In addition, the results from a mini-biosurvey conducted in 1991 within Bear Creek and Fish Creek were incorporated into this document.

Specific objectives of this survey were to:

1) monitor and assess chemical, physical, and biological integrity of the surface waters within the study area;

2) evaluate potential chemical, physical, and biological impacts to the St. Joseph River mainstem from the Edgerton WWTP and Edgerton Metal Products Inc.; and,

3) determine the attainment status of current aquatic life and non-aquatic life use designations, and to verify the appropriateness of existing use designations.

The findings of this evaluation may factor into regulatory actions taken by Ohio EPA (*e.g.* NPDES permits, Directors 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 document, and the biennial Ohio Water Resource Inventory (305[b] report).

Summary

St. Joseph River

The 1992 St. Joseph River mainstem study area extended from River Mile (RM) 81.5 (upstream of Montpelier WWTP) to RM 47.2 (near Ohio/Indiana state line). Chemical, physical, and biological sampling was conducted at 15 sampling stations, between June and September, 1992. The sampling effort included a total of 34.3 river miles. PARTIAL attainment of the Warmwater Habitat (WWH) use designation was observed throughout the entire study reach of the St. Joseph River mainstem (34.3 river miles).

The predominant cause of PARTIAL attainment of warmwater habitat biological criteria throughout the St. Joseph River was the failure of the fish community to perform at WWH levels. This appeared to be mostly related to submarginal habitat. Chemical water quality throughout the study area was characterized as good to fair. The only violation of water quality standards encountered during the 1992 sampling effort was an exceedence of the primary contact recreation fecal coliform criterion at RM 81.2 (upstream Montpelier WWTP). This exceedence was likely related to agricultural nonpoint sources, given the high river flows encountered throughout the study area in mid-July, 1992. All other parameters from the water column chemistry samples were well within water quality standards.

Sediment samples were collected from three stations within the St. Joseph River and were analyzed for heavy metal and organic contamination. The sediment metal scan revealed one highly elevated concentration of zinc at RM 50.8 (downstream of Edgerton Metal Products Inc.). The remaining analysis yielded metal concentrations that were either non-elevated or slightly elevated. Sediment organic scans indicated a slightly elevated concentration of DDT (and degradation products) at RM 49.8. Given the prevailing agricultural land use within the basin, the occurrence of DDT and other organochlorine pesticides within the St. Joseph River sediments was likely related to past agricultural applications. The remaining organic parameters where either below detection limits or observed concentrations were judged not elevated.

The benthic macroinvertebrate fauna was characterized as good to exceptional, meeting or exceeding WWH biological criteria at every station within the St. Joseph River mainstem. Habitat influences (primarily siltation and embedding of coarse substrates) were manifest within the benthic macroinvertebrate samples; however, performance within the benthic fauna was not significantly impaired by submarginal habitat. The benthic fauna within the St. Joseph River was indicative of good to excellent water quality. The condition of the benthic community did not suggest any impacts associated with nutrient and/or organic enrichment from point and nonpoint sources.

The fish assemblage within the St. Joseph River mainstem was much more indicative of marginal habitat quality. Past channel modification, maintenance activities, and low gradient coupled with the delivery of clayey silts from agricultural nonpoint sources has resulted in a heavy bedload of sediment, siltation, and modest channel heterogeneity. As a consequence of the present condition of instream habitats significant components of the fish community were diminished. Though performance at a poor or very poor level was not observed, the fish community throughout the study area remained fair, failing to fully achieve applicable WWH biological criteria. These results were typical of those associated with habitat impacts.

Within the biological community (benthic macroinvertebrate and fish assemblages) PARTIAL attainment of WWH biological criteria within the St. Joseph River mainstem was driven by the fair performance within the fish assemblage. A summary of aquatic life use attainment status for all biological sampling stations within the St. Joseph River study area can be found in Table 1.

Table 1. Aquatic life use attainment status for the Warmwater Habitat (WWH) use designation in the St. Joseph River study area, based on data collected between July and September 1992.

RIVER MILE Fish/Invert.	IBI	Modified Iwb	ICI[a]	QHEI	Attainment Status	Comment
St. Joseph River (1992)						
Eastern Corn Belt Plains WWH Use Designation (Existing)						
81.2/81.2	34*	7.2*	Good	63.0	PARTIAL	
73.1/73.1	29*	7.9*	42	58.0	PARTIAL	Dst Montpelier WWTP
62.0/62.1	32*	7.7*	42	75.5	PARTIAL	
57.0/56.8	30*	7.1*	48	57.0	PARTIAL	
51.9/51.4	29*	7.2*	48	54.0	PARTIAL	Dst Edgerton WWTP
50.8/50.8	27*	7.0*	42	60.0	PARTIAL	Dst Edgerton Metals Inc.
49.8/49.8	31*	6.7*	Good	33.0	PARTIAL	
47.2/47.3	30*	6.6*	48	58.0	PARTIAL	
Fish Creek (1992)						
Eastern Corn Belt Plains WWH Use Designation (Existing)						
30.5/30.5	44	N/A	Fair	42.5	PARTIAL	
Eastern Corn Belt Plains WWH Use Designation (Existing)/EWH (Recommended)						
5.4/5.4	46	9.3	50	75.0	FULL/FULL	Exceptional
Eastern Corn Belt Plains WWH Use Designation (Existing)						
0.2/0.3	42	7.6*	G	69.5	PARTIAL	
Fish Creek (1991)						
Eastern Corn Belt Plains WWH Use Designation (Existing)/EWH (Recommended)						
5.4/5.4	56	-	E	65.5	FULL/FULL	Exceptional
Bear Creek (1992)						
Eastern Corn Belt Plains WWH Use Designation (Existing)						
0.5/0.5	31*	6.9*	Very Good	74.0	PARTIAL	Recovering
Bear Creek (1991)						
Eastern Corn Belt Plains WWH Use Designation (Existing)/MWH (Recommended)						
4.2/4.2	26*	N/A	MG	42.5	**NON**/FULL	Channelized, recovering
2.4/2.4	22*	N/A	G	51.5	**NON**/FULL	Channelized, recovering
Eastern Corn Belt Plains WWH Use Designation (Existing)						
0.5/0.5	28*	N/A	G	65.5	PARTIAL	Recovering

Table 1. Continued.

RIVER MILE Fish/Invert.	IBI	Modified Iwb	ICI[a]	QHEI	Attainment Status	Comment
West Branch St. Joseph River (1992)						
Eastern Corn Belt Plains WWH Use Designation (Existing)						
10.5/10.5	45	8.0 ns	50	73.0	FULL	
3.2/3.2	45	8.8	40	80.0	FULL	Dst Seneca Lake
Silver Creek (1992)						
Eastern Corn Belt Plains WWH Use Designation (Existing)						
1.3/1.3	41	8.2 ns	52	68.5	FULL	

* - Significant departure from applicable biological criterion (≥4 IBI and ICI units or ≥0.5 Iwb units), poor and very poor results are underlined.

ns - Nonsignificant departure from biocriterion (≤4 IBI and ICI units or ≤ 0.5 Iwb units)

a - Narrative evaluation based upon qualitative benthic invertebrate sample.

N/A - Headwater site; Iwb not applicable.

Ecoregional Biological Criteria: Eastern Corn Belt (ECBP)

INDEX - Site Type	WWH	EWH	MWH[b]
IBI-Headwater/Wading	40	50	24
IBI-Boat	42	48	24
MIwb-Wading	8.3	9.4	5.8
MIwb-Boat	8.5	9.6	5.8

b - Modified Warmwater Habitat for channel modified areas

Permitted Entities Evaluated

Edgerton WWTP (RM 52.2)

Analysis of water column chemistry indicated no violations of Ohio water quality standards downstream of the Edgerton WWTP (RM 51.4), all parameters were well within water quality standards. Sediment samples analyzed for heavy metal contamination at RM 51.4 indicated concentrations that ranged between non-elevated and slightly elevated. A Sediment organic scan at this station indicated concentrations of organic contaminants near or below detection limits. The observed concentrations of both sediment metals and organic compounds most likely represented ambient background conditions. The Edgerton WWTP had no discernable effect upon biological community performance within the St. Joseph River. Performance of the benthic invertebrate fauna as measured by the ICI downstream of Edgerton WWTP (RM 51.4) was exceptional, and was unchanged when compared to sampling stations upstream. Fish community performance as measured by the IBI and MIwb was fair, but indicated no significant shifts within the fish community downstream of the Edgerton WWTP. Though the fish assemblage failed to achieve ecoregional expectations at RM 51.9 (IBI=29; MIwb=7.2), this did not appear related to this entity. Rather, fair performance of the fish community appeared more a function of subpar habitat.

Edgerton Metal Products Inc. (RM 50.9)

Analysis of water column chemistry data indicated no violations of Ohio water quality standards downstream from Edgerton Metal Products, Inc. (RM 50.8). Sediment samples downstream of Edgerton Metals indicated that only zinc occurred at highly elevated concentrations. Sediment organic scans at this station indicated concentrations of organic contaminants near or below detection limits. With the exception of the highly elevated zinc, the observed concentrations of both sediment metals and organic parameters likely represented ambient background conditions. Performance within the biological community (benthic invertebrate and fish assemblages) was modestly reduced downstream of Edgerton Metals, Inc., though a direct cause and effect relationship was not demonstrated. The condition of the benthic fauna, though reduced, was within nonsignificant departure of the EWH biological criteria (ICI=42). The performance within the fish assemblage as measured by the IBI and MIwb was modestly reduced in comparison to sampling stations upstream (IBI=27; MIwb=7.0); however, the influence from Edgerton Metals did not appear significant. Submarginal habitat was the most influential factor affecting the fish community.

Fish Creek

Biological, chemical, and physical sampling was conducted at three stations in Fish Creek. The most upstream station was located at RM 30.5. This station represented the headwaters of Fish Creek within Ohio. Two other stations were placed within the lower portion of Fish Creek at RM 5.4 and RM 0.2/0.3. No violations of Ohio water quality standards were documented within the Fish Creek study area. Chemical water quality was characterized as good at all stations.

The fish assemblage at RM 30.5 achieved the applicable WWH biological criteria (IBI=44). However, the performance of the benthic macorinvertebrate fauna was diminished, reflective of moderate nutrient enrichment from agricultural nonpoint sources and modified habitat. As a result of fair performance within the benthic community, PARTIAL attainment of applicable WWH biological criteria was observed.

Within the lower reach of the Fish Creek study area biological community (benthic invertebrate and fish assemblages) performance was considerably improved. FULL attainment of the WWH use designation was observed at RM 5.4 both in 1991 and 1992. The fish and benthic communities were characterized as very good to exceptional, reflective of good water quality, high quality habitat, and ecoregional expectations.

The most downstream sampling station (RM 0.2/0.3) was in PARTIAL attainment of WWH biological criteria. The habitats of this reach were generally of a lower quality than that encountered upstream. Limiting aspects of habitat included: previous channel modification (limited recovery observed), shifting and unstable substrates, and the lack of sustained swift current. During the six-week colonization period, the quantitative benthic macroinvertebrate artificial substrate samplers were buried by sand and pea gravel bedload associated with high river flows encountered in mid-July. This disturbance resulted in an artificially suppressed ICI score (ICI=24), invalidating this sample. In contrast, qualitative samples of the benthic invertebrate community yielded a narrative evaluation of good, and appeared more representative of the condition of the benthic fauna. The fish community was characterized as good/fair. Species richness and functional organization within the fish assemblage was maintained, achieving an IBI score of 42. However, structural components were reduced, which resulted in a lower MIwb value (MIwb=7.6). The fish assemblage appeared to integrate habitat influences. Despite community performance consistent with the WWH biological criteria, as measured by the IBI and the narrative evaluation of benthic invertebrate community, fair performance as measured by the MIwb within the fish community resulted in PARTIAL attainment of WWH biological criteria at this station.

Bear Creek

The only violation of chemical water quality standards encountered during the 1992 sampling effort was an exceedence of the primary contact recreation fecal coliform criterion. This exceedence was likely related to agricultural nonpoint sources, given the high river flows encountered during the sampling effort. All other parameters from the water column chemistry samples were well within water quality standards.

Results from biological surveys performed in 1991-92 indicated that Bear Creek showed much remaining evidence of recent and past channelization. The segment between the headwaters in Edon (RM 8.3) to RM 4.2 appeared to have been channelized within the past 5-10 years. The habitat within this reach was of a very poor quality The segment between RM 4.2 and RM 0.5 also showed evidence of channelization conducted in the late 1950s; however, at RM 0.5 the recovery of natural riverine characteristics appeared to be further along.

NON-attainment of the WWH biological criteria was recorded between RM 4.2 and RM 2.4 in 1991. The principle cause of diminished biological performance was the poor condition of physical habitat within this channel modified reach. PARTIAL attainment of the WWH biological criteria was documented at RM 0.5, in both 1991 and 1992 and appeared habitat related as well. Most significantly, the export of clayey silts and other fine sediments from the highly modified

headwaters. The increased bedload, and resulting accretion, tended to embed coarse substrates and reduce channel depth heterogeneity. Habitat condition appeared to improve (recover) longitudinally (upstream to downstream) which was reflected in the shift from **NON**-attainment within the upper and middle segments, to PARTIAL attainment of the WWH biological criteria within the lower segment.

Villages of Edon and Blakeslee are currently unsewered and deliver on-site treated sanitary waste water directly to Bear Creek. The Village of Edon discharges sanitary waste water through two storm drains that enter Bear Creek at RM 7.9 and RM 7.6. The Village of Blakeslee discharges sanitary waste water through a storm drain that enters Bear Creek at RM 1.2. However, significant nutrient enrichment from these sources was not evident in 1991-92.

West Branch St. Joseph River

FULL attainment of the WWH use designation was observed in 1992 at both sampling stations within the West Branch St. Joseph River (RM 10.5 and RM 3.2). The fish and macroinvertebrate assemblages were reflective of good water quality and the quality of near and instream habitats. The only violation of water quality standards encountered during the 1992 sampling effort was an exceedence of the secondary contact recreation fecal coliform criterion at RM 10.5 (upstream of Seneca Lake). This violation was likely related to agricultural nonpoint sources and the high river flows encountered during the 1992 sampling effort. All other parameters from water column chemistry samples were well within water quality standards.

Silver Creek

FULL attainment of the WWH use designation was observed in 1992 at RM 1.3 within Silver Creek. Fish and macroinvertebrate assemblages reflected good water quality and instream habitats. The only violation of water quality standards encountered during the 1992 sampling effort was an exceedence of the primary contact recreation fecal coliform criterion. As with other fecal coliform exceedences from this study, this violation also appeared to be associated with high river flows and agricultural nonpoint sources. All other water column chemical parameters were well within water quality standards.

Conclusions

St. Joseph River (mainstem)

- No significant impact to the aquatic biological communities was attributed to either the Edgerton WWTP or Edgerton Metal Products Inc.. The benthic macroinvertebrate community within the mainstem was characterized as good to exceptional. PARTIAL attainment of the WWH use designation was driven by the performance of the fish assemblage which was no better than fair. Performance within the fish community below ecoregional expectations appeared related to submarginal habitat.

- Chemical water quality within the St. Joseph River was characterized as fair to good. The only exceedence of Ohio Water Quality Standards in the mainstem St. Joseph River was the Primary Contact Recreation criterion for fecal coliform bacteria. This exceedence was likely related to agricultural nonpoint sources and associated with increased runoff during high river flows encountered in mid-July.

- Contamination by heavy metals and organic compounds did not appear to be a significant concern in the St. Joseph River. Only one zinc value at RM 50.8 was ranked as highly elevated. Edgerton Metal Products, Inc. is the likely source of this highly elevated level of zinc, either from treated plating process wastewater or zinc casting cooling water. This appeared to be a localized occurrence as no impairment nor sediment contamination were evident further downstream.

Selected Tributaries

- Chemical water quality within these St. Joseph River tributaries ranged between fair and good. The only exceedence of Ohio Water Quality Standards was the Primary Contact Recreation criterion for fecal coliform. These exceedences were likely related to agricultural nonpoint sources and increased runoff during high river flows encountered in mid-July.

- FULL attainment of applicable WWH biological criteria was observed within the West Branch St. Joseph River, Silver Creek, and portions of Fish Creek (RM 5.4) in 1991-92. These stream reaches contained diverse and functionally well organized biological communities (benthic invertebrate and fish assemblages) reflective of good water quality and instream habitat.

- PARTIAL attainment of the WWH biological criteria was observed within Bear Creek in 1991-92 at RM 0.5 and portions of Fish Creek (RM 30.5 and RM 0.2) in 1992. Performance below ecoregional expectations appeared habitat related.

- **NON**-attainment of the WWH biological criteria was observed at RM 4.2 and RM 2.4 within Bear Creek in 1991. This segment appeared to have been subject to significant, recent channel modification. The overall condition of physical habitat within the upper and middle segments of Bear Creek appeared poor, likely precluding the ability of this reach to support and maintain a community of aquatic organisms consistent with the WWH use designation.

Recommendations

Status of Aquatic Life Uses

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.

- The following streams within the St. Joseph River study were surveyed in 1991-92 and are recommended to retain the current WWH aquatic life use designations. The designations apply to the entire length of the streams unless otherwise noted.

  1) St. Joseph River (mainstem)

  2) Fish Creek (segments between RM 34.8 and RM 30.3 and between RM 2.4 and the confluence)

  3) Bear Creek (segment between RM 1.2 and the confluence)

  4) West Branch St. Joseph River

  5) Silver Creek

- Changes in use designation status are recommended for the following tributaries:

  Fish Creek (WWH - Existing/EWH - Recommended)
  The results from surveys conducted in 1991-92 indicated that the reach between RM 5.6 (Ohio/Indiana state line) and RM 2.4 (CR-3) supported a diverse and well organized community of aquatic organisms, consistent with the ecoregional EWH biological criteria. In addition, recent studies have documented three Federally endangered bivalve mollusk species (northern riffle shell, club shell mussel, and white catspaw pearly mussel) and an additional three state endangered bivalve mollusk species (rayed bean shell, rabbitsfoot, and purple lilliput mussel) within the lower portion of Fish Creek (Waters 1988; Hoggarth 1986; and Ohio DNR 1992). Given the unique and endangered mussel fauna supported within Fish Creek and the exceptional character of the benthic invertebrate and fish communities the EWH use designation is warranted for this segment. The remaining segments of Fish Creek (headwater segment within Ohio and the reach between RM 2.4 and the confluence) should retain the current WWH use designation.

