Biological and Water Quality Study of the St. Joseph River Basin, 2013

Williams and Defiance Counties

St. Joseph River, RM 76.72, Williams County Fairgrounds

Division of Surface Water
December 14, 2015

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Executive Summary

Rivers and streams in Ohio support a variety of uses such as recreation, water supply, and aquatic life. Ohio EPA evaluates each stream to determine the appropriate use designation and also to determine if the use is meeting the goals of the federal Clean Water Act. In 2013, eleven streams in the St. Joseph River basin study area, located in Williams and Defiance counties, were evaluated for aquatic life and recreation use potential (Figure 1 and Tables 1 & 2). All of the streams sampled in 2013 are listed in the Ohio Water Quality Standards with the Warmwater Habitat (WWH) aquatic life use (ALU) designation except for Bear Creek from the headwaters to RM 1.2 which is designated Modified Warmwater Habitat (MWH) and Fish Creek between RM 5.57 and RM 2.4 which is designated Exceptional Warmwater Habitat (EWH). The appropriateness of the current aquatic life uses were confirmed for all previously sampled stream segments.

In 2013, twenty-one years after the last assessment of the St. Joseph River watershed, ecological improvement was documented in the watershed. Of the 33 biological stations assessed, 28 sites (85%) were fully meeting the designated ALU and 5 (15%) were partially attaining (Figure 1; Table 1).

The 2013 St. Joseph River survey results showed that four streams in the watershed, Clear Fork, Nettle Creek, West Branch St. Joseph, and Eagle Creek, were partially attaining their ALU in certain sections of the streams due to fair fish communities, although departure from WWH criteria was very slight. The predominant cause of impairment for Nettle Creek and Eagle Creek sites was direct habitat alterations caused by habitat modification.

The Ohio EPA last surveyed the St. Joseph River watershed in 1992. The biological and water quality report (Ohio EPA, 1994) described the study area, causes and sources of impairment, status of beneficial uses, and pollutant reductions needed for attainment of applicable aquatic life and recreational uses. At that time the leading causes of aquatic life use impariment were sedimentation and channel modification.

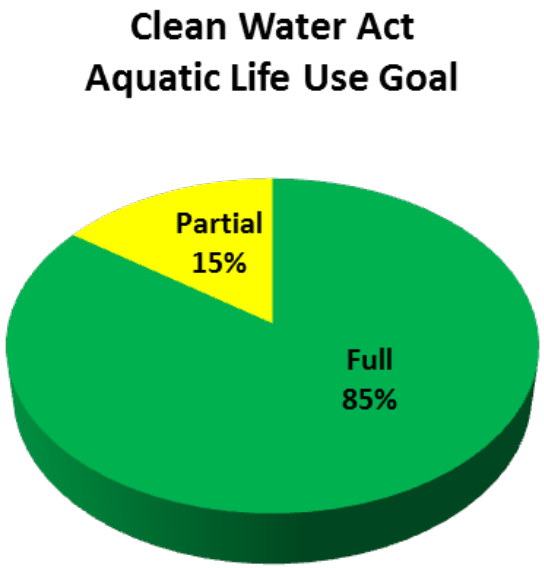

Figure 1. Eighty-five percent of the sites sampled in the St. Joseph River study area met their designated aquatic life use biocriteria.

The biological integrity of the St. Joseph River watershed has improved since the streams were last sampled in 1992. Repeat sampling of six sites on the St. Joseph River mainstem (RMs 81.2, 73.2, 62.1, 56.8, 49.8, and 47.3) allowed for a direct comparison of conditions with those of the earlier survey. In 1992, none of the mainstem sites met aquatic life use expectations due to fair fish communities. The 2013 survey produced full attainment of the designated ALU on the mainstem. Macroinvertebrate communities have remained relatively stable through time with an increase in the number of pollution sensitive Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa since the last survey. There were no highly consequential changes in water quality on the mainstem between 1992 and 2013 suggesting that other variables besides water quality were influencing biological performance. The improvements in the fish community indicated a major recovery of the St. Joseph River mainstem from impairments documented in the early 1990s. Multiple and interrelated factors are likely responsible for this and would include improved macrohabitat, achieved through both reduced sedimentation (modern tillage practices) and improved channel form and function (naturally directed restoration). Sedimentation was an important cause of impairment in the 1992 survey, and the drastic improvements observed on the St. Joseph River mainstem in 2013 are the combination of reduced sedimentation from soil conservation efforts and the gradual, naturally directed, physical recovery of the streams.

Tributaries sampled in both 1992 and 2013 include Silver Creek, West Branch of the St. Joseph River, Bear Creek, and Fish Creek. These tributaries have remained ecologicaly stable since 1992 but significant improvemts were documented in Bear Creek. Similar to observations on the St. Joseph mainstem, between 1992 and 2013 Bear Creek experienced a significant gain in fish species, including sensitive forms. The frequency of gross external anomalies, which include deformities, eroded fins, lesions and tumors (DELTs), was dramatically reduced through the upper middle segments of Bear Creek. DELT anomalies have proved a reliable indicator of chronic sublethal stress and are most commonly associated with poor water quality (Ohio EPA 1987b). Habitat measures at stations common to both field years identified modest improvement, likely attributable to both natural recovery and reduced sediment loads. Presently, waste loads to Bear Creek appear assimilated, and the resident fish community appears to be performing above the habitat potential as reflected in the existing MWH and WWH aquatic life use designations.

Nutrients were measured at 36 sampling locations, and included ammonia-N, nitrate-nitrite-N, total phosphorus, and total Kjeldahl nitrogen (TKN). River concentrations for total phosphorus increased with flow in March, April, and July on the mainstem of the St. Joseph River. Greater flows with higher concentrations provide for the most significant potential loading to Lake Erie and factor into Harmful Algal Bloom (HAB) formation. These loads may factor into HAB formation if they are delivered into the Western Basin of Lake Erie within 20-50 days (estimated retention time) of water temps meeting ~20 C (when water is warm enough for blooms to occur).

Twenty-four locations in the St. Joseph study area were tested for *E. coli* bacteria five times between May 28, 2013 and September 4, 2013. High bacteria concentrations were found in streams throughout the study area. Evaluation of *E. coli* results revealed that all of the locations sampled failed to meet the applicable geometric mean criterion, indicating non-attainment of the Primary Contact Recreation (PCR) use throughout the study area.

Table 1. St. Joseph River watershed sampling locations, 2013.

Site Number	Stream Name/Location	River Mile	Drainage Area (mi^2)	Latitude	Longitude
1	**St. Joseph River**/ Ust. Montpelier, CR N	81.18	288.0	41.619200	-84.588900
2	**St. Joseph River**/ CR M dead end, At county fair grounds	76.72	338.0	41.591306	-84.599014
3	**St. Joseph River**/ Dst Montpelier, CR 10	73.24	337.0	41.571700	-84.632500
4	**St. Joseph River**/ SR 34	62.08	394.0	41.519200	-84.697500
5	**St. Joseph River**/ Ust Edgerton WWTP, CR E-75	56.77	435.0	41.489200	-84.730600
6	**St. Joseph River** / Dst. Edgerton, SR 49	49.75	554.0	41.435398	-84.745640
7	**St. Joseph River**/ County Line Rd.	47.30	566.0	41.422200	-84.773900
8	**St. Joseph River**/ Near Ohio Indiana State Line, SR 249	42.34	609.0	41.385600	-84.801700
9	**East Branch St. Joseph River**/ CR S, ust. Pioneer WWTP	4.77	95.0	41.694894	-84.510384
10	**East Branch St. Joseph River**/ SR 15, dst. Pioneer WWTP	1.06	163.0	41.659735	-84.553454
11	**Silver Creek**/ CR 15	1.25	31.4	41.696100	-84.533900
12	**Clear Fork**/ SR 576	6.22	15.1	41.695300	-84.631100
13	**Clear Fork**/ CR 13	2.17	21.1	41.680800	-84.572800
14	**West Branch St. Joseph River**/ Near State Line, TR S	10.48	98.0	41.693900	-84.687500
15	**West Branch St. Joseph River**/ Ust. Seneca Lake, CR 8	8.50	99.0	41.683300	-84.684200
16	**West Branch St. Joseph River** / Dst, Seneca Lake, TR 115	3.13	109.0	41.659200	-84.602200
17	**West Branch St. Joseph River** / US 20, near mouth	0.70	114.3	41.653972	-84.572333
18	**Nettle Creek**/ Ust. Nettle Lake, TR 72	14.48	19.1	41.688900	-84.732800
19	**Nettle Creek** / Dst. Lake La Su An, CR 7	11.23	25.0	41.672200	-84.688900
20	**Nettle Creek** / CR 8.50, adj. Bridgewater Dairy	5.08	31.0	41.624200	-84.650600
21	**Nettle Creek** / CR N-30	1.37	36.0	41.621700	-84.606100
22	**North Branch Eagle Creek**/ At mouth, CR M-50	0.02	12.9	41.609700	-84.703900
23	**Eagle Creek**/ Dst. North Branch, CR 675	8.28	21.1	41.606900	-84.695800
24	**Eagle Creek** / CR M	4.90	24.2	41.600800	-84.660800
25	**Eagle Creek** / CR J	0.50	34.7	41.557083	-84.676423
26	**Bear Creek**/ Dst. Edon WWTP, CR 4	5.70	13.6	41.555600	-84.750000
27	**Bear Creek** / CR I	2.43	22.0	41.541700	-84.723300

Site Number	Stream Name/Location	River Mile	Drainage Area (mi^2)	Latitude	Longitude
28	**Bear Creek** / SR 34	0.54	24.2	41.520600	-84.715800
29	**Fish Creek**/ Ust Columbia, CR P-25	30.54	8.8	41.652200	-84.796400
30	**Fish Creek** / Dst. Stateline, TR 171, dst. UN Tributary	5.40	106.0	41.466100	-84.801400
31	**Fish Creek** / CR 3	2.40	108.0	41.472800	-84.767200
32	**Fish Creek** / Edgerton, SR 49	0.38	109.0	41.464200	-84.748300
33	**Big Run**/ Edgerton, Conkle Rd.	0.30	30.0	41.423300	-84.782200

*The color of the site number corresponds to the narrative biological score: blue is exceptional to very good and meets EWH goals, green is good to marginally good and meets WWH goals, yellow is fair, orange is poor and red is very poor. fair, poor and very poor do not meet the goals of WWH. Colors correspond to the lowest scoring organism group, either fish or macroinvertebrates.

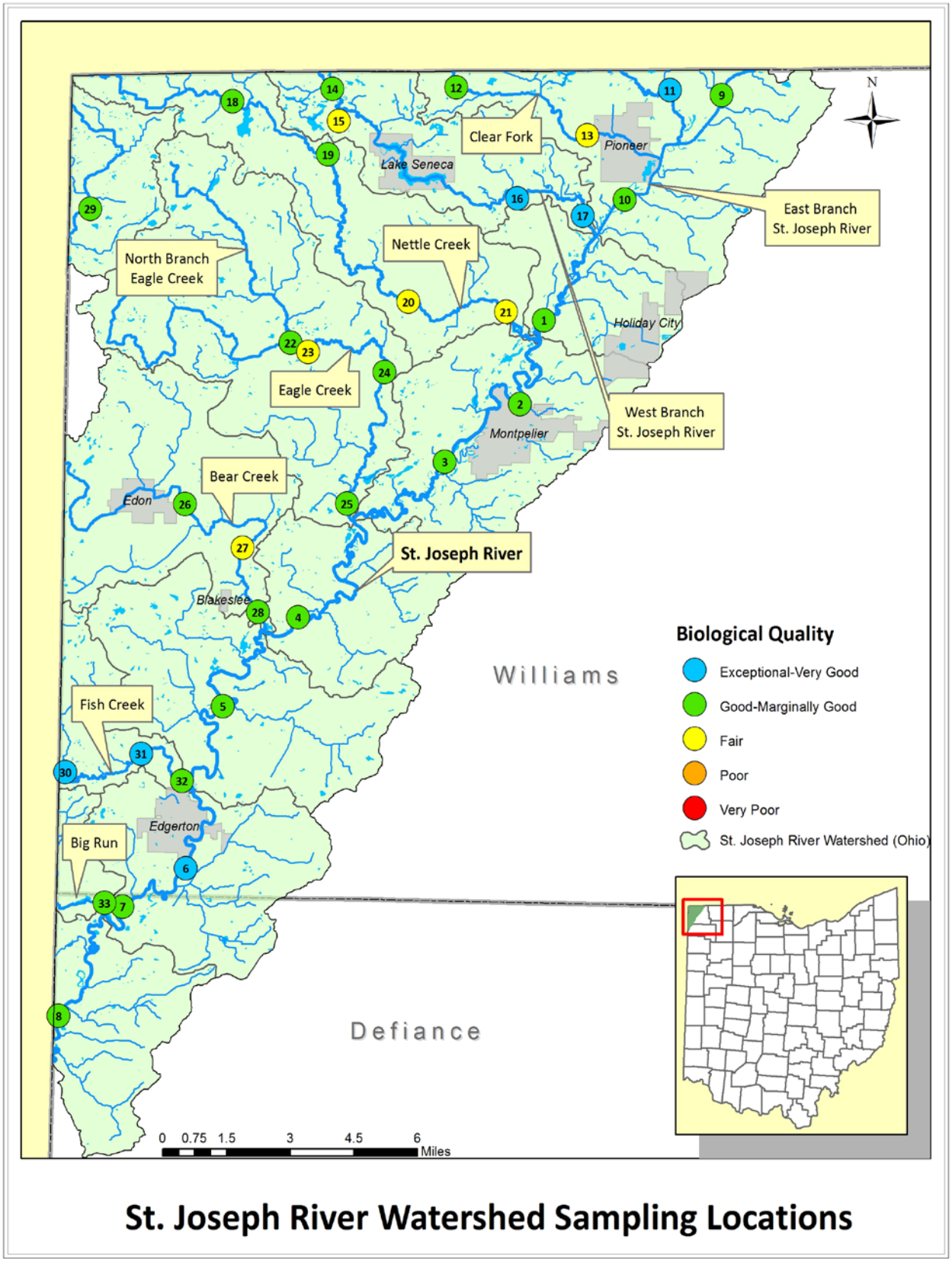

Figure 2. Narrative biological scores of sites in the St. Joseph study area, 2013. Colors correspond to the lowest scoring organism group, either fish or macroinvertebrates.

Table 2. Aquatic life use attainment status for stations sampled in the St. Joseph River basin based on data collected June-October, 2013. The Index of Biotic Integrity (IBI), Modified Index of well-being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community. The St. Joseph River basin is located in the Eastern Corn Belt Plains ecoregion. If biological impairment has occurred, the cause(s) and source(s) of the impairment are noted.

River Mile[a] - Location	Station	Drain. (mi^2)	IBI	MIwb[b]	ICI[c]	QHEI	Attainment Status[d]	Causes	Sources
St. Joseph River (04-400-000) *WWH Existing*									
81.18[B] – Ust. Montpelier	P08S19	288.0	39[ns]	9.5	42	67.3	Full		
76.72[B] – CR M, at fairgrounds	302199	338.0	43	9.5	48	70.8	Full		
73.24[B] – Dst Montpelier, CR 10	P08S18	337.0	46	10.4	34[ns]	68.8	Full		
62.08[B] – SR 34	P08S17	394.0	38[ns]	9.5	54	74.5	Full		
56.77[B] – CR E75	P08S16	435.0	42	9.5	52	61.5	Full		
49.75[B] – SR 49	510180	554.0	47	10.0	56	59.3	Full		
47.30[B] – County Line Rd.	P08K02	556.0	53	10.2	36	70.3	Full		
42.34[B] -- SR 249	510220	609.0	49	9.9	G	72.8	Full		
East Branch St. Joseph River (04-415-000) *WWH Existing*									
4.77[W] – CR S	P08K30	95.0	41	8.8	50	63.8	Full		
1.06[W] – SR 15	P08K29	163.0	44	8.9	42	68.5	Full		
Silver Creek (004-417-000) *WWH Existing*									
1.25[W] – CR 15	P08S23	31.4	47	9.1	46	67.0	Full		
Clear Fork (04-416-000) *WWH Existing*									
6.22[H] – SR 576	P08K32	15.1	42	NA	VG	62.0	Full		
2.17[W] – CR 13	P08K31	21.1	35*	8.1[ns]	34[ns]	62.8	Partial	Natural Conditions	Natural Sources
West Branch St. Joseph River (04-414-000) *WWH Existing*									
10.48[W] – Near State Line, TR S	P08S22	98.0	44	9.1	42	77.0	Full		
8.50[W] –Ust. Seneca Lake, CR 8 Dst. Lake La Su An	P08K28	99.0	34*	8.3	52	77.0	Partial	Nutrients	Source Unknown

River Mile[a] - Location	Station	Drain. (mi^2)	IBI	MIwb[b]	ICI[c]	QHEI	Attainment Status[d]	Causes	Sources
3.13[W] –Dst. Seneca Lake, TR 115	P08S21	109.0	49	10.0	48	82.5	Full		
0.7[W]/1.0 – US 20, near mouth	302198	114.3	46	9.0	VG	74.5	Full		
Nettle Creek (04-413-000) *WWH Existing*									
14.48[H]/15.5-Ust. Nettle Lake,TR72	P08S09	19.1	38[ns]	NA	E	64.0	Full		
11.23[W]–, CR 7, Dst. Nettle Lake	P08K25	25.0	38[ns]	8.2[ns]	42	49.8	Full		
5.08[W] – CR 8.50, adj. Dairy Farm	P08K24	31.0	34*	7.7*	VG	58.5	Partial	Direct Habitat Alterations	Habitat Modification
1.37[W] – CR N-30	P08S06	36.0	33*	7.6*	32[ns]	61.8	Partial	Direct Habitat Alterations	Habitat Modification
North Branch Eagle Creek (04-412-000) *WWH Existing*									
0.02[H] – At mouth, CR M-50	P08K23	12.9	38[ns]	NA	G	46.8	Full		
Eagle Creek (04-411-000) *WWH Existing*									
8.28[W] – CR 675	P8K22	21.1	34*	7.3*	MG[ns]	58.5	Partial	Direct Habitat Alterations and Nutrients	Habitat Modification and Agricultural NPSs
4.90[W] – CR M	P08K21	24.2	36[ns]	7.9[ns]	MG[ns]	59.0	Full		
0.50[W] – CR J	P08S01	34.7	39[ns]	8.3	42	66.0	Full		
Bear Creek (04-409-000) *MWH-C (Headwater to RM 1.2) / WWH Existing (RM 1.2 to Mouth)*									
5.7[H] – Dst. Edon WWTP, CR 4	P08K18	13.6	40	NA	MG	55.5	Full		
2.43[W] – CR I	P08K15	22.0	33	9.1	52	57.8	Full		
0.54[W] – SR 34	510150	24.2	41	8.3	42	55.3	Full		
Fish Creek (04-405-000) *WWH Existing (Headwaters to RM 5.6 and RM 2.4 to Mouth) / EWH Existing (RM 5.6 at Stateline to RM 2.4 CR 3)*									
30.54[H] – CR P-25, ust. Stateline	P08K12	8.8	42	NA	G	48.8	Full		
5.4[W] – Dst. Stateline, TR 171	P08K10	106.0	47[ns]	9.2[ns]	54	77.5	Full		
2.4[W] – CR 3	P08K09	108.0	-	-	46	-	(Full)		
0.38[W] – Edgerton, SR 49	P08S20	109.0	39[ns]	8.2[ns]	48	61.5	Full		

River Mile[a] - Location	Station	Drain. (mi^2)	IBI	MIwb[b]	ICI[c]	QHEI	Attainment Status[d]	Causes	Sources
Big Run (04-404-000) *WWH Existing*									
0.30[W]– Edgerton, Conkle Rd.	P08K08	30.0	37	8.7	50	55.3	Full		

Index – Site Type	EWH	WWH	MWH
IBI - Headwaters	50	40	24
IBI - Wading	50	40	24
IBI - Boat	48	42	24
MIwb - Wading	9.4	8.3	6.2
MIwb - Boat	9.6	8.5	5.8
ICI	46	36	22

a If two river miles are listed, the first is for the fish station and the second is for the macroinvertebrate station. H - headwater site. W - wading site, B - boat site.

b MIwb is not applicable (NA) to headwater streams with drainage areas $\leq$ 20 mi^2.

c A narrative evaluation of the qualitative sample based on attributes such as EPT taxa richness, number of sensitive taxa, and community composition was used when quantitative data was not available or considered unreliable. MG=Marginally Good, G=Good, VG=Very Good, E=Exceptional. Attainment status is given for the existing use designations. Attainment status was not assigned to isolated stream segments that were sampled with only qualitative macroinvertebrate methods.

NA Not Applicable

ns Nonsignificant departure from biocriteria ($\leq$4 IBI or ICI units, or $\leq$0.5 MIwb units).

* Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units).

Beneficial Use Designations and Recommendations

The streams in the St. Joseph River basin study area currently listed in the Ohio Water Quality Standards (WQS) are assigned the Warmwater Habitat (WWH), Exceptional Warmwater Habitat (EWH), and Modified Warmwater Habitat-Channel Modification (MWH-C) aquatic life use designations. The aquatic life use designation for the St. Joseph River, Silver Creek, West Branch St. Joseph River, Bear Creek, and Fish Creek had been previously verified using biological data. Big Run, Eagle Creek, North Branch Eagle Creek, Nettle Creek, East Branch St. Joseph River, and Clear Fork were originally designated for aquatic life use in the 1978 and 1985 Ohio WQS, but the techniques used then did not include standardized approaches to the collection of instream biological data or numerical biological criteria. This study used biological data to assess and verify aquatic life uses for streams in the St. Joseph River study area.

Eleven streams in the St. Joseph River watershed were evaluated for aquatic life and recreational use status in 2013 (Table 3). Significant findings include the following.

- Aquatic life uses were verified and should be maintained for all previously designated WWH, EWH, and MWH-C stream reaches. The WWH designation applies to the St. Joseph River, Silver Creek, West Branch St. Joseph River, Bear Creek from RM 1.2 to the mouth, the headwaters of Fish Creek to RM 5.6 and RM 2.4 to the mouth. The EWH designation applies to Fish Creek from RM 5.6 to RM 2.4. The MWH-C designation applies to Bear Creek from the headwaters to RM 1.2.

- Big Run, Eagle Creek, North Branch Eagle Creek, Nettle Creek, East Branch St. Joseph River, and Clear Fork currently have an unverified WWH aquatic life use dating back to the 1978 and 1985 Ohio WQS. Biological sampling conducted on these streams verified that WWH is appropriate (Table 3).

- All eleven streams in this study should retain the Primary Contact Recreation use along with the Agricultural Water Supply and Industrial Water Supply uses.

Some of the streams in the study area were affected by agricultural runoff, sedimentation, and direct habitat alterations. Re-establishing natural riparian buffers (wetland and wooded riparian corridors) in the watershed to help slow storm water and filter pollutants before they reach surface waters are positive mechanisms to reduce agricultural runoff. In addition to restoring riparian buffers, an effort to restore the natural assimilative capacity of streams would lessen pollutant impacts. Natural development of stream channels provide an array of beneficial services including settling fine sediments into adjacent floodplains, processing of nutrients into productive biomass instead of nuisance algae, improvement of water quality, creation of natural instream habitats to increase carrying capacity of biomass, and ultimately evolution into a stable channel and the slowing of erosion.

Table 3. Use designations for water bodies in the St. Joseph River basin. Designations based on the 1978 and 1985 water quality standards appear as asterisks (*). A plus sign (+) indicates a confirmation of an existing use.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
St. Joseph river		+							+	+		+		
Willow run		*							*	*		*		
Amaden ditch		*							*	*		*		
Greens ditch		*							*	*		*		
Big run		*/+							*/+	*/+		*/+		
Fish creek - state line (RM 5.6) to co. rte. 3 (RM 2.4)			+						+	+		+		
- all other segments		+							+	+		+		
Bluff run		*							*	*		*		
Ziegler ditch		*							*	*		*		
Bear creek - headwaters to RM 1.2				+					+	+		+		Channel modification
- all other segements		+							+	+		+		
Tamarack ditch		*							*	*		*		
Eagle creek		*/+							*/+	*/+		*/+		
North branch		*/+							*/+	*/+		*/+		
Nettle creek		*/+							*/+	*/+		*/+		
J. Lattaner ditch							+		*	*			+	Small drainageway maintenance
West branch		+							+	+		+		
East branch		*/+							*/+	*/+		*/+		
Clear fork		*/+							*/+	*/+		*/+		
Silver creek		+							+	+		+		

SRW = state resource water; WWH = warmwater habitat; EWH = exceptional warmwater habitat; MWH = modified warmwater habitat; SSH = seasonal salmonid habitat; CWH = coldwater habitat; LRW = limited resource water; PWS = public water supply; AWS = agricultural water supply; IWS = industrial water supply; BW = bathing water; PCR = primary contact recreation; SCR = secondary contact recreation

INTRODUCTION

Eleven streams encompassing 33 sampling locations were evaluated in the St. Joseph River watershed in Williams and Defiance counties in 2013. Eight sites on the mainstem of the St. Joseph River were sampled as well as twenty-five locations on tributaries including the East Branch St. Joseph River, Silver Creek, Clear Fork, West Branch St. Joseph River, Nettle Creek, North Branch Eagle Creek, Eagle Creek, Bear Creek, Fish Creek, and Big Run. A total of twelve National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge sanitary wastewater, industrial process water, and/or industrial storm water into the St. Joseph River watershed within Williams and Defiance counties.

During 2013, Ohio EPA conducted a water resource assessment of eleven streams in the St. Joseph River study area using standard Ohio EPA protocols as described in Appendix E. Included in this study were assessments of the biological, surface water and recreational (bacterial) condition. A total of 33 biological, 35 water chemistry, and 24 bacterial stations were sampled in the St. Joseph River study area. Summarized biological and raw chemical and bacterial results can be viewed in Appendices B, C, D, E, and G.

Specific objectives of the evaluation were to:

- ascertain the present biological conditions in the St. Joseph River watershed by evaluating fish and macroinvertebrate communities,
- identify the relative levels of organic, inorganic, and nutrient parameters in the sediments and surface water,
- evaluate influences from NPDES outfall discharges,
- assess physical habitat influences on stream biotic integrity,
- determine recreation water quality,
- compare present results with historical conditions, and
- determine the attainment status and recommend changes if appropriate.

The findings of this evaluation may factor into regulatory actions taken by the Ohio EPA (e.g. NPDES permits, Director's Orders, or the Ohio Water Quality Standards [OAC 3745-1]), and may eventually be incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, Total Maximum Daily Load (TMDL) reports and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d] report).

STUDY AREA DESCRIPTION

Location and Scope

The St. Joseph River system drains 1,060 miles of the tri-state area of Indiana, Michigan, and Ohio (Figure 3). The Ohio portion of the watershed covers 238 mi^2 (Ohio DNR 1960). Originating in Hillsdale County, Michigan, the St. Joseph River watershed drains to the southwest through Williams and Defiance counties in Ohio, and Dekalb and Allen counties in Indiana (Ohio EPA 1994).

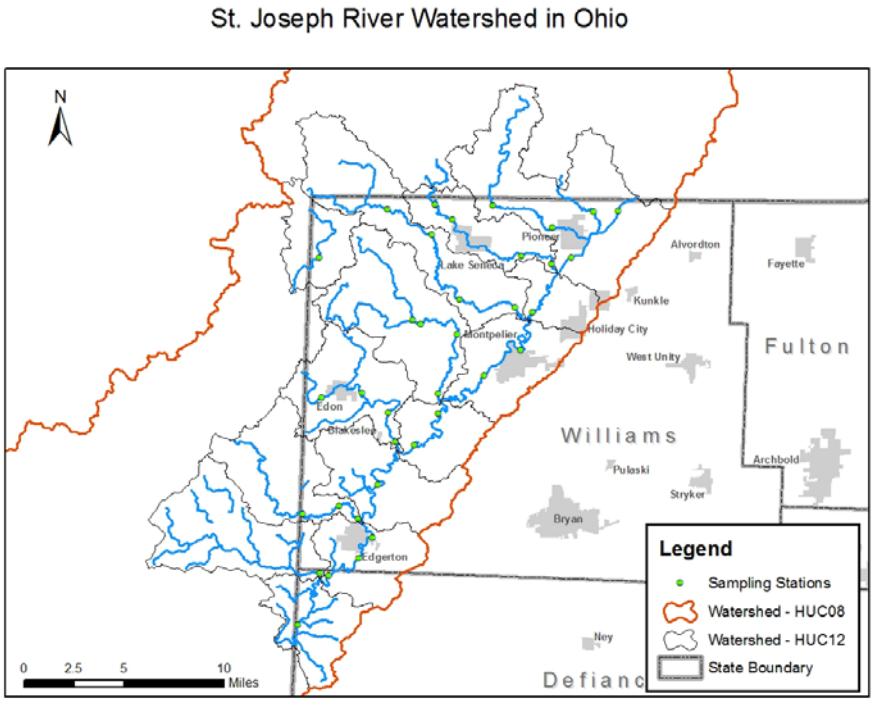

Figure 3: Study area within the St. Joseph River watershed in Ohio.

Ecoregions, Geology, & Soils

The watershed lies entirely within the Eastern Corn Belt Plains (ECBP) ecoregion (Omernik 1987). The ECBP is 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 (Figure 4). Major soil associations in the watershed range from level, poorly drained floodplains to gently sloping, moderately steep, and moderately well drained uplands. Relief is nearly level to more sloping near waterways. Clayey subsoils and seasonal high water tables lead to wetness in many soil types within the watershed (Ohio EPA 1994, USDA 1978, and Omernik and Gallant 1988).

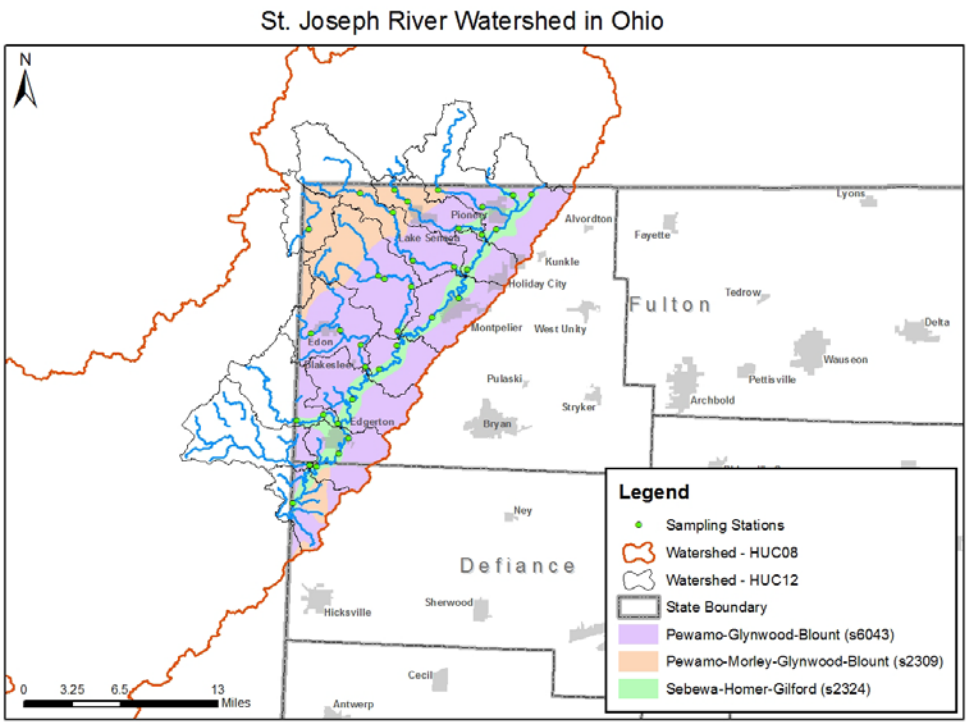

Figure 4: Soil types for the St. Joseph River study area (STATSGO).

Beneficial Uses

Beneficial use designations within the watershed include those for aquatic life, recreation and water supply. The effective use designations for the majority of streams in the St. Joseph River watershed include WWH or MWH for aquatic life uses, PCR for the recreational use, and AWS and IWS for the water supply use. The mainstem of the St. Joseph River is a Class A recreation stream. Portions of Fish Creek and the West Branch of the St. Joseph River are classified as Superior High Quality Waters and Fish Creek RM 5.57 to RM 2.4 is classified as an Outstanding State Water.

Hydrology

The St. Joseph River flows to the southwest from Michigan, through Ohio, and ultimately joins with the St. Mary's River in Fort Wayne, Indiana, forming the Maumee River. Major tributaries to the St. Joseph River include Fish Creek, Bear Creek, Eagle Creek, Nettle Creek, and the East Branch and West Branch of the St. Joseph River.

Fish Creek is the most ecologically significant tributary to the St. Joseph River, noted for the presence of federally and state endangered bivalve mollusks. Fish Creek drains 114 mi^2, divided into upper and lower sections of 10.1 and 6.6 mi^2, respectively, in Ohio (Ohio EPA 1994).

Land Use

The following communities are located within the Ohio portion of the St. Joseph River watershed (population in parenthesis): Blakeslee (96), Edgerton (2,012), Edon (834), Holiday City (52), Lake Seneca (57), Montpelier (4,072), and Pioneer (1,380) (US Census 2010). According to the 2010 census, the Ohio portion of the St. Joseph watershed is home to more than 17,000 people.

Land use within the watershed, as with the majority of northwest Ohio, is dominated by row crop agriculture (Table 4). The installation of an extensive artificial drainage network has resulted in negative impacts to the watershed, including but not limited to, flow regime changes and streamside habitat loss.

Land Use	Percent of Watershed
Ag	77.8%
Forest	6.2%
Grass	0.0%
Other	0.2%
Urban	7.3%
Water	1.0%
Wetland	7.5%

Table 4. Land use percentages for the St. Joseph River watershed in Ohio (Cropland Data Set, 2012).

Protected Lands

The Lake La Su An Wildlife Area is the most significant protected area in the watershed, comprising 2443.1 acres, which is nearly 87% of the protected land in the watershed (Table 5 and Figure 5).

Protected Area	Ownership	Type	Acres
Fish Creek Wildlife Area	State	Wildlife Area	156.3
Lake La Su An Wildlife Area	State	Wildlife Area	2443.1
Miller Park	Local	Park	41.2
Montpelier Memorial Park	Local	Park	27.3
Mud L. Bog State Nature Preserve	State	Nature Preserve	74.0
Nettle Lake Wildlife Fishing Access	State	Access Point	1.8
St. Joseph River Wildlife Area	State	Wildlife Area	95.8
Waltz Park	Local	Park	16.6
Williams County Fairgrounds	County	Fairgrounds	51.1
		Total Acres	2907

Table 5. Protected lands in the St. Joseph River watershed in Ohio.

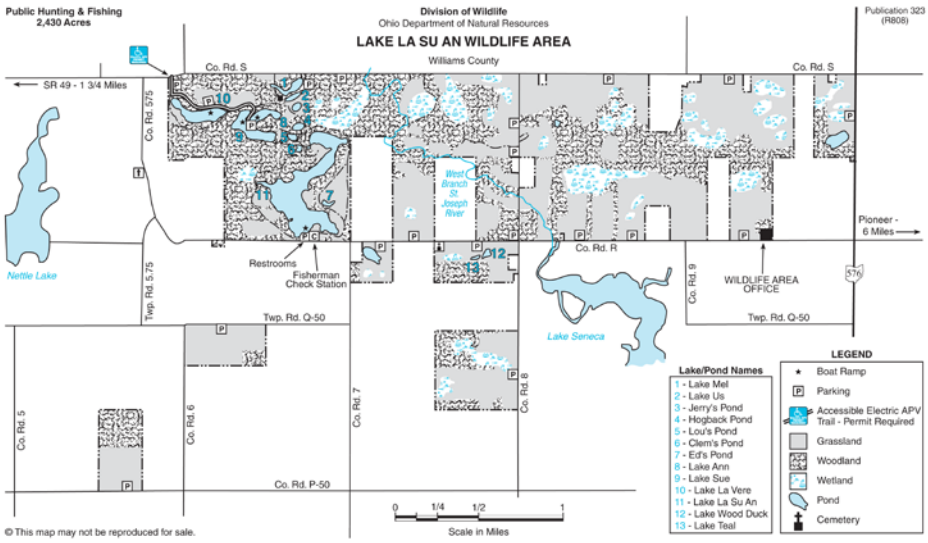

Figure 5: Lake La Su An Wildlife Area in the St. Joseph River watershed (ODNR 2014).

Lake La Su An Wildlife Area is situated on the Wabash end moraine deposited during the Wisconsin glaciation. Purchase of land for this wildlife area began in 1981. Additional land is being acquired as funds become available. Originally, the area was a beech-maple hardwood forest containing beech, white ash, white oak, red oak, and sugar maple. This combination of hardwood species still dominates the area. There are also several lowland areas that are poorly drained, forming wooded wetlands (http://wildlife.ohiodnr.gov/lakelasuan).