  Bear Creek (WWH - Existing/MWH - Recommended)
  Bear Creek is currently maintained under Ohio Drainage Law (ORC 6131). As a result, channelization and associated maintenance activities have produced significant habitat modifications, precluding the ability of Bear Creek to support and maintain a community of aquatic organisms consistent with the WWH biological criteria throughout the entire stream reach. The results from surveys conducted in 1991-92 documented the condition of the biological communities and physical habitat. Given the highly modified character of the upper and middle segments of Bear Creek, **NON**-attainment of WWH biological criteria within these areas, and channel maintenance activities required under Ohio Drainage Law (ORC 6131) the Modified Warmwater Habitat (MWH) used designation is appropriate for the segment from the headwaters to RM 1.2 (upstream CR-H). The lower reach (downstream CR-H to the confluence) has demonstrated considerable recovery from past channel modifications, and PARTIAL attainment of the WWH biological criteria was observed at RM 0.5. It appeared recovery within the lower reach of Bear Creek was well underway and the potential (over time) of this segment to support an aquatic community consistent with the WWH biological criteria was high. As a result the WWH use designation should be retained for this segment.

Status of Non-Aquatic Life Uses

Currently, the St. Joseph River and tributaries evaluated during the 1992 sampling effort are designated for Primary Contact Recreational (PCR), Agricultural and Industrial Water Supplies. Based upon the finding of this investigation, these use designations should be maintained.

Future Monitoring Needs

- A complete reevaluation should be conducted in 1997 or 2002 as provided in the Five Year Monitoring Basin Approach to monitoring and NPDES permit reissuance.

Other Recommendations

- The predominant land use practice in the St. Joseph River basin is agriculture, specifically row crop production. Consequently, the primary nonpoint source impacts are caused by siltation resulting from cropland erosion and hydrologic modifications, in terms of channelization and hydrological changes. Agricultural sediment should be reduced through implementation of conservation tillage, filter strips, establishment of wooded riparian corridors, and other best management practices. In addition, plans for snag clearing or channel modification within the St. Joseph River system should give careful consideration to the habitat impacts associated with these activities. The removal of accumulations of fallen timber and woody debris should be limited to *significant* flow obstructions, while leaving well entrenched, stable deadwood snags in place. By using a selective approach, the macrohabitats created and maintained by woody debris and deadwood snags would be conserved, improving ambient biological performance through increased habitat heterogeneity. In addition, the natural recovery process which encourages a narrow low-flow channel should not be further impeded.

Study Area

- The St. Joseph River system drains 1,060 square miles of the tri-state area of Indiana, Michigan, and Ohio. The Ohio portion of the St. Joseph River covers 238 square miles (approximately 152,000 acres) (Ohio DNR 1960). Stream characteristics and identified pollution sources within the St. Joseph river study area are listed in Table 2. Originating in Hillsdale County, Michigan, the St. Joseph River flows southwest through Williams and Defiance Counties in Ohio, and Dekalb and Allen Counties in Indiana, to join with the St. Marys River at Fort Wayne to form the Maumee River. Major tributaries of the St. Joseph River are Fish Creek, Bear Creek, Eagle Creek, Nettle Creek, East Branch, and West Branch St. Joseph River (Figure 1). The location of all chemical, physical, and biological sampling stations within the St. Joseph River and selected tributaries may be found in Table 3.

- The St. Joseph River watershed lies within the Eastern Corn Belt Plains ecoregion, distinguished by a gently rolling glacial till plain with moraines, kames, and outwash plains. Local relief is usually less than 50 feet. Soils of the watershed reflect the glacial history, having been formed mainly in glacial till or glacial outwash. Major soil associations in the watershed range from level, poorly drained floodplains to gently sloping, moderately steep, moderately well drained uplands (USDA 1978 and Omernik and Gallent 1988).

- Ohio's largest portion of the St. Joseph watershed is in Williams County, which has approximately 228 square miles (146,000 acres). As of 1992, approximately 18,500 acres were wooded (13 percent of the area), 82,850 acres were in crop production (57 percent), and 20,000 acres (14 percent) were enrolled in the Conservation Reserve Program. Approximately half of the cropland was planted in some form of conservation tillage (Williams SWCD 1993; personal communication). The remainder of the watershed in Ohio, 6,420 acres (approximately 10 square miles), is in northwestern Defiance County.

- One major tributary of specific ecological significance is Fish Creek, noted for the presence of federally and state endangered bivalve mollusks. The Fish Creek watershed is the subject of a joint project including Indiana and Ohio resources agencies, the Soil Conservation Service, and the U.S. Fish and Wildlife Service to reduce nonpoint source pollution and preserve the habitats upon which these listed species depend.

- The Fish Creek watershed covers 114 square miles (73,000 acres) in Ohio, Indiana, and Michigan (ODNR 1960). Ohio has 10.1 square miles in the upper portion of the watershed and 6.6 square miles in the lower portion (Williams SWCD 1993; personal communication).

- The St. Joseph River and all of its tributaries except J. Lattaner Ditch are designated WWH. The J. Lattaner Ditch is designated as a Limited Resource Water (LRW) (Ohio EPA 1988).

Table 2. Stream characteristics and significant identified pollution sources in the 1992 St. Joseph River areas (Ohio DNR 1960 and Ohio EPA 1992).

Stream Name (Miles)	Length	Average Fall (Feet/Mile)	Drainage Area (Square Miles)	Nonpoint Source Pollution Categories	Point Sources Evaluated
St. Joseph River (mainstem)	44.3	1.6 219.2 Mich.	1060.4 Ohio 603.2 Indiana	Agriculture; Channelization	Edgerton WWTP Edgerton Metals
Silver Creek	2.9	6.9 27.4 Mich.	29.6 Ohio Channelization	Agriculture;	
West Branch St. Joseph River	11.0	5.9	103.0 Ohio 87.2 Mich.	Agriculture; Channelization	
Bear Creek	11.2	8.5	24.4 Ohio Channelization	Agriculture;	
Fish Creek (Ohio/ Indiana border to St. Joseph River)	5.6	5.5	9.0 Ohio 92.9 Indiana (total 109)	Agriculture; Channelization	
Fish Creek (Head-waters to Ohio/ Indiana border)	2.8	5.4	7.1 Ohio	Agriculture; Channelization	

Table 3. Sampling locations (fish - F, benthic - B, water chemistry - C, sediment chemistry - S, Datasonde - D) in the St. Joseph River study area, 1992.

Stream/ River Mile	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad. Map
St. Joseph River (1992)				
81.5	(F)	41˚37'16"/84˚35'06"	ust. Montpelier	Montpelier
81.2	(B,C,D)	41˚37'09"/84˚35'20"	ust.Montpelier	Montpelier
73.2	(B,C,D)	41˚34'15"/84˚38'02"	dst.Montpelier	Montpelier
73.1	(F)	41˚33'43"/84˚38'05"	dst. Montpelier	Blakeslee
62.1	(B,C)	41˚31'15"/84˚41'47"	ust. SR 34	Blakeslee
62.0	(F)	41˚31'06"/84˚41'52"	ust. SR 34	Blakeslee
57.0	(F)	41˚29'02"/84˚43'36"	ust. CR 5	Butler
56.8	(B,C)	41˚29'21"/84˚43'47"	ust. CR 5	Butler
51.9	(F)	41˚24'39"/84˚44'00"	dst. Edgerton WWTP	Edgerton
51.4	(B,C,D,S)	41˚26'56"/84˚44'20"	dst. Edgerton WWTP	Edgerton
50.8	(F,B,S)	41˚26'44"/84˚44'47"	dst. Edgerton Metals	Edgerton
50.7	(C)	41˚26'37"/84˚44'46"	dst. Edgerton Metals	Edgerton
49.8	(F,B,C,S)	41˚26'04"/84˚44'51"	ust SR 49	Edgerton
47.3	(B,C)	41˚25'20"/84˚46'21"	dst. Line Rd	Butler East
47.2	(F)	41˚25'19"/84˚46'28"	dst. Line Rd	Butler East
Fish Creek				
30.5	(F,B)	41˚39'13"/84˚47'45"	ust. P25 Rd.	Clear Lake
5.4	(F,B)	41˚27'31"/84˚48'07"	ust. CR 1	Butler East
0.4	(C,D)	41˚27'51"/84˚44'54"	at CR 1	Edgerton
0.3	(B)	41˚27'44"/84˚44'58"	dst. SR 49	Edgerton
0.2	(F)	41˚27'43"/84˚44'54"	dst. SR 49	Edgerton
Bear Creek				
4.2	(F,B)	41˚32'58"/84˚47'45"	dst. SR 34	Blakeslee
2.4	(F,B)	41˚32'30"/84˚43'24"	dst. CR I	Blakeslee
0.5	(F,B,C)	41˚31'12"/84˚42'54"	dst. SR 34	Blakeslee
West Branch St. Joseph River				
10.5	(F,B,C)	41˚41'39"/84˚41'14"	ust. Seneca Lake	Nettle Lake
3.2	(F,B,C)	41˚39'04"/84˚36'13"	dst. Seneca Lake	Pioneer
Silver Creek				
1.3	(F,B,C)	41˚41'37"/84˚32'04"	dst. CR 15	Pioneer

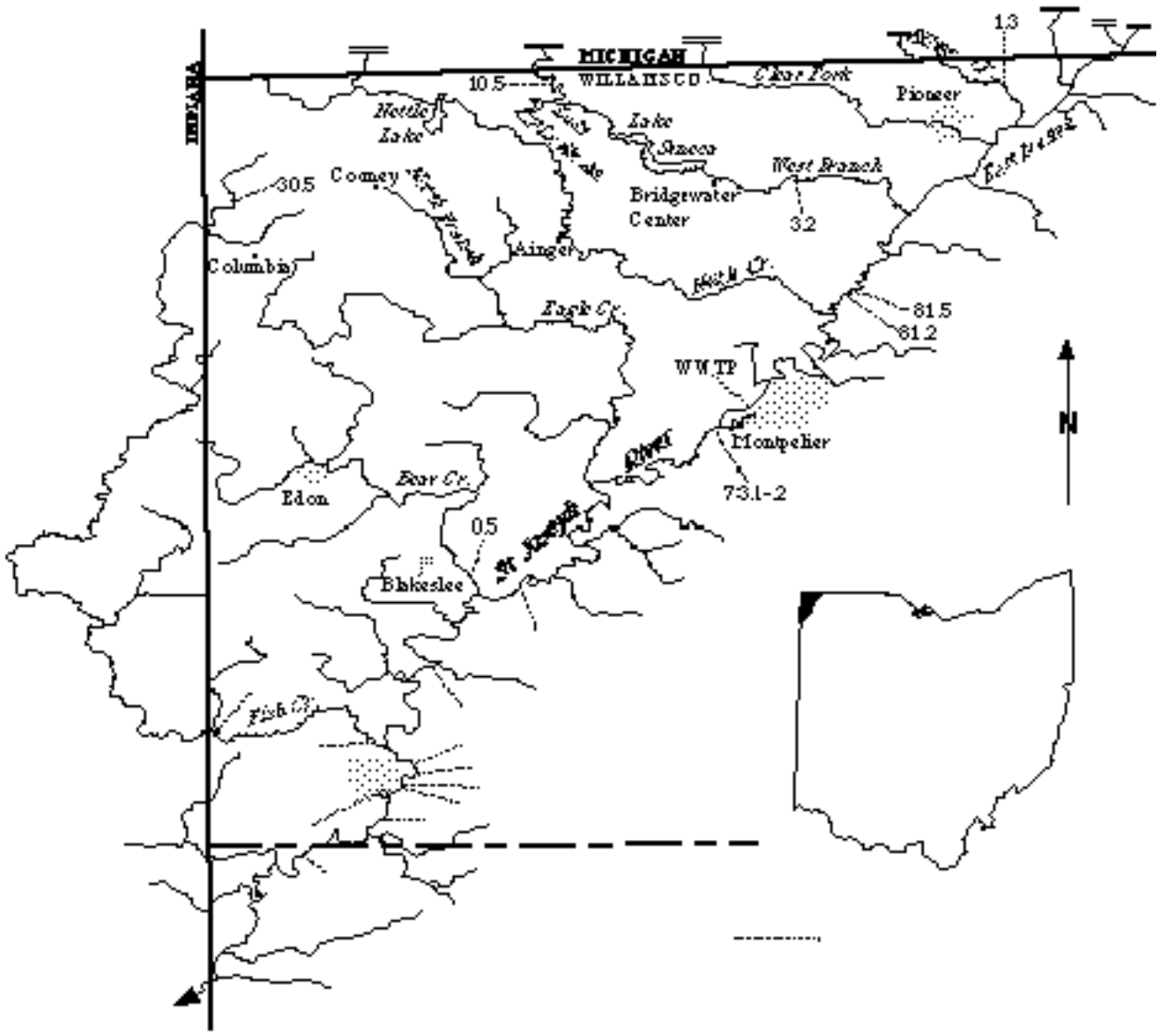


Figure 1. The 1992 St. Joseph River study area showing principle streams and tributaries, population centers, pollution sources, and water resource monitoring stations.

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 1989a) and Biological Criteria for the Protection of Aquatic Life, Volumes II-III (Ohio Environmental Protection Agency 1987, 1989b, 1989c), and The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application (Rankin 1989) for aquatic habitat assessment.

- Attainment/non-attainment 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 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 indices 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.

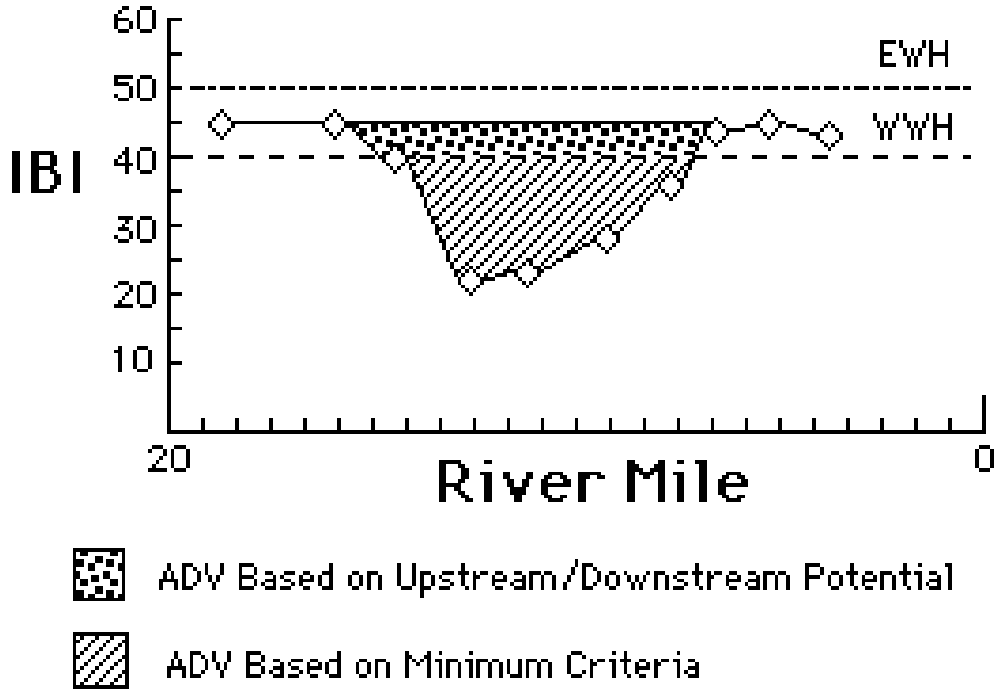


Figure 2. Graphic illustration of the Area of Degradation Values (ADV) based on upstream potential and the ecoregional warmwater habitat use or minimum criteria (WWH). Criteria for exceptional warmwater habitat use (EWH) is provided for reference.

- Fish were sampled 2-3 times using pulsed DC electrofishing gear using either the wading method (150 - 200 meter zones) or boat method (500 meter zones).

- 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. 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).

Results and Discussion

St. Joseph River

Pollutant Loadings

- The Village of Montpelier Wastewater Treatment Plant (WWTP), Ohio EPA permit # 2PD00003, is a secondary treatment system which was constructed in 1958 and last modified in 1981. The wastewater collection system contains 80% combined and 20% separate sewers. Final effluent from the plant discharges to the St. Joseph River at RM 74.2. Annual average flow is 0.84 million gallons per day (MGD) with a design capacity of 1.0 MGD.

- On December 4, 1989, Montpelier submitted to Ohio EPA a general plan for the elimination of combined sewer overflows (CSOs). Separation of combined sewers was recommended due to the large volume of stormwater that is received by the plant. It was proposed that a reevaluation and modification of the general plan be included in the conditions of next NPDES permit for Montpelier WWTP.