The wildlife area is moderately to gently sloping with natural drainage to the West Branch of the St. Joseph River, which cuts through the middle of the area. Approximately two-thirds of the wildlife area is in woods and brushland. The other one-third is divided between cropland and meadow. The water areas include 14 lakes and ponds ranging from 1/4 acre to 82 acres, and over 30 wooded wetlands and restored wetlands from two to 18 acres (http://wildlife.ohiodnr.gov/lakelasuan).

Ground Water Supply

Nineteen (19) public water systems all utilize ground water wells as their source (Table 6), in addition to private wells serving homes and other facilities not regulated by Ohio EPA's Division of Drinking and Ground Waters. There are no surface water drinking water supplies in the study area.

Water System	PWSID	County
Aqua Ohio - Seneca	OH8601512	Williams
Bridgewater Community Church	OH8634112	Williams
Burger King #9964 - Edon	OH8640912	Williams
Camp Diclair	OH8634512	Williams
Edgerton Village	OH8600312	Williams
Edon Village	OH8600512	Williams
Lazy River Resort Campground-Pioneer	OH8636212	Williams
Loveberrys Funny Farm Campground	OH8635512	Williams
Mid Toll Inc-Edon	OH8642112	Williams
Montpelier Village	OH8600912	Williams
Pioneer Scout Reserve [BSA]-Camp	OH8633912	Williams
Pioneer Scout Reserve [Bsa]-Pool	OH8637012	Williams
Pioneer Village	OH8601312	Williams
Sams Place Tavern	OH8632312	Williams
Shady Shore Campground	OH8637712	Williams
Silver Creek Ch Of The Brethren	OH8637812	Williams
Victory Barn Church	OH8640612	Williams
Windwood Hollow Golf Course	OH8633112	Williams
Zion Lutheran Church-Edgerton	OH2034412	Defiance

Table 6. Public drinking water systems in the St. Joseph River watershed in Ohio (Ohio EPA 2014).

Watershed Groups

The St. Joseph River Watershed Initiative exists to improve water quality in the St. Joseph River watershed by promoting economically and environmentally compatible land uses and practices. The St. Joseph Initiative, a non-profit partnership, exists to protect, restore and enjoy the St. Joseph River and its watershed, which stretches across 694,400 acres through six counties in Indiana, Ohio and Michigan. A draft watershed action plan is available online from the St Joseph Initiative at http://www.sjrwi.org/sites/default/files/docs/publications/MSJRW.pdf.

RESULTS

Water Chemistry

Surface water chemistry samples were collected from the St. Joseph River basin study area from December 2012 through September 2013 at 35 locations (Table 7). Stations were established in free-flowing sections of the stream and were collected directly from the stream or from bridge crossings. Surface water samples were dispensed into appropriate containers, preserved and delivered to Ohio EPA's Environmental Services laboratory. Collected water was preserved using appropriate methods, as outlined in the Ohio EPA Surface Water Field Sampling Manual (Ohio EPA 2013a).

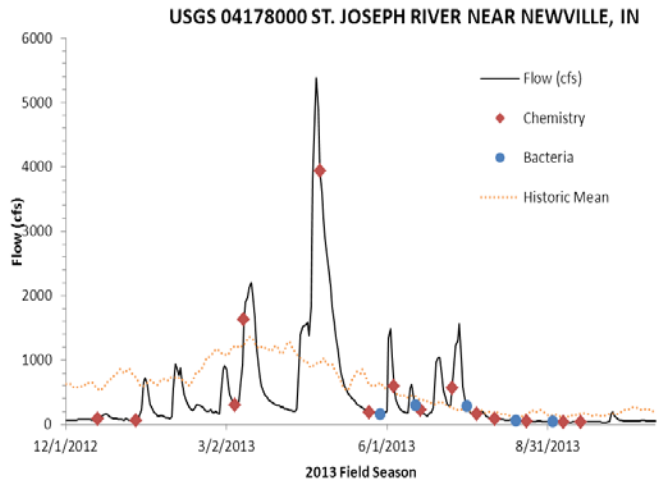

Figure 6. Mean flow conditions in the St. Joseph River during the 2013 field season.

USGS gage data from the St. Joseph River near Newville, Indiana were used to show flow trends in the watershed during the 2013 survey (Figure 6). Dates when water samples and bacteria samples were collected in the study area are noted on the graph. Flow conditions during the field season were typically lower than the historic median with low flow conditions observed from April through July with limited rain events occurring, most notably in late April. Water samples captured a variety of flow conditions in the study area during the field season. Bacteria were collected during the recreation use season (May 1 through October 31) and were typically collected during low flows.

Surface water samples were analyzed for metals, nutrients, semi-volatile organic compounds, bacteria, pH, temperature, conductivity, dissolved oxygen (D.O.), percent D.O. saturation, and suspended and dissolved solids (Appendix F). Parameters which were in exceedance of the Ohio WQS criteria are reported in Table 7. Bacteriological samples were collected from 24 locations, and the results are reported in the Recreation Use section. Datasonde™ water quality recorders were placed at locations to monitor hourly levels of temperature, pH, specific conductivity, and dissolved oxygen (Appendix J).

Metals were measured at nine locations with eighteen parameters tested (Appendix G). Iron results above the agricultural use criterion were found on nine occasions at five sites scattered across the watershed (Table 7). The elevated iron observed did not display a spatial or temporal pattern and is likely the influence of naturally occurring iron in ground water.

Nutrients were measured at 35 sampling locations, and included ammonia-N, nitrate-nitrite-N, total phosphorus, and total Kjeldahl nitrogen (TKN). In addition, nine sentinel sites were measured for orthophosphate and six sentinel sites were measured for total dissolved phosphorous. Summary statistics for nutrients measured in the St. Joseph River assessment units are detailed in Table 8. Nutrient geometric means calculated from the survey season data (May through October) were low at most monitoring locations in the study area. Total phosphorus single sample results only exceeded the target limit nine times on the St. Joseph mainstem and the geometric mean phosphorus levels were below the target at all but six locations for the sampling season across the watershed (Figure 7). Two sites on Fish Creek (EWH) and two sites on Eagle Creek (including North Branch Eagle Creek) (WWH) provided the greatest concentration of exceedances (Table 8).

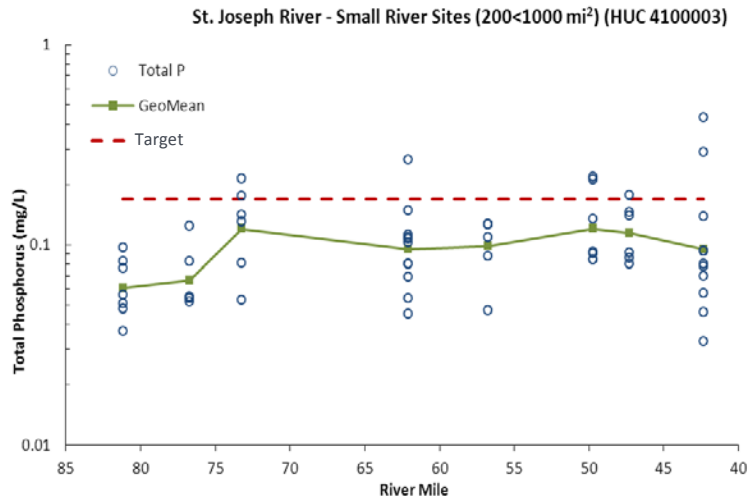

Figure 7. St Joseph River small river sites (200-1000 mi^2) total phosphorus data for 2013 with geometric mean and specified target for small river WWH designated use.

River concentrations for total phosphorus increased with flow in March, April, and July on the mainstem of the St. Joseph River. Greater flows saturated with higher phosphorus concentrations provide for the most significant potential loading to Lake Erie and factor into Harmful Algal Bloom (HAB) formation. These loads can factor into HAB formation if they are delivered into the Western Basin of Lake Erie within 20-50 days (estimated retention time) of water temps meeting ~20 C (when water is warm enough for blooms to occur).

Evaluation of data for sites on Nettle Creek may point to minor nutrient impacts from the Bridgewater Dairy. Nitrate-nitrite, ammonia, and phosphorus levels increased at the downstream site (Figure 8). Dissolved oxygen levels decreased over the same stream reach. Despite the increase in nutrients, it is important to note that none of these sites exceeded the specified targets (total phosphorus and nitrate-nitrite) or WQS criteria (ammonia).

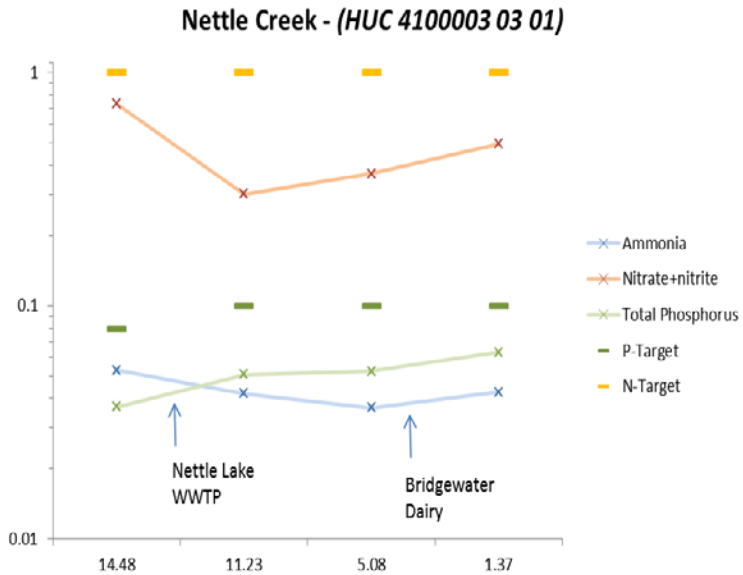

Figure 8. Nettle Creek geometric means for nutrients and specified targets for total phosphorus and nitrate-nitrite, 2013.

Figures 9, 10, & 11 plot the location of the NPDES permits along the St. Joseph River mainstem vs ammonia, phosphorus, and nitrate-nitrite data collected. In all cases, values reported as less than the lab's reporting limit were set at 50% of the detection limit. There were no phosphorus values below the limit. Additional discussion of individual facilities can be found in the NPDES section.

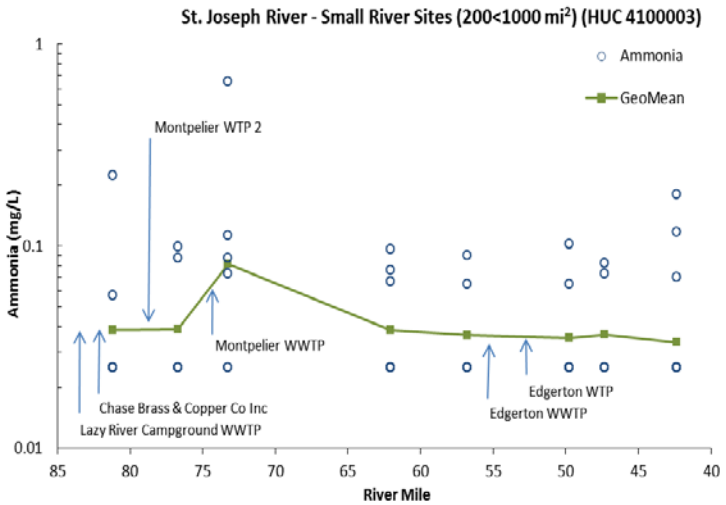

Figure 9. NPDES permitted discharges along the St. Joseph River mainstem vs. ammonia sampling results, 2013.

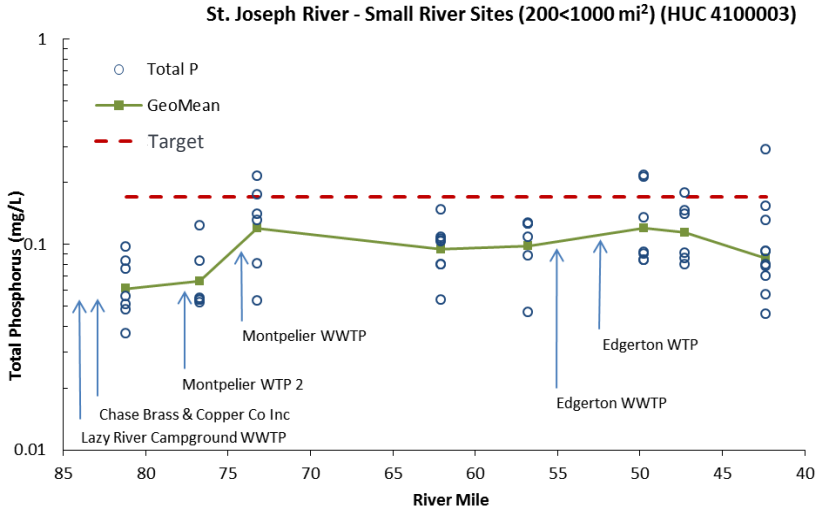

Figure 10. NPDES permitted discharges along the St. Joseph River mainstem vs. total phosphorus sampling results, 2013.

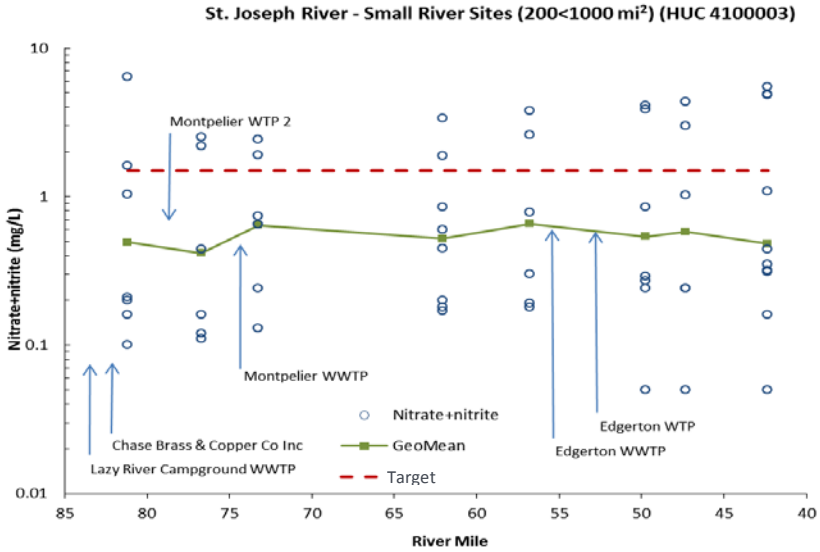

Figure 11. NPDES permitted discharges along the St. Joseph River mainstem vs. nitrate-nitrite sampling results, 2013.

Benthic chlorophyll *a* was monitored at various sites throughout the watershed in 2013 in order to better understand streams that may be impacted by excessive nutrient enrichment. Only one result from this sampling was found to indicate such a condition - West Branch St. Joseph River at river mile 8.50. The benthic chlorophyll a sample for this site was collected on July 30, 2013, and the result of 227 mg/m^2 was found. This value exceeds the concentration of 182 mg/m^2 that Miltner (2010) notes as a strong indication of enrichment for streams of this nature. Based on this, and other factors discussed in this report, nutrient enrichment is the cause of the aquatic life use impairment at this site. Benthic chlorophyll *a* was not sampled at the other assessment site in this watershed that is also impacted from nutrient enrichment (Eagle Creek at river mile 8.28).

Table 7. Exceedances of Ohio Water Quality Standards criteria (OAC 3745-1) for chemical/physical parameters measured in the Saint Joseph River Watershed study area, 2013. Bacteria exceedances are presented in the Recreational Use Section.

Stream/RM	**Location**	**Parameter (value – mg/l unless noted)**
St. Joseph River	*WWH Existing*	
81.18	Ust. Montpelier, CR N	*No exceedances.*
76.72	CR M dead end, At county fair grounds	*No exceedances.*
73.24	Dst. Montpelier, CR 10	*No exceedances.*
66.69	CR I	*No exceedances.*
62.08	SR 34	Temperature: 21.1^{o}C[t]
56.77	Ust Edgerton WWTP, CR E-75	*No exceedances.*
49.75	Dst. Edgerton, SR 49	Iron: 5,150[g].
47.30	County Line Rd.	*No exceedances.*
42.34	Near Ohio Indiana State Line, SR 249	Iron: 10,800[g]; 5,840[g]. Temperature: 21.3^{o}C[t]
E. Br. St. Joseph River	*WWH Existing*	
4.77	CR S, ust. Pioneer WWTP	*No exceedances.*
1.06	SR 15, dst. Pioneer WWTP	Iron: 5,280[g]; 5,490[g]. Temperature: 21.2^{o}C[t]
Silver Creek	*WWH confirmed and verified*	
1.25	CR 15	*No exceedances.*
Clear Fork Creek	*WWH Existing*	
6.22	SR 576	*No exceedances.*
2.17	CR 13	*No exceedances.*
W. Br. St. Joseph River	*WWH Existing*	
10.48	Near State Line, TR S	*No exceedances.*
8.50	Ust. Seneca Lake, CR 8	*No exceedances.*
3.13	Dst. Seneca Lake, TR 115	Temperature: 22.2^{o}C[t]
0.70	US 20, near mouth	*No exceedances.*
Nettle Creek	*WWH confirmed and verified*	
14.48	Ust. Nettle Lake, TR 72	*No exceedances.*
11.23	Dst. Lake La Su An, CR 7	*No exceedances.*
5.08	CR 8.50, adj. Bridgewater Dairy	*No exceedances.*
1.37	CR N-30	Iron: 6,390[g]; 7,110[g]. Temperature: 20.5^{o}C[t]
North Br. Eagle Creek	*WWH confirmed and verified*	
0.02	At mouth, CR M-50	Dissolved Oxygen: 3.53[m], 3.11[m].
Eagle Creek	*WWH Recommended*	
8.28	Dst. North Branch, CR 675	Dissolved Oxygen: 4.68[a], 4.74[a].
4.90	CR M	Dissolved Oxygen: 4.69[a].
0.50	CR J	*No exceedances.*
Bear Creek	*MWH confirmed and verified*	
8.80	Ust. Edon WWTP, CR 2	*No exceedances.*
5.70	Dst. Edon WWTP, CR 4	*No exceedances.*
2.43	CR I	*No exceedances.*

Stream/RM	**Location**	**Parameter (value – mg/l unless noted)**
Bear Creek	*WWH Existing*	
0.54	SR 34	*No exceedances.*
Fish Creek	*WWH Existing*	
30.54	Ust Columbia, CR P-25	*No exceedances.*
Fish Creek	*EWH Existing*	
5.40	Dst. Stateline, RT 171, dst. unnamed	*No exceedances.*
2.40	CR 3	*No exceedances.*
Fish Creek	*WWH Existing*	
0.38	Edgerton, SR 49	Iron: 5,870 [g]; 6,070 [g]. Temperature: 20.8°C [t]
Big Run	*WWH confirmed and verified*	
0.30	Edgerton, Conkle Rd.	*No exceedances.*

[a] Exceedance of the Outside Mixing Zone Average Dissolved Oxygen criteria (5.0 mg/l).
[m] Exceedance of the Outside Mixing Zone Maximum Dissolved Oxygen criteria (4.0 mg/l).
[t] Exceedance of daily average temperature criteria.
[g] Exceedance of the statewide criterion for the protection of agricultural uses.

Table 8 . Seasonal geometric mean values (mg/l) for nutrients calculated from grab samples collected in the St. Joseph River watershed. Target levels for phosphorus are 0.08 mg/l (WWH) and 0.34 mg/l (MWH) for headwaters, 0.05 mg/l (EWH), 0.10 mg/l (WWH), and 0.28 mg/l (MWH) for wadeable streams, and 0.17 mg/l (WWH) for small rivers. Target levels for nitrate-nitrite are 1.0 mg/l (WWH & MWH) for headwaters, 0.5 mg/l (EWH),1.0 mg/l (WWH), and 1.6 mg/l (MWH) for wadeable streams, and 1.5 mg/l (WWH) for small rivers. Highlighted results are above statewide recommended targets (Ohio EPA, 1999).

Headwaters (drainage area < 20 mi²)

04100003-01-06: Clear Fork – East Branch Saint Joseph River
6.22 (Clear Fork) - phosphorus (0.04), nitrate-nitrite (0.16)

04100003-03-01: Nettle Creek
14.48 (Nettle Creek) - phosphorus (0.04), nitrate-nitrite (0.73)

04100003-03-03: Eagle Creek
0.02 (North Branch Eagle Creek) - phosphorus (0.14), nitrate-nitrite (0.37)

04100003-03-05: Bear Creek
8.8 * (Bear Creek) - phosphorus (0.17), nitrate-nitrite (0.55)
5.8 * (Bear Creek) - phosphorus (0.41), nitrate-nitrite (5.09)

04100003-04-02: Headwaters Fish Creek
30.54 (Fish Creek) - phosphorus (0.07), nitrate-nitrite (1.88)

Wadeable Stream (drainage area ≥20 mi^2 to < 200 mi^2)

04100003-01-06: Clear Fork – East Branch Saint Joseph River
4.77 (East Branch St. Joseph River) - phosphorus (0.03), nitrate-nitrite (0.34)
2.17 (Clear Fork) - phosphorus (0.06), nitrate-nitrite (0.25)
1.25 (Silver Creek) - phosphorus (0.04), nitrate-nitrite (0.31)
1.06 (East Branch St. Joseph River) - phosphorus (0.05), nitrate-nitrite (0.35)

04100003-02-04: Lake La Su An – West Branch Saint Joseph River
10.48 (West Branch St. Joseph River) - phosphorus (0.04), nitrate-nitrite (0.38)
8.5 (West Branch St. Joseph River) - phosphorus (0.03), nitrate-nitrite (0.30)
3.13 (West Branch St. Joseph River) - phosphorus (0.04), nitrate-nitrite (0.26)
0.7 (West Branch St. Joseph River) - phosphorus (0.05), nitrate-nitrite (0.34)

04100003-03-01: Nettle Creek
11.23 (Nettle Creek) - phosphorus (0.05), nitrate-nitrite (0.30)
5.08 (Nettle Creek) - phosphorus (0.05), nitrate-nitrite (0.37)
1.37 (Nettle Creek) - phosphorus (0.06), nitrate-nitrite (0.49)

04100003-03-03: Eagle Creek
8.28 (Eagle Creek) - phosphorus (0.10), nitrate-nitrite (0.35)

4.9 (Eagle Creek) - phosphorus (0.12), nitrate-nitrite (0.41)
0.5 (Eagle Creek) - phosphorus (0.09), nitrate-nitrite (0.66)

04100003-03-05: Bear Creek
2.43 * (Bear Creek) - phosphorus (0.13), nitrate-nitrite (2.11)
0.5 (Bear Creek) - phosphorus (0.08), nitrate-nitrite (0.74)

04100003-04-06: Cornell Ditch – Fish Creek
5.4 ** (Fish Creek) - phosphorus (0.11), nitrate-nitrite (1.04)
2.43 ** (Fish Creek) - phosphorus (0.08), nitrate-nitrite (0.87)
0.38 (Fish Creek) - phosphorus (0.09), nitrate-nitrite (0.81)

04100003-05-02: Big Run
12.66 (Big Run) - phosphorus (0.06), nitrate-nitrite (2.05)

Small River (drainage area ≥ 200 mi^2 to <1000 mi^2)

04100003-03-02: Cogsworth Cemetary – Saint Joseph River
81.18 (St. Joseph River) - phosphorus (0.06), nitrate-nitrite (0.49)

04100003-03-04: Village of Montpelier – Saint Joseph River
76.72 (St. Joseph River) - phosphorus (0.07), nitrate-nitrite (0.42)
73.24 (St. Joseph River) - phosphorus (0.12), nitrate-nitrite (0.64)

04100003-03-06: West Buffalo Cemetary – Saint Joseph River
62.08 (St. Joseph River) - phosphorus (0.10), nitrate-nitrite (0.55)

04100003-05-01: Bluff Run – Saint Joseph River
56.77 (St. Joseph River) - phosphorus (0.10), nitrate-nitrite (0.66)

04100003-05-03: Russell Run – Saint Joseph River
49.75 (St. Joseph River) - phosphorus (0.12), nitrate-nitrite (0.54)
47.3 (St. Joseph River) - phosphorus (0.12), nitrate-nitrite (0.58)

04100003-05-05: Willow Run – Saint Joseph River
42.34 (St. Joseph River) - phosphorus (0.10), nitrate-nitrite (0.67)

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* Modified Warmwater Habitat
**Exceptional Warmwater Habitat

DATA SONDE SUMMARY

Introduction

Multi-parameter sondes are deployed within each study area to collect physical parameter data. The sondes have four electrical sensors that record water column dissolved oxygen, pH, electrical conductivity, and temperature. All parameters, excluding electrical conductivity, are exposed to daily (diel) mechanisms that result in general trends in the parameter (Odum 1956). Temperature shows strong diel fluctuations that reflect air temperature and solar radiation on the global scale, with local factors such as base flow (ground water), stream flow, and shading. In general, diel fluctuations in temperature increase as base flow, stream flow, and shading decrease. The inverse is also true.

Dissolved oxygen responds in a similar diel pattern to temperature, as they are affected strongest by similar factors. However, dissolved oxygen trends are directly dependent on temperature, with high temperatures decreasing the solubility of oxygen in water and increasing the reactions driving diel fluctuations. The inverse relationship, without the influence of other environmental conditions, would cause the two parameters to naturally follow opposite trends. The dissolved oxygen response to photosynthesis is strong enough in most instances to overwhelm the inverse relationship causing the trends to follow similar trajectories. The photosynthetic effect on dissolved oxygen is particularly useful for describing the trophic condition of a stream. Increased diel fluctuation relates to an increase in productivity as equilibrium dissolved oxygen concentrations are pushed to super saturation by photosynthesis and depleted by respiration. The result is a diel trend that typically reaches a maximum in the early evening and a minimum near sunrise. Diel trends in pH are reflective of this productivity because carbon dioxide, which dissolves in water to form carbonic acid, is consumed during photosynthesis, thus raising the pH of the stream.

Sonde Deployment

The St. Joseph River watershed was surveyed in the summer of 2013. Sixteen locations were sampled to provide a representative sample of the watershed and also target areas of concern (e.g. point sources or historically impaired areas). The monitoring efforts for this project were shared with that of the Tiffin River watershed.

Sondes were deployed July 30-August 1 and August 20-22 in 2013. Figure 12 shows the stream average daily streamflow relative to the daily median streamflow for the Tiffin River at Stryker OH, an adjacent watershed to the St. Joseph River watershed, during the field season of 2013. This plot indicates the periods of the St. Joseph River sonde surveys. The plot also includes the average daily air temperature for 2013 along with the normal air temperatures. Critical conditions for the parameters monitored with sondes are times when flows are low, temperatures are high, and daylight is long; these conditions are typical of the summer sampling period. The summer of 2013 was generally wetter than an average summer and capturing an effective critical condition was difficult due to the wet weather. Additionally, although flow was decreasing prior to the July survey, temperatures were relatively low compared to a typical summer. However, the second deployment (August 20-22) better represented critical conditions because it was preceded by continuously lower flows and hotter weather.

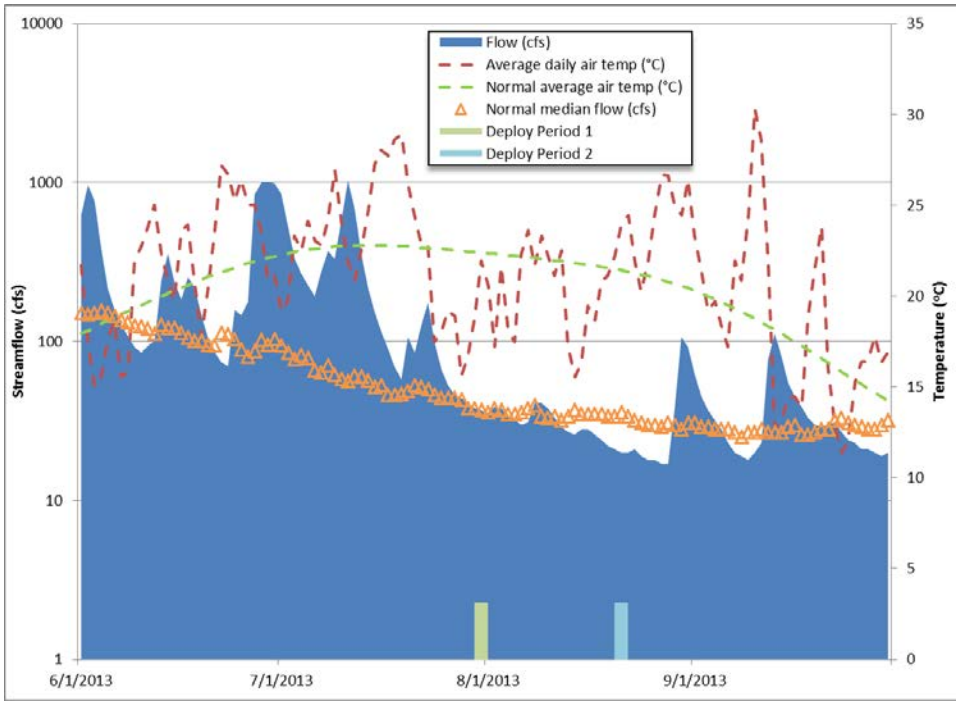

Figure 12. Graph of average daily streamflow relative to the daily median streamflow (USGS 04185000 Tiffin River at Stryker OH, an adjacent stream to the St. Joseph River watershed) including the average daily air temperature (NOAA -GHCND:USW00004851) for the 2013 sonde sampling season**.**

Sonde Results

Box-and-whisker plots are a way to help visualize data and compare stream water quality throughout the basin. Box-and-whisker plots represent the maximum value as the top of the upper whisker, the 75th percentile value as the top of the upper box, the median as the intersection of the two boxes, the 25th percentile value as the bottom of the lower box, and the minimum as the end of the lower whisker; the average value is represented by a diamond. Two sets of box-and-whisker plots show the "best" diel cycle for dissolved oxygen data during a sonde deployment in the St. Joseph River (Figures 13 and 14). The "best" 24-hour period from the survey represents the condition nearest the targeted dry/hot weather and low flow critical condition. Figure 13 shows the results for all sondes deployed on August 21, 2013 during the better of the two St. Joseph River watershed sonde surveys. Figure 14 shows the results from the sondes deployed July 31-August 1, 2013 that did not get deployed on August 21. In the plots shown, the outside mixing zone average (OMZA) and outside mixing zone minimum (OMZM) criteria for the applicable aquatic life use are shown by a red. More on deviations of these criteria is explained below.

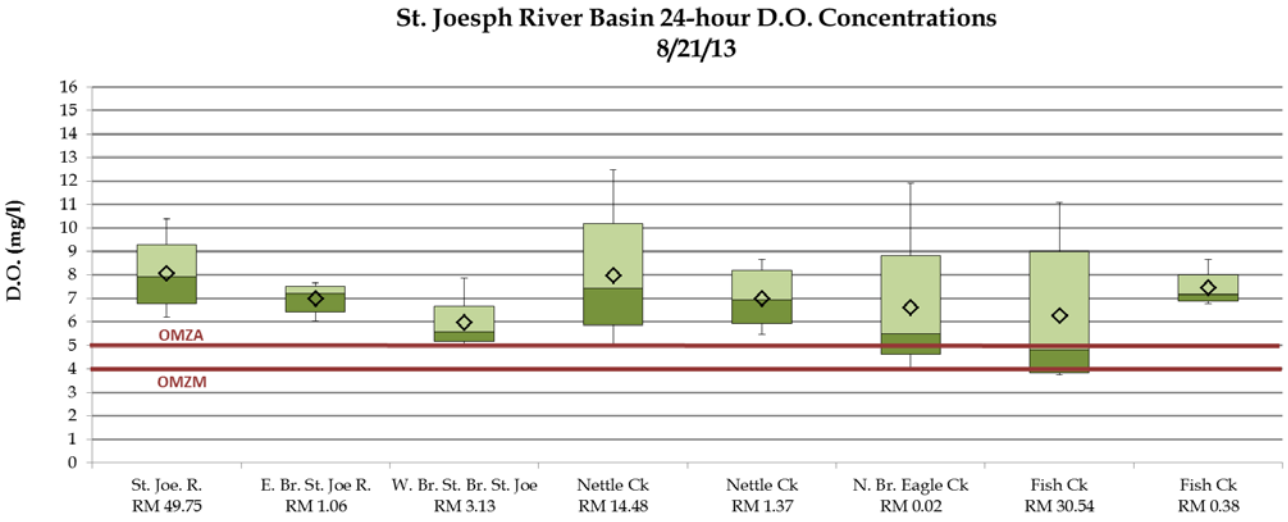

Figure 13. 24-hour dissolved oxygen values for sites in the St. Joseph River watershed (August 21, 2013).

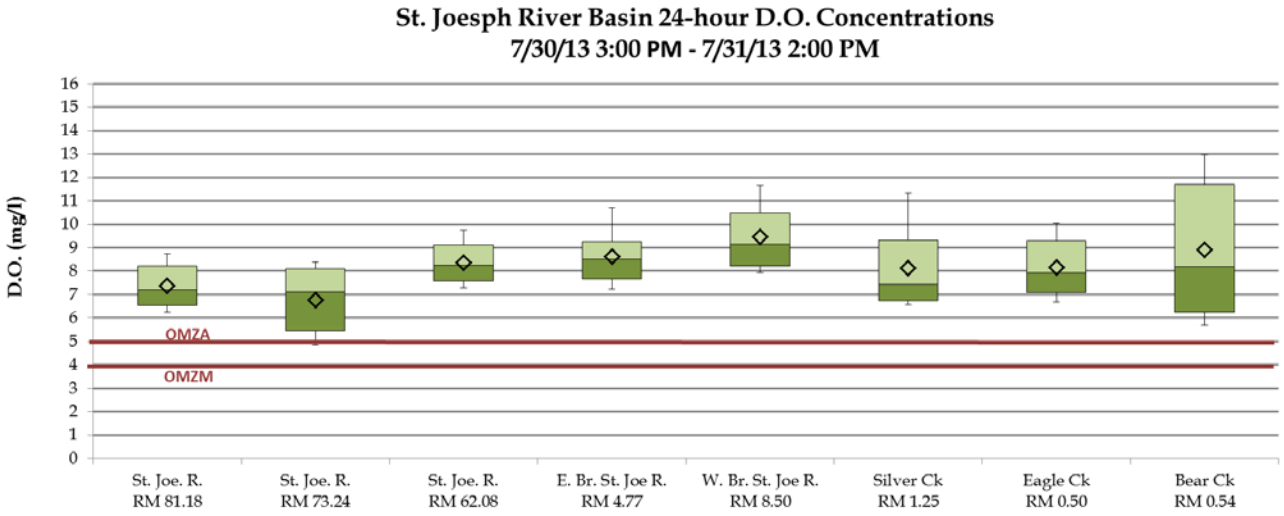

Figure 14. 24-hour dissolved oxygen values for sites in the St. Joseph River watershed (July 30-31, 2013, only showing sites not assessed during the August 21 survey).

Ohio promulgates water quality standards through Ohio Administrative Code Chapter 3745-1. The data collected during the sonde deployments are sufficient to evaluate exceedances of the standards for the protection of aquatic life for: maximum daily temperature, minimum dissolved oxygen, 24-hour average dissolved oxygen, pH, and specific conductivity. Absolute minima or maxima exceedances are compared directly to hourly readings reported from the water quality sondes. Dissolved oxygen 24-hour average criteria exceedances are compared to 24-hour rolling averages. An exceedance of the water quality criteria does not represent stream impairment; rather if biological impairment is present, the exceedances help develop a body of evidence that identifies the conditions that are stressing aquatic life. Exceedance summaries for the two St. Joseph River sonde surveys are noted on Table 9. This table includes descriptions of exceedances.

Of the sixteen monitoring sites where sondes were deployed, only two detected water quality exceedances; both were for violations of the minimum dissolved oxygen criterion. The monitoring location on Fish Creek at river mile 30.54, just upstream from the Ohio/Indiana boarder was not appropriate for a sonde to be placed. As such, the sonde was moved downstream about one mile to Indiana road N 950 E. A eutrophic dissolved oxygen signature was observed here, and this included low concentrations with many observations below 4.0 mg/l. Fish Creek in this area, in both Ohio and Indiana, has very little riparian cover and drains primarily row cropped land. During the monitoring of this site, the stream was noted to have a very sluggish, low volume flow. The same field observations are true of the site at the mouth of North Branch Eagle Creek, the other site with minimum dissolved oxygen criterion violations. The sonde data at these two sites exhibited the typical features of headwater streams in the Eastern Corn Belt Plains ecoregion during warm summer months where there is low gradient and limited material bed structure.