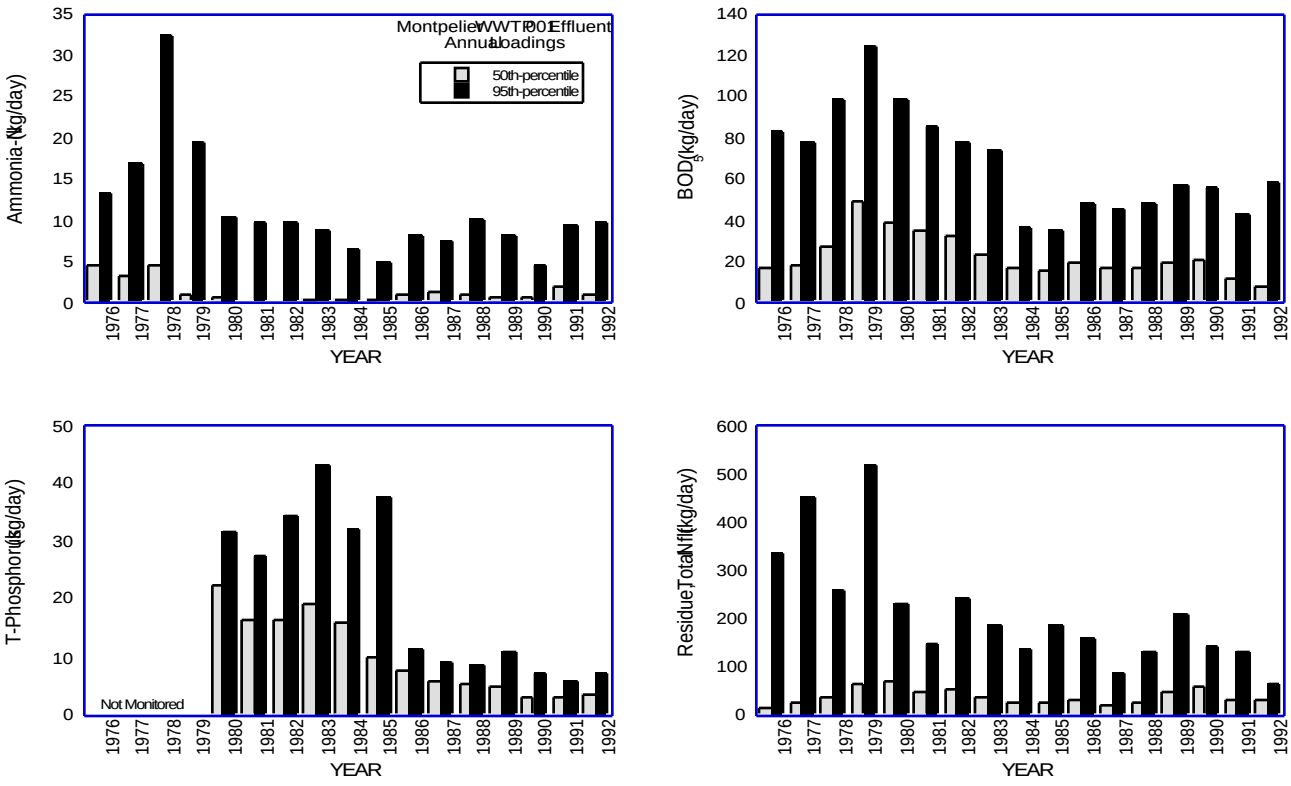
- The Village of Montpelier has made significant improvements to its sewage collection system since the early 1980's. Excessive stormwater flow and backflushing of water from the St. Joseph River through CSO structures were primary causes of inadequate wastewater treatment. Since these sources of excess volume were reduced, a dramatic decline in annual discharge and pollutant loadings has occurred (Figure 3). [Note: BOD_5 was not monitored after 1988, loadings for 1989-1992 were estimated using the following formula: BOD_5 kg/day = [($cBOD_5$ mg/l)·(1.2)]·(MGD)·(8.34) / 2.2046].

- A distinct decrease in total phosphorus loadings occurred after 1985, the likely result of a process change at Winzler Stamping, a pre-treatment industry (M. Smith Montpelier WWTP Superintendent; personal communication). An additional reduction of phosphorus loading occurred after 1989. The additional reduction may have represented the implementation of the Phosphate Detergent Act of 1990. The purpose of this act was to restrict the phosphorus content of household laundry detergent in order reduce phosphate loading within the lake Erie basin.

- The Village of Montpelier Water Treatment Plant (WTP), Ohio EPA permit # 2IW00170, is a lime softening water treatment facility. Overflow from the finishing pond discharges to the St. Joseph River at RM 74.2 via a tile and drainage ditch.

- The Village of Edgerton WWTP, Ohio EPA permit # 2PB00047, is a series of three facultative lagoons that were constructed in 1981. The system is operated as a controlled discharge, with a maximum monthly discharge of 0.025 MGD and a design capacity of 0.36 MGD. The collection system is 100% separate sewers, although 2% of the service area is unsewered. Final effluent from the lagoon system discharges to the St. Joseph River at RM 52.2.

- The Edgerton WWTP lagoon system is operated as a controlled discharge and as a result, pollutant loadings are extremely variable. Plots of total suspended solids and BOD_5 portray this variability, with significant increases after 1987, corresponding to an increasing trend in annual discharge (Figure 4). No effluent discharges were reported in 1981 and 1990. Loadings of



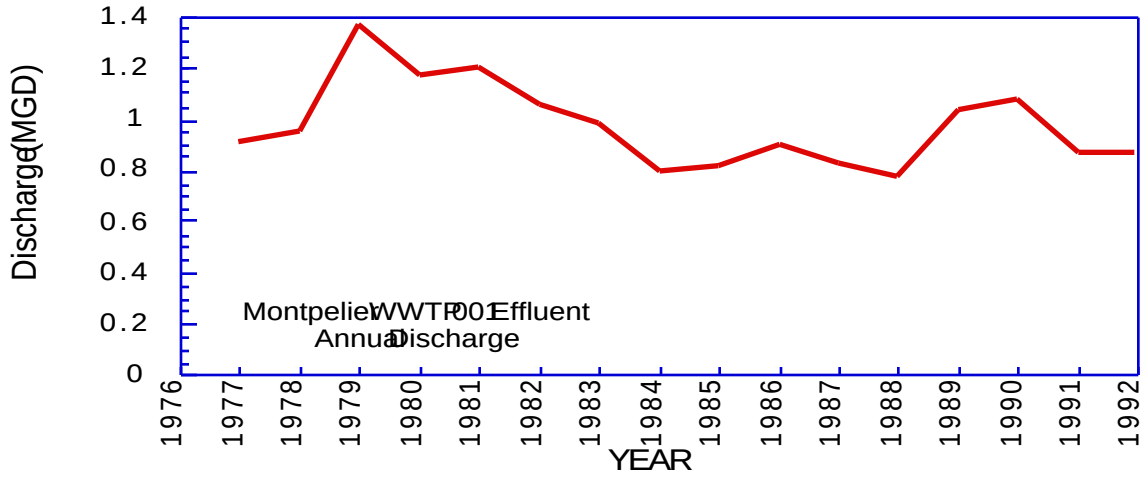


Figure 3. Annual loadings (kg/day) of ammonia-N, phosphorus, five-day biochemical oxygen demand(BOD_5), total suspended solids , and annual effluent discharge from the Montpelier WWTP.

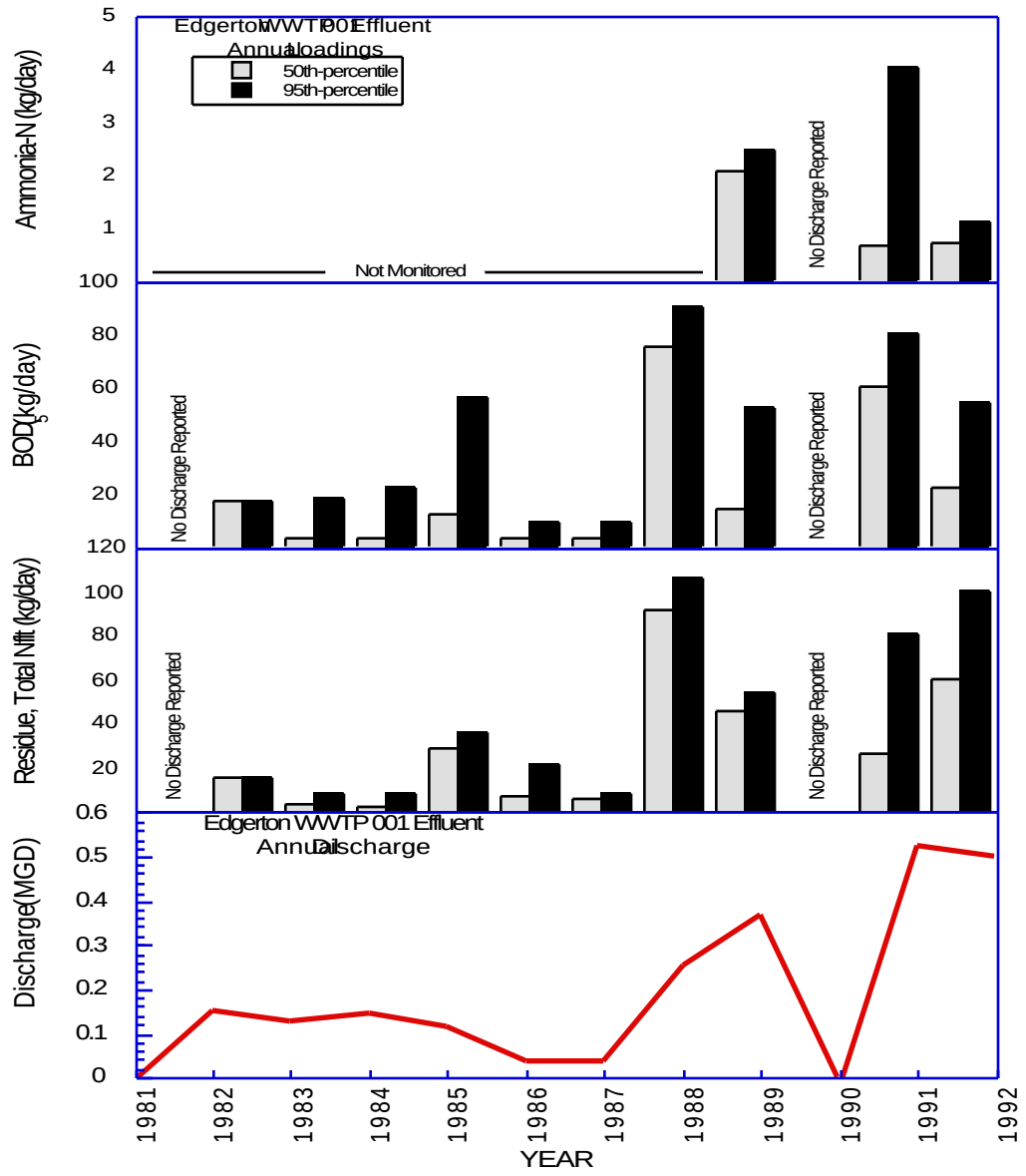


Figure 4. Annual loadings (kg/day) of Ammonia-N, five day-biochemical oxygen demand (BOD_5), total suspended solids, and annual discharge from the Edgerton WWTP.

ammonia-N were available only after 1988, when monitoring requirements were included in the NPDES permit. Based on the loadings data and due to the nature of this wastewater treatment system, impacts from the Edgerton WWTP on St. Joseph River water quality are likely to be nominal and isolated events. [Note: Since BOD_5 was not monitored after 1988, loadings for 1989-1992 were estimated using the following formula: BOD_5 kg/day = [($cBOD_5$ mg/l)·(1.2)]·(MGD)·(8.34) / 2.2046].

- The Village of Edgerton WTP, Ohio EPA permit # 2IZ00040, is an ion exchange and iron-manganese removal water treatment facility. Filter backwash and softener regeneration wastes are discharged to the St. Joseph River at RM 51.6.

- Edgerton Metal Products, Inc., Ohio EPA permit # 2IC00006, is a manufacturer of plated die-cast parts for the automobile and appliance industries. Edgerton Metal Products, Inc. has three permitted outfalls that discharge to the St. Joseph River at RM 50.9. Outfall 001 contains treated electroplating waste and has an annual average discharge of 0.25 MGD. Outfall 002 contains non-contact cooling water (untreated) from the aluminum casting operation and has an annual average discharge of 0.10 MGD. Outfall 003 contains non-contact cooling water (untreated) from the zinc casting operation and has an annual average discharge of 0.012 MGD.

- Entities permitted under the NPDES process are required to submit to Ohio EPA monthly operating reports (MORs) containing analytical results of self monitoring records. These MORs are reviewed by Ohio EPA, Division of Surface Waters, Enforcement Section for violations of permit limits. If any permit limits are violated, a Notice of Violation (NOV.) letter is sent to the entity. A summary of permit limit violations for the period January, 1988 through December, 1992 was obtained from the Federal Permit Compliance System and are presented in Table 4.

- Edgerton Metal Products, Inc. outfall 001 effluent was subjected to a screening bioassay (Bioassay Report # 92-935-NW) as part of a toxicity evaluation in conjunction with permit reissuance. The outfall 001 effluent was acutely toxic to both the fathead minnow *(Pimephales promelas)* and *Ceriodaphnia dubia*.. The test species exhibited 100% mortality in all effluent samples. The *P. promelas* 48 hr. through 96 hr. LC 50 and *C. dubia* 48 hr. LC 50 (95% confidence limit) averaged 3.5% effluent (range 6.1-2.0).

- During the 1992 study period, a distinct oil sheen was observed by several Ohio EPA field personnel downstream from the Edgerton Metal Products, Inc. discharges. This sheen was traced to the zinc casting/non-contact cooling water discharge (outfall 003). A sample of outfall 003 effluent was collected on 6 October, 1993. Analytical results showed that it contained 18.3 mg/l oil and grease. Other results indicated significant metal contamination, with an aluminum concentration of 62,300 µg/l, copper concentration of 2,100 µg/l, and zinc concentration of 1,590 µg/l.

- Outfall 001 is operated as a controlled discharge. Wastewater from the plating operation is accumulated until a sufficient volume is reached. This wastewater is then treated and discharged. Therefore, annual discharge from outfall 001 varies with production at the plant. Discharge decreased significantly after 1978, with a slight increase in 1981. Pollutant loadings also follow this general pattern of decline after 1978 (Figure 5).

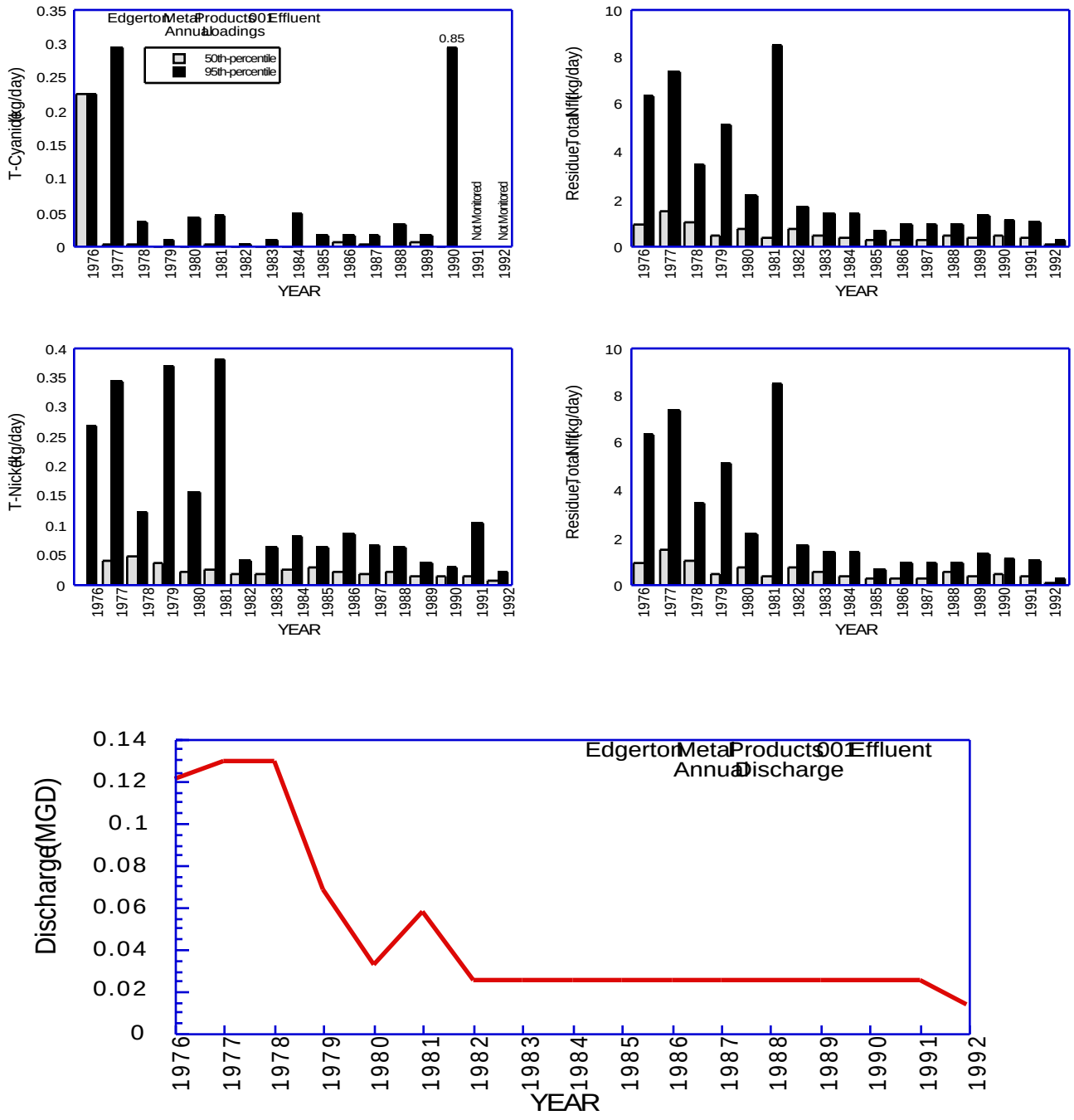


Figure 5. Annual loadings (kg/day) of cyanide, zinc, nickel, total suspended solids, and annual 001 discharge from Edgerton Metal Products Inc..

Table 4. Number of permit limit violations at Edgerton Metal Products, Inc. for the period January, 1988 through December 1992.

	PARAMETER								
Type of Violation	pH	Residue, T-Nflt	$T\text{-}CN^-$	$F\text{-}CN^-$	Hex. Cr	T-Cr	T-Cu	T-Ni	Oil and Grease
Avg. Monthly Load	0	0	0	2	5	0	0	0	0
Max. Monthly Load	0	0	0	2	5	0	0	0	0
Avg. Monthly Conc.	0	1	1	6	10	6	4	4	0
Max. Monthly Conc.	1	0	0	8	9	6	4	4	1

- Electroplating operation at Edgerton Metal Products Inc. ceased as of April 22, 1992. In addition, the zinc casting operation has been eliminated as well. Aluminum casting is the only remaining process.

Chemical Water Quality

- Thirteen sites in the St. Joseph River study area were selected for chemical/physical analysis of surface water. Eight of these sites were located on the mainstem St. Joseph River, two on the West Branch St. Joseph River, and one each on Silver Creek, Bear Creek, and Fish Creek. Samples submitted were analyzed for the parameters listed in Table 5. Temperature, dissolved oxygen (D.O.), and pH were measured in the field at the time of sample collection. A summary of these results can be found in Appendix-1. Datasonde continuous monitors were deployed at four sites in the study area to determine diurnal fluctuations in D.O. concentrations. These monitors recorded hourly readings over a 52 hour period. A summary of these results can be found in Appendix-2. Exceedences of Ohio Water Quality Standards (OAC 3745-1) were determined for those parameters which have numerical criteria established. A summary of all water quality standard exceedences can be found in Table 6. All stream segments in the study area are currently designated as Warmwater Habitat (WWH) and Primary Contact Recreation (PCR).