Table 9. Exceedances of Ohio Water Quality Standards criteria (OAC 3745-1) for chemical and physical parameters derived from diel monitoring, 2013**.** Sonde water quality monitors record hourly readings for the duration of the deployment. Consequently, exceedances can be presented as both a measure of magnitude and duration. Rolling 24-hour averages were calculated using the hourly readings for comparison against the average criteria. The duration is the count of consecutive hours that exceeded the criteria. The magnitude of an exceedance is presented as the most extreme value measured that exceeds the criteria and is presented in parenthesis after the duration. Applicable water quality criteria include: minimum dissolved oxygen (D.O.)[a], average D.O.[b], maximum temperature[c], pH[d] and specific conductance[e].

RM	Location	Parameter (D.O. in mg/L, Temp in °C)	Comments
St. Joseph River		*WWH Existing (ECBP)*	
81.18	N Montpelier @ CR N	None	
73.24	dst. Montpelier @ CR 10	None	
62.08	E of Blakeslee @ St. Rt. 34	None	
42.34	Near OH/IN state line @ St. Rt. 249	None	
Fish Creek		*WWH sites with sondes (ECBP)*	
~30.65	N 950 E (in Indiana)	Dissolved oxygen: 3.24 mg/l[c]	Min. criteria violation observed 19 of the 49 hours monitored 8/20 - 8/22/13; 3.24 was the lowest.
0.38	at Edgerton @ St. Rt. 49	None	
Bear Creek		*WWH Existing (ECBP)*	
0.54	*@ SR 34*	None	
Eagle Creek		*WWH Existing (ECBP)*	
0.50	@ CR J	None	
North Br. Eagle Creek		*WWH Existing (ECBP)*	
0.02	At mouth, CR M-50	Dissolved oxygen: 3.64 mg/l[c]	Min. criteria violation observed 3 of the 49 hours monitored 8/20 - 8/22/13; 3.64 was the lowest.
Nettle Creek		*WWH Existing (ECBP)*	
14.48	@ TR 72	None	

RM	Location	Parameter (D.O. in mg/L, Temp in °C)	Comments
1.37	N of Montpelier @ Co. Rd. N-30	None	
West Branch St. Joseph River		*WWH Existing (ECBP)*	
8.50	upst. Seneca Lake @ CR 8	None	
3.13	Dst, Seneca Lake, TR 115	None	
East Branch St. Joseph River		*WWH Existing (ECBP)*	
4.77	upst. Pioneer WWTP @ CR S	None	
1.06	S of Pioneer @ St. Rt. 15	None	
Silver Creek		*WWH Existing (ECBP)*	
1.25	@ CR 15	None	

Notes: ECBP – Eastern Corn Belt Plains
[a] The General Lake Erie basin daily maximum temperature criteria apply; See OAC 3745-1-07, Table 7-14(G).
[b] Applicable minimum 24-hour average D.O. criteria – EWH: 6.0 mg/L, WWH: 5.0 mg/L, MWH: 4.0 mg/L.
[c] Applicable minimum D.O. criteria – EWH: 5.0 mg/L, WWH: 4.0 mg/L.
[d] The criterion for pH is 6.5-9.0 S.U.
[e] The criterion for specific conductivity is 2400 µS/cm.

RECREATION USE

Water quality criteria for determining attainment of the recreation use are established in the Ohio Water Quality Standards (Table 7-13 in OAC 3745-1-07) based upon the quantities of bacteria indicators (*Escherichia coli*) present in the water column.

Escherichia coli (*E. coli*) bacteria are microscopic organisms that are normally present in large numbers in the feces and intestinal tracts of humans and other warm-blooded animals. *E. coli* typically comprises approximately 97 percent of the organisms found in the fecal coliform bacteria of human feces (Dufour 1977). There is currently no simple way to differentiate between human and animal sources of coliform bacteria in surface waters, although methodologies for this type of analysis are becoming more feasible. These microorganisms can enter water bodies where there is a direct discharge of human and animal wastes, or may enter water bodies along with runoff from soils where these wastes have been deposited.

Pathogenic (disease-causing) organisms are typically present in the environment in such small amounts that it is impractical to monitor every type of pathogen. Fecal indicator bacteria by themselves, including *E. coli*, are usually not pathogenic. However, some strains of *E. coli* can be pathogenic, capable of causing serious illness. Although not necessarily agents of disease, fecal indicator bacteria such as *E. coli* may indicate the potential presence of pathogenic organisms that enter the environment through the same pathways. When *E. coli* are present in high numbers in a water sample, it invariably means that the water has received fecal matter from one or multiple sources. Swimming or other recreation-based contact with water having a high *E. coli* count may result in ear, nose, and throat infections, as well as stomach upsets, skin rashes, and diarrhea. Young children, the elderly, and those with depressed immune systems are most susceptible to infection.

Portions of the St. Joseph River watershed are designated as primary contact recreation (PCR) use in OAC Rule 3745-1-07 and 3745-1-11. Water bodies with a designated recreation use of PCR "...are suitable for one or more full-body contact recreation activities such as, but not limited to, wading, swimming, boating, water skiing, canoeing, kayaking, and scuba diving" [OAC 3745-1-07 (B)(4)(b)]. At the time of completion of this basin survey, there were three classes of PCR use to reflect differences in the potential frequency and intensity of use. Streams designated PCR class A support, or potentially support, frequent primary contact recreation activities. Streams designated PCR class B support, or potentially support, occasional primary contact recreation activities. The streams in the study area are designated as Class A and Class B Primary Contact Recreation waters. The *E. coli* criterion that applies to PCR class A streams is a geometric mean of ≤126 colony forming units (cfu)/100 ml. The *E. coli* criterion that applies to PCR class B streams is a geometric mean of ≤161 cfu/100 ml. The geometric mean is based on two or more samples and is used as the basis for determining the attainment status of the recreation use (Table 10). Revisions to the WQS recreation rules, which eliminate the three PCR classes and establish one PCR class with a 90-day geometric mean criterion and a statistical threshold value, will become effective in January, 2016. Under the new rules, all attainment status results remain the same, although the five sampling events did not adhere to the 90-day window. The complete bacteria results dataset is reported in Appendix H.

Twenty-four locations in the watershed were tested for *E. coli* levels five times between May 28, 2013 and September 4, 2013. Evaluation of *E. coli* results revealed that all of the 24 locations sampled failed to meet the applicable geometric mean criterion, indicating non-attainment of the recreation use at these locations (Table 10).

Plausible sources of *E. coli* contamination at locations not attaining the recreation use criterion are failing home sewage treatment systems (HSTS), livestock pasture land runoff, agricultural runoff, and wildlife accumulations. Many of the sites sampled had extensive amounts of agricultural land and drastically reduced riparian buffer along the stream. In addition, land used for livestock rearing and grazing was sporadically located along the banks of the rivers. Blakeslee is an unsewered area draining to Bear Creek. The site downstream from Blakeslee at St. Rt. 34 had the second highest *E. coli* geomean in the watershed. Other unsewered areas include Columbia and Seneca Lake.

Areas listed in non-attainment of the recreation use standard for failing HSTS may need individual system improvements to reduce the discharge of bacteria. Runoff from livestock manure application and livestock grazing areas could be improved by the installation of additional buffers and/or livestock exclusion fencing between the activity and the stream.

Table 10. Recreation beneficial use attainment table for 24 locations in the St. Joseph River watershed, May 1 through October 31, 2013.

Note: All *E. coli* values are expressed as colony forming units (cfu) per 100 ml of water. Shaded values exceed applicable criteria. PCR classes used, associated criteria, and assessment procedures were those in effect at the time of the survey sampling in 2013.

Location	River Mile	Rec Class*	Number of Samples	Geometric Mean†	Attainment Status
St. Joseph River (04-400-000) WWH Existing					
Ust. Montpelier, CR N *(P08S19)*	81.18	A	5	418	**NON**
CR M dead end, At county fairgrounds *(302199)*	76.72	A	5	396	**NON**
Dst. Montpelier, CR 10 *(P08S18)*	73.24	A	5	386	**NON**
CR I *(302200)*	66.69	A	5	353	**NON**
SR 34 *(P08S17)*	62.08	A	5	408	**NON**
Ust Edgerton WWTP, CR E-75 *(P08S16)*	56.77	A	5	286	**NON**
Dst. Edgerton, SR 49 *(510180)*	49.75	A	5	426	**NON**
Near Ohio Indiana State Line, SR 249 *(510220)*	42.34	A	5	165	**NON**
East Branch St. Joseph River (04-415-000) WWH Existing					
CR S, ust. Pioneer WWTP (E Br St Joseph) *(P08K30)*	4.77	B	5	603	**NON**
SR 15, dst. Pioneer WWTP*(P08K29)*	1.06	B	5	432	**NON**
Silver Creek (04-417-000) WWH Existing					
CR 15 (Silver Creek) *(P08S23)*	1.25	A	5	651	**NON**
Clear Fork (04-416-000) WWH Existing					
CR 13 *(P08K31)*	2.17	B	5	666	**NON**
West Branch St. Joseph River (04-414-000) WWH Existing					
US 20, near mouth *(302198)*	0.7	B	5	275	**NON**
Nettle Creek (04-413-000) WWH Existing					
Ust. Nettle Lake, TR 72 *(P08S09)*	14.48	B	5	253	**NON**
Dst. Lake La Su An, CR 7 *(P08K25)*	11.23	B	5	540	**NON**
CR N-30 *(P08S06)*	1.37	B	5	803	**NON**
North Branch Eagle Creek (04-412-000) WWH Existing					
At mouth, CR M-50 (N Branch Eagle Ck) *(P08K23)*	0.02	B	5	1404	**NON**
Eagle Creek (04-412-000) WWH Existing					
Dst. North Branch, CR 6.75 *(P08K22)*	8.28	B	5	731	**NON**
CR J *(P08S01)*	0.5	B	5	949	**NON**
Bear Creek (04-409-000)					

Location	River Mile	Rec Class*	Number of Samples	Geometric Mean†	Attainment Status
SR 34 *(510150)*	0.5	B	5	952	**NON**
Fish Creek (04-405-000)					
Ust Columbia, CR P-25 *(P08K12)*	30.54	B	5	581	**NON**
Dst. Stateline, TR 171, dst. UN Tributary *(P08K10)*	5.4	B	5	575	**NON**
Edgerton, SR 49 *(P08S20)*	0.38	B	5	667	**NON**
Big Run (04-404-000)					
Edgerton, Conkle Rd. *(P08K08)*	0.28	B	5	410	**NON**

* Recreation class includes primary contact recreation classes A or B.

† Attainment status is determined based on the seasonal geometric mean. The status cannot be determined at locations where fewer than two samples were collected during the recreation season.

NPDES Permitted Facilities

A total of 12 NPDES permitted facilities discharge sanitary wastewater, industrial process water, and/or industrial storm water into the St. Joseph River watershed. Each facility is required to monitor their discharges according to sampling and monitoring conditions specified in their NPDES permit and report results to the Ohio EPA in a Discharge Monitoring Report (DMR). Individual NPDES permits in the St. Joseph River watershed are listed in Table 11. None of the facilities is considered a major discharger based on the volume (>1 MGD) and type of waste discharged. All individual NPDES permitted facilities in the watershed are considered minor dischargers.

General NPDES permits are a potential alternative for facilities that have a minimal effect on the environment, have similar operations and meet certain eligibility criteria. There are several different types of general permits, including, but not limited to, small sanitary sewer discharges, petroleum bulk storage and non-contact cooling water. A list of facilities covered under each type may be found at; http://epa.ohio.gov/dsw/permits/NonStormgplist.aspx. There are also several types of general permits specific to storm water, including, but not limited to, small MS4s, construction sites, industries and marinas. There are no MS4s in the study area. A list of MS4 facilities may be found at; http://epa.ohio.gov/dsw/permits/gplist.aspx.

Table 11. Facilities regulated by an Individual NPDES permit in the St. Joseph River Watershed Assessment Unit (04100003).

Facility Name	Ohio EPA Permit No.	Receiving Stream (HUC12 (04100003-xxxx))	River Mile	Wastewater Type and Treatment System (Population)
Aqua Ohio Lake Seneca WTP	2IY00120	West Branch St. Joseph River (0303)	7.95	0.008 MGD filter backwash water through sand filter
Chase Brass and Copper Co Inc.	2IC00007	CR M-50 Roadside Ditch (0304)	-	Storm Water Discharge
Edgerton WTP	2IZ00040	St. Joseph River (0305)	51.6	0.006 MGD softener backwash brine water
Edgerton WWTP	2PB00047	St. Joseph River (0204)	52.15	0.300 MGD Stabilization Pond (pop. 1,939)
Edon WWTP	2PA00031	Bear Creek (0106)	6.92	0.200 MGD Activated Sludge – extended aeration (pop. 980)
Exit One/Mid Tol	2PR00108	Eagle Creek (0302)	18.5	0.035 MGD Activated Sludge – extended aeration, stabilization pond
Lazy River Campground	2PR00272	St. Joseph River (0501)	83.9	0.045 MGD Lagoon System
Montpelier WTP No. 2	2IW00039	St. Joseph River (0304)	76.9	0.005 MGD Lime Sludge Lagoon
Montpelier WWTP	2PD00003	St. Joseph River (0301)	74.25	1.0 MGD Activated Sludge – contact stabilization (pop. 4,600)
Nettle Lake STP	2PG00046	Nettle Creek (0503)	12.6	0.105 MGD Stabilization Pond
Northwest Water District WTP	2IW00041	Eagle Creek (0303)	18.5	Filter backwash discharge from storm water pond
Pioneer WWTP	2PB00006	East Branch St. Joseph River (0302)	2.49	0.50 MGD Aerated Lagoon System (pop. 275)

The following pages provide a brief look at five NPDES facilities and the receiving streams. It is important to note that there were no violations of ammonia standards and only one exceedance of phosphorus targets at sites immediately downstream from NPDES permitted facilities.

Exit One WWTP (Ohio EPA Permit # 2PR00108)

The Exit One WWTP is a 0.035 MGD activated sludge system with extended aeration and a stabilization pond. It discharges into Eagle Creek at RM 18.5, along with the Northwest Water District water treatment plant (WTP). The site closest downstream is located over 10 river miles away, and meets the water quality targets for phosphorus and nitrate-nitrite (Figure 15). This site, at RM 8.28, is downstream from the confluence with the North Branch Eagle Creek, which had a phosphorus geometric mean that was above the target. The site on North Branch Eagle Creek may have been locally impacted by land use practices of the immediate upstream landowner, including disposal of yard waste in the stream. The only excursion from the water quality targets on Eagle Creek occurred at RM 4.9. Land use between the RM 8.28 and RM 4.9 sites is predominantly row crop agriculture and a single golf course.

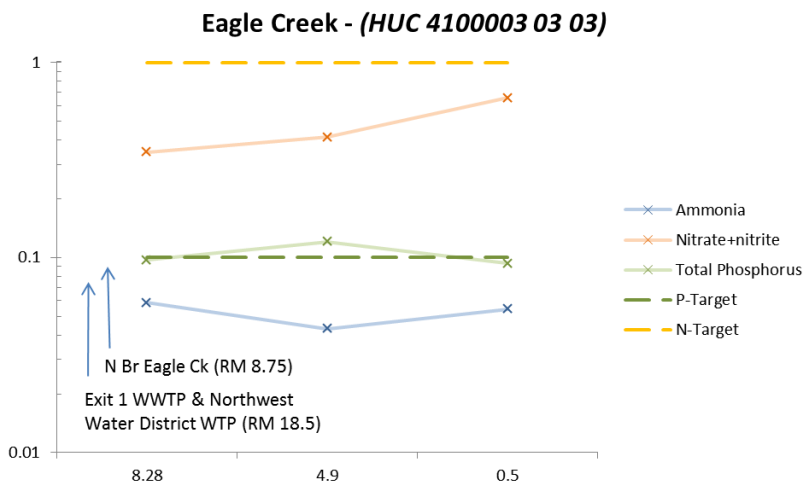

Figure 15 . Geomean values for ammonia, total phosphorus (vs. target), and nitrate-nitrite (vs. target) for Eagle Creek, 2013.

Montpelier WWTP (Ohio EPA Permit # 2PD00003)

The Montpelier WWTP is a 1.0 MGD design activated sludge system with contact stabilization serving a population of 4,600 people. It discharges into the St. Joseph River at RM 74.25. The collection system is 55% separate and 45% combined sewers.

The largest geometric mean increase in phosphorus concentrations on the mainstem of the St. Joseph River occurs between the immediate upstream and downstream sites bracketing the Montpelier WWTP. A similar increase in ammonia concentrations also occurs between these two sites. The geometric mean phosphorus value increases from 0.066 mg/l to 0.12 mg/l between these sites, but remains below the target value of 0.17 mg/l.

Date	Total Phosphorus	Nitrate-Nitrite	Stream Conditions
06/20/13	0.081	2.42	Normal
07/08/13	0.141	1.9	Wet
07/22/13	0.131	0.74	Normal
08/01/13	0.53	0.24	Dry
08/19/13	0.215	0.13	Dry
09/19/13	0.175	0.65	Dry
Geomean	0.12	0.64	

Table 12 . Sampling data and weather conditions for St. Joseph River RM 73.24.

The upstream sampling site at RM 76.72 is located at the county fairgrounds on the north side of Montpelier. The downstream site at RM 73.24 is located at Co. Rd. 10, just southwest of town. The city of Montpelier, and most notably, its wastewater plant discharge and combined sewer overflows, are likely to have the greatest impact on stream chemistry over this 3.5 mile stretch.

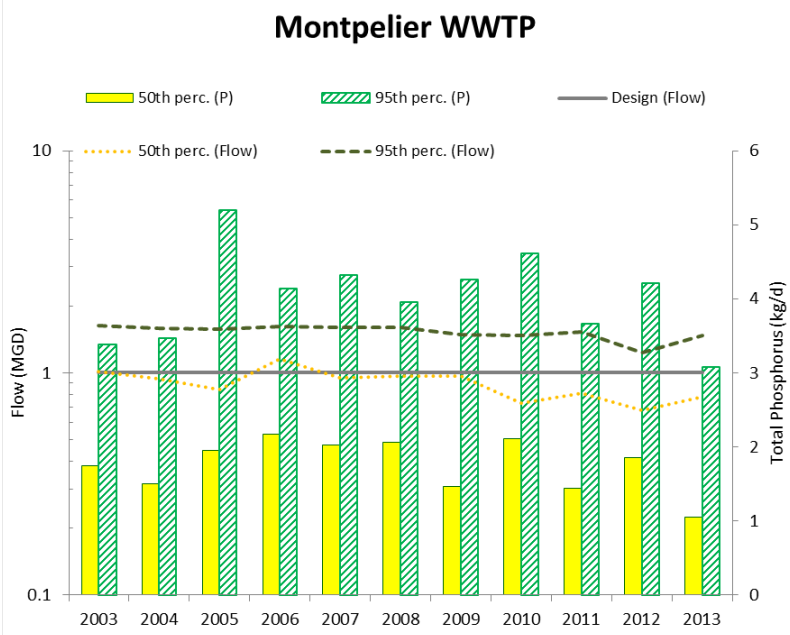

Figure 16. Montpelier WWTP total phosphorus (mg/l) and flow (MGD) (vs design) for 2003-2013.

Table 12 provides the total phosphorus and nitrate-nitrite data for the downstream site at RM 73.24. Three of the six events were sampled during dry stream conditions as determined using the modeled flow duration curve. Given the dry conditions, it is more likely that the phosphorus impacts to the stream are the result of discharge water from the WWTP rather than CSOs. Figure 16 provides a ten year snapshot of flow and phosphorus concentrations leaving the WWTP. The 2013 data represents a continued reduction in load to the watershed and was the lowest data during this timeframe.

Edon WWTP (Ohio EPA Permit # 2PA00031)

The Edon WWTP (constructed in 1994) is a 0.200 MGD activated sludge system with extended aeration serving 980 people. The collection system is 100% separate sanitary sewers. It discharges into Bear Creek at RM 6.92. The sampling location immediately downstream at RM 5.8 exceeded the phosphorus and nitrate-nitrite targets for the stream.

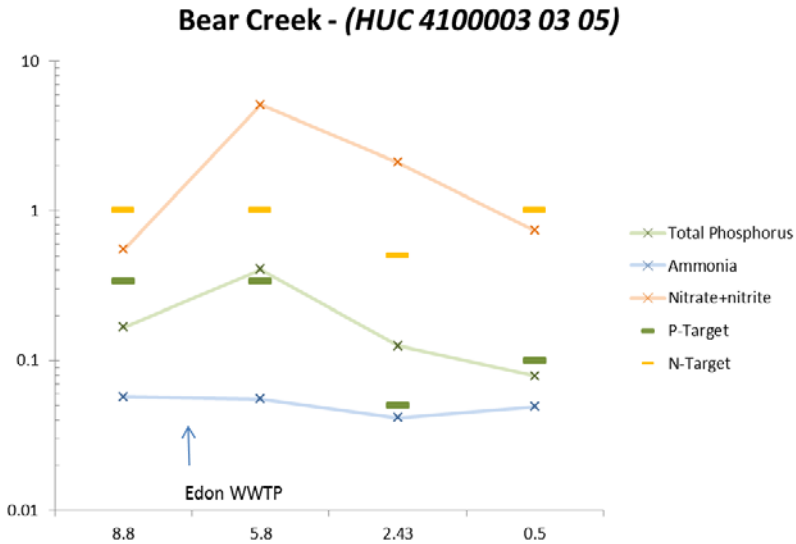

Figure 17. Geomean values for ammonia, total phosphorus (vs target), and nitrate+nitrite (vs target) for Bear Creek, 2013.

Figure 17 provides the linear geomean data for Bear Creek for the 2013 sampling season. Figure 18 provides the ten year flow and phosphorus concentration data for the Edon WWTP. The 50th percentile phosphorus concentrations over the ten year window equate to a geometric mean of 3.84 mg/l. The Edon WWTP is a significant source of phosphorus for the stream, and is likely contributing to the excursion from the target values. Nitrate-nitrite values for the Edon WWTP are only available for 2012-2013. The 50th percentile concentrations for those years were 36.1 mg/l and 30.6 mg/l, respectively. The Edon WWTP is a significant source of nitrate-nitrite for the stream, and is likely contributing to the excursion from the target values.

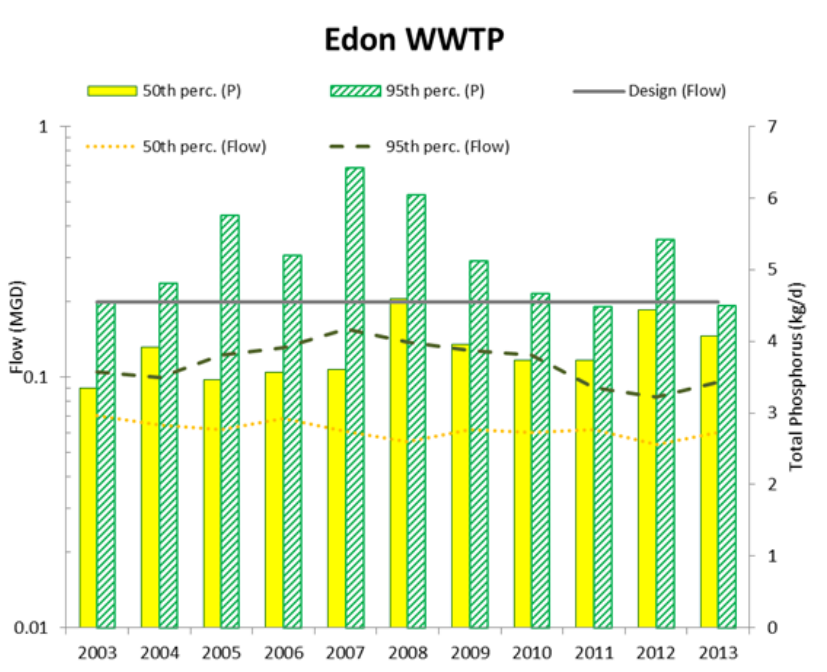

Figure 18. Edon WWTP total phosphorus (mg/l) and flow (MGD) (vs design) for 2003-2013.

Aqua Ohio Lake Seneca WTP (Ohio EPA Permit # 2IY00120)

The Aqua Ohio Lake Seneca WTP is permitted to release 8000 GPD filter backwash water through sand filters to West Branch St. Joseph River RM 7.95. Ammonia, nitrate-nitrite, and phosphorus increase between the sampling sites at RMs 8.5 and 3.13. The majority of this stretch is dominated by Seneca Lake. It is reasonable to assume that the impact to the stream in this area is from discharging HSTS. Figure 19 provides the linear geomean data for the West Branch St. Joseph River for the 2013 sampling season. At this time the stream is not likely significantly impacted by the HSTS inputs or the WTP NPDES permitted outfall.

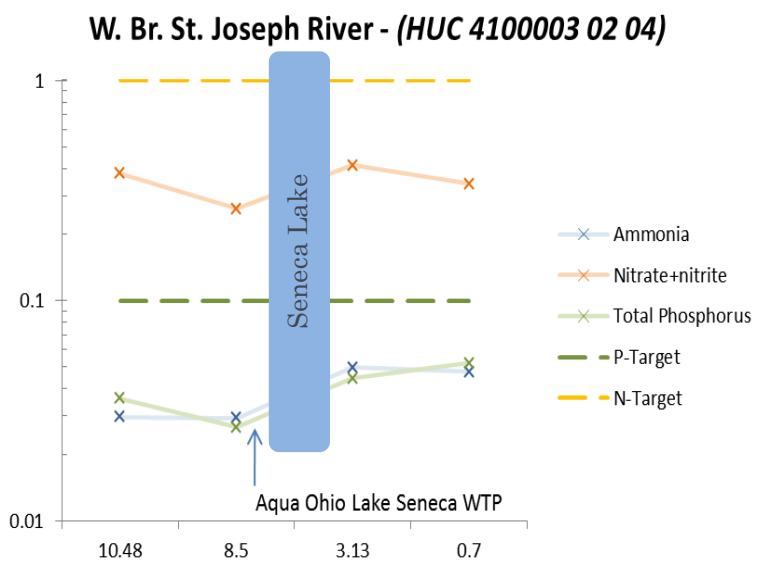

Figure 19. Geomean values for ammonia, total phosphorus (vs target), and nitrate+nitrite (vs target) for W. Br. St. Joseph River 2013.

Pioneer WWTP (Ohio EPA Permit # 2IY00120)

The Pioneer WWTP is a 0.50 MGD aerated lagoon system. It discharges to the East Branch St. Joseph River at RM 2.49. This NPDES permitted facility is not directly bracketed by sampling locations due to a lack of access points to the stream. Sampling was completed downstream from the outfall, near the mouths of Clear Fork and Silver Creek and upstream from the confluence of the East Branch with Silver Fork. Based on the available data, the downstream site located at RM 1.06 had the highest geometric mean for ammonia (Figure 20). There were no violations of ammonia values and ammonia is not likely resulting in significant impact to the stream.

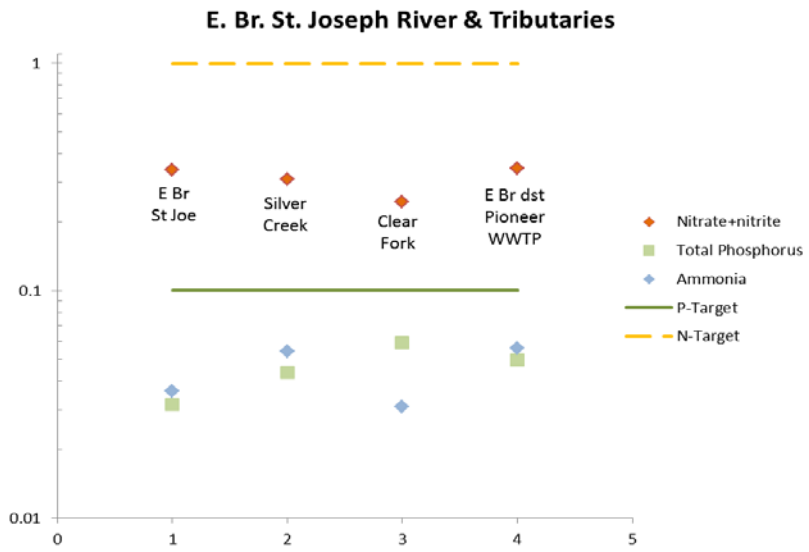

Figure 20. Geomean values for ammonia, total phosphorus (vs target), and nitrate+nitrite (vs target) for E. Br. St. Joseph River 2013.

Sediment Quality

Sampling locations were selected in the study plan to determine background sediment quality, assess the impact from point sources and urban nonpoint runoff and evaluate downstream transport and recovery. Samples were collected following the *Sediment Sampling Guide and Methodologies, 3rd Edition* in which the goal is to collect a representative sample that is composed of >30% silt and clay particles (Ohio EPA, 2012). These fine grained particles are much more physically, chemically and biologically reactive because they hold more interstitial water and have unbalanced electrical charges that can attract contaminants.

Most of the St. Joseph River mainstem contains little in the way of fine grained sediment in large enough volumes to have much of an ecological impact. This is due in part to a largely intact natural stream morphometry of the mainstem and suitable gradient. This allows for fine particles to be deflected into the floodplain or washed downstream during high flows. Exceptions to this include impounded segments, isolated eddies and in the headwaters where feeder streams are channelized.

Sediment sample results were evaluated using Tier I procedures for aquatic life described in the *Guidance on Evaluating Sediment Contaminant Results* (Ohio EPA, 2010). Numeric Sediment Quality Guidelines (SQGs) include Ohio Sediment Reference Values (SRVs) for metals contained in the *Ecological Risk Assessment Guidance* (Ohio EPA, 2008) and toxicity values in the *Development and Evaluation of Consensus-based Sediment Quality Guidelines for Freshwater Ecosystems* (MacDonald et al., 2000). When contaminants are at concentrations above the SQGs either appropriate treatment options should be explored to remediate the problem or consideration should be given to investigate if bioavailability affects toxicity. This would likely require further studies to be done.

A total of four sediment samples were collected in the St. Joseph River between Co. Rd. N (RM 81.18) and St. Rt. 249 (RM 42.34). Sediment samples were analyzed for metals, s-VOCs (PAHs), PCBs and pesticides (organo-chlorine insecticides). Analytical results are tabulated in Appendix G. No pesticides or s-VOCs were detected in any of the samples. All metals were below Ohio sediment reference values. PCBs were below the threshold effect concentration (TEC) and were only detected in one sample. The laboratory reporting limit for silver was greater than the SQG and, thus, is not able to be evaluated as a part of this study.

Lake Sampling

Inland Lakes Monitoring

Ohio EPA has implemented a sampling strategy that focuses on evaluating chemical conditions near the surface and physical conditions in the water column of inland lakes. Physical profile measurements are summarized either for the entire water column or the epilimnion depending on thermal stratification. The sampling target consists of an even distribution of a total of ten sampling events divided over a two-year period and collected during the index period of May 1 – October 31. Key parameters used to determine the attainment status of lakes include chlorophyll a, ammonia, dissolved oxygen, pH, total dissolved solids and various metals. Other parameters used to evaluate the degree of support or non-support includes secchi depth, total phosphorus and total nitrogen. Details of the sampling protocol are outlined in Appendix E of the Ohio EPA Surface Water Field Sampling Manual, available on Ohio EPA's web page at
http://www.epa.ohio.gov/portals/35/inland_lakes/Lake_Sampling_Procedures.pdf .

Water Quality Standards for the Protection of Aquatic Life in Lakes

Presently, lakes in Ohio are designated as Exceptional Warmwater Habitat (EWH) with respect to the aquatic life habitat use designation. Revisions to Ohio's WQS that would change the aquatic life use from EWH to Lake Habitat (LH) were proposed for adoption in December, 2011, but were subsequently withdrawn. A future rulemaking is anticipated but the timeframe is unknown. A primary reason for this revision is that, in Ohio, a set of biological criteria applies to rivers and streams, whereas no biocriteria apply to lakes. The numeric chemical criteria to protect the LH use will remain the same as the criteria to protect the EWH use that currently applies to lakes, with a suite of nutrient criteria added. These criteria are tiered based on the type of lake and the ecoregion it's located in. A set of numeric criteria that applies to all surface waters for the protection of aquatic life, regardless of specific use designation, also apply to inland lakes and are referred to as "base aquatic life use criteria" in the proposed WQS rules. The base aquatic life use criteria will be the same aquatic life numeric criteria that currently apply to lakes. Examples include various metals such as copper, lead, and cadmium as well as organic chemicals such as benzene and phenol. Specific details concerning the progress of revisions to Ohio's Water Quality Standards involving the proposed Lake Habitat aquatic life use and associated criteria can be found at the following Ohio EPA web site as information becomes available: http://www.epa.ohio.gov/dsw/rules/draftrules.aspx. Details of the proposed use designation, draft criteria and assessment methodology are previewed in the Ohio EPA 2012 Integrated Water Quality Monitoring and Assessment Report, available on Ohio EPAs web page at: http://epa.ohio.gov/dsw/tmdl/OhioIntegratedReport.aspx

Barton Lake

Barton Lake is located in Williams County on Co. Rd. J two miles west of St. Rt. 576, three miles southwest of Montpelier. The public boat ramp and parking are located on the southeast corner of the lake off of Co. Rd. J. The lake is an abandoned stone quarry located in the Michindoh Glacial Aquifer and is part of the St. Joseph River Wildlife Area. Uses include boating and fishing, no gas-powered boat motors are permitted (ODNR, 2012).

Key Attributes
Lake Type: Dugout Ecoregion: Eastern Corn Belt Plains
Surface Area: 19 acres Maximum Depth: 42 ft.

Lake Habitat Use
Environmental samples were collected during the 2013-14 recreation seasons. Data used to determine status of the Lake Habitat use is summarized in Table 13. Water quality parameters that were evaluated included dissolved solids, arsenic, cadmium, chromium, copper, lead, nickel, selenium and zinc. Individual sample concentrations are first compared to Outside Mixing Zone Average (OMZA) numeric criteria. If the OMZA is exceeded in more than 10% of the total samples tested for any parameter, the use is considered non-support.

Water quality parameters are evaluated using several methods. Chlorophyll *a*, total phosphorus, total nitrogen and secchi depth are evaluated by first calculating a median value from the two-year dataset. This value is then compared to the criteria in Table I-1 of the 2012 Integrated Report (http://epa.ohio.gov/dsw/tmdl/OhioIntegratedReport.aspx). Dissolved oxygen, pH and ammonia are evaluated in a manner similar to the base water quality parameters for aquatic life uses. Dissolved oxygen (average) and pH (median) numbers are calculated from profile readings taken in either the epilimnion or the entire water column if the lake isn't stratified. Status of the Lake Habitat use is considered non-support if chlorophyll *a*, dissolved oxygen, pH or ammonia exceeds criteria based on their assessment method. A watch list designation is assigned if total phosphorus, total nitrogen or secchi depth values exceed their criteria. The Lake Habitat use of Barton Lake was considered non-support due to median chlorophyll *a* levels exceeding the target value.

Useful information was also obtained from samples collected near the bottom. The hypolimnion can become depleted of oxygen if consumption by decomposing organic matter exceeds reaeration by atmospheric diffusion and photosynthesis. Fish access to habitat, cool water and benthic prey can be limited if conditions become hypoxic (DO < 2 mg/L). Hypoxia was documented during every sampling event. On several occasions, hypoxia was documented at depths as shallow as 2-3 meters from the surface. Chemistry data from samples collected 0.5 m from the bottom indicate that phosphorus bound to sediment particles is being released to the water column due to redox reactions that break the bond between phosphate molecules and calcium and iron. Mean total phosphorus concentration at the surface for the 10 sampling events was 17.09 ppb and bottom mean concentration was 416.9 ppb. This release of nutrients is what typically stimulates fall algae blooms when thermal stratification is broken and the lake "turns over".

A surficial sediment sample was collected in October 2013 and analyzed for metals, nutrients, s-VOCs (PAHs), PCBs and pesticides (organo-chlorine insecticides). Most compounds tested were either not detected or were well below guidelines used by Ohio EPA to evaluate data. The exception was cadmium which measured at 1.11 ppm, which is above the ecoregion reference value of 0.90 ppm, but does not exceed the probable effect concentration of 4.98 ppm above which harmful effects to aquatic life are likely to be observed.

Recreation Use
The recreation use was evaluated by measuring levels of *E. coli* bacteria at the lake (L-1) station. The site was sampled 10 times over the two-year assessment period and respective geometric mean values

were compared to the bathing water criterion of 126 cfu/100 ml. The recreation use was considered in support since the geometric mean was 4.99 cfu/100 ml at L-1.

Table 13. Summary of data used to determine status of the Lake Habitat use in Barton Lake.