- Surface water samples were collected in the St. Joseph River between RM 81.2 (upstream Montpelier WWTP) and RM 47.3 (near the Ohio/Indiana state line) for analysis of chemical water quality. Interpretation of analytical results indicates fair to good water quality in the St. Joseph River. The only exceedence of Ohio Water Quality Standards in the mainstem St. Joseph River was the Primary Contact Recreation criterion for fecal coliform at RM 81.2 on July 14 (Table 6). Since this sampling event was conducted during a period of increased runoff and high flow (Figure 6) following a large rainstorm. Since the station at RM 81.2 is located upstream from any point source discharges, this fecal coliform exceedence is likely due to nonpoint source runoff and interference from soil bacteria.

Table 5 List of physical/chemical parameters and method detection limits (MDLs) analyzed in St. Joseph River surface water grab samples.

Parameter	MDL
Dissolved Oxygen, mg/l	0-20
Temperature, ˚C	0-100
pH, SU	0-20
Arsenic, Total As, µg/l	2.0
Cadmium, Total Cd, µg/l	0.2
Calcium, Total Ca, mg/l	1.0
Chromium, Total Cr, µg/l	30.0
Copper, Total Cu, µg/l	10.0
Iron, Total Fe, µg/l	50.0
Lead, Total Pb, µg/l	2.0
Magnesium, Total Mg, mg/l	0.5
Nickel, Total Ni, µg/L	40.0
Zinc, Total Zn, µg/l	10.0
Hardness, Total $CaCO_3$, mg/l	1.0
BOD, 5-day, mg/l	1.0
cBOD, 5-day, mg/l	1.0
COD, mg/l	10.0
Conductivity (25˚C), µmhos/cm	0-200,000
Nitrate-Nitrite, as N, mg/l	0.05
Nitrite, as N, mg/l	0.02
Ammonia, as N, mg/l	0.05
Total Kjeldahl Nitrogen, mg/l	0.2
Phosphorus, Total, mg/l	0.05
Residue, Total Nflt, mg/l	5
Fecal Coliform, colonies/100ml	2

Table 6. Exceedences of Ohio EPA Warmwater Habitat criteria (OAC 3745-1) for chemical/physical parameters measured in grab samples taken from the St. Joseph River survey area during 1992 (units are colonies/100ml for fecal coliform). Iron is not listed since 55 of 65 samples (85%) exceeded 1.0 mg/l.

Stream	River Mile	Parameter (value)
W. Branch St. Joseph River		
	10.5	Fecal Coliform (>10,000 ◊◊)
St. Joseph River		
	81.2	Fecal Coliform (4,200 ◊)
Bear Creek		
	0.5	Fecal Coliform (3,200 ◊)
Silver Creek		
	1.3	Fecal Coliform (3,600 ◊)

◊ exceedence of the Primary Contact Recreation criterion
◊◊ exceedence of the Secondary Contact Recreation criterion

- Datasonde continuous monitors were deployed at RM 81.2, RM 73.2, and RM 51.4 to determine diurnal fluctuations in D.O. concentrations. None of the readings recorded were below either the daily minimum criteria (4.0 mg/l) or the daily average criteria (5.0 mg/l) for the WWH use designation. These results indicate that adequate dissolved oxygen concentrations were maintained within the St. Joseph River.

- Longitudinal trends of the mean concentrations for selected chemical pollutants were plotted to portray potential impacts from known sources discharging to the St. Joseph River (Figure 7).

- Average daytime grab sample D.O. concentrations showed slight decreases below the Village of Montpelier WWTP and Edgerton Metal Products, Inc. discharges and the confluence of Bear Creek. These decreasing D.O. concentrations are likely a response to inputs of compounds and materials that consume oxygen through decomposition. Biochemical oxygen demand (BOD) is a measure of this phenomenon in water. Often times, a decreasing trend in the D.O. concentration corresponds to an increasing trend in the BOD_5. The only exception to this pattern was observed between RM 49.8 and RM 47.3, where mean BOD_5 and $cBOD_5$ concentrations increased while the mean D.O. concentration remained essentially unchanged. In addition to a modest influence from oxygen demanding wastes, these fluctuations in mean D.O. concentration may also be affected by changes in stream hydrology and morphology and algal photosynthesis.

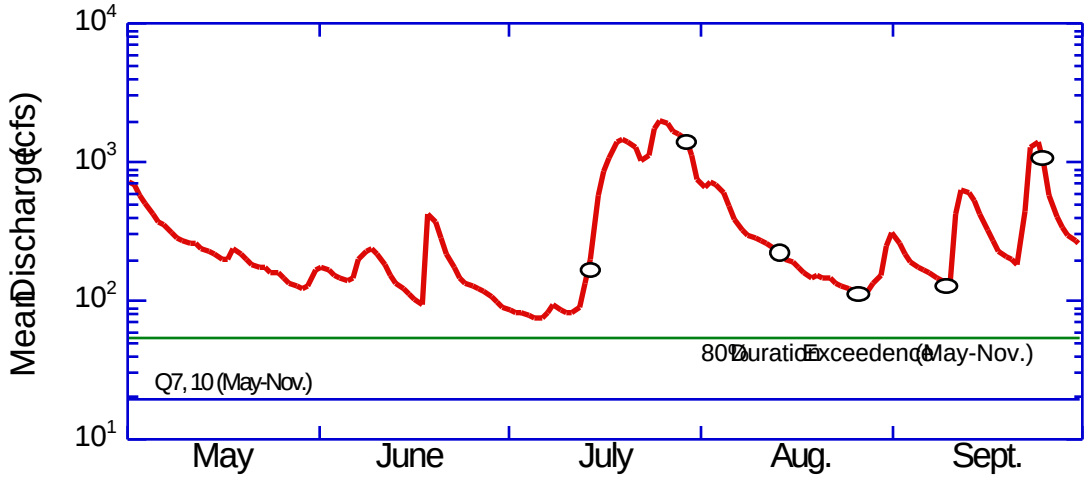


Figure 6. Flow hydrograph for the St. Joseph River at Newville Indiana (RM 42.3), May through September, 1992 (USGS 1992). May through November low-flow conditions (Q710[1.19cfs] and 80% duration flow [3.2cfs]) (USGS 1992).

- Enrichment from nutrients, primarily ammonia-N, nitrate-N, and phosphorus, did not appear to be a significant concern in the St. Joseph River study area. Mean ammonia-N concentrations displayed a modest increase between RM 81.2 and RM 73.2, likely associated with the Montpelier WWTP discharge at RM 74.2 (Figure 7). Mean concentrations decreased markedly between RM 73.2 and RM 62.1 to at or near method detection limits (0.05 mg/l) for the remaining portion of the survey area. No increase in the mean ammonia-N concentration was evident below the Edgerton WWTP lagoon or Edgerton Metal Products, Inc. discharges. The mean nitrate-N concentration was highest at RM 81.2, which likely represented the influence of agricultural nonpoint sources, and steadily decreased to RM 51.4 (Figure 7). A slight increase in the mean nitrate-N concentration was noted between RM 51.4 and RM 47.3. Mean phosphorus concentrations remained stable between RM 81.2 and RM 49.8, showing little or no response to discharges from the Montpelier WWTP, Edgerton WWTP lagoon, and Edgerton Metal Products, Inc. discharges (Figure 7). A significant increase in mean phosphorus concentration occurred between RM 49.8 and RM 47.3. This may have been due to the lower stream gradient which encourages the deposition of silts and clays with phosphorus compounds bound to the exchange complex. This change in stream gradient was also reflected by the trend for total nonfilterable residue (total suspended solids) since a significant decrease occurred between RM 49.8 and RM 47.3 (Figure 7).

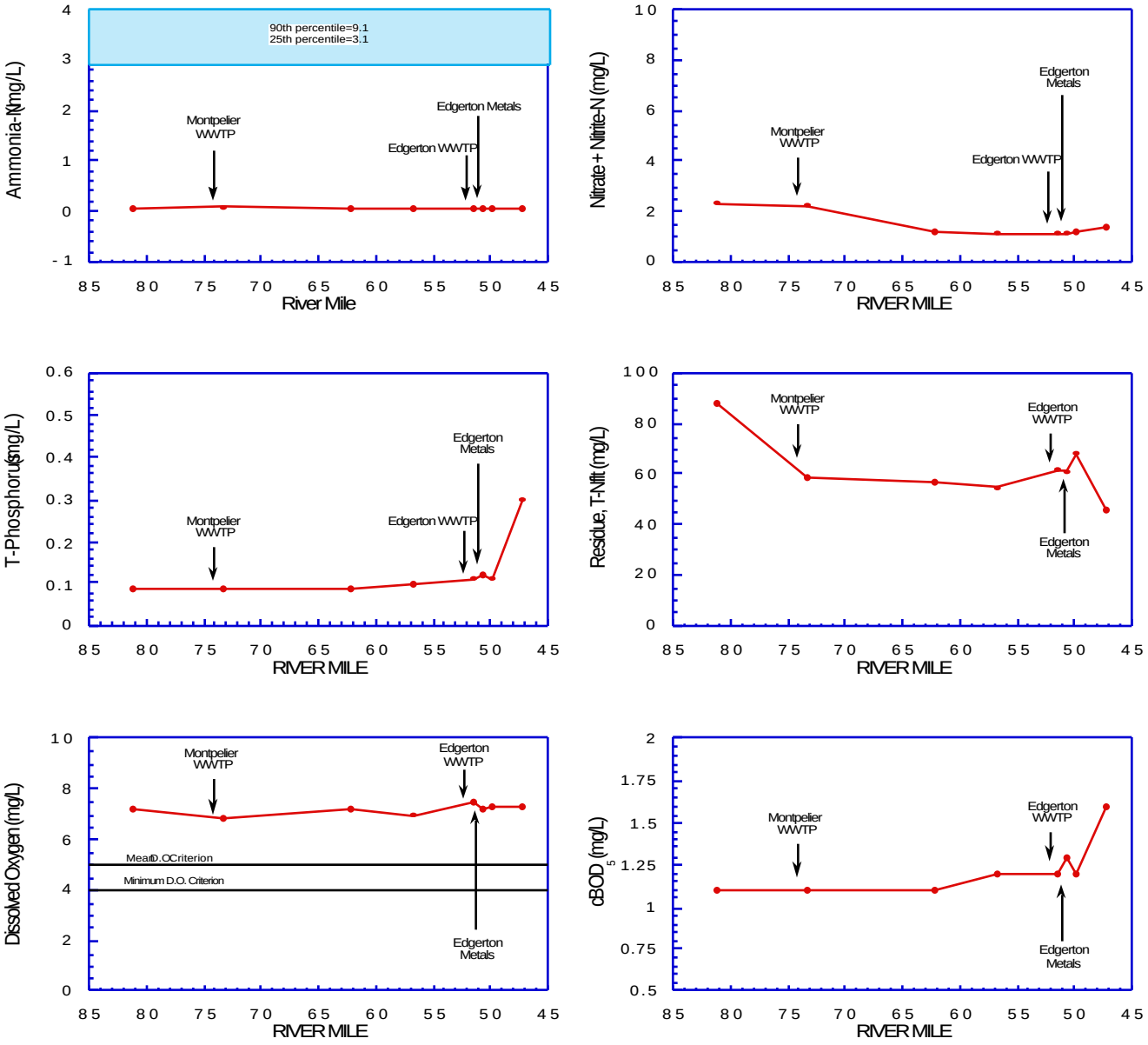


Figure 7. Longitudinal trends of mean ammonia-N, nitrate and nitrite-N, phosphorus, total suspended solids, dissolved oxygen, and five-day biochemical oxygen demand ($cBOD_5$) in the St. Joseph River, 1992. Shaded area in the ammonia-N plot represents the range of WQS criteria based on 90th and 25th percentile pH and temperature values from the study area.

Table 7. Sediment concentrations (mg/kg dry weight) of eight metals in the 1992 St. Joseph River Study area. Concentrations (excluding nickel) were ranked based on a stream sediment Classification system described by Kelly and Hite (1984). The Kelly and Hite classification system addresses relative concentrations, but does not directly assess toxicity.

River Mile	As	Cd	Cr	Cu	Fe	Pb	Ni	Zn
51.4	5.69[a]	0.372[a]	16.3[b]	14.9[a]	13,900[a]	32.8[b]	15.2	76.3[a]
50.8	4.56[a]	0.260[a]	17.3[b]	20.3[a]	11,200[a]	17.6[a]	13.0	**244[d]**
49.8	7.66[a]	0.387[a]	31.4[c]	19.5[a]	17,900[a]	26.0[a]	34.3	88.2[b]

[a] Non-elevated; [b] Slightly elevated; [c] Elevated; [d] **Highly elevated**; [e] **Extremely elevated**

Chemical Sediment Quality

- Three sites in the St. Joseph River study area were selected for chemical analysis of sediments. These sites were located at RM 51.4 (downstream Edgerton WWTP), RM 50.8 (downstream Edgerton Metal Products, Inc. discharges), and RM 49.8. Fine silts deposited in slack-water areas was the desired material to be collected. The sites at RM 51.4 and RM 49.8 contained ample amounts of silt deposits. Due to fluvial hydrology and predominant substrate types at RM 50.8 (sand, rock, and gravel), the sediment samples at this site were collected from a thin layer of silt located along the river margin.

- Based on the stream sediment classification system described by Kelly and Hite (1984), contamination from metals does not appear a significant concern in the St. Joseph River (Table 7). Only zinc at RM 50.8 was ranked as highly elevated. Edgerton Metal Products, Inc. is the likely source of this highly elevated level of zinc, either from treated plating process wastewater or zinc casting cooling water. Zinc continued to be slightly elevated at RM 49.8. Chromium was ranked as slightly elevated at RM 51.4 and RM 50.8, and elevated at RM 49.8. Lead was ranked as slightly elevated at RM 51.4. Stormwater runoff was the likely source of these slightly elevated levels. All other metal concentrations were ranked as non-elevated.

- Contamination from organochlorine insecticides does not appear a significant concern in the St. Joseph River (Table 8). Because of the intensive use of land for agricultural crops in the St. Joseph River basin, the presence of residual concentrations of these compounds is not unexpected. Only DDT (and degradation products) at RM 49.8 was ranked as slightly elevated. All other compounds that were detected are ranked as non-elevated.

- Two PAH compounds were detected in sediments of the St. Joseph River (Table 8). Fluoranthene (0.8 ppm) and pyrene (0.7 ppm) were both detected at RM 51.4. A measure of adverse biological effects of sediment-sorbed contaminants in coastal marine and estuarine environments has been evaluated by the National Oceanic and Atmospheric Administration

(NOAA) as part of the National Status and Trends (NS&T) Program (Long and Morgan, 1991). The chemical concentrations observed or predicted to be associated with biological effects from a variety of methods and approaches were sorted and the median concentration was identified as an Effects Range-Median (ER-M). Data for pyrene suggested an ER-M of approximately 2.2 ppm, while data for fluoranthene suggest an ER-M of about 3.6 ppm. The occurrence of both compounds were near detection limits and well below ER-M concentrations.

- Two phthalate compounds were detected in sediments of the St. Joseph River. Butylbenzyl phthalate (0.6 ppm), a known carcinogen, was detected at RM 50.8, while Di-N-butyl phthalate was detected at both RM 51.4 (0.9 ppm) and RM 50.8 (1.2 ppm). Much more testing is needed on the environmental toxicity of phthalates, given their widespread occurrence. Data reported by Mayer and Sanders (1973) have shown that certain phthalates may be detrimental to the reproduction of aquatic organisms at low concentrations

Table 8. St. Joseph River sediment organic pollutant scan detections during 1992. Corrected method detection limits, based on weight and dilutions of sample, for non-detected (ND) priority pollutants are presented in parenthesis.

PARAMETER	RM 51.4	RM 50.8	RM 49.8
POLYCYCLIC AROMATIC HYDROCARBONS (mg/kg)			
Fluoranthene	0.8	ND (0.6)	ND (0.6)
Pyrene	0.7	ND (0.6)	ND (0.6)
PHTHALATES (mg/kg)			
Butylbenzyl Phthalate	ND (0.6)	0.6	ND (0.6)
Di-N-Butyl Phthalate	0.9	1.2	ND (0.6)
PESTICIDES [1, 2] (ug/kg)			
d-BHC	ND (2.72)	1.02	2.12
Dieldrin	ND (2.72)	1.16[a]	1.63[a]
Endrin	ND (2.72)	0.80	ND (0.57)
Endosulfan II	ND (2.72)	0.81	ND (0.57)
Methoxychlor	ND (13.59)	ND (2.71)	6.55
DDT (sum)	ND (2.72)	1.14[a]	6.30[b]

1. Pesticide concentrations indicated were ranked with the following stream sediment classification system described by Kelly and Hite (1984). [a] Non-elevated; [b] Slightly elevated; [c] Elevated; [d] **Highly elevated**; [e] **Extremely elevated**
2. Sum DDT is the total of 4, 4' - DDE, 4, 4' - DDD, and 4, 4' - DDT.

Physical Habitat For Aquatic Life

- The St. Joseph River mainstem and the majority of the tributaries have been subject to significant hydrologic modifications. Early in the twentieth century the upper portion of the watershed was extensively modified to improve surface and subsurface drainage. Most significantly, the East Branch St. Joseph River and the mainstem were channelized (straightened and deepened) from Pratsville Michigan to Montpelier, Ohio (Williams County Engineers Office, personal communication). Recent drainage modifications to the St. Joseph River mainstem have not been nearly as dramatic, limited mainly to the removal of logjams and other maintenance activities. However, numerous smaller tributaries have been subjected to previous and frequent channelization, many being maintained under the Ohio Drainage Law (ORC 6131).