Parameter	Chl. *a* (µg/L)	Secchi (m)	T-N (µg/L)	T-P (µg/L)	D.O. (mg/L)	pH (SU)	NH_3-N (mg/l)
Draft Criteria	**≤6.0**	**≥2.60**	**≤450**	**≤18**	**≥6.0**	**6.5>pH<9.0**	**(WQS)**
5/15/13	40.6	0.92	1690	18	13.28	8.88	0.127 (0.2)
6/12/13	4.7	2.80	1340	<10	9.22	8.89	0.105 (0.1)
7/16/13	16.4	0.52	1360	20	9.82	8.71	<0.05 (0.2)
8/14/13	25.4	0.70	730	18	10.34	8.92	<0.05 (0.2)
9/24/13	18.8	1.35	650	<10	6.31	8.26	<0.05 (0.8)
5/20/14	38.3	1.80	4160	48.1	9.63	7.79	<0.05(1.5)
6/16/14	3.6	2.40	3090	17.1	9.02	8.51	<0.05 (0.3)
7/8/14	11.2	2.30	2660	13.6	9	8.52	<0.05 (0.3)
8/19/14	4	4.10	2550	8.7B	7.35	8.26	0.065 (0.5)
9/3/14	7.4	3.20	2110	7.4	9.47	8.53	<0.05 (0.3)
Median	**13.8**	**2.05**	**1900**	**15.4**	**NA**	**NA**	**NA**
% Exceeded	**NA**	**NA**	**NA**	**NA**	**0%**	**0%**	**10%**
Narrative	non-support	watch list	watch list	support	support	support	support

McKarns Lake

McKarns Lake is located in Williams County on Co. Rd. J two miles west of SR 576, three miles southwest of Montpelier. The public boat ramp and parking are located on the northwest corner of the lake off of Co. Rd. J. The lake is an abandoned stone quarry located in the Michindoh Glacial Aquifer and is part of the St. Joseph River Wildlife Area. Uses include boating and fishing, no gas-powered boat motors are permitted (ODNR, 2012).

Key Attributes

Lake Type: Dugout Ecoregion: Eastern Corn Belt Plains
Surface Area: 40 acres Maximum Depth: 75 ft.

Lake Habitat Use

Environmental samples were collected during the 2013-14 recreation seasons. Data used to determine status of the Lake Habitat use is summarized in Table 14. Water quality parameters that were evaluated included dissolved solids, arsenic, cadmium, chromium, copper, lead, nickel, selenium and zinc. Individual sample concentrations are first compared to OMZA numeric criteria. If the OMZA is exceeded in more than 10% of the total samples tested for any parameter the use is considered non-support.

Water quality parameters are evaluated using several methods. Chlorophyll *a*, total phosphorus, total nitrogen and secchi depth are evaluated by first calculating a median value from the two year dataset. This value is then compared to the criteria in Table I-1 of the 2012 Integrated Report. Dissolved oxygen, pH and ammonia are evaluated in a manner similar to the base water quality parameters for aquatic life uses. Dissolved oxygen (average) and pH (median) numbers are calculated from profile readings taken in either the epilimnion or the entire water column if the lake isn't stratified. Status of the Lake Habitat use is considered non-support if chlorophyll *a*, dissolved oxygen, pH or ammonia exceeds criteria based on their assessment method. A watch list designation is assigned if total phosphorus, total nitrogen or secchi depth values exceed their criteria. The Lake Habitat use of McKarns Lake was considered non-support due to median chlorophyll *a* level exceeding the target value.

Useful information was also obtained from samples collected near the bottom. The hypolimnion can become depleted of oxygen if consumption by decomposing organic matter exceeds reaeration by atmospheric diffusion and photosynthesis. Fish access to habitat, cool water and benthic prey can be limited if conditions become hypoxic (DO < 2 mg/L). Hypoxia was documented during every sampling event. Hypoxia was documented in the hypolimnion during every sampling event. Chemistry data from samples collected 0.5 m from the bottom indicate that phosphorus bound to sediment particles is being released to the water column due to redox reactions that break the bond between phosphate molecules and calcium and iron. Mean total phosphorus concentration at the surface for the 10 sampling events was 9.5 ppb and bottom mean concentration was 172.4 ppb. This release of nutrients is what typically stimulates fall algae blooms when thermal stratification is broken and the lake "turns over".

A surficial sediment sample was collected in October 2013 and analyzed for metals, nutrients, s-VOCs (PAHs), PCBs and pesticides (organo-chlorine insecticides). Most compounds tested were either not detected or were well below guidelines used by Ohio EPA to evaluate data. The exception was cadmium, iron and zinc which measured above the associated ecoregion reference values, but did not exceed the probable effect concentration above which harmful effects to aquatic life are likely to be observed.

Recreation Use

The recreation use was evaluated by measuring levels of *Escherichia coli* bacteria at the lake (L-1) station. The site was sampled 10 times over the two-year assessment period and respective geometric mean values were compared to the bathing water criterion of 126 cfu/100 ml. The recreation use was considered in support since the geometric mean was 0.9 cfu/100 ml at L-1.

Table 14. Summary of data used to determine status of the Lake Habitat use in McKarns Lake.

Parameter	Chl. *a* (µg/L)	Secchi (m)	T-N (µg/L)	T-P (µg/L)	D.O. (mg/L)	pH (SU)	NH_3-N (mg/l)
Draft Criteria	**≤6.0**	**≥2.60**	**≤450**	**≤18**	**≥6.0**	**6.5>pH<9.0**	**(WQS)**
5/15/13	8.7	1.4	2210	32	9.01	8.56	0.164(0.4)
6/12/13	12.3	1.74	1630	11	9.33	9.18	0.065(0.1)
7/16/13	4.7	1.64	1330	<10	4.80	8.835	<0.05(0.2)
8/14/13	11.4	1	1020	<10	9.13	8.98	<0.05(0.1)
9/24/13	22.4	1.05	940	<10	8.80	8.93	<0.05(0.2)
5/20/14	13.5	1.45	700	14.1	11.73	8.96	<0.05(0.2)
6/16/14	1.9	3.1	600	6.7	10.23	8.9	<0.05(0.2)
7/8/14	1.7	4.5	540	4.8	8.51	8.81	<0.05(0.2)
8/19/14	2	4.76	450	6.4B	8.51	8.6	<0.05(0.3)
9/3/14	2	5.71	460	5	9.63	8.51	<0.05(0.3)
Median	**6.7**	**1.69**	**820**	**5.7**	**NA**	**NA**	**NA**
% Exceeded	**NA**	**NA**	**NA**	**NA**	**10%**	**10%**	**0%**
Narrative	non-support	watch list	watch list	support	support	support	support

Nettle Lake

Nettle Lake is located in Williams County on Co. Rd. 4.75 off of SR 49, 2 miles northeast of Cooney. The public boat ramp is located on the southwest corner of the lake off of Co. Rd. 4.75. The lake is one of only a handful of natural lakes formed by glaciers as they moved through Ohio. It is an on-stream lake with Nettle Creek flowing into and out of the lake. Nettle Lake has 115 acres of fishing water and 3.8 miles of shoreline. The majority of the shoreline is privately owned, thereby limiting public shoreline access. Nettle Lake has no horsepower restrictions; however, there is a No Wake Rule (power boaters must operate at idle speed) between the hours of 6 p.m. and 10 a.m. From 10 a.m. until 6 p.m., there are no speed restrictions for power boaters (ODNR, 2012).

Key Attributes

Lake Type: Natural Ecoregion: Eastern Corn Belt Plains
Surface Area: 115 acres Maximum Depth: 27 ft.

Lake Habitat Use

Environmental samples were collected during the 2013-14 recreation seasons. Data used to determine status of the use is summarized in Table 15. Water quality parameters that were evaluated included dissolved solids, arsenic, cadmium, chromium, copper, lead, nickel, selenium and zinc. Individual sample concentrations are first compared to OMZA numeric criteria. If the OMZA is exceeded in more than 10% of the total samples tested for any parameter the use is considered non-support.

Water quality parameters are evaluated using several different methods. Chlorophyll *a*, total phosphorus, total nitrogen and secchi depth are evaluated by first calculating a median value from the two year dataset. This value is then compared to the criteria in Table I-1 of the 2012 Integrated Report. Dissolved oxygen, pH and ammonia are evaluated in a manner similar to the water quality parameters. Dissolved oxygen (average) and pH (median) numbers are calculated from profile readings taken in either the epilimnion or the entire water column if the lake isn't stratified. Status of the Lake Habitat use is considered non-support if chlorophyll *a*, dissolved oxygen, pH or ammonia exceeds criteria based on their assessment method. A watch list designation is assigned if total phosphorus, total nitrogen or secchi depth values exceed their criteria. The Lake Habitat use of Nettle Lake was considered non-support due to median chlorophyll *a* and total phosphorus levels exceeding the target values. In addition, dissolved oxygen levels in the epilimnion were measured below the target value on three occasions.

Useful information was also obtained from samples collected near the bottom. The hypolimnion can become depleted of oxygen if consumption by decomposing organic matter exceeds reaeration by atmospheric diffusion and photosynthesis. Fish access to habitat, cool water and benthic prey can be limited if conditions become hypoxic (DO < 2 mg/L). Hypoxia was documented during every sampling event. On most occasions hypoxia was documented at depths as shallow as 3 - 4 meters. Chemistry data from samples collected 0.5m from the bottom indicate that phosphorus bound to sediment particles is being released to the water column due to redox reactions that break the bond between phosphate molecules and calcium and iron. Mean total phosphorus concentration at the surface for the 10 sampling events was 31.79 ppb and bottom mean concentration was 203.4 ppb. This release of nutrients is what typically stimulates fall algae blooms when thermal stratification is broken and the lake "turns over".

A surficial sediment sample was collected in October 2013 and analyzed for metals, nutrients, s-VOCs (PAHs), PCBs and pesticides (organo-chlorine insecticides). Most compounds tested were either not detected or were well below guidelines used by Ohio EPA to evaluate data.

Recreation Use

The recreation use was evaluated by measuring levels of *Escherichia coli* bacteria at the lake (L-1) station. This site was sampled 10 times over the two-year assessment period and respective geometric mean values were compared to the bathing water criterion of 126 Ccfu/100 ml. The recreation use was considered in support since the geometric mean was 3.34 cfu/100 at L-1.

Table 15. Summary of data used to determine status of the Lake Habitat use in Nettle Lake.

Parameter	Chl. *a* (µg/L)	Secchi (m)	T-N (µg/L)	T-P (µg/L)	D.O. (mg/L)	pH (SU)	NH_3-N (mg/l)
Draft Criteria	**≤14.0**	**≥1.19**	**≤638**	**≤34**	**≥6.0**	**6.5>pH<9.0**	**(WQS)**
5/21/13	49.1	0.71	2020	28	12.56	8.7	<0.05 (0.3)
6/12/13	37.7	0.6	1740	48	6.71	8.22	0.1 (0.5)
7/17/13	75.2	0.58	1310	28	8.18	8.66	<0.05 (0.2)
8/15/13	39.7	0.62	830	26	6.16	8.19	<0.05 (0.7)
9/19/13	52.8	0.83	980	34	5.75	8.125	<0.05 (0.5)
5/21/14	46.5	0.98	2330	36	13.61	8.53	<0.05 (0.4)
6/17/14	17.2	1	1440	27	8.64	8.145	0.06 (0.6)
7/7/14	41.3	0.9	840	21.2	7.01	8.07	<0.05 (0.7)
8/18/14	41.1	0.93	740	26.8	5.13	7.945	<0.05 (0.5)
9/2/14	42.5	0.84	770	42.9	4.57	7.83	<0.05 (1.3)
Median	**41.9**	**0.84**	**1145**	**28**	**NA**	**NA**	**NA**
% Exceeded	**NA**	**NA**	**NA**	**NA**	**30%**	**0%**	**0%**
Narrative	non-support	watch list	watch list	support	Non-support	support	support

Macroinvertebrate Community

Macroinvertebrate communities were evaluated at 33 stations in the St. Joseph River study area (Table 18, Appendices D and E). The community performance was evaluated as exceptional at 14 stations, very good at 9, good at 4, and marginally good at 6. The station with the highest total mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera) taxa richness (EPT), insect orders generally considered representative of high quality resources, was on the West Branch St. Joseph River near the state line, Township Road S (RM 10.48) with 29 taxa. The station with the highest number of total sensitive taxa (ST) was on Fish Creek downstream from the state line, Township Road 171 (RM 5.4) with 36 taxa. Five uncommonly collected sensitive taxa and 22 species of freshwater mussels were collected during this study and their collection locations are listed in Tables 16 and 17. Nine of the freshwater mussel species were included in the state list of wildlife that are endangered, threatened or species of concern. Two species of freshwater mussels are federally endangered or threatened (Table 17).

St. Joseph River Mainstem

The St. Joseph River mainstem was sampled at eight stations in 2013 (Figure 21, Table 18). The St. Joseph River is formed at the confluence of the East Branch and West Branch St. Joseph River at RM 84.57 and flows through Ohio until entering Indiana at RM 40.8. All of the St. Joseph River mainstem stations were achieving the WWH macroinvertebrate biocriterion. Four of the eight sites were evaluated as exceptional. The Montpelier WWTP (RM 74.25) and the Edgerton WWTP (RM 52.1) have outfalls to the St. Joseph River but do not appear to be negatively affecting downstream attainment.

Brachycentrus numerosus, a state endangered caddisfly, was found at four different sites on the St. Joseph River mainstem (Table 16). Three sensitive stoneflies, *Paragnetina media, Perlinella drymo, and Acroneuria abnormis,* were also found at several sites throughout the river (Table 16). The St. Joseph River at RM 76.72 had a good diversity of freshwater mussels with seven different mussel species collected (Table 17). Eight live purple wartyback mussels (*Cyclonais tuberculata),* a state listed species of concern, were found at that site. Only two other mainstem sites (RMs 56.77 and 49.75) had purple

wartyback mussels, though only a single fresh dead purple wartyback mussel shell was found at each site.

Purple Wartyback (*Cyclonais tuberculata).* Listed in Ohio as a species of concern. St. Joseph River (RM 76.72).

Tributaries

Macroinvertebrate communities in 10 tributaries to the St. Joseph River sampled at 25 sites were assessed during the 2013 sampling index period. All of the 25 sites sampled fully met applicable macroinvertebrate biocriteria with ICI and narrative scores ranging from marginally good to exceptional (Table 18).

Eastern St. Joseph River subbasin - HUC 10 (0410000301) East Br. St. Joseph, Clear Fork, Silver Creek

The two sites sampled on the East Branch St. Joseph River (RMs 4.77 and 1.06) were evaluated as very good to exceptional. The Pioneer WWTP discharges into the East Branch St. Joseph at RM 3.18 but there was only a slight change in the macroinvertebrate narrative assessment downstream from the WWTP which decreased from exceptional above the discharge (RM 4.77) to very good at RM 1.06. The two Clear Fork sites (RMs 6.22, 2.17) supported good to very good communities. The single Silver Fork station (RM 1.25) was evaluated as exceptional.

West Branch St. Joseph River subbasin - HUC 10 (0410000302)

Four sites on the West Branch St. Joseph River were sampled and evaluated as very good to exceptional. The two most upstream sites (RMs 10.48 and 8.50) had some of the highest numbers of EPT for the survey, 29 and 27, respectively. There was a small decrease in EPT from upstream to downstream. The most downstream site (RM 0.75) had 18 EPT but was still received a very good assessment.

Middle St. Joseph River subbasin – HUC 10 (0410000303) Nettle Creek, Eagle Creek, N. Br. Eagle Creek, Bear Creek

The middle St. Joseph River subbasin consisted of 11 sites on four streams. Macroinvertebrate evaluations ranged from marginally good to exceptional. Nettle Creek had exceptional to very good ratings at the three upper most sites (RMs 14.48, 11.23 and 3.13) but the lowest site at RM 1.37 was evaluated as marginally good with only 10 EPT. Bridgewater Dairy, a 3900 herd dairy farm, is adjacent to Nettle Creek at RM 5.08. Eagle Creek, N. Br. Eagle Creek, and Bear Creek macroinvertebrate assessments were marginally good to good. Bear Creek at RM 2.43 achieved an ICI score of 52 which is in the exceptional range but only had 12 qualitative EPT and six qualitative sensitive taxa.

Fish Creek subbasin – HUC 10 (0410000304)

Four sites on Fish Creek were evaluated for macroinvertebrates. Three of the sites (RMs 5.40, 2.43 and 0.38) were exceptional and one site (RM 30.54) was evaluated as good. The most upstream site (RM 30.54) was in an agricultural area with no riparian habitat and had 14 qualitative EPT and 8 qualitative sensitive taxa but it did have a cold water taxon, *Baetis tricaudatus*. Fish Creek then enters Indiana and flows back into Ohio near RM 5.40. The three downstream sites (RMs 5.40, 2.43 and 0.38) had forested stream banks and were evaluated as exceptional (ICI scores of 54, 46 and48, respectively). Seventeen different species of freshwater mussels were collected in Fish Creek. The highest diversity of mussels was noted at RM 2.43 with 14 different species of which six were state listed as species of concern and two were listed as state endangered. The rayed bean (*Villosa fabalis*), which is one of the state endangered mussels, is also listed as federally endangered. The other state endangered mussel, rabbitsfoot (*Quadrula cylindrical cylindrical*), is a federally threatened species.

Lower St. Joseph River subbasin – HUC 10 (0410000304) Big Run

The lower St. Joseph River subbasin only included Big Run which was evaluated as exceptional for macroinvertebrates (ICI score of 50). Field observations noted predominant populations of heptageniid mayflies and hydropychid caddisflies.

Macroinvertebrate Trends

Macroinvertebrate communities in the St. Joseph River basin were evaluated in 1992 and 2013 with some sampling done in 1996 and 1997. The St. Joseph River mainstem had similar ICI scores in 1992 and 2013 which were all meeting WWH aquatic life use goals. The number of qualitative EPT and sensitive taxa did increase from mostly below WWH expectations in 1992 to above WWH expectations in 2013 (Figure 21). RM 73.24 and RM 47.30 appear to have declined in their ICI score since the 1992 survey but this was likely due to problems with the artificial substrate colonization at both sites. Although the number of sensitive taxa and EPT at these sites did not improve as much as the other mainstem sites, each site still had 15 and 17 EPT, respectively, which is considered good to very good. The tributaries to the St. Joseph River also followed the same trend of improvement since the last survey, similar to what was seen on the mainstem.

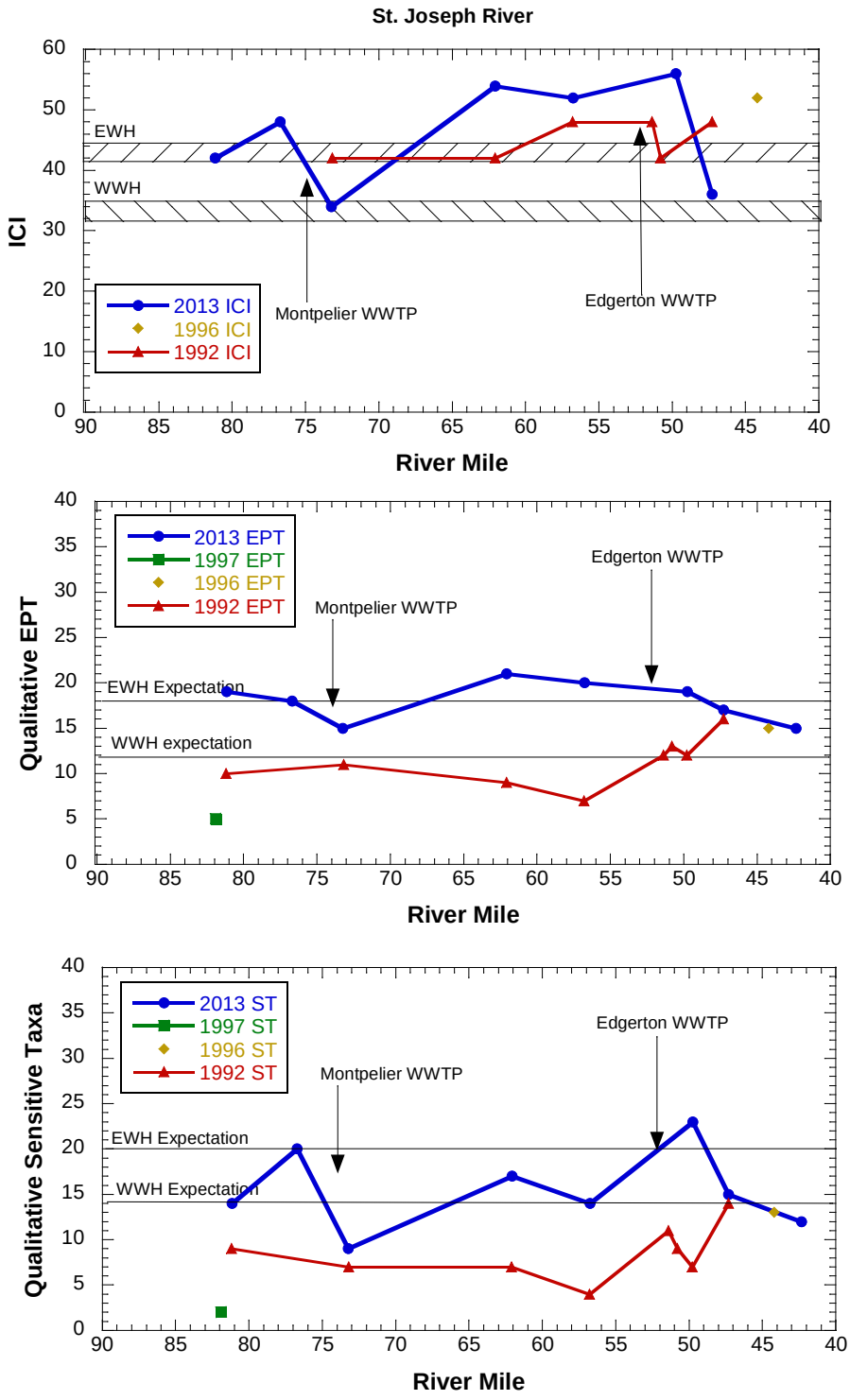

Figure 21. Longitudinal trend of the Invertebrate Community Index (ICI), number of EPT taxa in the qualitative sample, and the number of sensitive taxa in the qualitative sample in the St. Joseph River, 1992-2013.

Table 16. Uncommonly collected sensitive macroinvertebrate taxa locations in the St. Joseph River study area, 2013. State listed species: E= Endangered, T=Threatened, SC=Species of Concern.

Taxa	Collection Location by River Mile
Mayflies	
Baetis tricaudatus	Fish Cr. 30.54
Stoneflies	
Paragnetina media	St. Joseph R. 62.08, 56.55, 49.5, 47.3, 42.1; E. Br. St. Joseph R. 4.77
Perlinella drymo	St. Joseph R. 56.55
Acroneuria abnormis	St. Joseph R. 76.72
Caddisflies	
Brachycentrus numerosus(E)	St. Joseph R. 81.18, 76.77, 56.55, 49.5; E. Br. St. Joseph R. 1.06, 4.77; W. Br. St. Joseph R. 1.0, 8.5; Fish Cr. 0.38

Table 17. Freshwater mussel species collected live or fresh dead in the St. Joseph River study area, July to October, 2013. State listed species: E= Endangered, T=Threatened, SC=Species of Concern.

Stream River Mile	***Actinoanaias ligamentina carinata (Mucket)***	***Alasmidonata marginata (SC) (Elk Toe)***	***Alasmidonta viridis (Slippershell)***	***Amblema plicata plicata (Three Ridge)***	***Anodontoides ferussacianus (Cylindrical Papershell)***	***Cyclonais tuberculata (SC) (Purple Wartypack)***	***Elliptio dilatata (Spike)***	***Fusconaia flava (Wabash Pigtoe)***	***Lampsilis cardium (Plain Pocketbook)***	***Lampsilis radiata luteola (Fat Mucket)***	***Lasmigona complanata (White Heelsplitter)***	***Lasmigona compressa (SC) (Creek Heelsplitter)***	***Lasmigona costata (Fluted Shell)***	***Ligumia recta (T) (Black Sandshell)***	***Pleurobema sintoxia* (SC) *(Round Pigtoe)***	***Ptychobranchus fasciolaris (SC) (Kidney Shell)***	***Pyganodon grandis (Giant Floater)***	***Quadrula cylindrical cylindrical (E)[2] (Rabbitsfoot)***	***Simpsonaias ambigua (SC) (Salamander Mussel)***	***Strophitus undulatus undulates (Creeper)***	***Villosa fabalis (E)[1] (Raved Bean)***	***Vilosa iris iris (Rainbow)***
St. Joseph River (04-400-000)																						
81.18										x							x			x		
76.72		x				x				x	x			x		x	x					
73.24																						
62.08																	x			x		
56.77		x				x											x					
49.75	x	x				x		x		x	x	x					x			x		
47.30																						
42.34																	x			x		
East Branch St. Joseph River (04-415-000)																						
4.77				x				x		x												

Stream River Mile	***Actinoanaias ligamentina carinata* (Mucket)**	***Alasmidonata marginata* (SC) (Elk Toe)**	***Alasmidonta viridis* (Slippershell)**	***Amblema plicata plicata* (Three Ridge)**	***Anodontoides ferussacianus* (Cylindrical Papershell)**	***Cyclonais tuberculata* (SC) (Purple Wartypack)**	***Elliptio dilatata* (Spike)**	***Fusconaia flava* (Wabash Pigtoe)**	***Lampsilis cardium* (Plain Pocketbook)**	***Lampsilis radiata luteola* (Fat Mucket)**	***Lasmigona complanata* (White Heelsplitter)**	***Lasmigona compressa* (SC) (Creek Heelsplitter)**	***Lasmigona costata* (Fluted Shell)**	***Ligumia recta* (T) (Black Sandshell)**	***Pleurobema sintoxia* (SC) (Round Pigtoe)**	***Ptychobranchus fasciolaris* (SC) (Kidney Shell)**	***Pyganodon grandis* (Giant Floater)**	***Quadrula cylindrical cylindrical* (E)[2] (Rabbitsfoot)**	***Simpsonaias ambigua* (SC) (Salamander Mussel)**	***Strophitus undulatus undulates* (Creeper)**	***Villosa fabalis* (E)[1] (Rayed Bean)**	***Vilosa iris iris* (Rainbow)**
1.06										x							x					
Silver Creek (04-417-000)																						
1.25				x	x			x		x			x				x			x		
Clear Fork (04-416-000)																						
6.22										x												
2.17			x		x																	
West Branch St. Joseph River (04-414-000)																						
10.48							x													x		
8.50																						
3.13								x							x		x			x		
0.7																				x		
Nettle Creek (04-413-000)																						
14.48																						
11.23																	x					

Stream River Mile	***Actinoanaias ligamentina carinata* (Mucket)**	***Alasmidonata marginata* (SC) (Elk Toe)**	***Alasmidonta viridis* (Slippershell)**	***Amblema plicata plicata* (Three Ridge)**	***Anodontoides ferussacianus* (Cylindrical Papershell)**	***Cyclonais tuberculata* (SC) (Purple Wartypack)**	***Elliptio dilatata* (Spike)**	***Fusconaia flava* (Wabash Pigtoe)**	***Lampsilis cardium* (Plain Pocketbook)**	***Lampsilis radiata luteola* (Fat Mucket)**	***Lasmigona complanata* (White Heelsplitter)**	***Lasmigona compressa* (SC) (Creek Heelsplitter)**	***Lasmigona costata* (Fluted Shell)**	***Ligumia recta* (T) (Black Sandshell)**	***Pleurobema sintoxia* (SC) (Round Pigtoe)**	***Ptychobranchus fasciolaris* (SC) (Kidney Shell)**	***Pyganodon grandis* (Giant Floater)**	***Quadrula cylindrical cylindrical* (E)[2] (Rabbitsfoot)**	***Simpsonaias ambigua* (SC) (Salamander Mussel)**	***Strophitus undulatus undulates* (Creeper)**	***Villosa fabalis* (E)[1] (Rayed Bean)**	***Vilosa iris iris* (Rainbow)**
5.08											x						x					
1.37																						
Eagle Creek (04-411-000)																						
8.28										x							x					
4.90																						
0.5																						
North Branch Eagle Creek (04-412-000)																						
0.02																						
Bear Creek (04-409-000)																						
5.7					x																	
2.43					x																	
0.54																						
Fish Creek (04-405-000)																						
30.54										x												

Stream River Mile	***Actinoanaias ligamentina carinata* (Mucket)**	***Alasmidonata marginata* (SC) (Elk Toe)**	***Alasmidonta viridis* (Slippershell)**	***Amblema plicata plicata* (Three Ridge)**	***Anodontoides ferussacianus* (Cylindrical Papershell)**	***Cyclonais tuberculata* (SC) (Purple Wartypack)**	***Elliptio dilatata* (Spike)**	***Fusconaia flava* (Wabash Pigtoe)**	***Lampsilis cardium* (Plain Pocketbook)**	***Lampsilis radiata luteola* (Fat Mucket)**	***Lasmigona complanata* (White Heelsplitter)**	***Lasmigona compressa* (SC) (Creek Heelsplitter)**	***Lasmigona costata* (Fluted Shell)**	***Ligumia recta* (T) (Black Sandshell)**	***Pleurobema sintoxia* (SC) (Round Pigtoe)**	***Ptychobranchus fasciolaris* (SC) (Kidney Shell)**	***Pyganodon grandis* (Giant Floater)**	***Quadrula cylindrical cylindrical* (E)[2] (Rabbitsfoot)**	***Simpsonaias ambigua* (SC) (Salamander Mussel)**	***Strophitus undulatus undulates* (Creeper)**	***Villosa fabalis* (E)[1] (Rayed Bean)**	***Vilosa iris iris* (Rainbow)**
5.4		x					x	x		x	x	x			x	x	x					x
2.4		x				x	x	x	x	x			x		x	x	x	x	x	x	x	
0.38								x		x	x				x		x	x				
Big Run (04-404-000)																						
0.30					x																	

1= Federally Endangered freshwater mussel
2= Federally Threated freshwater mussel

Table 18. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the St. Joseph River study area, July to October, 2013.

Stream RM	Dr. Ar. (mi^2)	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Category(ies)	ICI	Narrative Evaluation
St. Joseph River (04-400-000)									
81.18	288.0	63	19 / 23	14 / 18	M/ 1927	0	Hydropsychid caddisflies (F,MI), baetid mayflies (F,MI)	42	Very Good
76.72	338.0	61	18 / 21	20 / 24	M / 1350	0	Hydropsychid caddisflies (F,MI), baetid mayflies (F,MI)	48	Exceptional
73.24	337.0	73	15 / 19	9 / 14	M / 461	0	Hydropsychid caddisflies (F,MI), baetid mayflies (F,MI), heptageniid mayflies (MI,F)	34^{ns}	Marginally Good
62.08	394.0	77	21 / 25	17 / 21	L / 1486	0	Hydropsychid caddisflies (F,MI), midges (F,MI), baetid mayflies (F,MI)	54	Exceptional
56.77	435.0	55	20 / 26	14 / 20	M / 825	0	Baetid mayflies (F,MI), hydropsychid caddisflies (F,MI), midges (F,MI)	52	Exceptional
49.75	554.0	73	20 / 24	23 / 27	M / 1538	0	Hydropsychid caddisflies (F,MI), baetid mayflies (F,MI), heptageniid mayflies (MI, F)	56	Exceptional
47.30	566.0	34	17 / 18	15 / 16	M / 985	0	Baetid mayflies (F,MI), hydropsychid caddisflies (F,MI)	36	Good
42.34	609.0	52	15	12	H-M	0	Hydropsychid caddisflies (MI, F), midges (F, MI), baetid mayflies (F, MI)	-	Good
East Branch St. Joseph River (04-415-000)									
4.77	95.0	62	23 / 27	23 / 26	M / 1209	0	Hydropsychid caddisflies (MI,F), baetid mayflies (F,MI)	50	Exceptional
1.06	163.0	70	20 / 24	17 / 21	H / 1,499	0	Hydropsychid caddisflies (MI,F), baetid mayflies (MI,F), midges (F,MI)	42	Very Good
Silver Creek (04-417-000)									
1.25	31.4	71	17 / 18	17 / 20	L / 732	0	Midges (F, MI), baetid mayflies (F, MI), hydropsychid caddisflies (F, MI)	46	Exceptional

Stream RM	Dr. Ar. (mi^2)	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Category(ies)	ICI	Narrative Evaluation
Clear Fork (04-416-000)									
6.22	15.1	68	17	19	M	0	Hydropsychid caddisflies (MI,F), baetid mayflies(MI,F), riffle beetles (MI,F)	-	Very Good
2.17	21.1	62	19 /19	14 / 15	M / 270	0	Hydropsychid caddisflies (F), baetid mayflies (F,MI), amphipod crustaceans (F), elmid beetles (F)	34^{ns}	Marginally Good
West Branch St. Joseph River (04-414-000)									
10.48	98.0	66	28 / 29	24 / 28	H / 4385	0	Hydropsychid caddisflies (MI,F), baetid mayflies (F,MI), Isonychia (MI), Simulium (F)	42	Very Good
8.50	99.0	62	26 / 27	20 / 25	H / 1548	0	Baetid mayflies (F,MI), heptageniid mayflies (F,MI), Isonychia sp. (MI)	52	Exceptional
3.13	109.0	62	15 / 20	15 / 19	M / 2264	0	Hydropsychid caddisflies (MI,F), baetid mayflies (F), midges (F, MI)	48	Exceptional
0.7/1.0	114.3	51	18	16	M	0	Hydropsychid caddisflies (MI,F), baetid mayflies (F,MI), midges (F)	-	Very Good
Nettle Creek (04-413-000)									
14.48/ 15.5	19.1	75	22	16	M	0	Hydropsychid caddisflies (MI), baetid mayflies (MI,F), midges (F,MI)	-	Exceptional
11.23	25.0	57	17 / 21	12 / 14	M / 142	0	Hydropsychid caddisflies (MI,F), baetid mayflies (F,MI), midges (F,MI)	42	Very Good
5.08	31.0	68	19	12	M	0	Hydropsychid caddisflies (MI,F), baetid mayflies (F,MI), heptageniid mayflies (F,MI)	-	Very Good
1.37	36.0	50	10 / 10	3 / 3	L / 337	0	Midges (F,T), heptageniids mayflies (MI,F)	32^{ns}	Marginally Good
North Branch Eagle Creek (04-412-000)									
0.02	12.9	56	13	7	L	0	Midges (F,T), Baetid mayflies (MI,F) hydropsychid caddisflies (F)	-	Good

Stream RM	Dr. Ar. (mi^2)	Qual. Taxa	EPT Ql. / Total	Sensitive Taxa Ql. / Total	Density Ql. / Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Category(ies)	ICI	Narrative Evaluation
Eagle Creek (04-411-000)									
8.28	21.1	47	11	6	L	0	Heptageniid mayflies (F), Baetid mayflies (MI, F)	-	Marg. Good
4.90	24.2	53	10	3	L	0	Midges (F,T), hydropsychid caddisflies (F)	-	Marg. Good
0.50	34.7	54	16/17	10 / 13	M / 700	0	Baetid mayflies (F,MI), hydropsychid caddisflies (F)	42	Very Good
Bear Creek (04-409-000)									
5.7	13.6	50	10	2	L-M	0	Hydropsychids (MI,F), midges (F,T)	-	Marg. Good
2.43	22.0	58	12 / 15	6 / 8	M / 2437	0	Baetid mayflies (F), hydropsychid caddisflies (F), midges (F,MI)	52	Exceptional
0.54	24.2	72	19/21	12 / 14	M / 871	0	Baetid mayflies (MI,F), hydropsychid caddisflies (F,MI), midges (F,MI)	42	Very Good
Fish Creek (04-405-000)									
30.54	8.8	65	14	8	M	1	Midge (F,T), baetid mayflies (MI,F), hydropsychid caddisflies (F)	-	Good
5.40	106.0	86	25 / 26	35 / 35	M / 816	0	Hydropsychid caddisflies (MI, F), heptageniid mayflies (MI, F)	54	Exceptional
2.4	108.0	70	22	30 / 33	M / 754	0	Hydropsychid caddisflies (MI, F), midges (MI, F)	46	Exceptional
0.38	109.0	43	16 / 23	16 / 25	M / 1606	0	Hydropsychid caddisflies (MI, F), heptageniid mayflies (MI, F)	48	Exceptional
Big Run (04-404-000)									
0.30	30.0	58	15 / 17	9 / 12	M / 1041	0	Hydropsychid caddisflies (F,MI), baetid mayflies (F,MI), midges (F,MI)	50	Exceptional

RM: River Mile.
Dr. Ar.: Drainage Area
Ql.: Qualitative sample collected from the natural substrates.