- These activities have had profound influences upon the macrohabitats and aquatic communities of the St. Joseph River basin. Pervasive siltation and relatively monotonous channel development appeared to be significant factors presently affecting the mainstem. Given the agricultural land use and drainage modifications associated with intensive cultivation, eroded sediments are rapidly delivered to this low gradient system. Processing an average gradient of 1.6 feet/mile (Ohio DNR 1960), and local gradients as low as 0.60 feet/mile, the retention time of suspended and bedload sediments is high, allowing considerable deposition. The resulting accretion has degraded instream habitats by reducing depth heterogeneity and embedding coarse substrates; greatly diminishing major components of riverine habitat. In addition, low stream gradient greatly limits the natural recovery of riverene characteristics after significant channel modifications.

- During the 1992 field sampling effort macrohabitats of the St. Joseph River mainstem were evaluated at eight fish sampling stations. Qualitative Habitat Evaluation Index (QHEI) values ranged between 33.0 at RM 49.8 and 75.5 at RM 62.0, with a mean value of 57.3. A mean reach QHEI score less than 60 suggested that near and instream habitats were somewhat degraded and may exert a negative influence upon ambient biological potential (Rankin 1989). To elucidate stream reaches of relatively homogeneous habitat and to better evaluate habitat influences within the study area a matrix of QHEI habitat characteristics appear in Table 9.

- The upper portion of the study area, between RM 81.2 and RM 62.0, contained the best habitats within the study area. Warmwater attributes were predominant and included: coarse glacial substrate (sand/gravel), pools greater than 40 cm in depth, instream cover in moderate abundance, and high/moderate functional sinuosity. Moderate influence modified habitat attributes were present within this segment. The most limiting aspects of physical habitat included: fair/poor channel development and moderate embedding of coarse substrates (Table 9).

- Within the lower reach of the study area between RM 57.0 and RM 47.2, the quality of instream macrohabitats habitats were diminished. The occurrence of warmwater attributes were reduced, while negative habitat attributes (high and moderate influence modified) displayed a substantial increase (Table 9). The most limiting components of in stream habitat included: high/moderate embedding of coarse substrates, heavy/moderate siltation, fair/poor channel development, and the lack of swift current velocities.

Table 9. Qualitative Habitat Evaluation Index (QHEI) matrix showing warmwater and modified habitat attributes for the St. Joseph River study area, 1992.

Biological Assessment: Macroinvertebrate Community

- The macroinvertebrate fauna inhabiting the eight sites sampled between RM 81.2 and RM 47.3 on the St. Joseph River was indicative of good to excellent conditions (Table 9). Invertebrate Community Index (ICI) scores from six artificial substrates that were collected ranged from 42 to 48. The macroinvertebrate assemblage did not appear at any location to be impacted by excessive nutrient enrichment, however, pervasive sedimentation of the stream bed was probably somewhat limiting the diversity of the macroinvertebrate fauna. A thick layer of silt was present at all except those limited areas where sufficient current velocity prevented deposition. Consequently, qualitative sampling was most productive from woody debris.

Table 10. Summary of macroinvertebrate data collected from artificial substrate samplers (quantitative) and natural substrates (qualitative sampling) in the St. Joseph River, August-October , 1992.

Quantitative Evaluation							
Stream River Mile	Relative Density	Quant. Taxa	Qual. Taxa	Qual. EPT[b]	QCTV[c]	ICI	Narrative Evaluation
West Branch St. Joseph River							
10.5	1627	36	44	12	38.9	50	Excellent
3.2	1800	32	27	11	39.1	40	Good
St. Joseph River							
81.2	-	Qual. Only	25	10	40.9	-	Good
73.2	577	41	27	10	38.5	42	Good
62.1	463	47	21	9	40.9	42	Good
56.8	678	42	18	7	41.3	48	Excellent
51.4	861	38	32	12	39.1	48	Excellent
50.8	570	24	27	13	40.5	42	Good
49.8	-	Qual. Only	24	12	41.4	-	Good
47.3	1046	33	42	16	39.1	48	Excellent
Silver Creek							
1.3	601	46	39	12	37.5	52	Excellent
Fish Creek							
30.5	-	Qual. Only	35	7	31.8	-	Fair
5.4	718	38	34	13	40.9	50	Excellent
0.3	-	Qual. Only	26	12	41.4	-	Good
Bear Creek							
0.5	587	43	37	7	35.3	46	Very Good

Table 9 continued.

Stream River Mile	No. Qual. Taxa	QCTV[c]	Qual. EPT[b]	Relative Density	Predominant Organisms	***Qualitative Evaluation*** Narrative Evaluation[a]
St. Joseph River						
81.2	25	40.9	10	Mod.	Caddisflies, Mayflies	Good
49.8	24	41.4	12	Mod.	Caddisflies, Mayflies	Good
Fish Creek						
30.5	35	31.8	7	Mod.	Fingernail Clams	Fair
0.3	26	41.4	12	Mod.	Midges, Caddisflies	Good

Ecoregion Biocriteria:

E. Corn Belt Plains (ECBP)

	INDEX	WWH	EWH	MWHe
ICI	36	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).

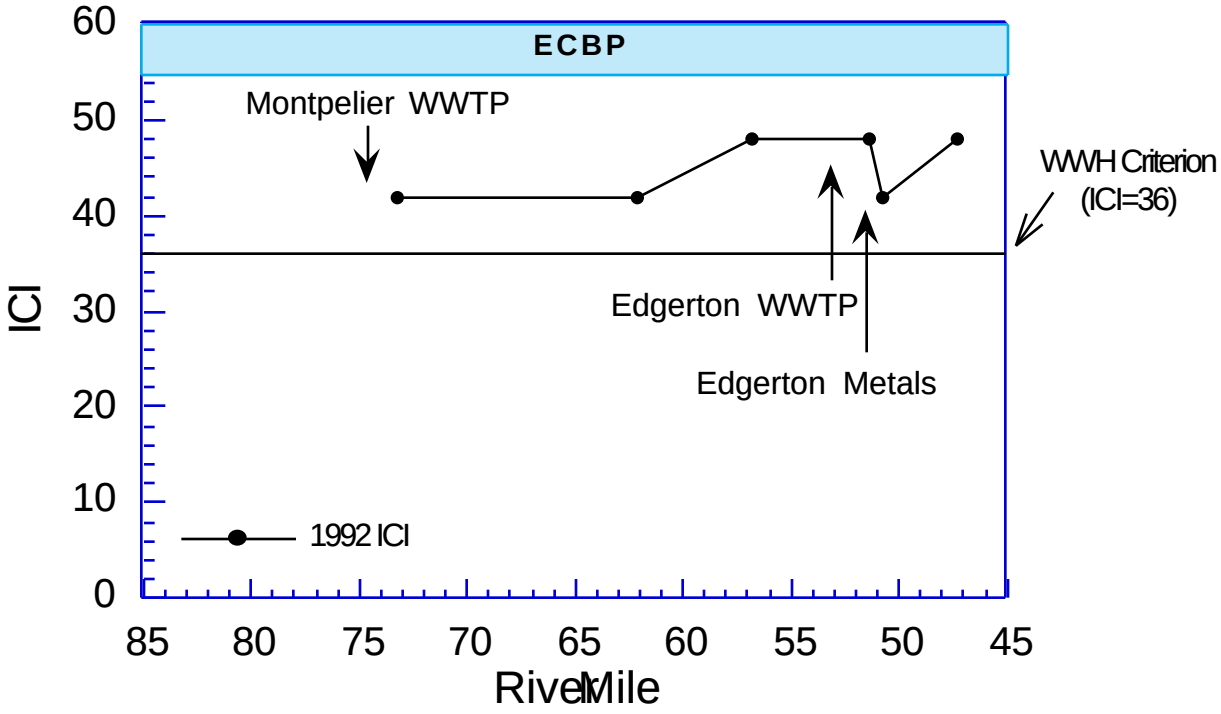


Figure 8. Longitudinal performance of the Invertebrate Community Index (ICI) within the St. Joseph River manstem, 1992.

- The macroinvertebrate community at RM 51.4 was unaffected by the Edgerton WWTP. The ICI score was in the exceptional performance range (ICI=48) and no significant enrichment was indicated based on the results of the qualitative and the quantitative sampling. Both methods produced results that were similar to upstream sampling sites (Figure 8).

- Though the ICI score declined by six points downstream from Edgerton Metals (RM 50.8), a direct cause and affect relationship with the discharger does not seem warranted. The ICI score of 42 was within the range of non-significant departure of the EWH biocriteria and was the same value scored at sites that were upstream from any significant point sources (RM 73.2 and RM 62.1). As discussed previously, siltation appeared to be the overriding influence affecting the macroinvertebrate community.

Biological Assessment: Fish Community

- A total of 3,308 fish comprised of 38 species and three hybrids was collected from the St. Joseph River mainstem, between August 12 and September 16, 1992. The sampling effort included a total 55.2 km at eight sampling stations between RM 81.5 (upstream Montpelier) and RM 47.2 (downstream Line Rd.).

- The numerically predominant fish species were: spotfin shiner (28.9%), gizzard shad (18.1%), common carp (13.9%), bluntnose minnow (8.89%), and golden redhorse (4.41%). Species that predominated in terms of biomass were: common carp (78.7%), golden redhorse (5.01%), channel catfish (3.40%), rockbass (3.17%), and northern hogsucker (2.68%). Species listed as endangered within the state of Ohio included the greater redhorse (Ohio DNR 1992). A total five greater redhorse were collected from the St. Joseph River mainstem during the 1992 sampling effort.

- Though not all of the most abundant fish species within the St. Joseph River are not classified as highly tolerant, two of these species (spotfin shiner and gizzard shad) have demonstrated a marked preference for low gradient, silted, or otherwise physically disturbed waters (Becker 1983 and Trautman 1981). The numerical predominance of these and highly tolerant forms (bluntnose minnow and common carp) were reflective of the pervasive modified habitat characteristics of the St. Joseph River. In addition, the overwhelming predominance of common carp in terms of biomass (78.7%) was also indicative of the habitat problems within the St. Joseph River.

- Fish community indices ranged between (IBI=29; MIwb=7.9) at RM 73.1 and (IBI=27; MIwb=7.0) at RM 50.8. Viewed in total (all sampling stations), community performance within the St. Joseph River was characterized as fair (Table 11). Community performance consistent with the WWH biological criteria was not observed within the fish assemblage at any sampling station (Figure 9).

- Community performance at the most upstream station (RM 81.5; upstream Montpelier) was characterized as fair (IBI=34; MIwb=7.2). Functional and structural organization of the fish assemblage suggested that the quality and extent of instream habitat represented the most significant influence upon fish community performance. The percent occurrence of simple lithophilic species and of round-bodied suckers were diminished, suggesting modified habitat influence (primarily siltation and embedding of coarse substrates). However, species intolerant of chemical disturbances to water quality were represented within the assemblage, though not a significant component, which suggested that chemical water quality alone may not be a factor. Community performance at RM 81.5 likely represented ambient background conditions within the St. Joseph River study area.

- Community performance throughout the remainder of the St. River mainstem remained fair. Significant shifts within the fish assemblage downstream of permitted dischargers within the study area was not observed. A modest decline in community performance was recorded downstream of the Montpelier WWTP and Edgerton Metals discharges, while the Edgerton WWTP had no appreciable effect upon the fish community (Figure 9).

Table 11. Fish community indices based on pulsed D.C. electrofishing samples at 15 locations sampled by Ohio EPA in the St. Joseph River study area during August - September, 1992. Sites sampled with boat, wading , and headwater methods.

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[a]
St. Joseph River								
Eastern Corn Belt Plains - WWH Use designation (Existing)								
81.2	19.0	21	423	108.6	63.0	7.2*	34*	Fair
73.1	18.5	22	446	91.52	58.0	7.9*	29*	Fair
62.0	19.0	21	495	111.8	75.5	7.7*	32*	Fair
57.0	19.0	24	382	88.02	57.0	7.1*	30*	Fair
51.9	17.0	22	281	110.7	54.0	7.2*	29*	Fair
50.8	18.0	22	504	125.5	60.0	7.0*	27*	Fair
49.8	20.5	24	386	66.82	33.0	6.7*	31*	Fair
47.2	19.5	23	391	109.8	58.0	6.6*	30*	
Fish Creek								
Eastern Corn Belt Plains - WWH Use designation (Existing)								
30.5	16.5	17	4777	14.94	42.5	N/A	44	Good
5.4	27.0	30	587	21.81	75.0	9.3	46	Good
0.2	21.5	26	695	42.74	69.5	7.6*	42	Fair/Good
Bear Creek								
Eastern Corn Belt Plains - WWH Use designation (Existing)								
0.5	19.0	23	1777	33.52	74.0	6.9*	31*	Fair
West Branch St. Joseph River								
Eastern Corn Belt Plains - WWH Use designation (Existing)								
10.5	24.0	28	1807	30.35	73.0	8.0[ns]	45	M.Good/Good
3.2	29.0	34	827	44.15	80.0	8.8	45	Good
Silver Creek								
Eastern Corn Belt Plains - WWH Use designation (Existing)								
1.3		28	693	20.59	68.5	8.2[ns]	41	M.Good/Good

* -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.

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

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

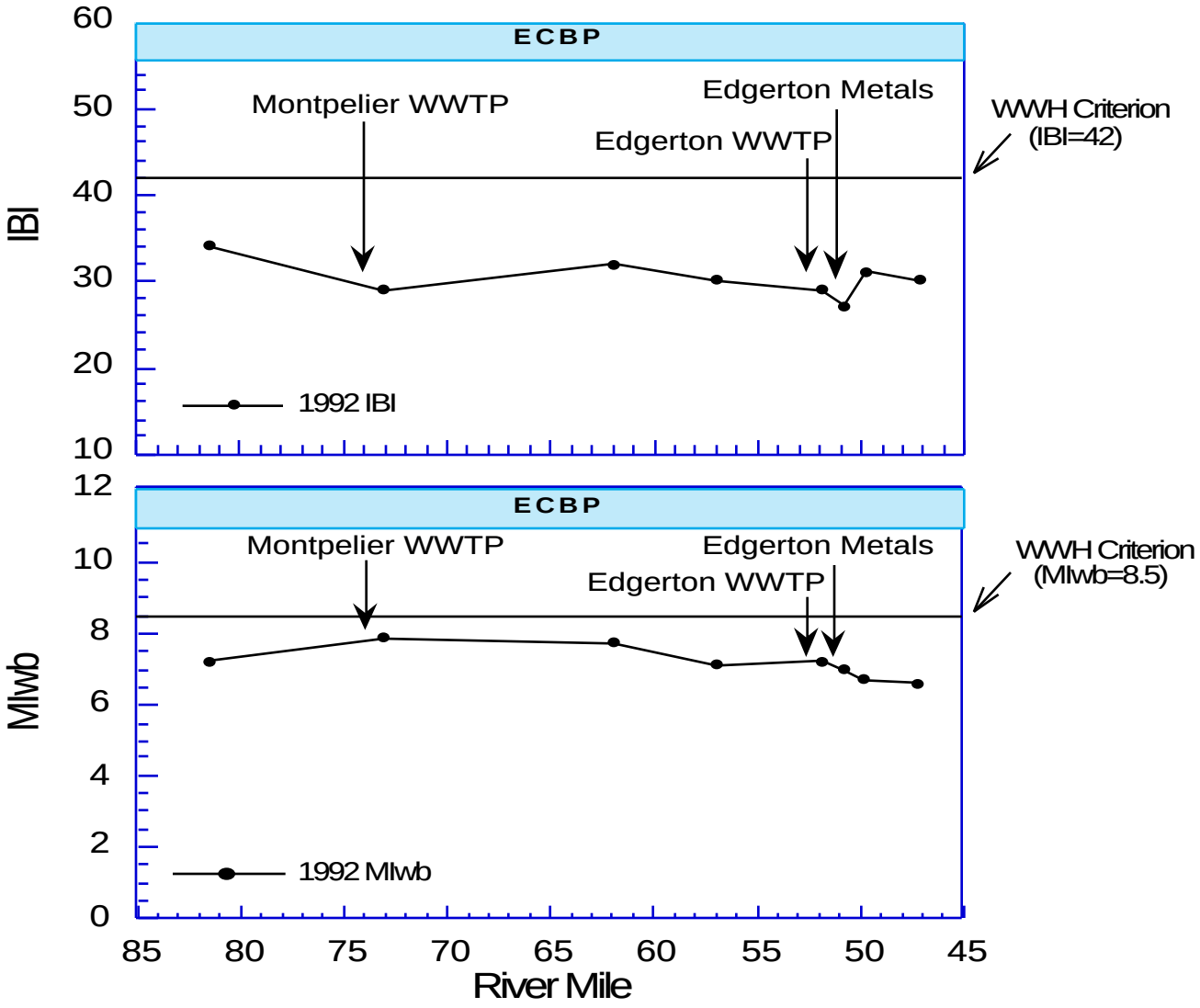


Figure 9. Longitudinal performance of the Index of Biotic Integrity (IBI, upper plot) and the Modified Index of Well-being (MIwb, lower plot) within the St. Joseph River mainstem, 1992.

- Background conditions recorded at RM 81.2 suggested that habitat influences were the primary forcing function in determining community performance. Although waste water discharged by the Montpelier WWTP and Edgerton Metals precipitated a detectable response within the fish assemblage, the effects were limited and did not appear to prevent attainment of the WWH biological criteria. The lack of quality habitat, particularly within the lower reach of the study area, was the overriding influence presently affecting the fish community.

Fish Creek

Chemical Water Quality

- Fish Creek receives no discharges from NPDES permitted entities in Ohio. It also receives no septic inputs from communities without centralized wastewater collection and treatment systems.

- A single Datasonde continuous monitor was deployed in Fish Creek at RM 0.4 to determine diurnal fluctuations in D.O. concentrations. None of the readings recorded were below either the daily minimum criterion (4.0 mg/l) or the daily average criterion (5.0 mg/l) for the WWH use designation. These results indicate that low D.O. is not a significant concern at this site.

- Surface water samples were collected in Fish Creek at RM 0.4 for analysis of chemical water quality. Interpretation of analytical results indicates good water quality in Fish Creek. No exceedences of Ohio Water Quality Standards were detected in any of the samples submitted. The mean ammonia-N concentration of 0.06 mg/l (range 0.09-0.05) is well below the maximum and 30-day average criterion for the WWH use designation. Five of six results for ammonia-N were below the method detection limit of 0.05 mg/l.