Sensitive Taxa: Taxa listed on the Ohio EPA Macroinvertebrate Taxa List as MI (moderately intolerant) or I (intolerant).
Qt.: Quantitative sample collected on Hester-Dendy artificial substrates, density is expressed in organisms per square foot.
Qualitative sample relative density: L=Low, M=Moderate, H=High.
CW: Cold Water.
Tolerance Categories: VT=Very Tolerant, T=Tolerant, MT=Moderately Tolerant, F=Facultative, MI=Moderately Intolerant, I=Intolerant.

Physical Habitat for Aquatic Life

The St. Joseph River system drains 1,060 mi^2 of the tri-state area of Indiana, Michigan, and Ohio. The portion of the St. Joseph River contained within Ohio constitutes just over 22% (238 mi^2) of the watershed. Originating in southeastern Michigan, the St. Joseph River flows in a southwesterly direction through the Ohio counties of Williams and Defiance for a distance of 43.2 river miles until entering Indiana, and eventually joining the St. Marys River at Fort Wayne to form the Maumee River. Like all major Maumee River tributaries, the St. Joseph River basin is defined by Wisconsin age, glacial and post glacial features. Derived from the advance and retreat of the Erie ice lobe, the Wabash and Fort Wayne end or terminal moraines delimit the St. Joseph River valley. The St. Joseph River mainstem closely parallels the northwest face of the Fort Wayne moraine for its entire length (Clark 1977,Trautman 1981, Pavey 1999 and Angle et al. 2003). Nearly every tributary of consequence originates from the opposing dissected Wabash moraine complex, coursing downgrade through the intervening low relief ground moraine (i.e., valley floor) in a general southeasterly direction, largely perpendicular to the southwesterly course of the St. Joseph River.

The study area is contained in the Eastern Corn Belt Plains (ECBP) ecoregion which is characterized by flat to gently rolling topography, primarily represented by ground moraine, with areas of higher relief defined by dissected end moraine and related glacial features. Soils here are primarily derived from glacial drift and are typically well to moderately well-drained (Omernik 1987, Omernik and Gallant 1988). The combination of naturally adequate drainage and moderate relief associated with most streams and waterways within this region tends to obviate the need for extensive or otherwise pervasive hydrological manipulation to facilitate various and sundry modern human land uses. However, local or subregional conditions can and do depart from the central tendency of the ECBP, and this is the case with the St. Joseph River basin.

Outside of the morainal uplands, major soil associations of the valley floor are moderately to poorly drained, with locale areas waterlogged or otherwise regularly saturated (USDA 1978). Relief through this area is level to gently sloping. These conditions are reflected directly in the very low gradient of the St. Joseph River itself, averaging 1.6 ft./mile (Ohio DNR 1960) and the moderate to low gradient of its tributaries on the valley floor. These subregional conditions have necessitated extensive drainage improvements and other hydrological modification greater than commonly needed or observed throughout the ECBP region as a whole. Furthermore, owing to the interaction between the Erie and Saginaw ice lobes, collapse topography is common on the uplands of the Wabash moraine, resulting in multiple and locally extensive closed depressions, containing bogs, lakes, and related low relief features (Clark 1977 and Pavey and Martin 2013). Under these conditions, the absence of naturally occurring, well-integrated drainage necessitated hydromodification of many of the St. Joseph River tributaries, not only to meet local drainage needs, but also to render the low relief areas of the uplands of the Wabash moraine suitable for human habitation, agriculture and other modern land uses.

The relationship between existing stream conditions and the adjacent landscape throughout the St. Joseph River basin are best explained and comprehended as a nexus between land use and physiography. In many important ways, the degree and extent of hydromodification and its physiographic antecedents are important variables supporting the overall appraisal of macrohabitat quality and its direct influence upon ambient biological performance or potential, or both. Given the general low relief and poor natural drainage identified above, much of the St. Joseph River watershed was subjected to significant hydromodification during the late 19th and early 20th centuries. In terms of channel manipulation, the most ambitious drainage effort of that time was the dredging (widening and

deepening) of the East Branch St. Joseph River and the St. Joseph River mainstem, from Prattville Michigan to a point just north of Montpelier, Ohio (Office of Williams County Engineer, pers. Com. 1992, Blacker 1972). Although specific documentation of historical drainage improvements throughout the basin as a whole are not readily available, multiple contemporary and historical sources attest to both the naturally poor drainage common to much of the study area and the substantial socioeconomic benefits following wide spread drainage improvements (Dachnowski 1912, Bowersox 1920, USDA 1978, SJRWI 2006). Furthermore, direct observations by Ohio EPA field staff over the past 21 years found most waterbodies within the St. Joseph River study area, including segments of the mainstem, to contain ample evidence of historical channel modification.

Presently, most very small waters and the primary headwaters of many of the principal St. Joseph River tributaries are actively maintained as open drainage ways by county authorities. Waterbodies so affected include, upper Fish Creek, upper and middle Eagle Creek, upper North Branch Eagle Creek, upper Nettle Creek, a portion of Clear Fork, and the entire Bear Creek subbasin (Office of Williams County Engineer, pers. com. 2015). The lower five Ohio miles of the St. Joseph River through Defiance County, is itself on active drainage maintenance (Office of the Defiance County Engineer, pers. com. 2014).

St. Joseph River (mainstem)

The assessment of the influence of physical stream features and riparian conditions on ambient biological performance for the St. Joseph River basin will proceed in a longitudinal manner (upstream to downstream). The discussion of tributaries will either be treated in the aggregate, or if sufficiently large, tributaries or subbasins will be broken-out separately for discussion. For the purposes of continuity, this longitudinal reporting structure will also be applied to the assessment of ambient biological performance throughout this document.

Mean Qualitative Habitat Evaluation Index (QHEI) values from rivers or river segments equal to or greater than 60.0 generally indicate a level of macrohabitat quality sufficient to support an assemblage of aquatic organisms fully consistent with the WWH aquatic life use designation. Reach average values at or greater than 75.0 are generally considered adequate to fully support EWH communities (Ohio EPA 2006, Rankin 1989 and Rankin 1995). Values between 55 and 45 indicate limiting components of physical habitat are present and may exert a negative influence upon ambient biological performance. However, due to the potential for compensatory stream features (e.g., strong ground water influence) or other watershed variables, QHEI scores within this range do not necessarily exclude WWH or even EWH assemblages. Values below 45 indicate a higher probability of habitat derived aquatic life use impairment, but should not be viewed as determinant.

As part of the 2013 fish sampling effort, the quality of near and in-steam macrohabitats of the St. Joseph River mainstem were evaluated at eight sampling locations, assessing approximately 42.9 miles of the mainstem between its origin at the confluence of the East and West Branch St. Joseph Rivers (RM 84.6) and Ohio-Indiana state-line at RM 41.7. Through this reach, QHEI values ranged between 59.3 and 74.5, with a mean score of 68.2 ($\pm$10.62 two SD). A matrix of QHEI macrohabitat features, by station, and the longitudinal performance of the QHEI for the St. Joseph River are presented in Table 19 and Figure 22. Performance of the QHEI, by stream, subbasin or other aggregation is presented in Figure 23.

As measured by the QHEI, the quality of near and in-stream macrohabitat throughout most of the St. Joseph River appeared capable of supporting a diverse, functionally organized, and well-structured assemblages of aquatic organisms, consistent with its respective ecoregional benchmarks. Most sites contained a complement of positive channel, substrate, and riparian features, compatible with the river's WWH aquatic life use designation. Significantly deficient, degraded or otherwise limiting

macrohabitat was nowhere observed, and in fact the central tendency of the mainstem can be characterized, narratively, as good to very good, with selected monitoring stations supporting near exceptional conditions. Aquatic life use impairment derived solely from deficient or otherwise substandard habitat did not appear likely.

Table 19. A matrix of Qualitative Habitat Evaluation Index (QHEI) scores and macrohabitat features of river and streams contained within the St. Joseph River study area, 2013.

Key QHEI Components			WWH Attributes											MWH Attributes																						
														High Influence									*Moderate Influence*													
River Mile	QHEI	Gradient (ft/mi)	Not Channelized or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low/Normal Embeddedness	Max Depth>40cm	Low/Normal Riffle Embeddedness	WWH Attributes	Channelized/No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth <40cm	High-influence Modified Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1 or 2 Cover Types	Intermittent/Poor Pools	No Fast Current	High/Moderate Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	M.I. Modified Attributes	MWH H.I.+1/WWH+1 Ratio	MWH M.I./WWH Ratio
04-400-000			**St. Joseph River**																																	
Year:		**2013**																																		
81.1	67.3	1.75	X				X	X			X		4						0		X	X		X				X	X		X	6	0.20	1.40
76.7	70.8	1.75	X	X		X	X	X	X		X	X	8						0	X	X			X	X				X	X		6	0.22	0.89
74.1	68.8	0.60					X	X		X	X	X	5						0	X	X	X		X				X	X			6	0.33	1.17
62.1	74.5	0.60	X	X		X	X	X	X		X	X	8						0		X								X	X		3	0.11	0.56
56.8	61.5	1.36		X			X	X	X		X		5						0	X	X			X	X				X		X	6	0.33	1.33
49.7	59.3	0.91	X	X		X		X			X		5						0	X	X			X	X			X	X		X	7	0.33	1.50
47.3	70.3	0.91	X	X		X	X	X			X		6						0		X							X	X		X	4	0.14	0.86
42.3	72.8	1.12	X	X		X		X	X		X		6						0	X	X				X				X	X		5	0.29	1.00
04-404-000			**Big Run**																																	
Year:		**2013**																																		
0.3	55.3	6.94			X				X	X	X	X	5				X		1	X				X	X		X					4	0.50	1.00
04-405-000			**Fish Creek**																																	
Year:		**2013**																																		
30.5	48.8	7.14		X				X	X	X		X	5	X		X	X	X	4					X	X							2	0.83	0.67
5.4	77.5	3.96	X	X		X	X	X		X	X	X	8				X		1					X				X				2	0.22	0.33
0.4	61.5	2.67	X					X			X		3						0		X			X	X			X	X		X	6	0.25	2.00
04-409-000			**Bear Creek**																																	
Year:		**2013**																																		
5.7	55.5	14.08											0	X			X	X	3	X	X			X	X			X	X	X		7	4.00	9.00
2.4	57.8	9.71	X	X				X	X	X	X		6				X		1	X	X			X	X		X		X	X		7	0.43	1.29
0.5	55.3	3.42		X			X	X		X	X	X	6				X		1	X	X			X	X			X	X	X	X	8	0.43	1.43
04-411-000			**Eagle Creek**																																	
Year:		**2013**																																		
8.3	58.5	5.26		X				X			X	X	4						0	X	X			X	X			X	X	X		7	0.40	1.80
4.9	59.0	5.49	X	X				X		X	X		5						0		X		X	X	X			X	X	X	X	8	0.17	1.67
0.5	66.0	8.93	X					X		X	X	X	5						0		X			X	X			X		X		5	0.17	1.17

Table 19. continued.

Key QHEI Components			WWH Attributes																MWH Attributes																		
																			High Influence					*Moderate Influence*														
River Mile	QHEI	Gradient (ft/mi)	Not Channelized or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low/Normal Embeddedness	Max Depth>40cm	Low/Normal Riffle Embeddedness	WWH Attributes	Channelized/No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth <40cm	High-influence Modified Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1 or 2 Cover Types	Intermittent/Poor Pools	No Fast Current	High/Moderate Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	M.I. Modified Attributes	MWH H.I.+1/WWH+1 Ratio	MWH M.I./WWH Ratio
04-412-000			**North Branch Eagle Creek**																																		
Year:		**2013**																																			
0.1	46.8	5.68											0				X	X	2	X	X			X	X			X	X	X	X	8	4.00	10.00
04-413-000			**Nettle Creek**																																		
Year:		**2013**																																			
15.4	64.0	5.00	X	X		X	X	X		X	X	X	8						0		X			X				X	X			4	0.11	0.67
11.2	49.8	7.09						X			X		2		X		X		2	X	X			X	X		X	X	X	X		8	1.33	3.00
5.1	58.5	9.71		X				X			X		3						0	X	X			X	X		X	X	X	X	X	9	0.50	2.50
1.4	61.8	7.81		X				X			X		3				X		1	X	X			X	X			X	X	X	X	8	0.75	2.50
04-414-000			**West Branch St. Joseph River**																																		
Year:		**2013**																																			
10.5	77.0	5.68	X	X		X	X	X	X	X	X	X	9						0		X			X							X	3	0.10	0.50
8.5	77.0	6.62	X	X			X	X	X	X	X	X	8						0					X								1	0.11	0.33
3.1	82.5	4.22	X	X		X	X	X	X	X	X	X	9						0					X								1	0.10	0.30
0.7	74.5	2.37	X	X			X	X	X	X	X	X	8						0		X			X							X	3	0.11	0.56
04-415-000			**East Branch St. Joseph River**																																		
Year:		**2013**																																			
4.8	62.5	3.85	X				X	X			X		4				X		1		X			X				X	X	X		5	0.40	1.40
4.8	65.0	3.85	X				X	X		X	X	X	6						0		X			X				X				3	0.14	0.71
1.1	68.5	1.71	X			X	X	X		X	X	X	7						0		X			X	X			X	X			5	0.13	0.88
04-416-000			**Clear Fork**																																		
Year:		**2013**																																			
6.2	62.0	10.20	X				X	X			X		4				X		1	X	X			X			X	X	X	X		7	0.60	1.80
2.2	62.8	4.67	X			X	X	X	X	X	X	X	8						0	X				X			X		X			4	0.22	0.67
04-417-000			**Silver Creek**																																		
Year:		**2013**																																			
1.3	67.0	9.43	X	X			X	X			X		5						0	X	X			X				X	X	X		6	0.33	1.33

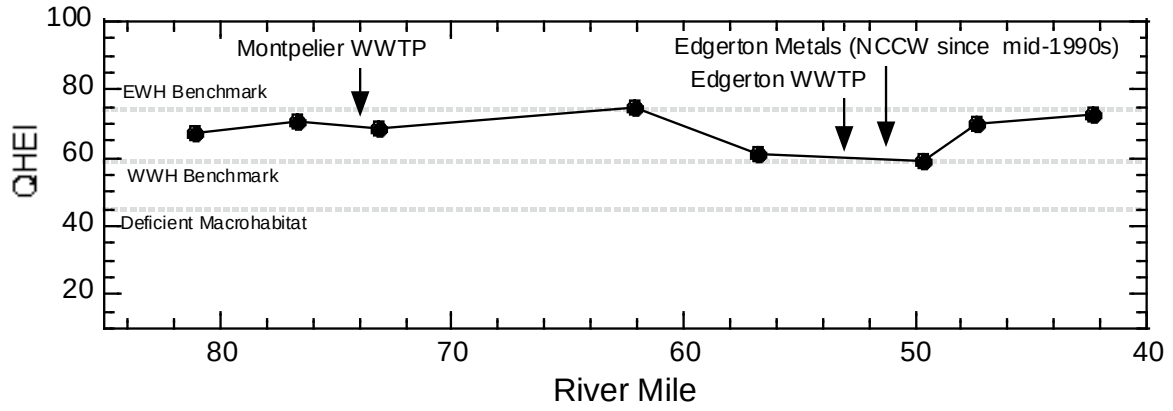

Figure 22. Longitudinal performance of the Qualitative Habitat Evaluation Index (QHEI) for the St. Joseph River mainstem, 2013. Horizontal dashed lines indicate EWH and WWH benchmarks, and index scores typical of significantly deficient or otherwise potentially limiting macrohabitat (Rankin 1989 and Rankin 1995). The entire St. Joseph River study area is contained wholly within the ECBP ecoregion (Omernik 1987, Omernik and Gallant 1988).

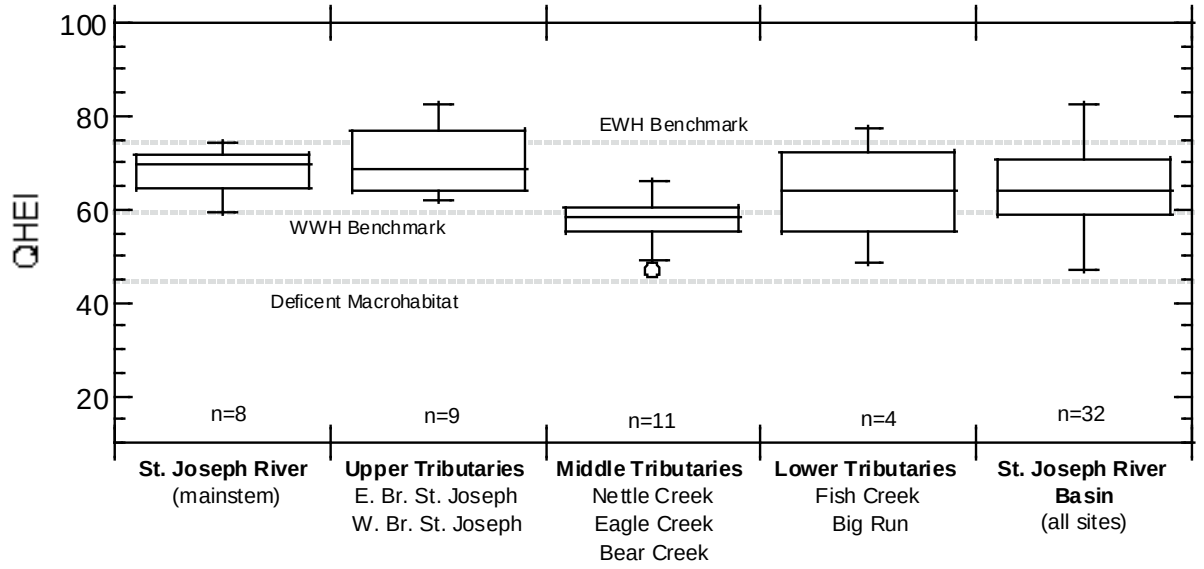

Figure 23. Performance of the Qualitative Habitat Evaluation Index (QHEI) for the St. Joseph River study area, 2013: mainstem, consolidated tributaries, and study area aggregate (all sites). Horizontal dashed lines indicate EWH and WWH benchmarks, and index scores typical of significantly deficient or otherwise potentially limiting macrohabitat (Rankin 1989 and Rankin 1995).

East Branch St. Joseph River

The principal drainage network of the East Branch subbasin consists of three named streams: East Branch St. Joseph River, the principal conveyance, and two tributaries, Silver Creek and Clear Fork. The vast majority of both drainage area and linear stream miles of this system arise and are contained within the political boundaries of the state of Michigan, with only the lower 3-6 miles of these streams situated

within Ohio. Five sampling stations were allocated among these waters: two sites on the East Branch St. Joseph River (RM 4.8, CR S upstream from the Pioneer WWTP and RM 1.1, SR 15, downstream from Pioneer), two sites on Clear Fork (RM 6.2, SR 576 and RM 2.2, CR 13) and a site on Silver Creek at RM 1.3, CR 15. Taken together these sites allowed for the evaluation of 15.5 cumulative Ohio stream miles of the East Branch St. Joseph River subbasin.

Aggregated QHEI values ranged between 62.0 and 68.5, with a mean score of 64.8 (±5.6, two SDs). A matrix of QHEI macrohabitat features, by stations, aggregate QHEI performance of the subbasin, and the longitudinal performance of the QHEI for the East Branch St. Joseph River subbasin are presented in Table 19 and Figures 23-25. Although evidence of previous channel modification was readily apparent at all sites, particularly the East Branch St. Joseph River mainstem, naturally directed recovery or reestablishment of a minimum compliment of positive channel and riparian features appeared well advanced. Both individual and aggregated QHEI score were consistently found at or above a level of macrohabitat complexity associated with WWH aquatic communities, and as such aquatic life use impairment derived solely from deficient or otherwise degraded habitat did not appear likely.

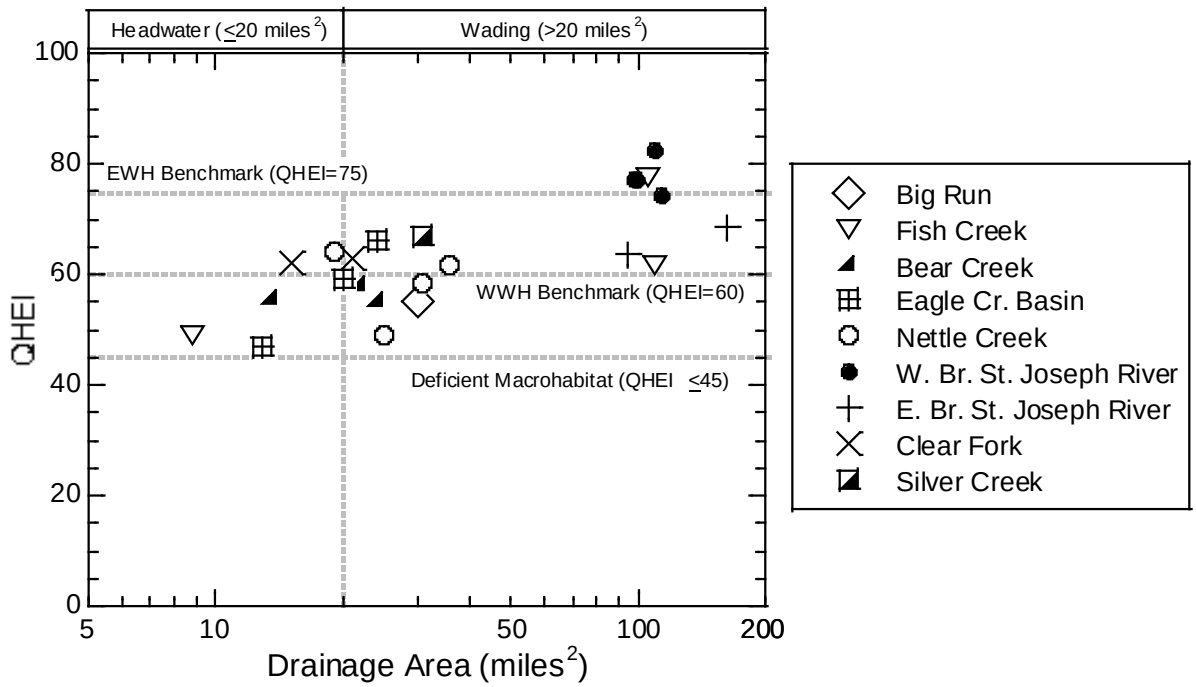

Figure 24. Distributions of Qualitative Habitat Evaluation Index (QHEI) scores for all St. Joseph River tributaries by stream size (drainage area). Vertical dashed line represents the threshold between headwaters (≤20 mi^2) and wading (>20 mi^2) sites. From top to bottom, horizontal dashed lines indicate EWH and WWH benchmarks and a threshold at or below which macrohabitat is likely to be limiting.

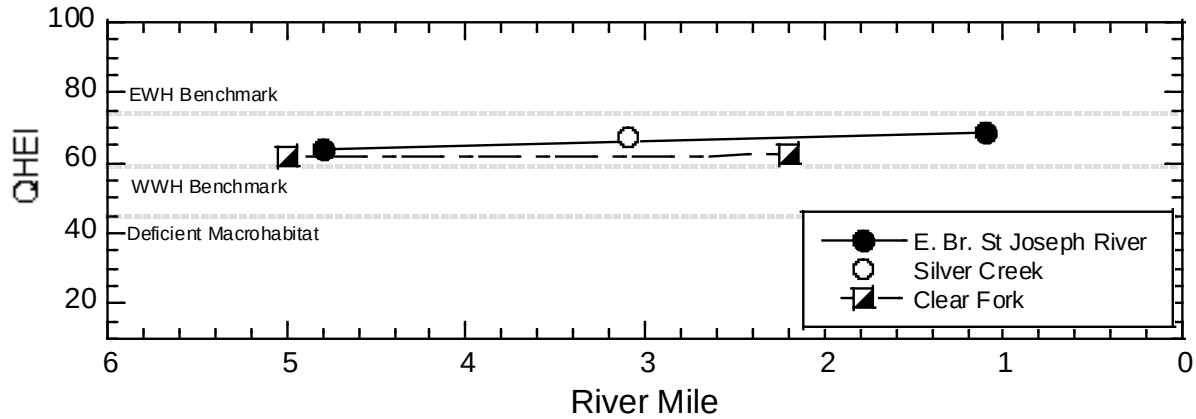

Figure 25. Longitudinal performance of the Qualitative Habitat Evaluation Index (QHEI), East Branch St. Joseph River subbasin, 2013. Horizontal dashed lines indicate EWH and WWH benchmarks, and index threshold at or below which macrohabitat is likely to be limiting (Rankin 1989 and Rankin 1995). Longitudinally, East Branch St. Joseph River tributaries coordinates are derived from the point at which they join the mainstem.

West Branch St Joseph River

The majority the West Branch St. Joseph River catchment lies within the political boundaries of the state of Michigan, with only the lower 11.4 miles of the mainstem within Ohio. Sampling of this subbasin was limited to four monitoring stations distributed throughout the entire Ohio length of the West Branch, between RM 10.5 (TR S) and RM 0.7 (US 20). Taken together these sites allowed for evaluation of the entire Ohio length of the West Branch.

Two lakes are located within the Ohio portion of the watershed: Lake La Su An and Lake Seneca. The first, Lake La Su An, is situated near the Ohio-Indiana state line and connected to the West Branch via an outlet at approximately RM 9.5. Lake Seneca is a 2.5 mile impoundment on the West Branch St. Joseph River. The spillway is located at RM 5.7 and the upper limit of the dam pool at normal pool elevation is approximately RM 8.2. Of the two waterbodies, the impoundment formed by Lake Seneca is potentially the most consequential to macrohabitat, water quality, and ambient biological performance of the West Branch. The most immediate and direct effect is the loss of a free-flowing river segment. The accumulation of water to the height of a dam effectively converts a complex and heterogeneous lotic environment to a simplified artificial lentic environment, rendering the affected reach unsuitable for most of the existing aquatic taxa. Depending on its height, the dam itself can serve as a barrier to fish passage and macrobenthos drift. As flow is the primary feature of riverine environments, nearly all chemical, physical and biological processes are controlled or strongly influenced by hydrology, thus, the thermal regime, nutrient cycling, sediment transport, and other aspect of water chemistry can be affected by impoundments. The degree and magnitude of these effects, however, is dependent upon the size of the impoundment and management, if any, of water stored behind the dam. Given its small size, and static features, the effects of Lake Seneca should be minimal, limited mainly to the loss of stream miles associated with the dam pool itself, and potentially modest near field disruptions up and downstream from the impoundment.

Aggregated QHEI values from the West Branch ranged between 74.5 and 82.5, with a mean score of 77.7 (±6.74, two SDs). A matrix of QHEI macrohabitat features, by stations, aggregate QHEI performance of the subbasin, and the longitudinal performance of the QHEI are presented in Table 19 and Figures 23,

24, and 26. As measured by the QHEI, all free-flowing segments of the West Brach were found to contain a full suite of positive channel, substrate and riparian features, well in excess of the WWH benchmark. All stations yielded QHEI values within the exceptional range. In general, the West Branch possesses classic channel form and function typical of high quality till-plains streams. Riffle and run complexes were common throughout. Trench and lateral scour pools were regularly observed and often found well-structured with woody debris and fallen timber. Dominant substrates were coarse, mainly glacial sand and gravel, and were generally unencumbered by excessive deposits of clayey silts. Riparian areas at most sites were vegetated, more often wooded, the stream-side vegetation attenuating sunlight and providing instream structure in the form of woody debris and root wad formations. Outside of the impounded segment formed by Lake Seneca, there is little doubt that the West Brach St. Joseph River represents the largest reach of intact or recovered riverine macrohabitat within the St Joseph River study area. Given this, aquatic life use impairment derived solely from deficient habitat did not appear likely.

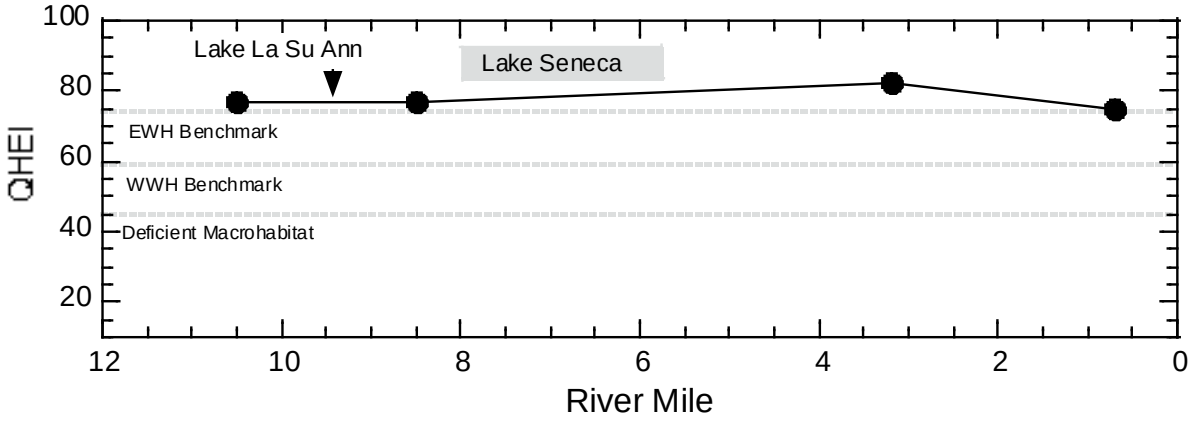

Figure 26. Longitudinal performance of the Qualitative Habitat Evaluation Index (QHEI), West Branch St. Joseph River, 2013. Horizontal dashed lines indicate EWH and WWH benchmarks, and index threshold at or below which macrohabitat is likely to be limiting (Rankin 1989 and Rankin 1995).

Nettle Creek

The vast majority of the Nettle Creek catchment lies within the state of Ohio, with only a small fraction of its headwaters draining Indiana. Sampling of this subbasin was limited to four monitoring stations distributed throughout its entire 18.4 miles within Ohio, between RM 14.5 (TR 72) and RM 1.4 (CR N-30). Taken together these sites allowed for the evaluation of 16 cumulative Ohio stream miles of Nettle Creek. The subbasin contains a single lake, Nettle Lake, located on the upper reaches of Nettle Creek, and it is one of only a handful of natural glacial lakes in Ohio. It is not an impoundment or otherwise artificial, rather it's an on-stream lake, with Nettle Creek serving as both a water source and outlet. Given the lake's origin (emerging from the retreating Wisconsin glacier), its position on the landscape, and rarity as a habitat type, its relationship to and effects within the Nettle Creek watershed are positive. Nettle Lake supports two rare, state endangered, glacial relic fish species: Iowa darter (*Etheostoma exile*) and pugnose minnow (*Notropis emiliae*) (Ohio DNR 2009). Although looked for, these species were not found in the riverine portions of Nettle Creek in 2013.

Aggregated QHEI values from Nettle Creek ranged between 49.0 and 64.0, with a mean score of 58.3 ($\pm$7.22, two SDs). A matrix of QHEI attributes, by stations, aggregate QHEI performance of the subbasin,

and the longitudinal performance of the QHEI are presented in Table 19 and Figures 23, 24, and 27. All sites sampled on Nettle Creek contained evidence of previous channelization, with the degree of natural recovery varying considerably over its entire length. Despite selected QHEI values at or near the WWH benchmark, a high proportion of modified habitat attributes persisted throughout the lower 12 miles. Lingering evidence of past channel modification included a high degree of channel entrenchment, fair channel development, and moderate to low sinuosity. Riffles, where present, were typically shallow and poorly developed, and much of the channel took the form of shallow glides. Where recovery was well advanced, bank erosion was the engine of redevelopment. The reestablishment of lateral meander, critical to naturally directed stream restoration, is only possible at the expense of existing stream banks. Presently, the upper three miles of Nettle Creek, headwaters to approximately RM 16.0, are maintained as an open drain by county authorities (Office of the Williams County Engineer, pers. comm. 2015).

It should be noted that the aggregate conditions observed on Nettle Creek were by no means profoundly degraded; rather, all sites appeared to labor, to varying degrees, under the effects of previous hydromodification, from which the stream is gradually recovering. Nonetheless, QHEI scores suggest subpar macrohabitat of Nettle Creek may serve to limit ambient biological performance, either directly through habitat loss or indirectly, by facilitating secondary water quality effects, or a combination of both.

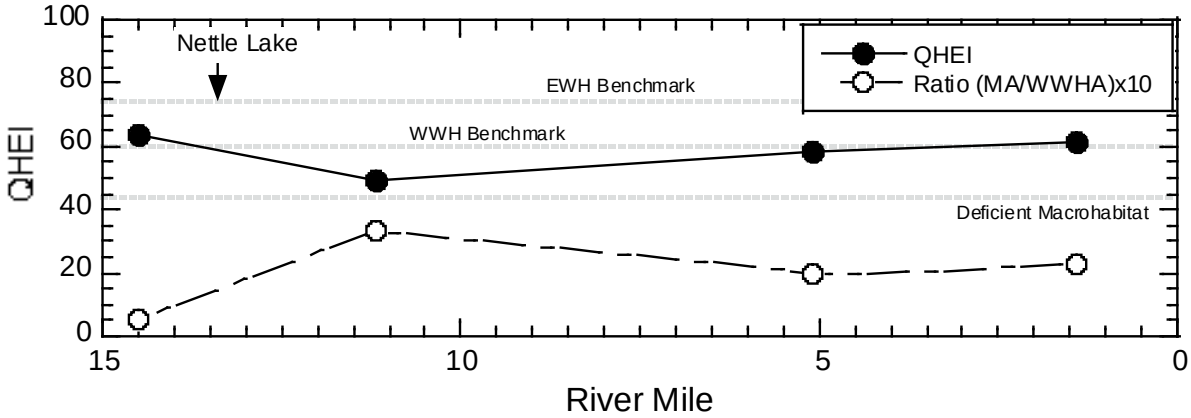

Figure 27. Longitudinal performance of the Qualitative Habitat Evaluation Index (QHEI), Nettle Creek, 2013. Horizontal dashed lines indicate EWH and WWH benchmarks, and index threshold at or below which macrohabitat is likely to be limiting (Rankin 1989 and Rankin 1995). Ratio indicated in the legend is the quotient of all negative influence Modified Attributes (MA) and positive Warmwater Habitat attributes (WWHA). Note the relatively high ratio of modified habitat attributes/warmwater habitat attributes (MA/WWHA) near the mouth, despite the QHEI score at the WWH benchmark.

Eagle Creek

The principal drainage network of Eagle Creek consists of two named streams: Eagle Creek, the primary conveyance, and its principal tributary, North Branch Eagle Creek. The entire Eagle Creek catchment is within Ohio. Four sampling stations were allocated among these waters, three sites on Eagle Creek, between RM 8.3 (CR 675) and RM 0.5 (CR J), and a single station on Clear Fork at RM 0.1 (CR M-50). Taken together these sites allowed for the evaluation of 12 cumulative stream miles of the Eagle Creek subbasin.

Aggregated QHEI values ranged between 46.8 and 66.0, with a mean score of 57.6 (±15.92, two SDs). A matrix of QHEI attributes, by stations, aggregate QHEI performance of the subbasin, and the longitudinal

performance of the QHEI for the Eagle Creek subbasin are presented in Table 19 and Figures 23, 24 and 28. Based upon field observation and direct appraisal of channel and riparian features, it is clear that upper Eagle Creek has been modified to varying degrees in the past, resulting in channel incision, limited or monotonous development, a dominance of fine substrates and loss of fixed riparian vegetation, through encroachment. Although evidence of naturally directed recovery was evident throughout the Eagle Creek basin, macrohabitat deficits observed on upper Eagle Creek, including the North Branch, may serve to limit ambient biological performance directly through habitat loss, or indirectly, by exacerbating the effects or otherwise limiting the efficient assimilation of background pollutant loads (e.g., phosphorus, nitrogen, organic carbon, and sediment), or a combination of both.

Presently, 13.3 miles (57%) of the cumulative 23.5 linear stream miles that comprise the Eagle Creek watershed are under permanent maintenance as an open drain (Office of the Williams County Engineer, pers. com. 2015). Excluding a small 1.5 mile segment on the lower mainstem, maintained reaches were limited to the headwater of both Eagle Creek and the North Branch Eagle Creek.

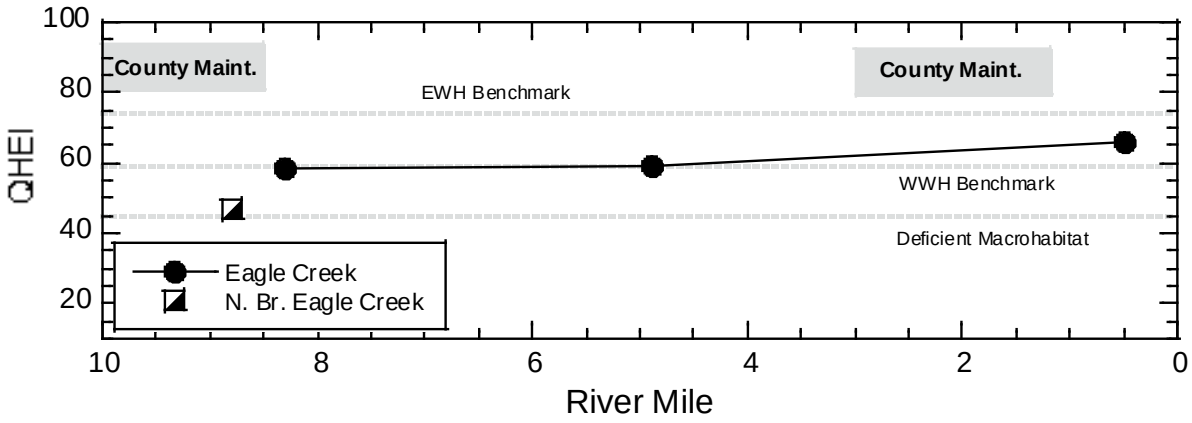

Figure 28. Longitudinal performance of the Qualitative Habitat Evaluation Index (QHEI), Eagle Creek subbasin, 2013. Horizontal dashed lines indicate EWH and WWH benchmarks, and index threshold at or below which macrohabitat is likely to be limiting (Rankin 1989 and Rankin 1995). Shaded areas identify the approximate locations of Eagle Creek segments presently maintained by Williams County as open drainage ways. The uppermost maintained segment extends upstream to include the headwaters of Eagle Creek (Office of the Williams County Engineer, pers. com. 2015).

Bear Creek

The vast majority of the Bear Creek catchment lies within the state of Ohio, with only small portions of the headwaters draining Indiana. Sampling of this subbasin was limited to three monitoring stations distributed on Bear Creek, between RM 5.7 (CR 4, downstream from Edon) and RM 0.6 (SR 34). Taken together these sites allowed for the evaluation of seven stream miles of the Bear Creek mainstem.

As early as 1992, all or portions of Bear Creek and its principal tributaries were identified by Ohio EPA as being maintained as an open drainage way by county authorities (Ohio EPA 1994). Unlike much of the St. Joseph River study area, segments of active drainage maintenance on Bear Creek coincided with all stream segments monitored and assessed at that time. The 1991 and 1992 survey results found the upper and middle segments of Bear Creek highly modified (QHEI range between 42.5-51.5) with corresponding fair to poor aquatic communities. Given the artificial character of much of Bear Creek, its failure to support WWH communities, and channel maintenance activities required under Ohio drainage

law (ORC 6131), the reach from its headwater to RM 1.2 (CR H) was redesignated to MWH. As the lower 1.2 miles had shown considerable physical recovery (QHEI of 65.5) and modestly improved ambient biology, the WWH aquatic life use designation was retained, anticipating that naturally directed recovery would, over time, bring the lower reach into full WWH attainment. Following the 2013 St. Joseph River biosurvey, Bear Creek's status as an open ditch was affirmed (Office of the Williams County Engineers, pers. comm. 2015).

Aggregated QHEI values from the 2013 Bear Creek survey ranged between 55.3 and 57.8, with a mean score of 56.2 (±2.78, two SDs). A matrix of QHEI attributes, by stations, aggregate QHEI performance of the subbasin, and the longitudinal performance of the QHEI for Bear Creek are presented in Table 19 and Figures 23, 24 and 29. Based upon field observation and direct appraisal of channel and riparian features, Bear Creek retains much evidence, some very fresh or recent, of direct channel modification. Associated channel and substrate features included channel incision, limited or monotonous development, a dominance of finer substrates and a loss or diminution of fixed woody riparian vegetation. Although naturally directed physical recovery was noted at all sites, macrohabitat deficits observed appeared consistent with the MWH aquatic life use, where Bear Creek is so designated. Similar conditions were noted on the lower WWH designated reach. Here, these may serve to limit ambient biological performance directly, through habitat loss, or indirectly, by exacerbating the effects or otherwise limiting the efficient assimilation of background pollutant loads (e.g., phosphorus, nitrogen, organic carbon, and sediment), or a combination of both.

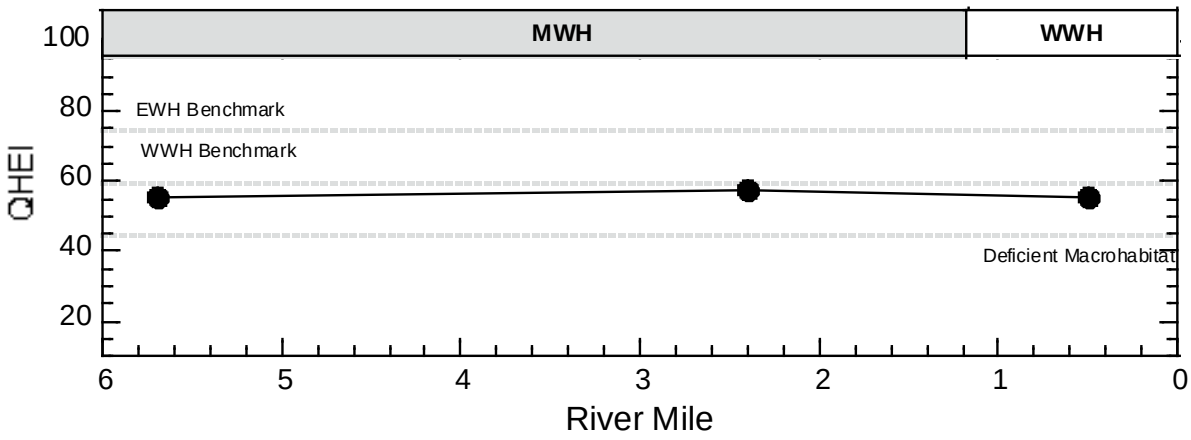

Figure 29. Longitudinal performance of the Qualitative Habitat Evaluation Index (QHEI), Bear Creek, 2013. Horizontal dashed lines indicate EWH and WWH benchmarks, and index threshold at or below which macrohabitat is likely to be limiting (Rankin 1989 and Rankin 1995). Horizontal rectangles perched atop figure 29 identify existing aquatic life use designations: Modified Warmwater Habitat (MWH) and Warmwater Habitat (WWH).

Fish Creek

The vast majority of the principal drainage network of Fish Creek is contained within the political boundaries of the state of Indiana. Arising in the extreme northwest quadrant of Williams County, Ohio, upper Fish Creek flows in a southwesterly direction for a distance of 2.7 miles before entering Indiana. Approximately 12 miles south of this point, Fish Creek reenters Ohio from the west, flowing for 5.5 miles before joining the St Joseph River, just north of the city of Edgerton. Combined, these two Ohio segments account for only 8.2 linear miles (25.6%) of Fish Creek proper. Three fish monitoring stations were deployed to assess these portions of Fish Creek: a single site in the Ohio headwaters at RM 30.5 (CR P-25), and two sites on the lower 5.5 miles at RM 5.4 (TR 171, near the state line) and RM 0.4 (SR 49).

Based upon the results and recommendations from previous Ohio EPA investigations, multiple aquatic life use designations are presently in place on Fish Creek (Ohio EPA 1994). Exceptional characteristics of physical habitat and aquatic communities, combined with the presence of a unique and endangered mussel fauna (Waters 1988, Waters 1998, Hoggarth 1986, Ohio DNR 2009), warranted the designation of a segment of lower Fish Creek to EWH. Beginning at the Ohio-Indiana state line (RM 5.5), this 3.1 mile reach extends downstream to CR 3 (RM 2.4). At that time, the WWH designation was affirmed for all remaining Fish Creek segments within Ohio.

Results from the 2013 Fish Creek survey found aggregated QHEI values to range between 48.8 and 77.5, with a mean score of 62.6 ($\pm$28.76, two SDs). A matrix of QHEI macrohabitat features, by stations, and aggregate and ordinal QHEI performance are presented in Table 19 and Figures 23 and 24. Given the disparate nature of the Ohio segments, the predictive power of the aggraded QHEI scores is diminished. Station density was adequate to describe conditions on the lower 5.5 miles, but the upper 2.7 miles are separated from the lower by well over 20 river miles, and, as such, macrohabitat appraisal of these segments are treated separately.

Evidence of hydromodification was regularly observed throughout Fish Creek, with the degree of naturally directed physical recovery varying considerably. Presently, the upper 2.7 miles of Fish Creek, between RM 32.0 and RM 29.3, is actively maintained as an open drain (Office of the Williams County Engineers, pers. comm. 2015). As appraised by the QHEI (at RM 30.5), macrohabitat quality through this reach reflected both significant historical hydromodification and drainage maintenance activities, resulting in a QHEI score of 48.8. Specifically, the site showed paucity of instream cover, limited sinuosity, fair to poor channel development, and a loss or significant diminution of fixed woody riparian vegetation. Together these physical deficiencies yielded a narrative evaluation of low fair to poor. In the absence of compensatory features, the macrohabitat deficit observed here may serve to limit ambient biological performance directly through habitat loss, or indirectly, by exacerbating the effects or otherwise limiting the efficient assimilation of background pollutant loads (e.g., phosphorus, nitrogen, organic carbon, and sediment), or a combination of both.

Although subjected to hydromodification in the distant past, macrohabitat quality was found much improved through lower Fish Creek. Evaluated just below the state line at RM 5.4, exceptional conditions persisted through the EWH designated reach. Similarly, an evaluation near the mouth (RM 0.4, within the WWH designated reach) yielded a QHEI score consistent with the WWH benchmark. Aquatic life use impairment derived solely from deficient or otherwise substandard macrohabitat did not appear likely through the lower 5.5 miles of Fish Creek.

Big Run

Ohio contains only a small portion of lower Big Run, with the majority of the catchment arising in and draining a small portion of northeastern Indiana. The condition of near and instream macrohabitat of Big Run was evaluated at a single fish monitoring station located at RM 0.3 (Conkle Rd.), resulting in the appraisal of all 1.6 Ohio stream miles.

As with nearly all waters within the St. Joseph River study area, Big Run offered much evidence of previous hydromodification. Again, as observed with most surface waters within the St. Joseph River study area, the process of natural physical recovery appeared well advanced. Big Run yielded a QHEI score of 55.3 (high fair range). A matrix of QHEI, macrohabitat attributes, by stations, and ordinal QHEI performance are presented in Table 19 and Figures 23 and 24. Deficits here were similar to those encountered elsewhere in the study area, affecting channel development, sinuosity, instream cover, and riparian quality. Although by no means optimal, positive features that have been conserved or recovered included low levels of physical siltation, modest riffle development, and lateral scour pools approaching 0.7m in depth. In the absence of compensatory features, the macrohabitat deficit observed here may serve to limit ambient biological performance directly, through habitat loss, or indirectly, by exacerbating the effects or otherwise limiting the efficient assimilation of background background pollutant loads (e.g., phosphorus, nitrogen, organic carbon, and sediment), or a combination of both.

Fish Community

A total of 40,382 fish comprising 60 species and six hybrids were collected from the St. Joseph River watershed between July and September, 2013. The survey effort included 32 monitoring stations (58 fish sampling events) distributed among eleven named waterbodies, evaluating 112.1 cumulative linear stream miles of the St. Joseph River mainstem and tributaries.

Fish species classified as rare, threatened, endangered, or otherwise recognized for special conservation status by the Ohio DNR included only the greater redhorse (Ohio DNR 2009). Four individuals of this state threatened species were collected at two St. Joseph River mainstem monitoring stations: RM 47.3 (County-line Rd) and RM 42.3 (SR 249). Other intolerant, rare, declining or otherwise ecologically significant species included American brook lamprey, black redhorse, hornyhead chub, river chub, silver shiner, rosyface shiner, stonecat madtom, and brindled madtom (Ohio EPA 1987b and 1996a). Although not presently imperiled, species so defined have experienced a significant reduction in their historical distributions statewide or have been found to be sensitive to a wide range of environmental disturbance, or both, and are therefore considered associates of the good quality riverine habitats in Ohio.

Fish community indices and accompanying narrative evaluations for the entire 2013 St. Joseph River survey ranged between exceptional (IBI=53 and MIwb=10.4) and fair (IBI=33 and MIwb=7.3), with a basin average characterized as good (IBI=40.9 and MIwb=8.9). Summarized index scores and descriptive community statistics, by station, are presented in Table 20. Raw index scores, metrics, fish species and abundance data by sampling station for the entire St. Joseph River study area are located in Appendix A and B.

Table 20. Fish community indices, descriptive statistics, and biological narratives for the St. Joseph River study area, 2013. All monitoring stations within the St. Joseph River study area are contained within the Eastern Corn Belt Plains (ECBP) ecoregion.

River/Stream RM	Drain. Area (mi^2)	Total Species	Mean Rel. No. (No./km)[a]	Mean Rel. Wt. (Wt./km)[a]	QHEI	IBI	MIwb	Narrative
St. Joseph River (04-400-00) WWH+								
81.18[B]	288.0	32	580.0	222.3	67.3	39[ns]	9.5	M. Good/V. Good
76.72[W]	338.0	35	573.5	81.0	70.8	43	9.5	Good/V. Good
73.24[B]	337.0	36	954.8	154.9	68.8	46	10.4	Exceptional
62.08[B]	394.0	36	938.0	102.9	74.5	38[ns]	9.4	M. Good/V. Good
56.77[B]	434.0	31	728.3	163.3	61.5	42	9.4	Good/V. Good
49.75[B]	554.0	36	667.0	116.2	59.3	47	9.9	V. Good/Exceptional
47.30[B]	578.0	38	911.0	151.1	70.3	53	10.2	Exceptional
42.34[B]	609.0	36	641.0	103.7	72.8	49	9.9	Exceptional
East Branch St. Joseph River (04-415-000) WWH*/+								
4.77[W]	95.0	32	639.9	21.6	63.8	41	8.8	Good
1.06[W]	163.0	33	718.5	51.1	68.5	44	8.9	Good
Clear Fork (04-416-000) WWH*/+								
6.22[H]	15.1	20	1132.0	-	62.0	42	-	Good
2.17[W]	21.1	24	1007.2	13.2	62.8	35*	8.1[ns]	Fair/Marginally Good
Silver Creek (04-417-000) WWH+								
1.25[H]	31.4	31	828.0	25.7	67.0	47	9.1	Very Good
West Branch St. Joseph River (04-414-000) WWH+								
10.48[W]	98.0	30	588.7	27.5	77.0	44	9.1	Good/Very Good
8.50[W]	99.0	27	1019.1	33.7	77.0	34*	8.2[ns]	Fair/M. Good
3.13[W]	109.0	36	1524.7	98.5	82.5	49	10.0	V. Good/Exceptional
0.75[W]	114.3	33	831.0	36.2	74.5	46	9.0	Very Good
Nettle Creek (04-413-000) WWH*/+								
14.48[H]	18.1	25	1530.0	-	64.0	38[ns]	-	Marginally Good
11.23[W]	25.0	26	1101.7	12.9	49.8	38[ns]	8.2[ns]	Marginally Good
5.08[W]	31.0	28	1329.9	14.0	58.5	34*	7.7*	Fair
1.37[W]	36.0	28	435.0	20.9	61.8	33*	7.6*	Fair
Eagle Creek(04-411-000) WWH*/+								
8.28[W]	21.1	25	884.2	13.1	58.5	34*	7.3*	Fair
4.90[W]	24.2	27	1515.0	14.9	59.0	36[ns]	7.9[ns]	Marginally Good
0.50[W]	34.7	29	1278.0	10.8	66.0	39[ns]	8.3[ns]	Marginally Good
North Branch Eagle Creek (04-412-000) WWH*/+								

River/Stream RM	Drain. Area (mi^2)	Total Species	Mean Rel. No. (No./km)[a]	Mean Rel. Wt. (Wt./km)[a]	QHEI	IBI	MIwb	Narrative
0.02[H]	12.9	16	1674.0	-	46.8	38[ns]	-	Marginally Good
Bear Creek (04-409-000) MWH+								
5.70[H]	13.6	18	3528.0	-	55.5	40	-	Good
2.43[W]	22.0	24	4776.0	26.0	57.8	33	9.1	Fair/Very Good
WWH+								
0.54[W]	24.2	26	871.5	36.6	55.3	41	8.3[ns]	Good/Fair
Fish Creek 04-405-000 WWH +								
30.54[H]	8.8	18	1222.0	-	48.8	42	-	Good
EWH+								
5.40[W]	106.0	34	1276.8	12.8	77.5	47[ns]	9.2[ns]	Very Good
WWH+								
0.38[W]	109.0	31	418.5	24.3	61.5	39[ns]	8.2[ns]	Marginally Good
Big Run 04-404-000 WWH*/+								
0.30[W]	30.0	28	1332.0	5.2	55.3	37[ns]	8.7	M. Good/Good

a - Relative abundance and relative weight estimates standardized to 0.3 km for wading and headwater sites and 1.0 km for boat sites, respectively.
H - Headwaters: sites draining areas ≤ 20 $miles^2$.
W - Wadable streams: sites draining areas > 20 $miles^2$.
B - Boat sites: large or deep waters, necessitating the use of Boat sampling methods.
ns - Non-significant departure from the bio criteria (≤4 IBI units or ≤0.5 MIwb units).
* - Significant departure from the biocriteria (>4 IBI units or >0.5 MIwb units).
+ - Aquatic life use designation field verified by previous investigation(s).
***/+** - Field verification of aquatic life use designation(s) based upon the results from the 2013 survey of the St. Joseph River, superseding pervious unverified status.

Ecoregional Criteria (OAC 3745-1-07, Table 7-15)
Eastern Corn Belt Plains (ECBP)

Index Site Type	WWH	EWH	MWH[b]
IBI - Headwaters/Wading	40	50	24
MIwb -Wading	8.3	9.4	6.2
IBI - Boat	42	48	24
MIwb - Boat	8.5	9.6	5.8

b - Modified Warmwater Habitat (MWH) for channel modified areas.

St. Joseph River (mainstem)

The fish sampling effort on the St. Joseph River mainstem included 16 sampling events, at eight stations, evaluating approximately 43 river miles, between its origin at the confluence of the East and West Branches (RM 84.6) and the Indiana-Ohio state line (RM 41.7).

The sampling effort yielded a total of 6,107 fish comprising 50 species and three hybrids. Based on aggregated catch statistics, numerically dominant species (no./km) were spotfin shiner (19.0%), bluntnose minnow (17.2%), golden redhorse (11.9%), bluegill sunfish (7.8%), northern hog sucker (5.5%), and rockbass (4.5%). In terms of relative biomass (kg/km), dominant species were common carp (30.4%), golden redhorse (19.9%), silver redhorse (18.6%), channel catfish (9.2%), and rock bass (3.8%). Over a quarter of the numerically dominant species and nearly 50% of the biomass of dominant fish were comprised of environmentally sensitive taxa.

Community indices and accompanying narrative evaluations for the St. Joseph River ranged between exceptional (IBI=53 and MIwb=10.4) and marginally good-very good (IBI=38 and MIwb=9.4), with a mainstem average characterized as very good-exceptional (IBI=44.6 and MIwb=9.78, ± two SDs, 10.18 IBI units and 0.769 MIwb units). Aggregated and longitudinal performance of the IBI, MIwb, and other relevant indicators are presented in Figures 30 and 31.

Presently, the entire length of the St. Joseph River is designated WWH. Performance of the IBI and MIwb through the entire length of the St. Joseph River was found fully consistent with the WWH biocriteria. Every station was found to support an assemblage of fish possessing the expected structure, functional organization, and species richness, comparable to the reference conditions within the ECBP ecoregion. Environmentally sensitive taxa were well represented and made up a significant proportion of the catch (relative abundance and biomass) from each fish sampling station. The incidence of serious disease or other external anomalies was typically at or below expected levels. As measured or otherwise indicated by the performance of the fish community, in every instance, point and non-point source pollutant loads currently delivered to the St. Joseph River appeared safely assimilated.

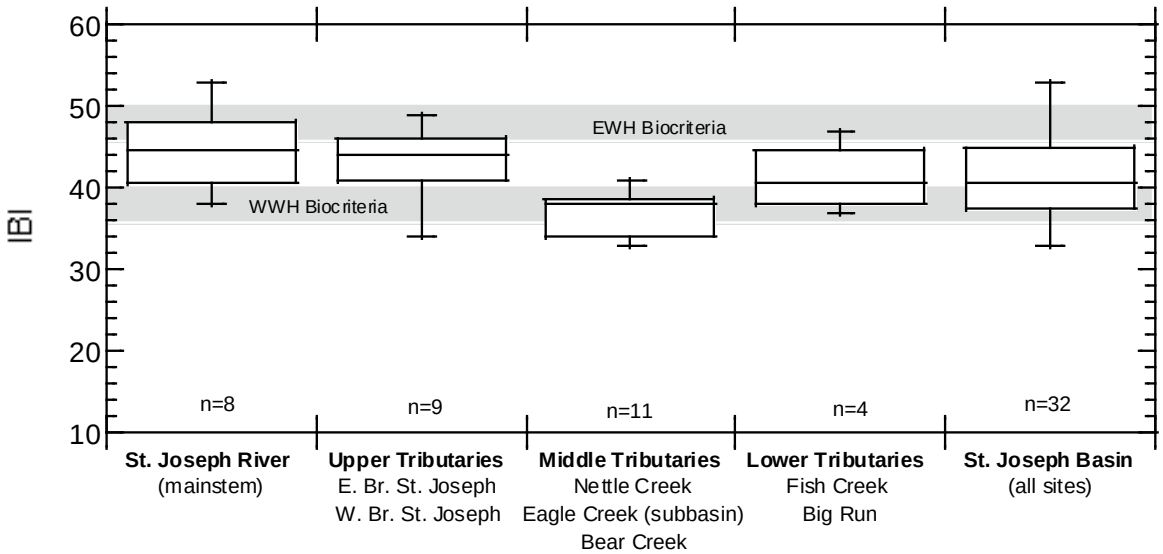

Figure 30. Performance of the IBI for the St. Joseph River study area, 2013, aggregated by mainstem, consolidated tributaries, and all study area sites. Grey-scale horizontal bars identify EWH and WWH biocriteria.

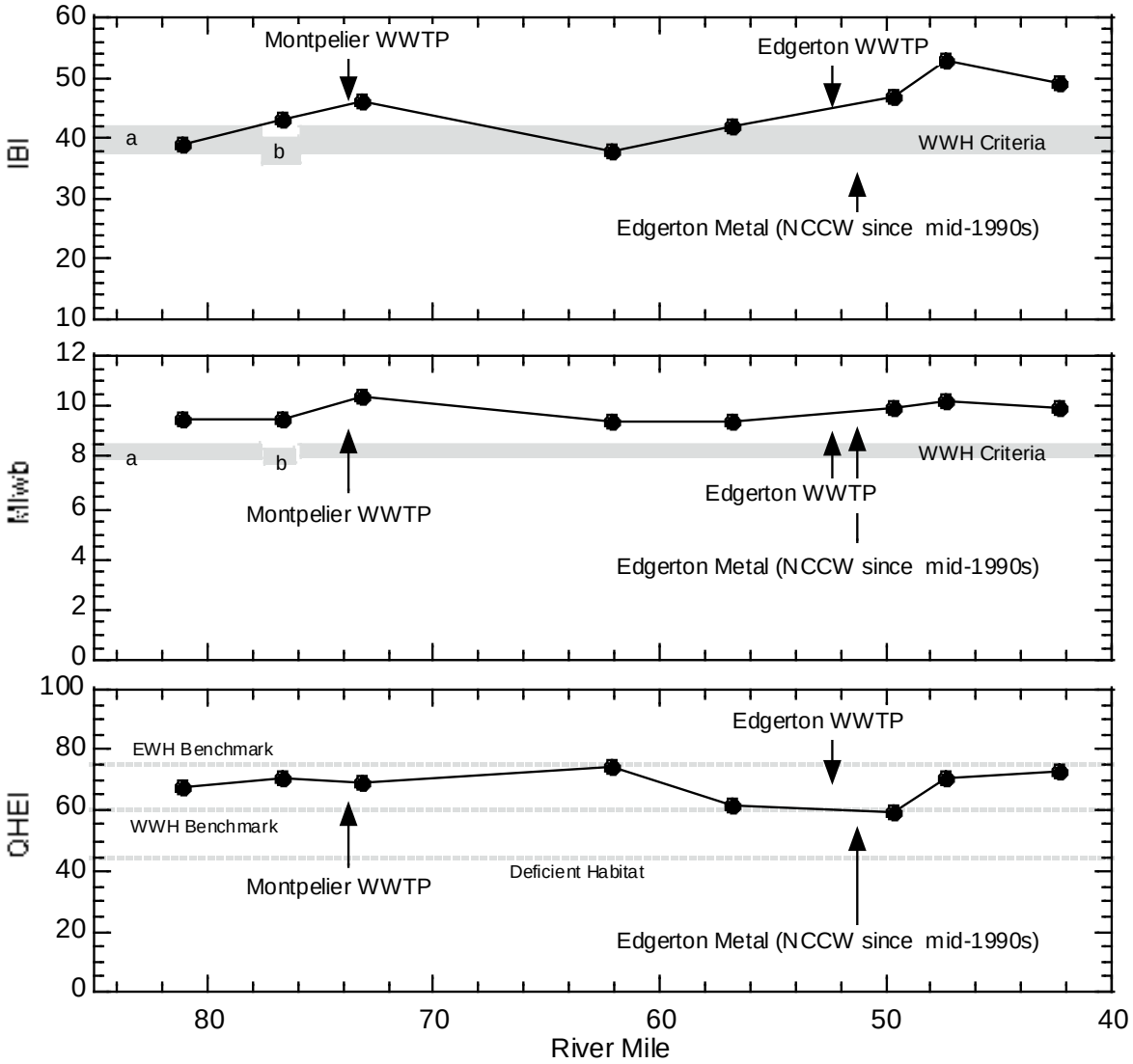

Figure 31. Longitudinal performance of the IBI, MIwb, and QHEI for the St. Joseph River mainstem, 2013. Grey-scale horizontal bars ***a*** and ***b*** represent the existing WWH biocriteria and areas of non-significant departure for Boat and Wading methodologies, respectively. Arrows identify significant direct points of discharge for NPDES permitted entities. Horizontal dashed lines indicate EWH and WWH benchmarks, and QHEI scores typical of significantly deficient or otherwise potentially limiting macrohabitat (Rankin 1989 and Rankin 1995). The entire St. Joseph River study area is contained wholly within the ECBP ecoregion (Omernik 1987, Omernik and Gallant 1988).

St. Joseph River Tributaries

Within Ohio, ten direct and indirect tributaries comprise the principal drainage network of the St. Joseph River. As part of the 2013 St. Joseph River survey, 24 fish monitoring stations (42 sampling events) were deployed among these waters, resulting in the evaluation of 69.2 cumulative stream miles. These streams included East Branch St. Joseph River (tributaries, Silver Creek and Clear Fork), West Branch St. Joseph River, Nettle Creek, Eagle Creek (tributary, North Branch Eagle Creek), Bear Creek, Fish Creek, and Big Run.

Among these waters, community indices and accompanying narrative evaluations ranged between very good-exceptional (IBI=49/MIwb=10.0) and fair (IBI=33/MIwb=7.3). Overall, community performance was characterized as marginally good (IBI=39.7/MIwb=8.5). Aggregated performance of the IBI, MIwb, and other relevant indicators are presented in Figures 30 and 32. Summarized index scores and descriptive community statistics by station are presented in Table 20.

Of the cumulative 69.2 tributary stream miles assessed, over 80% (55.9 miles) were found to support fish assemblages consistent with their respective aquatic life use designation and supporting biocriteria. These waters included all or portions of nine St. Joseph River tributaries. Associated fish communities of these streams or stream segments consistently displayed species richness, functional organization, structural evenness, and general condition/health comparable to regional benchmarks. Departures from the prescribed biocriteria were limited to segments or reaches of only four of the ten St. Joseph River tributaries, accounting for 19.2% (13.3 miles) tributary stream miles. It is important to note that deficient assemblages for the entire study area (all waters, including the mainstem) were limited to these four tributaries. Furthermore, at the watershed scale, impaired streams accounted for only 11.9% of the basin, while well over 80% supported fish assemblages that meet or exceeded their respective biocriteria.

East Branch St. Joseph River

The principal drainage network of the East Branch subbasin consists of three named streams: East Branch St. Joseph River and two tributaries, Silver Creek and Clear Fork. Five sampling stations were allocated among these waters: two sites on the East Branch (RM 4.8, CR S upstream from the Pioneer WWTP and RM 1.1, SR 15, downstream from Pioneer), two sites on Clear Fork (RM 6.2, SR 576 and RM 2.2, CR 13) and a site on Silver Creek at RM 1.3, CR 15. Presently, these waterbodies are designated WWH.

Community indices and accompanying narrative evaluations for the East Branch subbasin ranged between very good (IBI=47/MIwb=9.1) and fair-marginally good (IBI=35/MIwb=8.1). Overall, community performance, as described by the subbasin mean, was characterized as good (IBI=41.8/MIwb=8.7, ± two SDs, 8.88 IBI units and 0.898 MIwb units). Departure from the WWH biocriteria was limited to the lowest station on Clear Fork at RM 2.17 (CR 13) and was delineated by the IBI. As this site drains an area greater than 20 mi^2, the final site index scores were derived from the average of two sampling events. A comparison of the results from each summer sampling event revealed a very modest divergence in the performance of the IBI calculated from the second sample. Specifically, the proportion of intolerant and lithophilic species were slightly higher and slightly lower, respectively, compared against the same metrics from the first sampling event. However modest, these differences were at scoring break-points for each of these metrics, and the resulting overall site evaluation (site average IBI) fell just below the WWH threshold.

Macrohabitat quality did not appear to be contributing to WWH departure, as QHEI values for Clear Fork here and farther upstream were consistent with the minimum WWH benchmark. Although evidence of previous channel modification was observed throughout Clear Fork, naturally directed recovery or

reestablishment of positive channel and riparian features appeared well advanced. Given the adequacy of habitat and the good performance of the MIwb and first pass IBI, the very modest nature of the WWH departure identified here was attributed to natural variation, just beyond that accounted for in IBI variability documentation and biocriteria derivation (Ohio EPA 1987b).

All remaining waters contained within the East Branch subbasin: East Branch mainstem, Silver Creek, and upper Clear Fork, were found to support fish communities fully consistent with the WWH biocriteria.

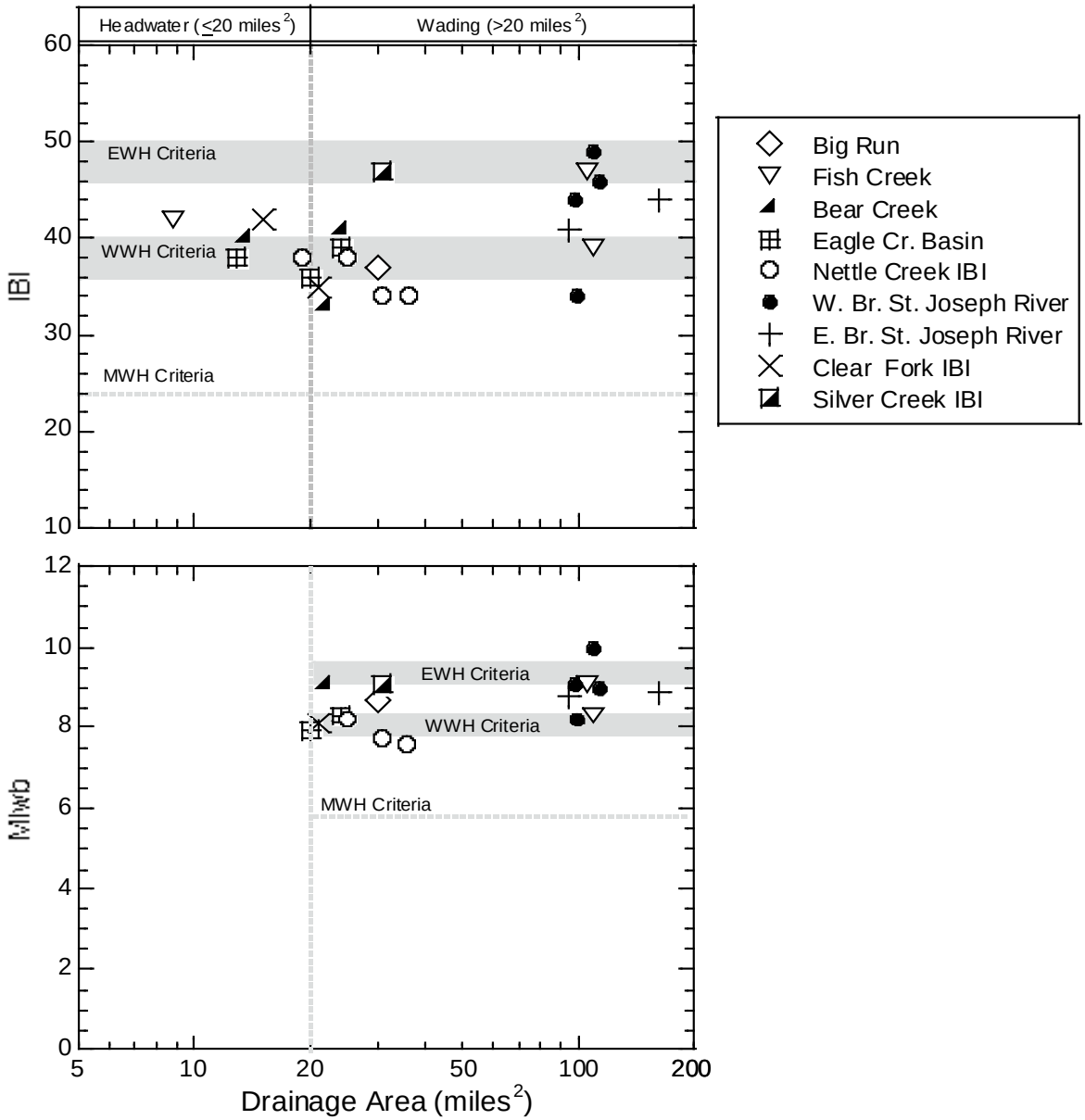

Figure 32. Distribution of IBI and MIwb scores for all St. Joseph River tributaries by stream size (drainage area). Vertical dashed line represents the threshold between headwaters (≤20 mi^2) and wading (>20 mi^2) sites. From top to bottom, horizontal grey-scale areas indicate EWH and WWH biocriteria for the IBI and MIwb, respectively. The dashed horizontal line identifies the MWH biocriteria. The entire St. Joseph River study area is contained within the ECBP ecoregion.

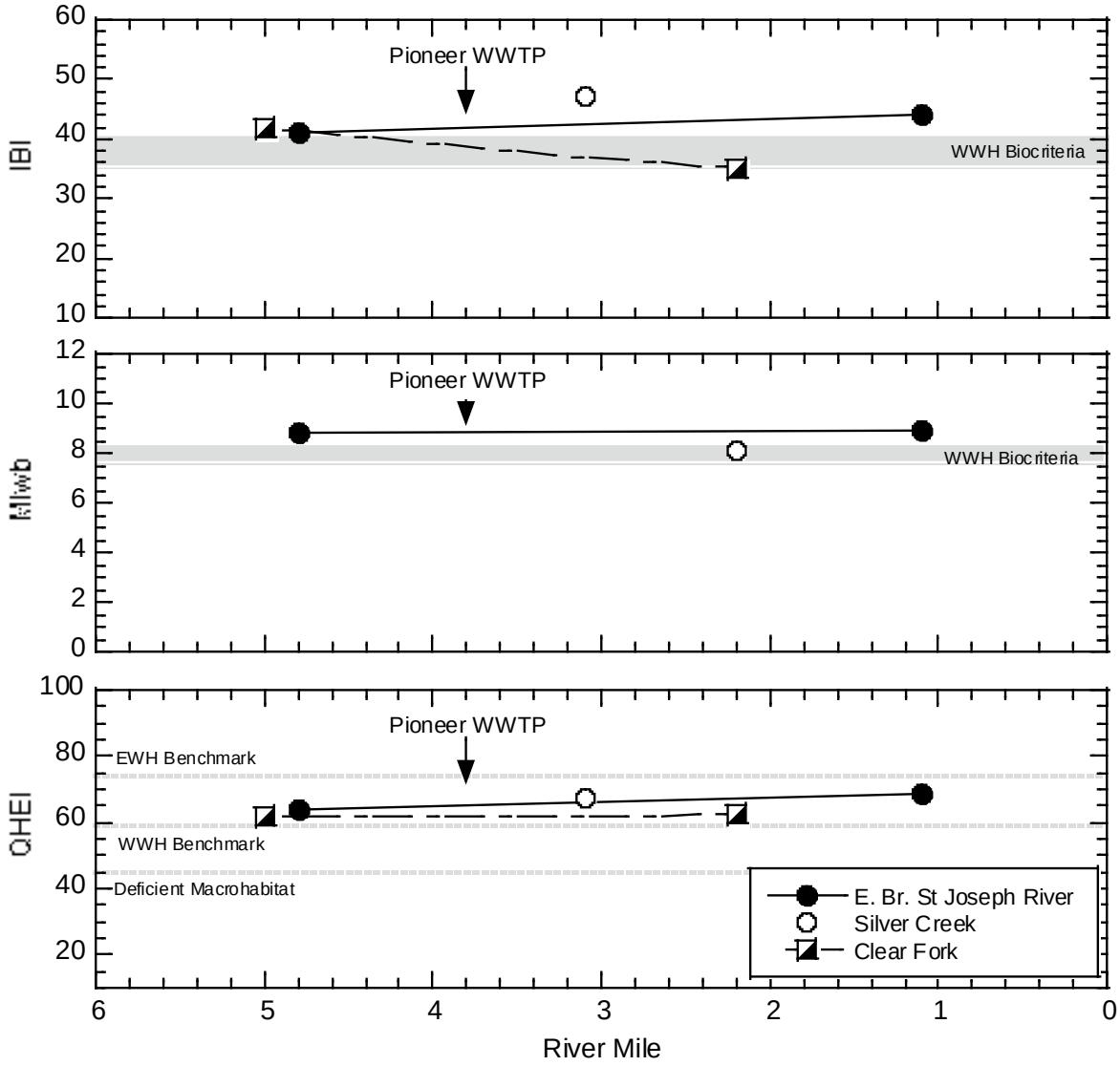

Figure 33. Longitudinal performance of the IBI, MIwb, and the QHEI for the East Branch St. Joseph River and its principal tributaries, 2013. Ordinations of East Branch tributaries are referenced from the point at which they join the mainstem. Grey-scale horizontal bars represent the existing WWH biocriteria and areas of non-significant departure. Horizontal dashed lines indicate EWH and WWH benchmarks, and QHEI scores typical of significantly deficient or otherwise potentially limiting macrohabitat (Rankin 1989 and Rankin 1995). Arrow identifies direct point of discharge for the minor POTW for the village of Pioneer. The East Branch St. Joseph River is contained wholly within the ECBP ecoregion (Omernik 1987, Omernik and Gallant 1988).