Physical Habitat for Aquatic Life

- Macrohabitats of Fish Creek were evaluated at three fish sampling stations. Qualitative Habitat Evaluation Index values ranged between 42.5 at RM 30.5 and 75.0 at RM 5.4. The macrohabitats of Fish Creek at RM 5.4 appeared to be of a sufficient quality to support and maintain a community of aquatic organisms capable of attaining, at least, the WWH biological criteria (Rankin 1989). Macrohabitats encountered at RM 30.5 and RM 0.2 were of a lesser quality, and may have had a negative influence upon ambient biological potential.

- The station at RM 30.5 (upstream of P-25 Rd.) represented the headwaters of Fish Creek within Ohio. This station demonstrated an overwhelming predominance of high and moderate influence modified attributes which included: poor channel development, low functional sinuosity, sparse instream cover, and a lack of wooded riparian corridor (Table 9). These negative habitat characteristics are those commonly encountered in stream reaches that have been subject to channel modification and maintenance activities. Though components of physical habitat were diminished at this station, limited mitigation was provided by the ground water inputs. The ground water influence furnished stable stream flow and temperature.

- The lower reach of Fish Creek, between RM 5.4 and RM 0.2, contained habitats of a much higher quality than that encountered within the headwaters. Near and instream habitats at RM 5.4 can be characterized as being of very high quality. This station was predominated by warmwater attributes which included: abundant coarse glacial substrate, good/excellent channel development, high/moderate functional sinuosity, and mixed current velocities (Table 9).

- Near and instream habitats encountered at RM 0.2 were of a lower quality than that found at RM 5.4 (Table 9). The station at RM 0.2 demonstrated an increase in occurrence of moderate influence habitat attributes. Habitat characteristics at this station that may be limiting included: shifting and unstable coarse substrates, past channel modification, lack of mixed current velocities (particularly swift current velocity).

Biological Assessment: Macroinvertebrate Community

- The uppermost site on Fish Creek (RM 30.5) was channel modified with a narrow grass riparian buffer and appeared to be nutrient enriched. Qualitative macroinvertebrate sampling produced 35 primarily pollution tolerant and intermediate taxa. Fingernail clams (*Sphaerim spp*.) were the predominant taxa observed.

- Habitat was much improved and nutrient levels appeared to be lower at RM 5.4, consequently the macroinvertebrate community was in significantly better condition than at RM 30.5. Relatively high numbers of mayfly and caddisfly taxa were collected and the ICI score was in the exceptional range (ICI=50). The artificial substrates were nearly buried under sand and gravel at RM 0.3, consequently the ICI was invalidated. Sampling of the natural substrates yielded a relatively diverse fauna primarily from woody debris; however, the number of taxa collected in the qualitative sampling decreased from 34 at RM 5.4 to 26 at RM 0.3. These two results point out the primary negative factor affecting the benthos, that being an unstable substrate. Based primarily on the narrative evaluation, the macroinvertebrate community was classified as being in good condition at RM 0.3.

Biological Assessment: Fish Community

- A total of 6,486 fish comprised of 38 species and two hybrids was collected from Fish Creek, between August 21 and September 18, 1992. The sampling effort included three stations. The most upstream station was placed within the northwest portion of Williams County at RM 30.5. Two additional stations were placed within the lower portion of Fish Creek located in the southwest portion of Williams County at RM 0.2 and RM 5.4. The remaining segment of Fish Creek is located within northeast Indiana.

- The numerically predominant fish species recorded from the three sampling stations were: johnny darter (18.2%), creek chub (17.3%), blacknose dace (14.3%), central stoneroller (13.0%), and gizzard shad (8.07%). Fish species that predominated in terms of biomass were: common carp (38.9%), northern hog sucker (16.7%), rockbass (7.92%), creek chub (5.98%), and golden redhorse (5.08%).

- The fish assemblage at RM 30.5 was somewhat typical of headwater stream systems within Ohio. Though generalists, omnivorous, and herbivorous cyprinid species were numerically predominant, reflective of modest nutrient enrichment and submarginal habitat, functional organization within the fish assemblage was maintained. Performance within the fish community at this station was consistent with the WWH biological criteria (Table 11).

- Community performance within the lower reach of the Fish Creek study area was characterized as good to fair (Table 11). The station at RM 5.4 contained a fish community performing at an exceptional level (IBI=46;MIwb=9.3), reflective of in stream habitats and ecoregional expectations. The fish assemblage at this station possessed a high degree of functional organization with an abundance of fish species sensitive to and intolerant of disturbances to physical habitat and chemical water quality.

- Performance within the fish community at RM 0.2 was somewhat reduced in comparison to sampling stations upstream. A high level of functional organization was maintained; however, structural aspects of the fish assemblage were diminished. Diminished performance within the MIwb may have reflected habitat influences. Though physical habitat at this station was generally good, substrates were predominantly unstable and shifting, consisting mainly of sand and pea gravel. This type of substrate tends to be naturally limiting providing less than optimal refugia for stream dwelling organisms. In addition, the station had been channel modified in the past, though limited recovery was evident. These two aspects of physical habitat likely reduced the capacity of this reach to support and maintain a warm water fish community capable of fully achieving WWH biological criteria

Bear Creek

Chemical Water Quality

- The Village of Edon is located near the source of Bear Creek. Edon currently has no centralized collection or treatment of household sanitary waste. Therefore, wastes from on-site treatment systems discharge to Bear Creek either directly or via storm sewers. The storm sewers located adjacent Waltz Park at RM 7.9 and near SR 49 at RM 7.6 collect the majority of sanitary waste in Edon. On 28 May, 1992, Ohio EPA issued Directors Final Findings and Orders to Edon regarding a proposed wastewater treatment facility. As required in the orders, Edon shall achieve and maintain compliance with the terms and conditions of the effective NPDES permit (Ohio EPA #2PA00031) by 1 June, 1994.

- Plas-Tec Corporation (Ohio EPA permit # 2IQ00020) is located in the Village of Edon at 601 W. Indiana Street. Plas-Tec molds and assembles polyethylene plastic products. A discharge of non-contact cooling water (untreated) and sanitary waste treated by extended aeration enter Bear Creek at approximately RM 8.2.

- The Village of Blakeslee also has no centralized collection or treatment of household sanitary waste. Sanitary waste from on-site treatment systems are discharged to a storm sewer which flows along Williams CR-H and meets Bear Creek at RM 1.2 (Williams County Department of Health, personal communication). This storm sewer also receives a discharge from the Thiel Subdivision package plant located near the intersection of SR 34 and Williams CR 5.

- Surface water samples were collected in Bear Creek at RM 0.5 for analysis of chemical water quality. Interpretation of analytical results indicates fair water quality in Bear Creek. The only exceedence of Ohio Water Quality Standards in Bear Creek was the Primary Contact Recreation criterion for fecal coliform on July 14 (Table 6). Since this sampling event was conducted during a high flow period following a large rainstorm, this fecal coliform exceedence is likely due to nonpoint source runoff and interference from soil bacteria. However, fecal coliform counts at this site do appear to be affected by discharges of on-lot sanitary waste at Edon and Blakeslee, with a mean count of 2090 colonies/100ml (range 3200-980). Impacts from these discharges are also reflected in the mean ammonia-N results, with a concentration of 0.14 mg/l (range 0.23-0.05). Five of the six samples analyzed for ammonia-N were above the method detection limit of 0.05 mg/l.

Physical Habitat for Aquatic Life

- Macrohabitats of Bear Creek were evaluated at one location (RM 0.5) during the 1992 sampling effort. This station achieved a QHEI score of 74.0, reflective of good quality stream habitat. Warmwater attributes were predominant at this station (Table 9). Near and instream habitats at RM 0.5 appeared capable of supporting a community of aquatic organisms able to attain the WWH biological criteria. However, QHEI values require interpretation on a reach or segment level. The 1992 evaluation at RM 0.5 represents only one sample, and thus may not have been representative of over all habitat quality within Bear Creek . Based upon a mini-biosurvey conducted in 1991, which included four stations between RM 8.3 and RM 0.5, Bear Creek was found to possess stream habitat of a much poorer quality than that encountered at RM 0.5 alone. A mean reach QHEI value of 46.5 from 1991 field investigation indicated that the relatively high quality habitat encountered at RM 0.5 in 1992 was not indicative of the basin. The finding from the 1991 survey indicated that channelization and associated maintenance activities have resulted in significant habitat modifications, likely precluding the ability of Bear Creek to support and maintain a community of aquatic organisms consistent with the WWH biological criteria throughout the entire stream reach. Given the level of basin-wide disturbance, Bear Creek is a candidate for the Modified Warmwater Habitat (MWH) use within the upper and middle segments. The lower reach has been subject little recent channel modification and has demonstrated considerable recovery from past channelization. As a consequence, macrohabitats within the lower segment appeared consistent with the WWH use and this designation should be retained within lower reach.

Biological Assessment: Macroinvertebrate Community

- Macroinvertebrate sampling of Bear Creek at RM 0.5 produced an ICI score of 46. A relatively high number of blackflies (*Simulim spp.*) on the natural substrates reflected a significant amount of enrichment from agricultural nonpoint and/or point sources in the village of Edon and/or the village of Blakeslee.

Biological Assessment: Fish Community

- A total of 2,209 fish comprised of 23 species were collected from Bear Creek during the 1992 sampling effort at RM 0.5. The numerically predominant fish species were: bluntnose minnow (35.9%), creek chub (24.0%), gizzard shad (10.9%), johnny darter (10.3%), and white sucker (8.69%). Fish species that were predominant in terms of biomass were: white sucker (66.7%), creek chub (13.0%), northern hog sucker (7.53%), bluntnose minnow (3.89%), and rockbass (1.38%).

- Community performance within Bear Creek at RM 0.5 was characterized as fair, failing to perform at a level consistent with the WWH biological criterion (IBI=31; MIwb=6.9). The fish assemblage was predominated by tolerant, omnivorous and generalists species. Near and instream habitats at RM 0.5 appeared to be of a sufficient quality to support a diverse and functionally organized fish community. However, results from a biosurvey conducted in 1991 indicated that basin-wide habitat condition is generally poor, reflective of pervasive channelization and maintenance activities. The failure of the fish community to perform at WWH levels in 1991 and 1992 appeared habitat related, given the level of disturbance within the watershed. Modest nutrient and organic enrichment from upstream point sources (Village of Edon and/or Villages of Blakeslee) and/or agricultural nonpoint sources were of secondary importance.

West Branch St. Joseph River

Chemical Water Quality

- The West Branch St. Joseph River receives no discharges from NPDES permitted entities in Ohio. However, sanitary waste water from homes surrounding Lake Seneca is a possible source of contamination. The majority of household sanitary waste water is treated by on-site systems consisting of a septic tank, aeration, and at least 600 linear feet of leach field (Williams County Department of Health, personal communication). It is suspected that some direct discharges of domestic sanitary wastes to Lake Seneca may exist.

- Surface water samples were collected in the West Branch St. Joseph River at RM 10.5, upstream from Lake Seneca, and RM 3.2, downstream from Lake Seneca for analysis of chemical water quality. The only exceedence of Ohio Water Quality Standards was the Secondary Contact Recreation criterion for fecal coliform at RM 10.5 on 14 July (Table 6). This was the highest fecal coliform count measured in the study area during the survey period. Although this elevated result is likely due to the increased runoff and associated high flows experienced during this sampling event, it is possible some unknown source of contamination exists, such as a livestock feedlot.

- Interpretation of other analytical results indicates good water quality in the West Branch St. Joseph River. The mean ammonia-N concentration at RM 10.5 of 0.12 mg/l (range 0.05-0.45) was slightly higher than the mean concentration at RM 3.2 of 0.06 mg/l (range 0.05-0.09). It should be noted that at both sites, four of six ammonia-N results were below the method detection limit of 0.05 mg/l. The mean D.O. concentration at RM 10.5 of 8.5 mg/l (range 10.1-7.2) was also slightly higher than the mean concentration at RM 3.2 of 7.2 mg/l (range 8.5-6.6).

Physical Habitat for Aquatic Life

- Macrohabitats of the West Branch St. Joseph River were evaluated at two fish sampling stations. Near and instream habitats at both stations contained a predominance of warmwater attributes which included: good/excellent channel development, coarse glacial substrates (sand/gravel), moderate/high functional sinuosity, and mixed current velocities (Table 9). The range of QHEI values was 73.0 at RM 10.5 and 80.0 at RM 3.2 and were found to have a mean reach score of 76.5. A mean QHEI 76.5 suggest that macrohabitats of the West Branch St. Joseph River were fully capable of supporting a community of aquatic organisms capable of attaining WWH biological criteria (Rankin 1989).

Biological Assessment: Macroinvertebrate Community

- The uppermost segment of the West Branch St. Joseph River (RM 10.5) appeared to be one of the most undisturbed river reaches found in northwestern Ohio. The water was very clear and slightly tannin stained under low flow conditions. The benthic community was reflective of a low nutrient, cool water environment. The site at RM 3.2, though physically similar, was downstream from Seneca Lake, a large instream impoundment, and supported a macroinvertebrate community that reflected a significantly more enriched and warm water condition. The Invertebrate Community Index score was 50 at RM 10.5 and 40 at RM 3.2, while the QCTV displayed little change between stations (Table 9). Hydropsychid caddisflies were especially indicative of the impact that the impoundment had on the stream. Six hydropsychid taxa were collected at the upper site including three species that are indicative of relatively cool water and/or undisturbed conditions. At RM 3.2, only three hydropsychid taxa were collected and the density of hydropsycids on the artificial substrates was more than three

and one-half times the number collected at RM 10.5. The assemblage at RM 3.2 was more typical of large river systems. The shift within the benthic invertebrate fauna observed at RM 3.2 appeared related to the export of plankton to the West Branch St. Joseph River from Seneca Lake.

Biological Assessment: Fish Community

- A total of 3,512 fish comprised of 39 species and two hybrids was collected from the West Branch St. Joseph River, between August 20 and September 18, 1992. The sampling effort included two stations located at RM 10.5 (upstream of Seneca Lake) and RM 3.2 (downstream Seneca Lake).

- Numerically predominant fish species were: gizzard shad (63.3%), spotfin shiner (11.3%), river chub (5.52%), northern hog sucker (2.73%), and green sunfish (0.82%). Fish species that predominated in terms of biomass were: common carp (49.4%), northern hogsucker (10.1%), gizzard shad (9.77%), river chub (6.07%), and golden redhorse (4.91%).

- Both stations on the West Branch St. Joseph River (RM 10.5 and RM 3.2) contained fish assemblages reflective of quality instream habitats and ecoregional biological expectations. Fish community samples indicated a high degree of functional and structural organization, consistent with the WWH biological criteria.

Silver Creek

Chemical Water Quality

- Silver Creek receives no discharges from NPDES permitted entities in Ohio. It also receives no septic inputs from communities without centralized wastewater collection and treatment systems. It does, however, receive a discharge from a wastewater stabilization lagoon system in Michigan, across the Ohio-Michigan border at approximately RM 3.6.

- Surface water samples were collected in Silver Creek at RM 1.2 for analysis of chemical water quality. Interpretation of analytical results indicated good water quality in Silver Creek. The only exceedence of Ohio Water Quality Standards in Silver Creek was the Primary Contact Recreation criterion for fecal coliform on 14 July (Table 6). Since this sampling event was conducted during a period of increased runoff and associated high flows, this fecal coliform exceedence was likely due to nonpoint source runoff and interference from soil bacteria. The mean ammonia-N concentration of 0.12 mg/l (range 0.43-0.05) is well below the minimum and 30 day average criterion for WWH. Four of six results for ammonia-N were below the method detection limit of 0.05 mg/l.

Physical Habitat for Aquatic Life

- Macro habitats of Silver Creek were evaluated at one station (RM 1.3). This station achieved QHEI score of 68.5, suggesting that Silver Creek is capable of supporting a community of aquatic organisms attaining the WWH biological criteria (Rankin 1989). Though moderate influence modified attributes were present at this station, the influence did not appear sufficient to significantly suppress biological community performance (Table 9)

Biological Assessment: Macroinvertebrate Community

- Silver Creek at RM 1.3 supported a relatively pollution sensitive macroinvertebrate community that included good numbers of mayfly, caddisfly and sensitive midge taxa. The ICI score clearly exceeded the EWH biocriterion (ICI=52). The stream appeared to support a high number of unionid mollusks based on the prevalence of living, fresh-dead, and sub-fossil specimens at this site.

Biological Assessment: Fish Community

- A total of 924 fish comprised of 28 species and two hybrids was collected from silver Creek at RM 1.3 (downstream CR 15) during the 1992 field sampling effort. Numerically predominant fish species were: creek chub (24.1%), green sunfish (13.5%), northern hog sucker (7.03%), spotfin shiner (8.55%), and bluntnose minnow (7.58%). Fish species that predominated in terms of biomass were: white sucker (27.6%), creek chub (24.3%), northern hog sucker (17.0%), green sunfish (9.96%), and common carp (4.61%).

- Community performance at this station was characterized as good/marginally good (IBI=41; MIwb=8.2), consistent with the WWH biological criteria. Relatively high species richness, predominance by lithophilic and insectivorous species and the presence of intolerant forms was reflective of good instream habitat and water quality.

Area of Degradation (ADV) Statistics

- Area Degradation Values (ADV) for the 1991-92 sampling effort provides a measure of the degradation portrayed by the IBI, MIwb, and ICI from ecoregional expectations for the St. Joseph River study area. This information will provide the basis for future trend analysis of the St. Joseph River and tributaries.

- The high ADV/mile of the IBI and MIwb from the St. Joseph River mainstem was most reflective of nonpoint (primarily siltation) and habitat impacts to the fish assemblage (Table 12). The ADV/mile of the ICI within the St. Joseph River mainstem was zero (0), which indicated performance below ecoregional expectations within the benthic macroinvertebrate community was not encountered. The method employed by Ohio EPA to collect benthic macroinvertebrate community samples are essentially habitat neutral. Consequently, in river systems where macrohabitats are degraded, the benthic invertebrate community tends to better delineate impacts to *chemical* water quality than the more habitat dependant fish assemblage. Thus, the apparent discrepancies between the ADV/mile within the invertebrate and fish community indices indicated no significant impacts to *chemical* water quality within the St. Joseph River mainstem. Rather, the marginal quality of the macrohabitats within the St. Joseph River were reflected within the elevated ADV/mile for both fish community indices (IBI and MIwb). These results were fairly typical of habitat modified streams within Ohio.