West Branch St. Joseph River

Sampling of this subbasin was limited to four monitoring stations distributed throughout the Ohio length of the West Branch St. Joseph River, between RM 10.5 (TR S) and RM 0.7 (US 20). Taken together these sites allowed for the evaluation of 11.4 stream miles. Presently, this waterbody is designated WWH.

Community indices and accompanying narrative evaluations for the West Branch ranged between very good-exceptional (IBI=49/MIwb=10.0) and fair-marginally good (IBI=34/MIwb=8.2). As described by the subbasin mean, overall community performance was characterized as good-very good (IBI=43.2/MIwb=9.07, ± two SDs, 13 IBI units and 1.46 MIwb units). Aggregated performance of the IBI, MIwb, and other relevant indicators are presented in Figures 30, 32, 34, and 35. Summarized index scores and descriptive community statistics by station are presented in Table 20.

Aquatic life use impairment was limited to a single station, the middle West Branch RM 8.5 (CR 8, upstream from Lake Seneca) and was delineated by the IBI alone. The remaining fish biometric, the MIwb, was found consistent with its respective WWH criterion at all stations. The WWH departure of the IBI was significant, not only measured against expected natural variation as expressed by the area of non-significant departure, but also by direct comparison to adjacent stations. In this regard, the IBI at RM 8.5 was at least 10 IBI units lower than all other West Branch stations. The strong longitudinal divergence was primarily derived from an inordinate number of a single and highly tolerant species, bluntnose minnow. Given both its generalized life history (feeding and reproductive habits) and overall tolerance of poor water quality, the bluntnose minnow is found in an exceedingly wide range of lotic habitats and water quality conditions, and as such, is among the most ubiquitous fish species in Ohio. Although this taxa is almost never absent from Ohio waters, it tends to hold a dominant position only in areas of poor to marginal water quality, degraded physical habitat, or a combination of the two. Average proportion of bluntnose minnow observed throughout the entire St. Joseph study area was just under nine percent. In keeping with the study area's central tendency, this species constituted no more than 10% of the fish assemblage of the West Branch, at all sites up and downstream from the impaired station. Here, however, bluntnose minnow accounted for over 50% of all fish captured. The dominance of this species did not appear to be a temporal anomaly or a related sampling error, as both samples collected at this site in 2013 yielded nearly identical numerical abundance estimates. The super abundance of this generalist species served to overwhelm selected proportional metrics contained within the IBI. Specifically and most consequentially, negative metrics (proportion of tolerants and omnivores) were inflated and selected positive metrics (proportion of specialist insectivores) were diluted, thus driving the resulting IBI score well below both the central tendency of the West Branch and the minimum WWH threshold. Yet, despite this, the fish assemblage was in many other important ways comparable or otherwise similar to that found at adjacent stations, this being particularly evident in nonproportional measures. These similarities included, but were not limited to, overall high species richness, high number of environmentally sensitive fish taxa, very low incidence of significant disease, and comparable structural evenness as measured by the MIwb. Regarding the latter, the MIwb was negatively affected, but remained within the WWH range. As related to biocriteria in Ohio, it is uncommon for single taxa to exercise a controlling influence upon a final assessment. Although uncommon, previously encountered examples of this typically involved a late season pulse of a species known for large seasonal movements (e.g., gizzard shad). Bluntnose minnow is not known to aggregate (beyond that which is typical of lotic cyprinids) and engage in significant seasonal movements; therefore, the dominance of this species at RM 8.5 appears "real" and very likely related to environmental variables.

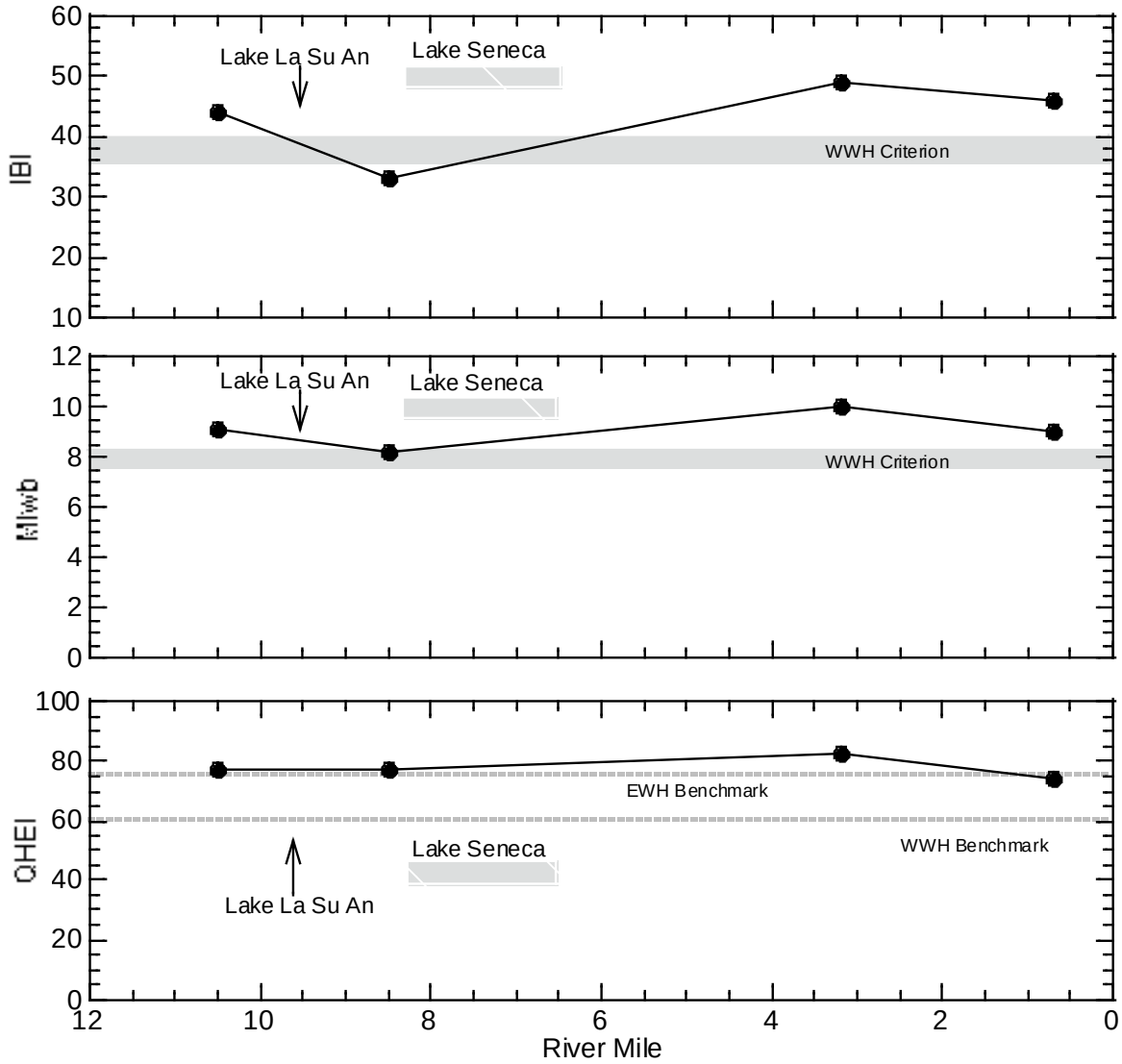

Figure 34. Longitudinal performance of the IBI, MIwb, and the QHEI in the West Branch St. Joseph River, 2013. From top to bottom, horizontal grey-scale areas indicate WWH biocriteria for the IBI and MIwb, respectively. Horizontal dashed lines indicate EWH and WWH benchmarks for QHEI scoring. Arrow and remaining marker identify the outlet and extent of Lake La Su An and Lake Seneca, respectively. The entire St. Joseph River study area is contained wholly within the ECBP ecoregion (Omernik 1987, Omernik and Gallant 1988).

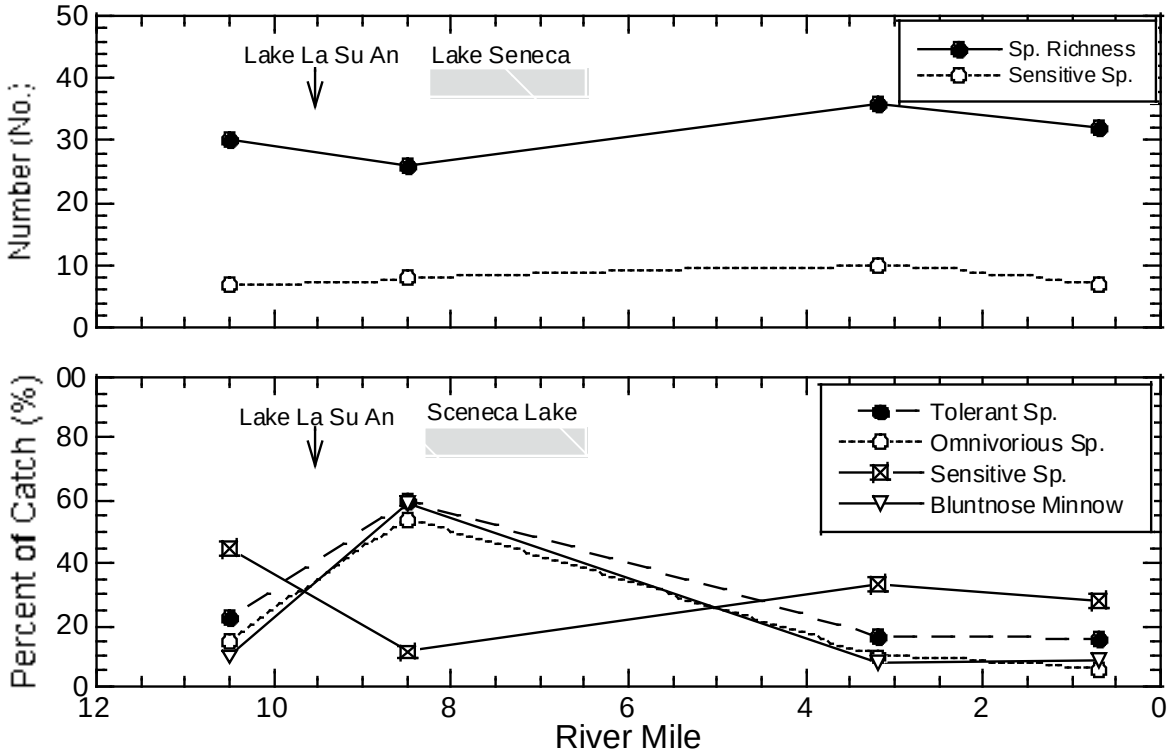

Figure 35. Longitudinal performance of selected biometrics for the West Branch St. Joseph River, 2013. Note the relatively low longitudinal variation of numerical abundance metrics (upper) opposed to the strong divergence of proportional metrics (lower) at the impacted West Branch station at RM 8.5.

Local macrohabitat quality at RM 8.5 did not appear to be a contributing factor to the WWH departure, as QHEI values at this site and elsewhere remained well above that commonly associated with WWH. In fact, macrohabitat quality as measured by the QHEI was found consistently within the excellent range. The possible influence(s) of the reservoirs (Lake La Su An and Lake Seneca) in the watershed were considered. The outlet of Lake La Sue An joins the West Branch approximately one mile upstream from RM 8.5. In contrast, Lake Seneca is formed by the impounding of 2.5 miles of the West Branch. The spillway is located at RM 5.7 and the upper limit of the dam pool at normal pool elevation is approximately RM 8.2. Of the two waterbodies, the impoundment formed by Lake Seneca is potentially the most consequential to ambient biological performance at RM 8.5. Specifically, the transitional area demarking the boundary between free-flowing, classic riverine habitat and upper limits of Lake Seneca may provide optimal habitat for bluntnose minnow, the surplus production of this species dispersing upstream due to density dependent factors. Possible downstream effects from Lake La Su An cannot be entirely discounted. Either singularly or in combination, downstream reservoir effects commonly observed can include: 1) ammonia toxicity from the summer hypolimnion, effects highly localized as ammonia is oxidized with increasing downstream distance from the spillway; or 2) trophic shift and secondary and tertiary water quality effects associated with releases from the typically warm and photic summer epilimnion; and 3) export of lotic fish species (primarily sunfishes) to river segments immediately up and downstream from an impounded reach. These and other generalized effects of on-stream impoundments are detailed in Yeager (1993). Field observations, habitat appraisal and analysis of the structure and species composition of the fish community at RM 8.5 yielded little direct or

inferential evidence of these effects. However, these findings are not adequate in and of themselves, and must be corroborated by or compared against both diel and day time water chemistry results.

Nettle Creek

Fish community monitoring was limited to four sampling stations on Nettle Creek, between RM 14.5 (TR 72) and RM 1.4 (CR N-30). Taken together, these sites allowed for the evaluation of 16 cumulative Ohio stream miles of this St. Joseph tributary. Resulting community indices and accompanying narrative evaluations ranged between marginally good-good (IBI=38/MIwb=8.2) and fair (IBI=34/MIwb=7.6). Overall, community performance, described by the subbasin mean, was marginally good-fair (IBI=36/MIwb=7.7, ± two SDs, 4.62 IBI units and 0.643 MIwb units). Aggregated and longitudinal performance of the IBI, MIwb, and other relevant indicators are presented in Figures 30, 32, 36, and 37. Summarized index scores and descriptive community statistics by station are presented in Table 20.

Based upon the existing WWH aquatic life use designation, departures from the WWH biocriteria on Nettle Creek were identified at two monitoring stations within the lower 5.1 miles. Both the IBI and MIwb from stations at RM 5.08 (adjacent Bridgewater Dairy) and RM 1.37 (CR N-30, downstream from Bridgewater Dairy) failed to meet the minimum WWH biocriteria. A combination of both marginal performance of selected proportional fish community metrics and declining relative abundance near the mouth were responsible for the sub-par scoring of these indices. All sites sampled on Nettle Creek showed evidence of previous channelization, with the degree of natural recovery varying considerably over its entire length. QHEI scores ranged between 64.0 in the headwaters at RM 14.5 (upstream from Nettle Lake) to 49.8 at RM 11.2 (TR 72). Despite selected QHEI values at or near the WWH benchmark, a high proportion of modified habitat attributes persisted throughout the lower 12 miles.

It is important to indicate that the degree of departure from habitat suitable to support WWH communities here was modest, and by no means constituted a profound or otherwise severe impact. Furthermore, the affected segment did not provide any obvious evidence of egregious water quality problems (e.g., anoxic substrates, septic odors, excessive algae/phytoplankton). Fish communities on lower Nettle Creek appeared to labor under the deleterious effects attendant to previous channel modification, on both local and upstream segments. The quality and extent of the riparian corridor and channel form/function (development, sinuosity, substrate composition, etc.) have a direct bearing not only on ambient biological potential or performance, through the provision of physical habitat for aquatic life, but are equally consequential to a waterbody's ability to assimilate, with minimal disturbance, background sources of nitrogen, phosphorus and organic carbon common throughout rural Ohio.

The upper 10.9 miles of Nettle Creek, evaluated at two monitoring sites located at RM 14.8 (TR 72) and RM 11.2 (CR 7, downstream from Nettle Lake), were found to support WWH fish communities. Species richness, functional organization, structural evenness, and the frequency of disease at sites so identified were consistent with regional reference conditions.

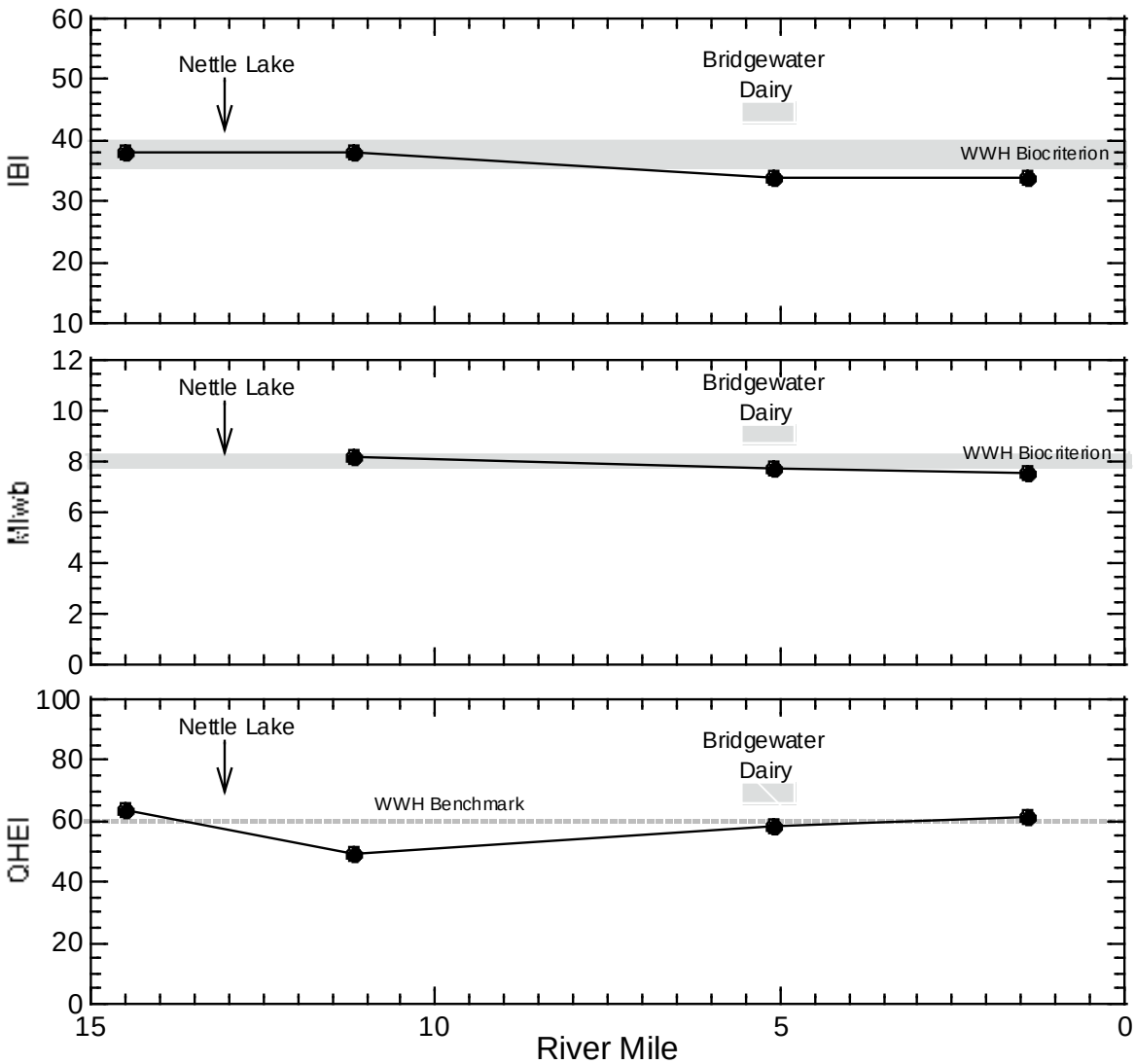

Figure 36. Longitudinal performance of the IBI, MIwb, and the QHEI, Nettle Creek, 2013. From top to bottom, horizontal grey-scale areas indicate WWH biocriteria for the IBI and MIwb, respectively. Horizontal dashed lines indicate EWH and WWH QHEI benchmarks. Arrow and remaining marker identify the outlet of Nettle Lake and approximate location of Bridgewater Dairy (3,500 head CAFO), respectively. All of Nettle Creek is contained within the ECBP ecoregion (Omernik 1987, Omernik and Gallant 1988).

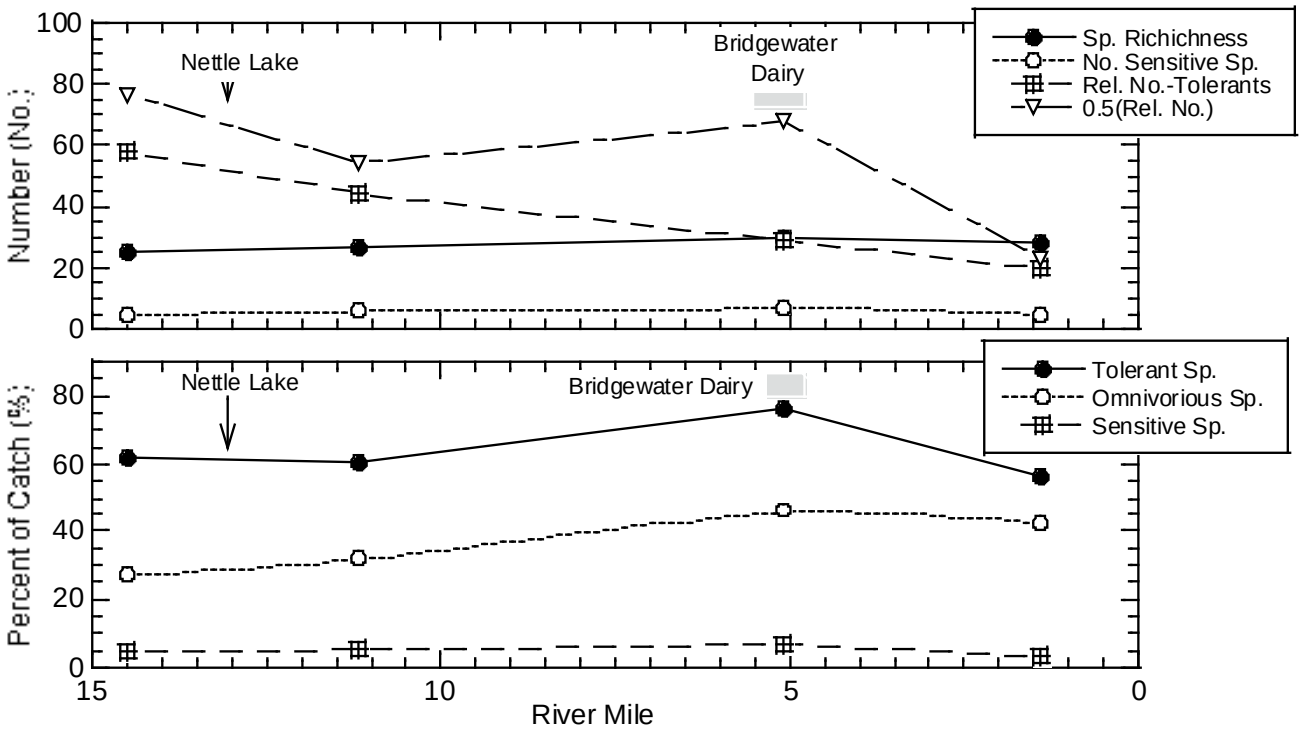

Figure 37. Longitudinal performance of selected biometrics, Nettle Creek, 2103. Arrow and remaining marker identify the outlet of Nettle Lake and approximate location of Bridgewater Dairy (3,500 head CAFO), respectively.

Eagle Creek

Four fish monitoring stations were allocated to the Eagle Creek subbasin: three sites on Eagle Creek, between RM 8.3 (CR 675) and RM 0.5 (CR J), and a single station on the North Branch Eagle Creek, at RM 0.1 (CR M-50). Taken together, these sites allowed for the evaluation of 12 cumulative stream miles of the subbasin. Resulting community indices and accompanying narrative evaluations ranged between marginally good-good (IBI=39/MIwb=8.3) and fair (IBI=34/MIwb=7.3). Overall, community performance, described by the subbasin mean, was marginally good-fair (IBI=36.7/MIwb=7.8, ±2 SDs, 4.43 IBI units and 1.01 MIwb units). Aggregated and longitudinal performance of the IBI, MIwb, and other relevant indicators are presented in Figures 30, 32, and 38. Summarized index scores and descriptive community statistics by station are presented in Table 20. Presently, both Eagle Creek and North Branch Eagle Creek are designated WWH.

Departure from the WWH biocriteria identified within the Eagle Creek subbasin was limited to a single station on upper Eagle Creek at RM 8.3. Although delineated by both the IBI and MIwb, the magnitude of the departure was modest in nature, as biological narratives remained within the upper fair range. Based upon field observation and direct appraisal of channel and riparian features, it is clear that Eagle Creek has been modified to varying degrees in the past, resulting at times in channel incision, limited or monotonous development, a dominance of finer substrates and riparian encroachment. Over 50% of the subbasin is presently under permanent Williams County maintenance as open drains, the majority of this upstream from monitoring stations throughout the Eagle watershed. Although evidence of naturally directed recovery was evident at most sites, macrohabitat deficits observed on upper Eagle Creek, including tributaries, may serve to limit ambient biological potential. As observed elsewhere in the St. Joseph River survey, modest departure from the WWH biocriteria on Eagle Creek appeared a

result of habitat deficits, either local or on upstream segments or tributaries, resulting in the loss or diminution of macrohabitat competency, in terms of both the provision of physical habitat for aquatic life and secondary or tertiary water quality effects attendant to reduced assimilative capacity, or both.

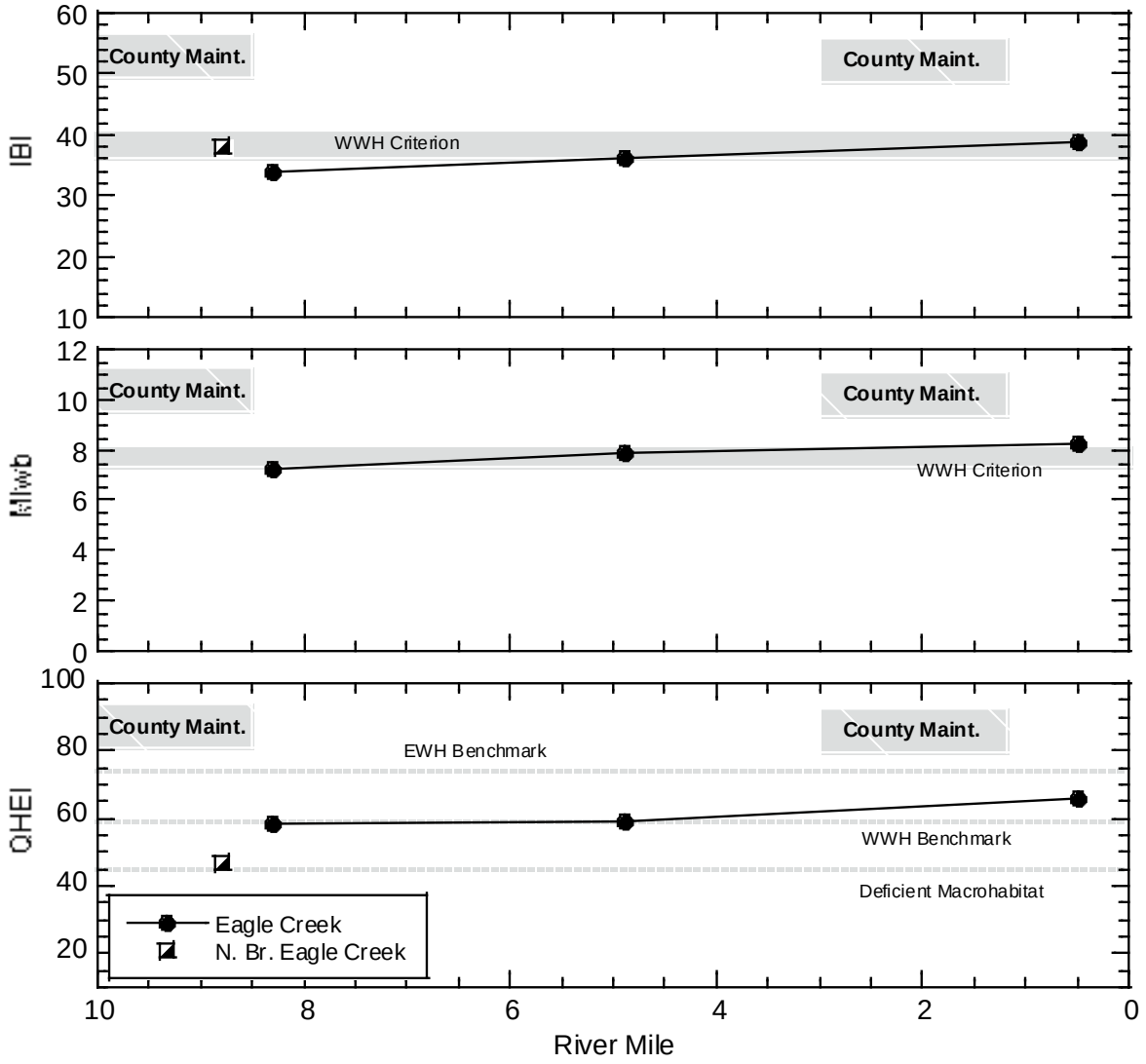

Figure 38. Longitudinal performance of the IBI, MIwb, and the QHEI, Eagle Creek and North Branch Eagle Creek, 2013. Ordination of the North Branch is referenced from the point at which it joins the Eagle Creek mainstem. Solid, grey-scale horizontal bars represent the existing WWH biocriteria and areas of non-significant departure. Horizontal dashed lines indicate EWH and WWH benchmarks, and QHEI scores typical of significantly deficient or otherwise potentially limiting macrohabitat (Rankin 1989 and Rankin 1995). The remaining markers approximate the stream reaches of Eagle Creek presently maintained by Williams County as open drains (Office of Williams County Engineer, pers. com. 2015). Eagle Creek is contained wholly within the ECBP ecoregion (Omernik 1987, Omernik and Gallant 1988).

Bear Creek

Three monitoring stations were directed to Bear Creek, evaluating the stream reach between RM 5.7, CR 4 (downstream from Edon) and RM 0.6 (SR 34). Taken together, these sites allowed for the evaluation of seven stream miles of the Bear Creek mainstem.

Bear Creek and its principal tributaries have been maintained as open drainage ways by county authorities since at least the early 1990s (Ohio EPA 1994). Unlike much of the of the St. Joseph River study area, segments of active drainage maintenance coincided with waters assessed as part of both historical and contemporary surveys. Earlier surveys found the upper and middle segments of Bear Creek highly modified (QHEI range 42.5-51.5) with corresponding fair to poor aquatic communities. In light of the artificial character of much of Bear Creek, its consistent failure to support WWH communities, and anticipated channel maintenance activities required under Ohio drainage law (ORC 6131), the reach from its headwater to RM 1.2 (CR H) was redesignated to MWH. As the lower 1.2 miles had shown considerable physical recovery (QHEI of 65.5) and modestly improved ambient biology, the WWH aquatic life use designation was retained, anticipating that naturally directed recovery would, over time, bring the lower reach into full WWH attainment. Following the 2013 St. Joseph River biosurveys, Bear Creek's status as an open ditch was affirmed by Office of the Williams County Engineer, pers. com. (2015).

Community indices and accompanying narrative evaluations from the 2013 survey of Bear Creek ranged between good-very good (IBI=41/MIwb=9.1) and fair-good (IBI=33/MIwb=8.3). Overall, community performance, described by the subbasin mean, was marginally good-good (IBI=38/MIwb=8.7, ±2 SDs, 8.71 IBI units and 1.13 MIwb units). Aggregated and longitudinal performance of the IBI, MIwb, and other relevant indicators are presented in Figures 30, 32, and 39. Summarized index scores and descriptive community statistics by station are presented in Table 20.

As measured by the IBI and MIwb, the latter where appropriate, all Bear Creek sites were found to support fish communities fully consistent with the prescribed WWH and MWH biocriteria. Despite evidence of extensive previous channel modification, and the majority of the watershed presently maintained as open drains, community performance was surprisingly good. Even through the upper MWH designated segment, fish consistently exceeded the MWH benchmark and either met or nearly met minimum WWH criteria. At every station, Bear Creek appeared to safely assimilate diffuse and point source pollutant loads as indicated by the species composition, structure, and functional organization of its resident fish assemblage.

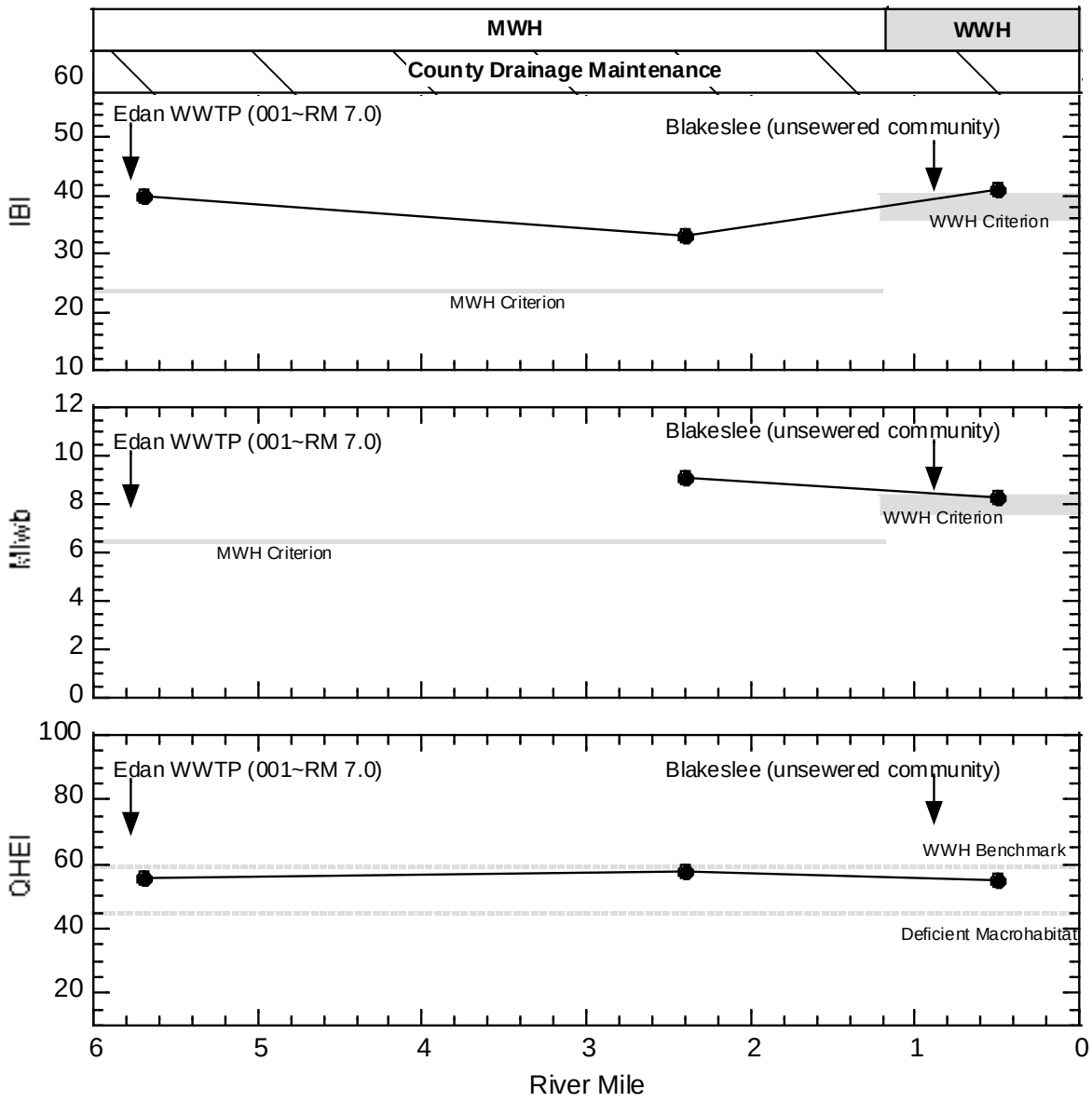

Figure 39. Longitudinal performance of the IBI, MIwb, and the QHEI, Bear Creek, 2013. Grey-scale horizontal bars and solid lines represent the WWH biocriteria and areas of non-significant departure, and MWH biocriteria, respectively. Horizontal dashed lines indicate WWH benchmarks, and QHEI scores typical of significantly deficient or otherwise potentially limiting macrohabitat (Rankin 1989 and Rankin 1995). Arrows identify direct or diffuse points of discharge for the villages of Edon and Blakeslee, respectively. The remaining markers identify the suite of aquatic life use designations for Bear Creek (WWH and MWH). Presently, Bear Creek and its principal tributary are maintained by Williams County as open drains (Office of Williams County Engineer, pers. com. 2015). Bear Creek is contained wholly within the ECBP ecoregion (Omernik 1987, Omernik and Gallant 1988).