- The fish community ADV/mile statistics for Bear Creek (1991-92) were elevated. In comparison with St. Joseph River mainstem ADV/mile for fish indices, the values from Bear Creek (1991) were significantly higher, indicating the relative severity of the habitat impacts within this highly channel modified system (Table 12). All other tributaries of the St. Joseph River evaluated in 1991-92 possessed ADV/mile values at or near zero, indicating that community performance (fish and benthic invertebrate) fairly consistent with ecoregional expectations.

Table 12. Area of Degradation (ADV) statistics for the St. Joseph River study area, 1991-92. (calculated using ecoregional criteria as the background community performance).

Biological Index Scores					ADV Statistics			Attainment Status (miles)			
Stream Index	Upper RM	Lower RM	Mini mum	Maxi mum	**ADV**	ADV/ Mile	Poor/VP ADV	FULL	PARTIAL	**NON**	Poor/VP
St. Joseph River (1992)											
IBI			27	34	**2388**	69.8	0.0				
MIwb	81.5	47.3	6.7	7.9	**805**	23.5	0.0	0.0	34.2	0.0	0.0
ICI			42	48	**0**	0.0	0.0				
Fish Creek (1992)											
IBI	30.5	30.5	44	44	0	0.0	0.0	0.1	0.0	0.0	0.0
IBI			42	46	**0**	0.0	0.0				
MIwb	0.2	5.4	7.5	9.3	**10**	1.92	0.0	4.5	0.8	0.0	0.0
ICI			36	50	**0**	0.0	0.0				
Bear Creek (1992)											
IBI			31	31	**5**	50	0.0				
MIwb	0.5	0.5	6.8	6.8	**5**	50	0.0	0.0	0.1	0.0	0.0
ICI			46	46	**0**	0.0	0.0				
Bear Creek (1991)											
IBI			22	28	**434**	117.3	94.0				
MIwb	0.5	4.2	4.5	4.9	**395**	106.8	25.0	0.0	0.0	3.8	3.6
West Branch St. Joseph River (1992)											
IBI			45	45	**0**	0.0	0.0				
MIwb	3.2	10.5	7.9	8.8	**0**	0.0	0.0	7.3	0.0	0.0	0.0
ICI			40	50	**0**	0.0	0.0				
Silver Creek (1992)											
IBI			41	41	**0**	0.0	0.0				
MIwb	1.3	1.3	8.2	8.2	**0**	0.0	0.0	0.1	0.0	0.0	0.0
ICI			52	52	**0**	0.0	0.0				

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Appendix Tables

Appendix Table 1. Results of chemical/physical sampling in the St. Joseph River study area during July-September, 1992. Violations of WWH water quality standards are noted with an asterisk (*) and values below detection limits are noted with less-than symbol.

West Branch St. Joseph River: RM 10.5 - Bridgewater TR S

Date	Time	Temp (˚C)	D.O. (mg/l)	pH (field) (S.U.)	pH (lab) (S.U.)	BOD_5 (mg/l)	$cBOD_5$ (mg/l)	COD (mg/l)
920714	1050	19.8	7.2	8.2	7.77	5.0	2.7	27
920729	1025	19.9	7.5	8.5	8.13	1.8	<1.0	46
920813	1028	17.2	8.4	8.4	8.10	2.3	1.2	39
920825	1030	19.4	9.7	8.5	8.32	<1.0	<1.0	23
920908	1005	19.1	8.1	8.3	8.24	<1.0	<1.0	29
920924	1055	11.4	10.1	8.3	8.22	1.1	<1.0	31

West Branch St. Joseph River: RM 3.1 - Bridgewater TR 11.5

Date	Time	Temp (˚C)	D.O. (mg/l)	pH (field) (S.U.)	pH (lab) (S.U.)	BOD_5 (mg/l)	$cBOD_5$ (mg/l)	COD (mg/l)
920714	1115	23.0	6.7	8.4	7.90	2.9	1.3	21
920729	1045	21.5	6.9	8.3	8.16	1.0	<1.0	34
920813	1055	21.5	6.6	8.5	8.23	<1.0	<1.0	31
920825	1050	23.2	7.6	8.5	8.24	1.9	1.1	34
920908	1025	21.3	6.9	8.4	8.35	2.7	1.3	34
920924	1115	16.5	8.5	8.4	8.25	2.1	1.2	32

Appendix Table 1 (cont.)

Silver Creek: RM 1.2 - Williams CR 15

Date	Time	Temp (˚C)	D.O. (mg/l)	pH (field) (S.U.)	pH (lab) (S.U.)	BOD_5 (mg/l)	$cBOD_5$ (mg/l)	COD (mg/l)
920714	1025	21.8	7.2	8.0	7.88	4.6	1.6	24
920729	0950	21.1	7.4	8.3	8.20	1.5	<1.0	44
920813	1000	19.2	7.6	8.4	8.26	1.9	<1.0	50
920825	1010	21.3	8.3	8.4	8.24	1.0	<1.0	47
920908	0945	20.4	7.5	8.2	8.21	1.3	<1.0	39
920924	1000	14.1	9.0	8.3	8.30	3.3	3.3	44

St. Joseph River: RM 81.2 - Williams CR N

Date	Time	Temp (˚C)	D.O. (mg/l)	pH (field) (S.U.)	pH (lab) (S.U.)	BOD_5 (mg/l)	$cBOD_5$ (mg/l)	COD (mg/l)
920714	1130	20.7	6.3	7.8	7.67	4.2	1.8	29
920729	1105	20.7	6.4	7.9	8.00	2.0	<1.0	43
920813	1100	19.2	6.8	8.4	8.16	1.6	<1.0	37
920825	1105	21.4	7.7	8.3	8.24	1.0	<1.0	30
920908	1040	20.6	7.1	8.3	8.22	2.0	1.0	30
920924	1130	13.9	8.6	8.3	8.12	1.8	1.0	36

St. Joseph River: RM 73.2 - Williams CR 10

Date	Time	Temp (˚C)	D.O. (mg/l)	pH (field) (S.U.)	pH (lab) (S.U.)	BOD_5 (mg/l)	$cBOD_5$ (mg/l)	COD (mg/l)
920714	1155	21.6	6.2	8.1	7.74	2.9	NA	21
920729	1120	21.1	6.1	8.0	7.99	2.6	<1.0	49
920813	1125	19.3	6.4	8.5	8.14	2.0	1.3	48
920825	1125	21.6	7.1	8.3	8.17	1.3	<1.0	29
920908	1100	20.1	6.6	8.2	8.17	2.3	<1.0	31
920924	1200	14.3	8.2	8.3	8.04	2.1	1.3	35

Appendix Table 1 (cont.)

St. Joseph River : RM 62.1 - SR 34

Date	Time	Temp (˚C)	D.O. (mg/l)	pH (field) (S.U.)	pH (lab) (S.U.)	BOD_5 (mg/l)	$cBOD_5$ (mg/l)	COD (mg/l)
920714	1245	22.6	6.2	8.2	7.90	2.4	1.2	22
920729	1155	21.1	6.2	8.2	7.92	2.3	<1.0	46
920813	1150	19.9	6.8	8.5	8.06	2.0	1.0	42
920825	1145	21.3	8.4	8.5	8.18	1.0	<1.0	30
920908	1135	19.8	7.1	8.4	8.15	1.7	<1.0	26
920924	1225	14.4	8.2	8.2	7.95	2.7	1.6	37

St. Joseph River: RM 56.8 - Williams CR E-75

Date	Time	Temp (˚C)	D.O. (mg/l)	pH (field) (S.U.)	pH (lab) (S.U.)	BOD_5 (mg/l)	$cBOD_5$ (mg/l)	COD (mg/l)
920714	1215	22.2	6.0	8.2	7.82	1.6	<1.0	20
920729	1200	21.0	5.5	8.0	7.89	2.2	<1.0	37
920813	1145	19.6	6.7	8.2	7.94	2.1	<1.0	50
920825	1220	21.4	8.5	8.4	8.19	1.4	<1.0	29
920908	1150	19.8	7.2	8.3	8.16	1.9	<1.0	30
920924	1345	14.3	8.1	7.9	7.86	2.7	2.0	36

St. Joseph River: RM 51.4 - US 6

Date	Time	Temp (˚C)	D.O. (mg/l)	pH (field) (S.U.)	pH (lab) (S.U.)	BOD_5 (mg/l)	$cBOD_5$ (mg/l)	COD (mg/l)
920714	1100	21.9	6.6	8.3	7.89	2.9	1.4	20
920729	1135	20.9	6.0	8.0	8.09	2.0	<1.0	38
920813	1100	19.9	6.9	8.2	8.02	1.6	1.1	37
920825	1245	21.5	9.7	8.3	8.24	1.4	<1.0	26
920908	1225	19.7	7.4	8.4	8.17	1.7	<1.0	29
920924	1415	14.4	8.3	8.1	7.86	2.6	1.6	43

Appendix Table 1 (cont.)

St. Joseph River: RM 50.8 - adjacent Aqua Lane Dr.

Date	Time	Temp (˚C)	D.O. (mg/l)	pH (field) (S.U.)	pH (lab) (S.U.)	BOD_5 (mg/l)	$cBOD_5$ (mg/l)	COD (mg/l)
920714	1120	21.7	6.5	8.0	7.88	2.7	2.2	29
920729	1105	20.6	5.9	7.6	7.97	1.9	1.0	39
920813	1035	20.0	6.7	8.1	7.98	1.7	1.0	42
920825	1320	21.1	8.3	8.1	8.23	1.7	<1.0	27
920908	1245	20.0	7.3	8.3	8.15	1.8	<1.0	33
920924	1440	14.4	8.2	7.8	7.82	2.9	1.6	37

St. Joseph River: RM 49.8 - SR 49

Date	Time	Temp (˚C)	D.O. (mg/l)	pH (field) (S.U.)	pH (lab) (S.U.)	BOD_5 (mg/l)	$cBOD_5$ (mg/l)	COD (mg/l)
920714	1045	22.0	6.7	8.3	7.84	3.4	1.7	20
920729	1040	20.7	6.0	8.0	7.94	1.7	1.1	46
920813	1020	19.9	6.6	8.1	8.14	1.6	<1.0	36
920825	1335	21.4	8.8	8.5	8.22	<1.0	<1.0	24
920908	1305	19.9	7.6	8.5	8.17	1.7	1.2	30
920924	1455	14.6	8.2	8.0	7.85	2.8	1.5	39

St. Joseph River: RM 47.3 - Line Rd.

Date	Time	Temp (˚C)	D.O. (mg/l)	pH (field) (S.U.)	pH (lab) (S.U.)	BOD_5 (mg/l)	$cBOD_5$ (mg/l)	COD (mg/l)
920714	1020	22.0	6.1	8.2	7.86	3.5	2.3	19
920729	1025	20.7	6.1	7.9	7.90	1.9	<1.0	38
920813	1000	20.4	6.6	8.1	8.15	1.9	<1.0	38
920825	1355	22.1	9.5	8.6	8.28	2.2	<1.0	25
920908	1315	19.8	7.8	8.6	8.20	2.4	1.2	35
920924	1505	14.7	7.9	8.0	7.84	3.0	2.9	42

Appendix Table 1 (cont.)

Bear Creek: RM 0.5 - SR 34

Date	Time	Temp (˚C)	D.O. (mg/l)	pH (field) (S.U.)	pH (lab) (S.U.)	BOD_5 (mg/l)	$cBOD_5$ (mg/l)	COD (mg/l)
920714	1300	21.6	6.2	8.2	7.75	3.6	1.4	24
920729	1205	20.7	6.6	8.1	7.84	1.8	<1.0	52
920813	1209	17.6	7.2	8.5	8.03	1.2	<1.0	39
920825	1155	20.0	8.5	8.4	8.07	<1.0	<1.0	24
920908	1125	18.2	5.7	8.0	7.94	1.3	<1.0	22
920924	1240	13.3	8.6	7.8	7.69	<1.0	<1.0	45

Fish Creek: RM 0.4 - SR 49

Date	Time	Temp (˚C)	D.O. (mg/l)	pH (field) (S.U.)	pH (lab) (S.U.)	BOD_5 (mg/l)	$cBOD_5$ (mg/l)	COD (mg/l)
920714	1150	21.9	6.5	8.3	7.79	1.9	1.0	17
920729	1225	21.0	6.5	8.1	8.06	1.6	<1.0	34
920813	1120	19.0	7.0	8.3	8.03	<1.0	<1.0	33
920825	1230	21.0	7.7	8.3	8.18	1.2	<1.0	21
920908	1210	19.5	7.3	8.4	8.16	1.1	<1.0	23
920924	1405	14.2	8.7	8.1	7.89	2.1	1.4	46

West Branch St. Joseph River: RM 10.5 - Bridgewater TR S

Date	Time	Conduct (µmhos/cm)	NO_3-NO_2 (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	T-P (mg/l)	T-Nflt Residue (mg/l)
920714	1050	486	4.84	0.18	0.45	1.1	0.30	466
920729	1025	434	1.87	0.06	0.06	0.6	0.06	21
920813	1028	484	0.69	0.04	<0.05	0.9	0.11	25
920825	1030	590	0.98	0.02	<0.05	0.3	<0.05	<5
920908	1005	559	0.82	NA	<0.05	0.4	0.06	6
920924	1055	567	0.93	0.02	<0.05	0.7	<0.05	5

Appendix Table 1 (cont.)

West Branch St. Joseph River: RM 3.1 - Bridgewater TR 11.5

Date	Time	Conduct (µmhos/cm)	NO_3-NO_2 (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	T-P (mg/l)	T-Nflt Residue (mg/l)
920714	1115	555	2.03	0.08	0.09	0.7	0.08	99
920729	1045	514	1.60	0.05	<0.05	0.4	0.12	58
920813	1055	537	1.12	0.02	<0.05	0.5	0.07	10
920825	1050	476	0.21	0.03	<0.05	0.6	<0.05	21
920908	1025	486	0.79	NA	<0.05	0.6	<0.05	16
920924	1115	499	0.56	0.05	0.06	0.7	<0.05	24

Silver Creek: RM 1.2 - Williams CR 15

Date	Time	Conduct (µmhos/cm)	NO_3-NO_2 (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	T-P (mg/l)	T-Nflt Residue (mg/l)
920714	1025	559	9.79	0.19	0.43	1.6	0.14	177
920729	0950	533	1.62	0.07	0.09	0.6	<0.05	57
920813	1000	537	0.61	0.04	<0.05	0.9	<0.05	16
920825	1010	545	5.24	0.03	<0.05	1.0	<0.05	20
920908	0945	547	0.24	NA	<0.05	0.7	0.36	20
920924	1000	543	<0.10	0.02	<0.05	0.8	<0.05	21

St. Joseph River: RM 81.2 - Williams CR N

Date	Time	Conduct (µmhos/cm)	NO_3-NO_2 (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	T-P (mg/l)	T-Nflt Residue (mg/l)
920714	1130	445	8.62	0.24	0.15	1.0	0.22	359
920729	1105	491	1.78	0.06	<0.05	0.6	0.09	53
920813	1100	538	0.73	0.04	0.05	0.7	<0.05	36
920825	1105	576	0.38	0.02	<0.05	0.5	0.06	30
920908	1040	551	0.42	NA	0.06	0.6	0.06	28
920924	1130	552	0.61	0.03	<0.05	0.8	0.05	23

Appendix Table 1 (cont.)

St. Joseph River: RM 73.2 - Williams CR 10

Date	Time	Conduct (µmhos/cm)	NO_3-NO_2 (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	T-P (mg/l)	T-Nflt Residue (mg/l)
920714	1155	518	7.76	0.20	0.10	0.8	0.14	178
920729	1120	469	1.79	0.06	<0.05	0.6	0.10	42
920813	1125	524	0.71	0.04	0.06	0.7	<0.05	44
920825	1125	577	0.59	0.03	<0.05	0.4	0.10	29
920908	1100	517	0.42	NA	0.19	0.7	0.06	28
920924	1200	522	0.82	0.04	<0.05	0.8	0.08	30

St. Joseph River : RM 62.1 - SR 34

Date	Time	Conduct (µmhos/cm)	NO_3-NO_2 (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	T-P (mg/l)	T-Nflt Residue (mg/l)
920714	1245	551	2.23	0.10	<0.05	0.5	0.15	115
920729	1155	449	1.84	0.07	<0.05	0.7	0.08	38
920813	1150	549	0.70	0.03	<0.05	0.6	<0.05	58
920825	1145	588	0.53	0.02	<0.05	0.5	0.07	43
920908	1135	543	0.48	NA	0.05	0.5	0.09	46
920924	1225	492	1.14	0.05	<0.05	0.8	0.09	43

St. Joseph River: RM 56.8 - Williams CR E-75

Date	Time	Conduct (µmhos/cm)	NO_3-NO_2 (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	T-P (mg/l)	T-Nflt Residue (mg/l)
920714	1215	567	1.38	0.06	<0.05	0.5	0.12	97
920729	1200	444	1.87	0.06	0.06	0.5	0.11	45
920813	1145	556	0.75	0.03	<0.05	0.6	0.07	50
920825	1220	603	0.50	0.02	<0.05	0.4	0.08	38
920908	1150	550	0.53	NA	<0.05	0.5	0.07	48
920924	1345	464	1.43	0.06	<0.05	0.8	0.12	49

Appendix Table 1 (cont.)

St. Joseph River: RM 51.4 - US 6

Date	Time	Conduct (µmhos/cm)	NO_3-NO_2 (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	T-P (mg/l)	T-Nflt Residue (mg/l)
920714	1100	588	1.30	0.06	<0.05	0.4	0.19	151
920729	1135	434	1.86	0.07	<0.05	0.5	0.10	44
920813	1100	566	0.85	0.03	<0.05	0.5	0.09	50
920825	1245	659	0.60	0.02	<0.05	0.4	0.09	27
920908	1225	560	0.54	NA	<0.05	0.5	0.08	40
920924	1415	427	1.32	0.06	<0.05	0.8	0.12	58

St. Joseph River: RM 50.8 - adjacent Aqua Lane Dr.

Date	Time	Conduct (µmhos/cm)	NO_3-NO_2 (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	T-P (mg/l)	T-Nflt Residue (mg/l)
920714	1120	592	1.35	0.05	<0.05	0.4	0.15	136
920729	1105	460	1.86	0.06	<0.05	0.4	0.10	51
920813	1035	570	0.88	0.03	<0.05	0.6	<0.05	51
920825	1320	620	0.61	0.02	<0.05	0.4	0.25	26
920908	1245	564	0.54	NA	<0.05	0.4	0.06	42
920924	1440	434	1.27	0.06	<0.05	0.7	0.14	60

St. Joseph River: RM 49.8 - SR 49

Date	Time	Conduct (µmhos/cm)	NO_3-NO_2 (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	T-P (mg/l)	T-Nflt Residue (mg/l)
920714	1045	580	1.64	0.06	<0.05	0.5	0.20	156
920729	1040	441	1.88	0.07	<0.05	0.4	0.10	50
920813	1020	568	0.86	0.03	<0.05	0.7	<0.05	48
920825	1335	660	0.84	0.02	<0.05	0.3	0.11	28
920908	1305	NA	0.55	NA	<0.05	0.6	0.08	NA
920924	1455	435	1.35	0.06	<0.05	0.8	0.12	59

Appendix Table 1 (cont.)

St. Joseph River: RM 47.3 - Line Rd.

Date	Time	Conduct (µmhos/cm)	NO_3-NO_2 (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	T-P (mg/l)	T-Nflt Residue (mg/l)
920714	1020	605	2.33	0.07	<0.05	0.7	0.17	67
920729	1025	437	1.95	0.07	<0.05	0.6	0.11	39
920813	1000	571	0.81	0.03	<0.05	0.5	0.10	52
920825	1355	604	0.55	0.02	<0.05	0.3	1.25	27
920908	1315	560	0.47	NA	<0.05	0.5	<0.05	27
920924	1505	421	1.58	0.06	<0.05	0.9	0.13	64

Bear Creek: RM 0.5 - SR 34

Date	Time	Conduct (µmhos/cm)	NO_3-NO_2 (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	T-P (mg/l)	T-Nflt Residue (mg/l)
920714	1300	725	3.30	0.41	0.23	1.1	0.32	48
920729	1205	525	2.33	0.17	0.12	1.1	0.13	22
920813	1209	743	0.93	0.05	<0.05	0.6	0.13	7
920825	1155	770	0.47	0.04	0.14	0.4	0.19	<5
920908	1125	712	0.56	NA	0.14	0.3	0.12	<5
920924	1240	478	3.02	0.08	0.14	1.2	0.13	39

Fish Creek: RM 0.4 - SR 49

Date	Time	Conduct (µmhos/cm)	NO_3-NO_2 (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	TKN (mg/l)	T-P (mg/l)	T-Nflt Residue (mg/l)
920714	1150	592	2.93	0.11	0.09	0.6	0.12	130
920729	1225	480	1.30	0.03	<0.05	0.6	0.08	48
920813	1120	595	1.00	0.03	<0.05	0.9	<0.05	31
920825	1230	612	0.64	0.02	<0.05	0.5	0.07	25
920908	1210	642	0.65	NA	<0.05	0.4	<0.05	23
920924	1405	419	0.81	0.04	<0.05	0.7	0.10	49

Appendix Table 1 (cont.)

West Branch St. Joseph River: RM 10.5 - Bridgewater TR S

Date	Time	T-As (µg/l)	T-Cd (µg/l)	T-Ca (mg/l)	T-Cr (µg/l)	T-Cu (µg/l)	T-Fe (µg/l)	T-Pb (µg/l)
920714	1050	4	<0.2	77	<30	<10	7430	6
920729	1025	<2	<0.2	63	<30	<10	1350	<2
920813	1028	<2	<0.2	68	<30	<10	1030	<2
920825	1030	<2	<0.2	84	<30	<10	244	<2
920908	1005	<2	<0.2	80	<30	<10	533	<2
920924	1055	<2	<0.2	86	<30	<10	448	<2

West Branch St. Joseph River: RM 3.1 - Bridgewater TR 11.5

Date	Time	T-As (µg/l)	T-Cd (µg/l)	T-Ca (mg/l)	T-Cr (µg/l)	T-Cu (µg/l)	T-Fe (µg/l)	T-Pb (µg/l)
920714	1115	2	<0.2	80	<30	<10	1980	<2
920729	1045	<2	<0.2	78	<30	<10	2150	<2
920813	1055	<2	<0.2	82	<30	<10	700	3
920825	1050	2	<0.2	63	<30	<10	686	<2
920908	1025	2	<0.2	68	<30	<10	651	<2
920924	1115	2	<0.2	77	<30	<10	1330	<2

Silver Creek: RM 1.2 - Williams CR 15

Date	Time	T-As (µg/l)	T-Cd (µg/l)	T-Ca (mg/l)	T-Cr (µg/l)	T-Cu (µg/l)	T-Fe (µg/l)	T-Pb (µg/l)
920714	1025	3	<0.2	80	<30	<10	3420	2
920729	0950	<2	<0.2	83	<30	<10	2060	<2
920813	1000	3	<0.2	80	<30	<10	962	<2
920825	1010	2	<0.2	78	<30	<10	929	<2
920908	0945	3	<0.2	79	<30	<10	1280	<2
920924	1000	3	<0.2	84	<30	<10	1250	<2

Appendix Table 1 (cont.)

St. Joseph River: RM 81.2 - Williams CR N

Date	Time	T-As (µg/l)	T-Cd (µg/l)	T-Ca (mg/l)	T-Cr (µg/l)	T-Cu (µg/l)	T-Fe (µg/l)	T-Pb (µg/l)
920714	1130	3	<0.2	61	<30	11	7780	7
920729	1105	<2	<0.2	70	<30	<10	2230	<2
920813	1100	2	<0.2	78	<30	<10	1810	<2
920825	1105	2	<0.2	79	<30	<10	1350	<2
920908	1040	3	<0.2	74	<30	<10	1400	<2
920924	1130	<2	<0.2	83	<30	<10	1460	<2

St. Joseph River: RM 73.2 - Williams CR 10

Date	Time	T-As (µg/l)	T-Cd (µg/l)	T-Ca (mg/l)	T-Cr (µg/l)	T-Cu (µg/l)	T-Fe (µg/l)	T-Pb (µg/l)
920714	1155	2	<0.2	68	<30	<10	3760	3
920729	1120	<2	<0.2	69	<30	<10	2060	<2
920813	1125	<2	<0.2	78	<30	<10	2330	<2
920825	1125	2	<0.2	79	<30	<10	1340	<2
920908	1100	<2	<0.2	76	<30	<10	1590	<2
920924	1200	2	<0.2	77	<30	<10	1890	<2

St. Joseph River : RM 62.1 - SR 34

Date	Time	T-As (µg/l)	T-Cd (µg/l)	T-Ca (mg/l)	T-Cr (µg/l)	T-Cu (µg/l)	T-Fe (µg/l)	T-Pb (µg/l)
920714	1245	2	<0.2	68	<30	<10	2690	<2
920729	1155	<2	<0.2	65	<30	<10	1920	<2
920813	1150	3	<0.2	84	<30	<10	2670	<2
920825	1145	3	<0.2	81	<30	<10	1680	<2
920908	1135	2	<0.2	76	<30	<10	2070	<2
920924	1225	<2	<0.2	70	<30	<10	2970	<2

Appendix Table 1 (cont.)

St. Joseph River: RM 56.8 - Williams CR E-75

Date	Time	T-As (µg/l)	T-Cd (µg/l)	T-Ca (mg/l)	T-Cr (µg/l)	T-Cu (µg/l)	T-Fe (µg/l)	T-Pb (µg/l)
920714	1215	3	<0.2	76	<30	<10	3200	<2
920729	1200	<2	<0.2	62	<30	<10	2160	<2
920813	1145	2	<0.2	84	<30	<10	2200	<2
920825	1220	<2	<0.2	82	<30	<10	1580	<2
920908	1150	3	<0.2	77	<30	<10	2130	<2
920924	1345	3	<0.2	68	<30	<10	3940	<2

St. Joseph River: RM 51.4 - US 6

Date	Time	T-As (µg/l)	T-Cd (µg/l)	T-Ca (mg/l)	T-Cr (µg/l)	T-Cu (µg/l)	T-Fe (µg/l)	T-Pb (µg/l)
920714	1100	2	<0.2	73	<30	<10	3490	2
920729	1135	<2	<0.2	63	<30	<10	2440	<2
920813	1100	2	<0.2	80	<30	<10	2130	<2
920825	1245	2	<0.2	84	<30	<10	1170	<2
920908	1225	2	<0.2	78	<30	<10	1860	<2
920924	1415	3	<0.2	60	<30	<10	4180	<2

St. Joseph River: RM 50.8 - adjacent Aqua Lane Dr.

Date	Time	T-As (µg/l)	T-Cd (µg/l)	T-Ca (mg/l)	T-Cr (µg/l)	T-Cu (µg/l)	T-Fe (µg/l)	T-Pb (µg/l)
920714	1120	4	<0.2	80	<30	<10	3200	2
920729	1105	<2	<0.2	63	<30	<10	2670	<2
920813	1035	2	<0.2	78	<30	<10	2180	<2
920825	1320	<2	<0.2	91	<30	<10	1380	<2
920908	1245	<2	<0.2	78	<30	<10	1950	<2
920924	1440	2	<0.2	61	<30	<10	4350	<2

Appendix Table 1 (cont.)

St. Joseph River: RM 49.8 - SR 49

Date	Time	T-As (µg/l)	T-Cd (µg/l)	T-Ca (mg/l)	T-Cr (µg/l)	T-Cu (µg/l)	T-Fe (µg/l)	T-Pb (µg/l)
920714	1045	2	<0.2	74	<30	<10	3770	3
920729	1040	<2	<0.2	63	<30	<10	2700	<2
920813	1020	2	<0.2	80	<30	<10	2240	<2
920825	1335	<2	<0.2	89	<30	<10	1210	<2
920908	1305	3	<0.2	77	<30	<10	1650	<2
920924	1455	3	<0.2	60	<30	<10	4240	<2

St. Joseph River: RM 47.3 - Line Rd.

Date	Time	T-As (µg/l)	T-Cd (µg/l)	T-Ca (mg/l)	T-Cr (µg/l)	T-Cu (µg/l)	T-Fe (µg/l)	T-Pb (µg/l)
920714	1020	2	<0.2	78	<30	<10	1640	<2
920729	1025	<2	<0.2	62	<30	<10	2380	<2
920813	1000	3	<0.2	82	<30	<10	2240	<2
920825	1355	<2	<0.2	91	<30	<10	1220	<2
920908	1315	2	<0.2	77	<30	<10	1280	<2
920924	1505	3	<0.2	59	<30	<10	4570	<2

Bear Creek: RM 0.5 - SR 34

Date	Time	T-As (µg/l)	T-Cd (µg/l)	T-Ca (mg/l)	T-Cr (µg/l)	T-Cu (µg/l)	T-Fe (µg/l)	T-Pb (µg/l)
920714	1300	4	<0.2	77	<30	<10	1500	<2
920729	1205	2	<0.2	78	<30	<10	1240	<2
920813	1209	3	<0.2	98	<30	<10	568	<2
920825	1155	<2	<0.2	96	<30	<10	513	<2
920908	1125	2	<0.2	82	<30	<10	622	<2
920924	1240	3	<0.2	75	<30	<10	3510	<2

Appendix Table 1 (cont.)

Fish Creek: RM 0.4 - SR 49

Date	Time	T-As (µg/l)	T-Cd (µg/l)	T-Ca (mg/l)	T-Cr (µg/l)	T-Cu (µg/l)	T-Fe (µg/l)	T-Pb (µg/l)
920714	1150	3	<0.2	80	<30	<10	2980	<2
920729	1225	<2	<0.2	68	<30	<10	2250	<2
920813	1120	2	<0.2	81	<30	<10	1510	<2
920825	1230	<2	<0.2	91	<30	<10	1140	<2
920908	1210	2	<0.2	85	<30	<10	1010	<2
920924	1405	3	<0.2	62	<30	<10	3210	<2

West Branch St. Joseph River: RM 10.5 - Bridgewater TR S

Date	Time	T-Mg (mg/l)	T-Ni (µg/l)	T-Zn (µg/l)	Hardness (mg/l)	Fecal Coliform (#/100 ml)
920714	1050	20	<40	29	275	>10,000
920729	1025	14	<40	<10	215	
920813	1028	18	<40	<10	244	80
920825	1030	23	<40	<10	304	
920908	1005	21	<40	<10	286	230

West Branch St. Joseph River: RM 3.1 - Bridgewater TR 11.5

Date	Time	T-Mg (mg/l)	T-Ni (µg/l)	T-Zn (µg/l)	Hardness (mg/l)	Fecal Coliform (#/100 ml)
920714	1115	23	<40	11	294	1,200
920729	1045	18	<40	<10	269	
920813	1055	21	<40	<10	291	30
920825	1050	20	<40	<10	240	
920908	1025	18	<40	<10	244	230
920924	1115	19	<40	10	271	

Appendix Table 1 (cont.)

Silver Creek: RM 1.2 - Williams CR 15

Date	Time	T-Mg (mg/l)	T-Ni (µg/l)	T-Zn (µg/l)	Hardness (mg/l)	Fecal Coliform (#/100 ml)
920714	1025	23	<40	13	294	3,600
920729	0950	17	<40	<10	277	
920813	1000	19	<40	<10	278	250
920825	1010	21	<40	<10	281	
920908	0945	21	<40	<10	284	510
920924	1000	21	<40	<10	296	

St. Joseph River: RM 81.2 - Williams CR N

Date	Time	T-Mg (mg/l)	T-Ni (µg/l)	T-Zn (µg/l)	Hardness (mg/l)	Fecal Coliform (#/100 ml)
920714	1130	17	<40	39	222	4,200
920729	1105	15	<40	11	237	
920813	1100	20	<40	<10	277	130
920825	1105	22	<40	<10	288	
920908	1040	20	<40	<10	267	200
920924	1130	20	<40	<10	290	

St. Joseph River: RM 73.2 - Williams CR 10

Date	Time	T-Mg (mg/l)	T-Ni (µg/l)	T-Zn (µg/l)	Fecal Hardness (mg/l)	Coliform (#/100 ml)
920714	1155	19	<40	21	248	1,600
920729	1120	15	<40	<10	234	
920813	1125	20	<40	<10	277	96
920825	1125	21	<40	<10	284	
920908	1100	21	<40	<10	276	230
920924	1200	19	<40	11	271	

Appendix Table 1 (cont.)

St. Joseph River : RM 62.1 - SR 34

Date	Time	T-Mg (mg/l)	T-Ni (µg/l)	T-Zn (µg/l)	Hardness (mg/l)	Fecal Coliform (#/100 ml)
920714	1245	20	<40	14	252	580
920729	1155	14	<40	<10	220	
920813	1150	20	<40	<10	292	78
920825	1145	22	<40	<10	293	
920908	1135	21	<40	30	276	180
920924	1225	17	<40	14	245	

St. Joseph River: RM 56.8 - Williams CR E-75

Date	Time	T-Mg (mg/l)	T-Ni (µg/l)	T-Zn (µg/l)	Hardness (mg/l)	Fecal Coliform (#/100 ml)
920714	1215	23	<40	<10	284	39
920729	1200	14	<40	<10	212	
920813	1145	20	<40	<10	292	140
920825	1220	22	<40	<10	295	
920908	1150	21	<40	<10	279	170
920924	1345	15	<40	16	232	

St. Joseph River: RM 51.4 - US 6

Date	Time	T-Mg (mg/l)	T-Ni (µg/l)	T-Zn (µg/l)	Hardness (mg/l)	Fecal Coliform (#/100 ml)
920714	1100	22	<40	<10	273	610
920729	1135	15	<40	<10	219	
920813	1100	21	<40	<10	286	130
920825	1245	23	<40	<10	304	
920908	1225	22	<40	<10	285	210
920924	1415	14	<40	18	207	

Appendix Table 1 (cont.)

St. Joseph River: RM 50.8 - adjacent Aqua Lane Dr.

Date	Time	T-Mg (mg/l)	T-Ni (µg/l)	T-Zn (µg/l)	Hardness (mg/l)	Fecal Coliform (#/100 ml)
920714	1120	23	<40	18	294	1,200
920729	1105	15	<40	<10	219	
920813	1035	19	<40	<10	273	170
920825	1320	26	<40	<10	334	
920908	1245	22	<40	30	285	290
920924	1440	15	<40	21	214	

St. Joseph River: RM 49.8 - SR 49

Date	Time	T-Mg (mg/l)	T-Ni (µg/l)	T-Zn (µg/l)	Hardness (mg/l)	Fecal Coliform (#/100 ml)
920714	1045	22	<40	<10	275	1,100
920729	1040	14	<40	16	215	
920813	1020	20	<40	<10	282	130
920825	1335	25	<40	<10	325	
920908	1305	22	<40	<10	283	160
920924	1455	15	<40	36	212	

St. Joseph River: RM 47.3 - Line Rd.

Date	Time	T-Mg (mg/l)	T-Ni (µg/l)	T-Zn (µg/l)	Hardness (mg/l)	Fecal Coliform (#/100 ml)
920714	1020	23	<40	<10	289	1,500
920729	1025	15	<40	<10	217	
920813	1000	20	<40	<10	287	90
920825	1355	25	<40	<10	330	
920908	1315	21	<40	<10	279	NA
920924	1505	14	<40	23	205	

Appendix Table 1 (cont.)

Bear Creek: RM 0.5 - SR 34

Date	Time	T-Mg (mg/l)	T-Ni (µg/l)	T-Zn (µg/l)	Hardness (mg/l)	Fecal Coliform (#/100 ml)
920714	1300	24	<40	<10	291	3,200
920729	1205	17	<40	<10	265	
920813	1209	27	<40	<10	356	430
920825	1155	34	<40	<10	380	
920908	1125	30	<40	<10	328	980
920924	1240	15	<40	18	249	

Fish Creek: RM 0.4 - SR 49

Date	Time	T-Mg (mg/l)	T-Ni (µg/l)	T-Zn (µg/l)	Hardness (mg/l)	Fecal Coliform (#/100 ml)
920714	1150	23	<40	16	294	1,100
920729	1225	17	<40	<10	240	
920813	1120	22	<40	<10	293	330
920825	1230	25	<40	<10	330	
920908	1210	25	<40	<10	315	210
920924	1405	16	<40	25	221	