Fish Creek
Three fish monitoring stations were deployed to assess the two Ohio segments of Fish Creek: a single site in the Ohio headwaters at RM 30.5 (CR P-25), and two sites on the lower 5.5 miles at RM 5.4 (TR 171, near the state-line) and RM 0.4 (SR 49).

Multiple aquatic life use designations are presently in place on Fish Creek. A 3.1 mile segment of lower Fish Creek, beginning at the Ohio-Indiana state line (RM 5.5.) and extending downstream to CR 3 (RM 2.4) is designated EWH. All remaining Ohio segments, upper and lower, are designated WWH. The headwaters of Fish Creek are presently maintained as an open drain by Williams County (Office of the Williams County Engineer pers. com. 2015). Outside of Bear Creek, this represents the only instance within the St. Joseph River study area where active monitoring and assessment by Ohio EPA is coincidental to a stream segment on active county maintenance.

Community indices and accompanying narrative evaluations from Fish Creek ranged between very good (IBI=47/MIwb=9.1) and marginally good-good (IBI=39/MIwb=8.3). Overall, community performance, described by the subbasin mean, was good (IBI=42.7/MIwb=8.7, ±2 SDs, 8.01 IBI units and 1.13 MIwb units). Aggregated performance of the IBI, MIwb, and other relevant indicators are presented in Figures 30 and 32. Summarized index scores and descriptive community statistics by station are presented in Table 20.

All Fish Creek segments and stations were found to support resident fish assemblages fully consistent with the prescribed WWH and EWH biocriteria. The fish community within the EWH segment, evaluated at RM 5.4, was particularly rich, displaying species composition, functional organization, and structure comparable to the best waters of the ECBP ecoregion. Within the study area as a whole, only the best segments of the West Branch approached the richness, diversity, and overall biological integrity observed in the EWH segment of Fish Creek.

Big Run
Fish community monitoring in Big Run was limited to a single fish station located at RM 0.3 (Conkle Rd.), resulting in the appraisal of all 1.6 Ohio miles of this waterbody. Performance of the IBI, MIwb, and other relevant indicators are presented in Figures 30 and 32. Summarized index scores and descriptive community statistics by station are presented in Table 20.

Despite macrohabitat deficient of a kind, degree, and magnitude encountered on most St. Joseph River tributaries, Big Run was found to support a resident fish assemblage fully consistent with its WWH aquatic life use designation. Bear Creek appeared to safely assimilate diffuse and point source pollutant loads, as indicated by the species composition, structure, and functional organization of its resident fish assemblage.

Fish Community Trends: 1992-2013

Prior the 2013 sampling effort, the fish fauna of the St. Joseph River basin was last systematically surveyed and assessed by Ohio EPA in 1992 (Ohio EPA 1994). Other monitoring efforts within the watershed, either predating the 1992 effort or occurring during the intervening 21 years between 1992 and 2013, were scattered or otherwise limited in scope, supporting various water quality management goals (e.g. NPDES, stream regionalization, use attainability analysis, reference site monitoring, and

natural resource damage assessment). The most robust of these included a multi-year monitoring effort on 30 miles of Fish Creek (headwaters to the mouth), following a 30,000 gallon spill of diesel fuel in the fall of 2003. Except as it may pertain to conditions on the lower, Ohio, portion of Fish Creek, the findings from these efforts will not be detailed here. For these data and the resulting assessments, the reader is directed to Ohio EPA (1995, 1996a, 2003, and 2005). To serve the purposes of this report, the assessment of trends on the St. Joseph River centered on a comparison between monitoring stations, streams, or stream reaches common to both the 1992 and 2013 basin-wide surveys. Each of these efforts evaluated the entire length of the mainstem, with a high degree of actual or functional correspondence between and among sites. Unlike the 2013 survey, which included segments of all principal tributaries, the 1992 effort included only the West Branch St. Joseph River, Bear Creek, Fish Creek, and Silver Creek. Therefore, the appraisal of the condition of St. Joseph River tributaries, through time, will be limited to these common waterbodies.

In order to succinctly summarize and evaluate survey results between field years, analysis of trends will take two basic forms: 1) aggregated annual trends, examining cumulative performance of selected measures and indexes from comparable field years through time, including, as needed, basic parametric and non-parametric analysis to discern gross statistical differences between 1992 and 2013 results; and 2) comparative longitudinal ordination, relative to the principal associated stressors. Where stream specific data are limited to a few sampling stations or waterbodies, trends assessment will take the form of a narrative, as these data do not lend themselves to statistical treatment, aggregation, or longitudinal ordination. A great deal of overlap between the 1992 and 2013 surveys provided an excellent opportunity to evaluate meaningful changes, or lack thereof, in the environmental conditions of the St. Joseph River watershed through the period of record. These approaches will be applied to both the mainstem and its tributaries.

Aggregate Community Performance

The mainstem survey of 2013 was complimentary to previous efforts in terms of spatial coverage and station density, nearly duplicating the work from 1992. Given the robustness and contiguous nature of the larger efforts, the overarching trends of the mainstem are best described by these data. Cumulative community performance, summarized by box and whisker plots, of the IBI for each of the field years identified above are presented in Figure 40. These data portray significant improvement in the performance of the fish assemblage of the St. Joseph River since the first intensive biosurvey. Although not profoundly degraded at that time, all 1992 mainstem monitoring stations failed to support WWH fish communities. Although readily apparent from even a cursory examination of these data, non-parametric statistical treatment (Wilcoxon-Mann-Whitney Rank Sum Test) indicated a strong and significant statistical difference between station IBIs collected in 1992 and 2013 (*p values <0.05*).

Aggregated by subbasin, only Bear Creek was found similarly improved. Here, all sites have accrued or otherwise recruited fish assemblages fully consistent with its associated MWH and WWH aquatic life use designations. The remaining tributaries, Fish Creek, West Branch St. Joseph River, and Silver Creek, have continued to support fish assemblages not only fully consistent with their respective WWH and EWH aquatic life use designations, but have also maintained a high degree of biological integrity over the past 21 years. The correspondence through time, of both use attainment and community performance, is noteworthy, and affirms the persistence and stability of riverine fish assemblages, absent significant environmental stress.

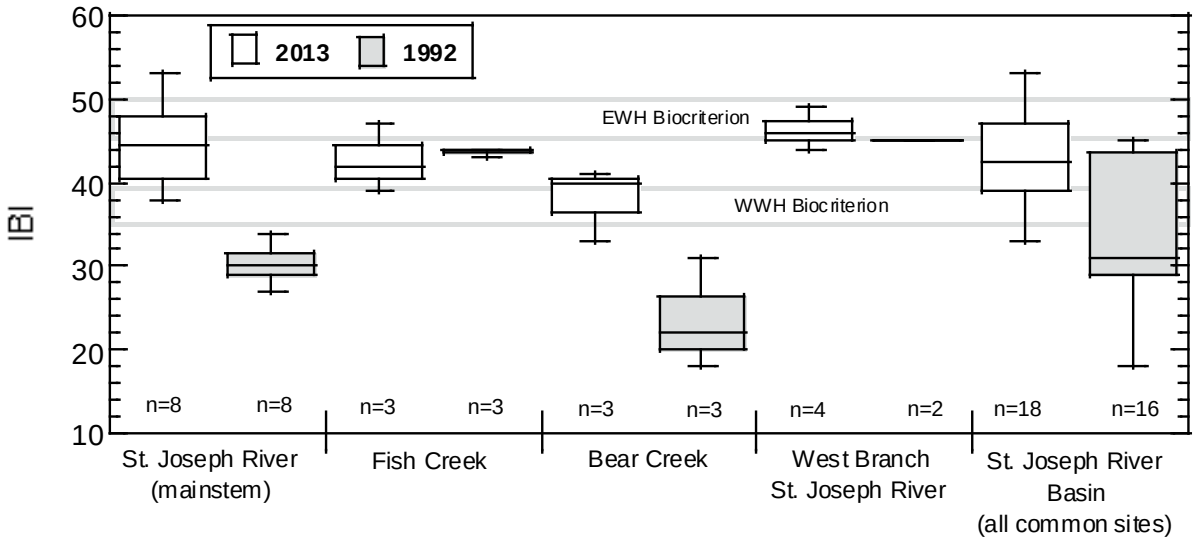

Figure 40. Aggregated performance of the IBI from the St. Joseph River basin, 1992 and 2013. Solid grey-scale lines represent the EWH and WWH biocriteria and areas of non-significant departure.

Although not yet fully documented, reductions in carp biomass through time appears to be an emerging phenomenon throughout Ohio. Several large-scale, state sponsored water quality surveys across multiple ecoregions and including many of Ohio's major drainages have revealed consistent declines in the numerical abundance and aggregate biomass of common carp over the past 20 plus years. These efforts include at least three reporting cycles, and found incremental reductions in the numbers and biomass of carp for each field year. The common carp is a classic generalist species, having a great tolerance for disturbed macrohabitat and degraded water quality (Panek 1987). Because of this, it may serve as an inverse indicator of overall environmental conditions of a given waterbody.

In an effort to further explore and test these observations, trends in aggregated carp abundance on the St. Joseph River mainstem were examined (Figure 41). In 1992, common carp comprised 79% of total fish biomass and over 50% of all fish captured on the St. Joseph River, with station relative averages of 57.5/km and 80.8 kg/km. By 2013, common carp accounted for only 30.4% of total biomass and comprised only 16.8% of the total catch. Relative station averages of numerical abundance and biomass were equally compelling, falling to 16.7/km and 41.6 kg/km, respectively. Curiously, the average weight of carp appears to have increased through time, perhaps reflecting improved condition of individuals associated with reduced density dependent factors related to less intra-species competition. The steady and significant reduction of this highly tolerant and exotic species is viewed as a positive trend, an observation supported by Kennard et al. (2005).

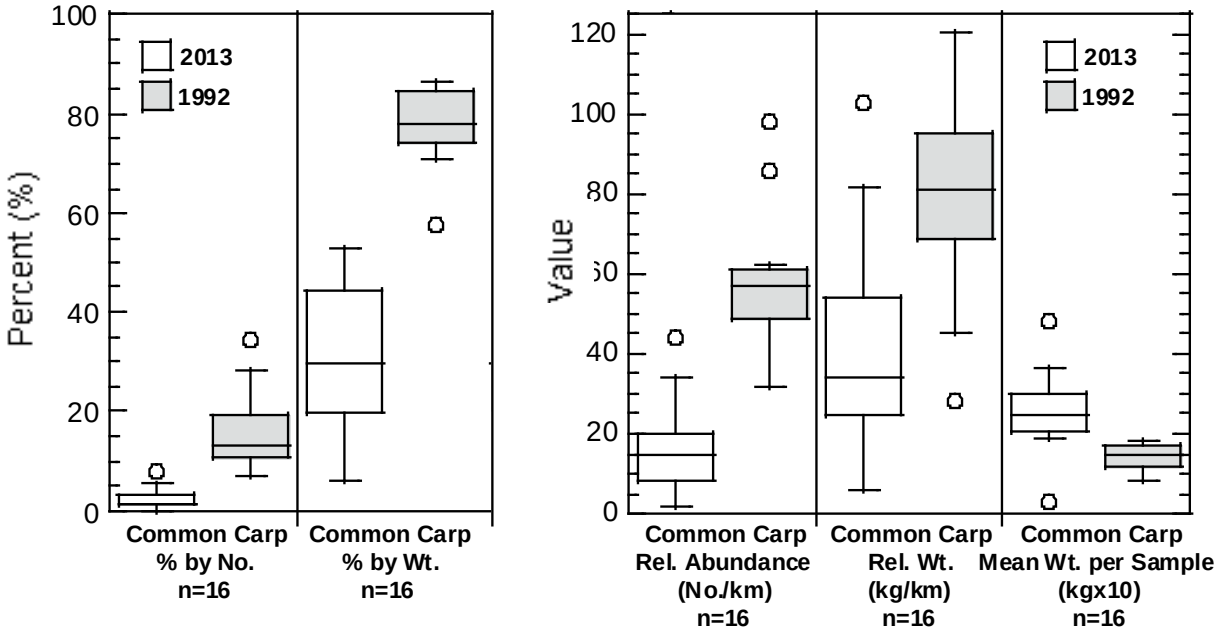

Figure 41. Box plots of aggregate descriptive statistics for common carp, St. Joseph River mainstem, 1992 and 2013.

Longitudinal Trends

Longitudinal trends of the St. Joseph River were derived from the same data sets as used for the aggregate assessment detailed above. The great advantage of longitudinal ordination is that the spatial relationships of the survey data are conserved. This allows relational variables and other relevant features of the study area (e.g., permitted entities, use designations, sampling method, associated biocriteria, impoundments, and tributaries) to be displayed not only concurrently, but with the additional benefit of adequate spatial accuracy, resulting in figures that are simultaneously information dense, yet easily comprehended. Longitudinal ordinations of the indices, biometrics, and other measures, through time, are presented in Figures 42 and 43.

In keeping with the trends described thus far, longitudinal performance of fish community biometrics portrayed significant recovery since the initial 1992 survey. In terms of numerical abundance and biomass, the 1992 fish assemblage was dominated by tolerant, omnivorous or otherwise generalist species. Taxa richness was well below the regional benchmark and environmentally sensitive forms poorly represented. The frequency of gross external anomalies was elevated at stations or reaches directly influenced by the major NPDES permitted facilities on the St. Joseph River. Structural evenness was diminished, as the assemblage was skewed towards facultative taxa and overall relative abundance was below regional expectations.

In contrast, the 2013 survey found every monitoring station on the entire reach of the St. Joseph River mainstem consistent with the prescribed biocriteria, with many sites supporting fully exceptional assemblages. Every measure of fish community structure, functional organization, and general health was advanced, including species richness, relative abundance, sensitive taxa (numbers and proportions), diversity of breeding and feeding guilds, and frequency of external anomalies.

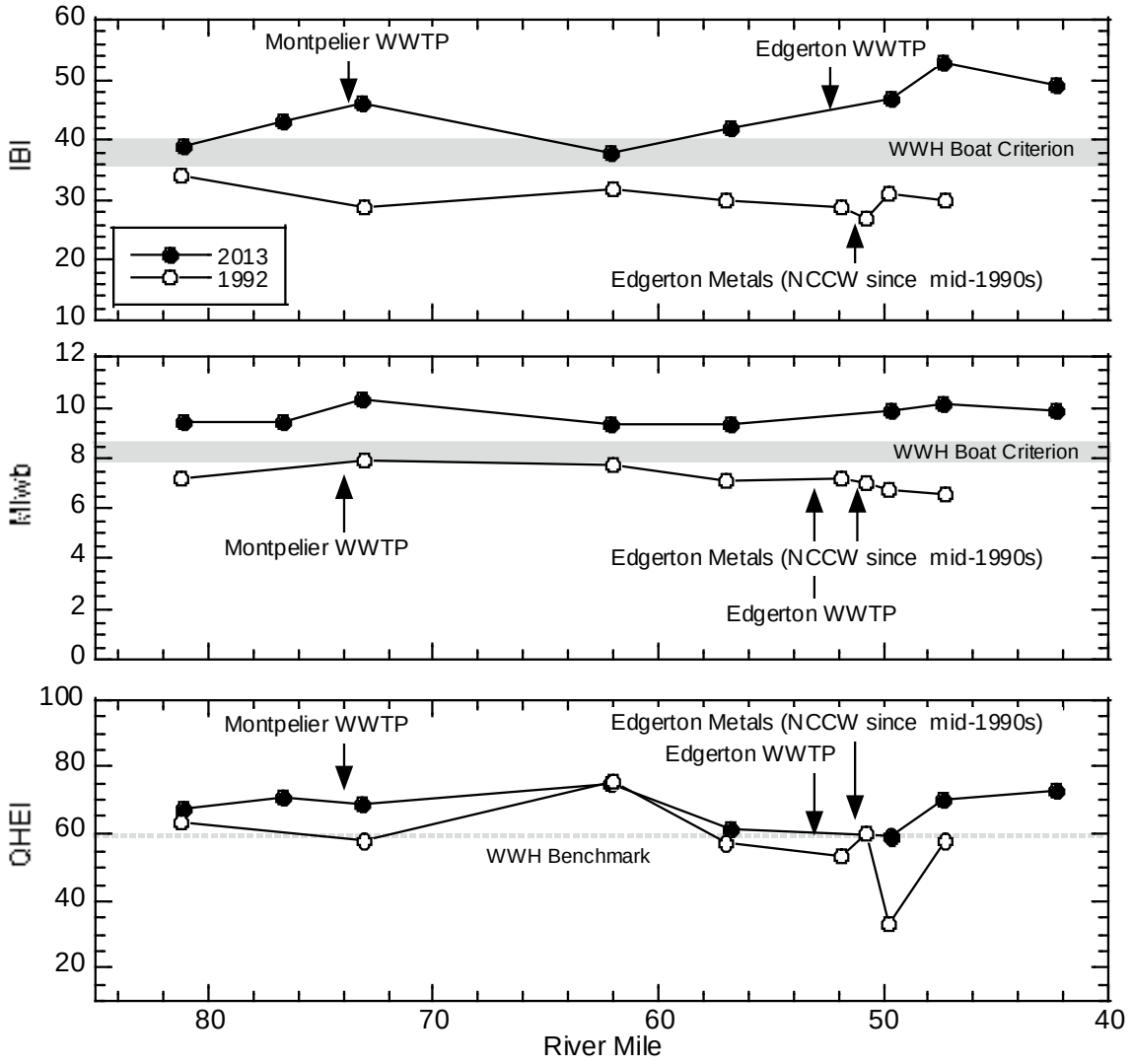

Figure 42. Longitudinal performance of the IBI and MIwb, and QHEI, St. Joseph River, 1992 and 2013. Grey-scale horizontal bars represent the existing WWH biocriteria and areas of non-significant departure. Horizontal dashed lines indicate WWH QHEI benchmark (Rankin 1989 and Rankin 1995). Arrow identifies direct point of discharge for the major NPDES facilities on the St. Joseph River.

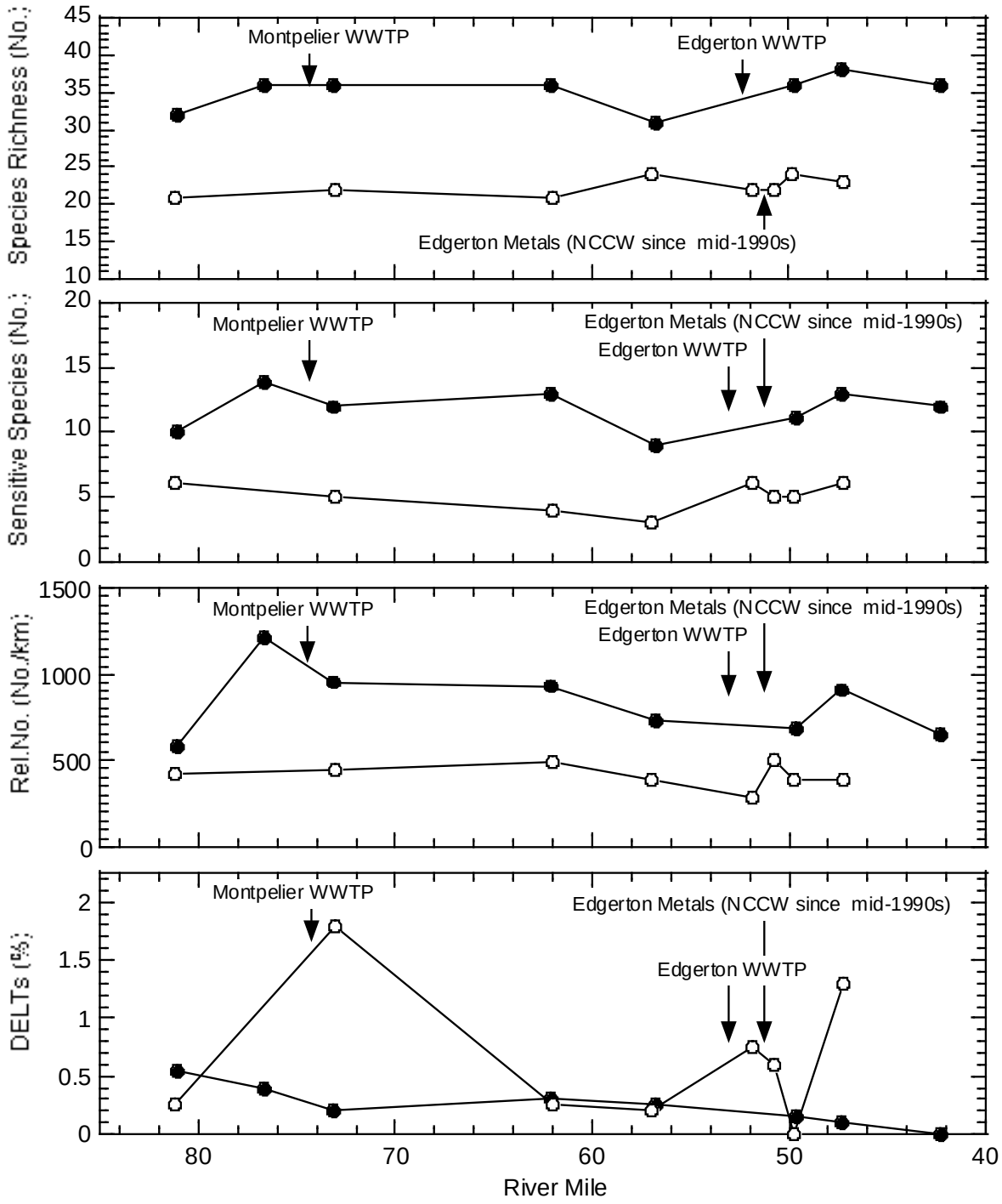

Figure 43. Longitudinal performance of selected biometrics, St. Joseph River 1992 and 2013. Arrow identifies direct point of discharge for the major NPDES facilities on the St. Joseph River.

The results from the 2013 survey portrayed, in clear and unambiguous terms, full recovery of the St. Joseph River from impairments documented in the early 1990s. Multiple and interrelated factors are likely responsible for this and would include gradual natural rehabilitation of previously modified segments, reduced siltation, and improved water quality. Taxa richness, recruitment, and the performance of other important measures of ecological function and organization of lotic fish and invertebrate communities are closely linked to the particle size of streambed sediments. The most immediate and consequential effect of excessive sedimentation upon riverine habitat is the smothering or embedding of coarser bed material by sands, clayey silts and related fines, resulting in loss or diminution of substrate interstices. It is through the associated loss or degradation of living space (critical feeding and breeding substrates) that aquatic communities are primarily, negatively affected by sediment (Fajen and Layzer 1993, Waters 1995). The cumulative effects of the full suite of modern tillage and related soil and water conservation practices has resulted in significant reduction in gross erosion documented at national and regional scales since the late 1970s (NRCS 2007). Studies within the Maumee River basin (and other watersheds) have demonstrated an association between agricultural BMPs, reduced soil loss, in-stream sedimentation and a concurrent positive response of the ambient biology (Barton and Farmer 1997, Meyer and Metzker 2000, Yoder et al. 2004, Richards et al. 2009, and Tessler and Gottgens 2012). These findings parallel emerging phenomena Ohio EPA has observed state-wide regarding the reestablishment of not only formerly imperiled, substrate sensitive fish taxa (e.g., bigeye chub and sand darter), but large and positive community shifts towards lithophilic and specialist insectivorous species in general, with a corresponding decline in ecological generalists (e.g., common carp). The on-going, naturally directed restoration of aquatic taxa acutely sensitive to the ecological effects of sedimentation has served as a broad and functional indicator of ultimate effects.

In very general terms, the adoption of modern tillage practices and related conservation measures on agricultural lands within Ohio's portion of the St. Joseph River has remained around 50% since the early 1990s (Ohio EPA 1994, Palmer and Loomis 2006). Although this does not represent either a radical recent shift to, or a steady increase in, modern tillage over the past 21 years, these landscape treatments none-the-less appeared very consequential over the period of record. It is not difficult to comprehend nor is it reckless to contend that the lag time between the initial large scale adoption of modern tillage through the late 1980s and early 1990s, and measurable in-stream effects is conceptually, very large. Limiting or otherwise reducing the delivery of clayey silts to adjacent waterbodies represents only the first step, as it may well take years to work through the vast amount of fine sediment entrained in the drainage, the rate and efficiency dependent upon multiple physical and hydrological variables. The eventual coarsening of the stream bed will, over time, stimulate a biological response in the form of the recruitment of substrate sensitive taxa, and an eventual restructuring of the entire assemblage. Although the rate of adoption of conservation measures in the St. Joseph River watershed has remain relatively stable over the past 21 years, the associated benefits or ultimate in-stream effects of reduced soil loss are protracted, or perhaps better stated as being fully realized only over the long term. Key to success appears to be an initial broad adoption and the persistence of the adopted land treatments over long periods of time.

As measured by the QHEI, macrohabitat complexity and its overall competency to support a diverse and well-organized fish community has increased though the period of record (Figure 44). This was manifest in the aggregate scores, as well as many of the habitat metrics that combine to form the QHEI. Either singularly or in combination, parametric (Student t) and nonparametric tests (rank sum: Mann-Whitney and Kurskal-Wallis) found strong statistical differences ($p<0.05$) between aggregated QHEI scores and

substrate and in-stream cover metrics from the 1992 and 2013 survey results. Although not statistically different, 2013 results for the remaining metrics were generally higher (e.g., medians, quartile, and range) than those from 1992. The combination of gradual, naturally directed physical recovery and soil conservation efforts represents a highly beneficial, self-reinforcing phenomenon, and in combination, appeared an important factor associated with the recovery of the St. Joseph River mainstem. Improved channel form and function and better riparian conditions not only improved the ambient biological potential of the St. Joseph River, but also enhanced the ability of the river to process (i.e., transport, sort, and deposit) sediment.

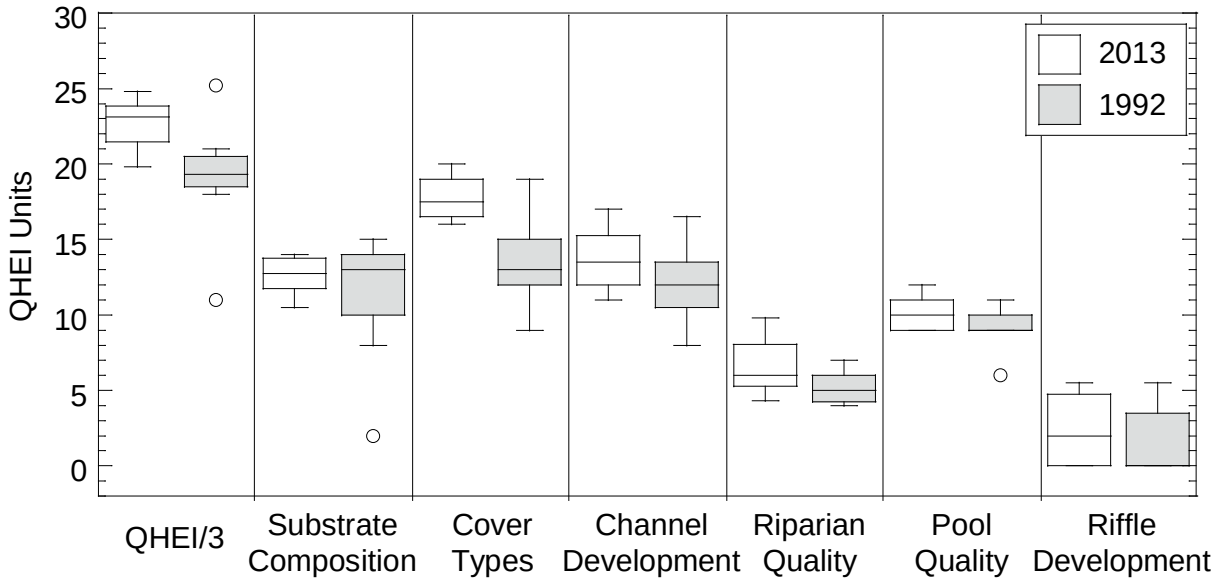

Figure 44. Box plots of the QHEI and its various subcomponents from the St. Joseph River mainstem, 1992 and 2013.

Water quality, through time, is also a potentially important explanatory variable regarding improved condition of the St. Joseph River. To that end, water quality data from 1992 and 2013 were compiled and analyzed (Figure 45). Either singularly or in combination, parametric (Student t, where data were normal or could be normalized) and nonparametric tests (rank sum: Mann-Whitney and Kurskal-Wallis) found statistical significant differences ($p<0.05$) for ammonia-N and TKN, between 1992 and 2013 surveys. As ammonia-N and TKN are related measurements, the correspondence between these two parameters was not surprising. However, the difference between 1992 and 2013 was expressed for both as being higher in 2013. Furthermore, although not statistically different, other parameters (e.g., phosphorus, nitrate-nitrite, and dissolved oxygen) were either comparable between field years or 2013 results were generally higher (e.g., medians, quartile, and range) than those from 1992. It must be noted that, in most instances, the differences between and among these parameters, statistical or not, was not great, and the variation observed between years could be attributable to temporal factors of precipitation and stream discharge. The most compelling findings of this analysis is that in broader terms, water quality of the St. Joseph River has remained relatively stable over the past 20 plus years.

Although not subjected to ordination or statistical testing, selected heavy metal parameters were reviewed, and in nearly every instance found at or near their respective method detection limits or

otherwise comparable between field years. Although at the station scale there was direct and indirect evidence of local water quality improvements, aggregated data from the St. Joseph River mainstem did not provide any compelling evidence of highly consequential changes between 1992 and 2013. These data would suggest that changes in macrohabitat, derived from a combination of naturally directed physical recovery and reduced sedimentation, are the primary variables responsible for the drastic improvements observed on the St. Joseph River mainstem in 2013.

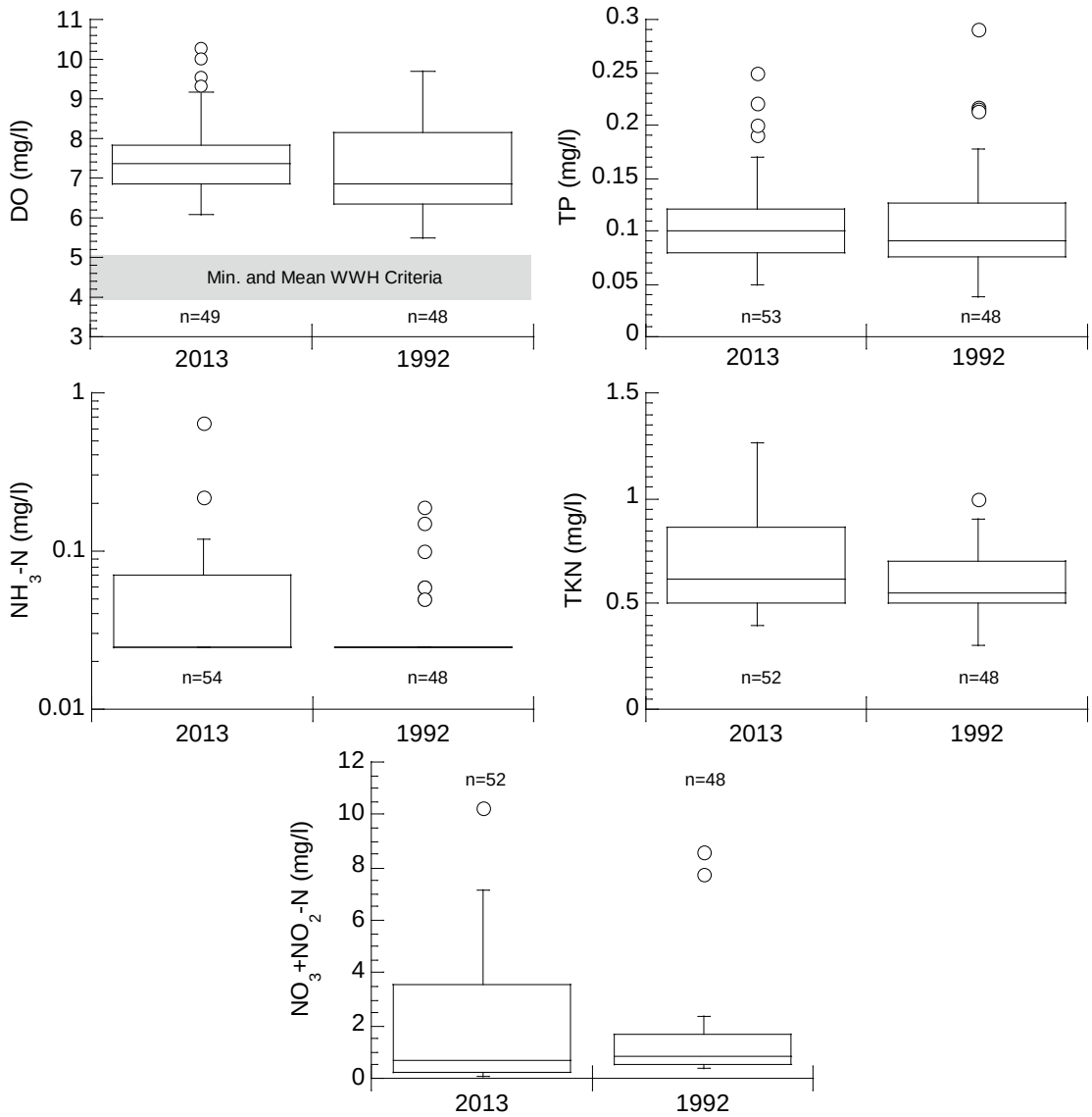

Figure 45. Box plots of aggregated water quality data for selected parameters from the St. Joseph River mainstem, 1992 and 2013. Grey-scale bar on dissolved oxygen plot indicates the average and minimum WWH DO criteria.

Given the ecological stability of nearly all St. Joseph River tributaries common to both the 1992 and 2013 efforts, longitudinal ordination of current and historical community data will be limited to Bear Creek, where significant improvements were documented. The performance of indices, metrics and other relevant measures are presented in Figures 46 and 47. As observed on the St. Joseph River mainstem, between 1992 and 2013 Bear Creek experienced a significant gain in species, including sensitive forms. Structural evenness was similarly improved, including increased relative abundance of nontolerant species. The frequency of gross external anomalies (DELTs) was dramatically reduced through the upper middle segments of Bear Creek. DELT anomalies have proved a reliable indicator of chronic sublethal stress and are most commonly associated with poor water quality (Ohio EPA 1987b).

Habitat measures at stations common to both field years identified modest improvement, likely attributable to both natural recovery and reduced sediment loads. Historical water quality data was unfortunately limited to the lowest Bear Creek station at RM 0.5 (SR 34). Between 2013 and 1992, most parameters remained comparable, with the exception of ammonia-N which was found three times above background concentration in 1992. This may reflect the influence of the village of Blakeslee (an unsewered community at that time) or possibly effluents from the Edon WWTP, located further upstream. Although water quality data are lacking for most of Bear Creek, biometrics, particularly the incidence of DELT anomalies, would suggest significant water quality problems at that time, compounded by significant habitat deficits, particularly at the upper most station. Presently, waste loads to Bear Creek appear assimilated, and the resident fish community appears to be performing up the habitat potential as reflected in the existing MWH and WWH aquatic life use designations.

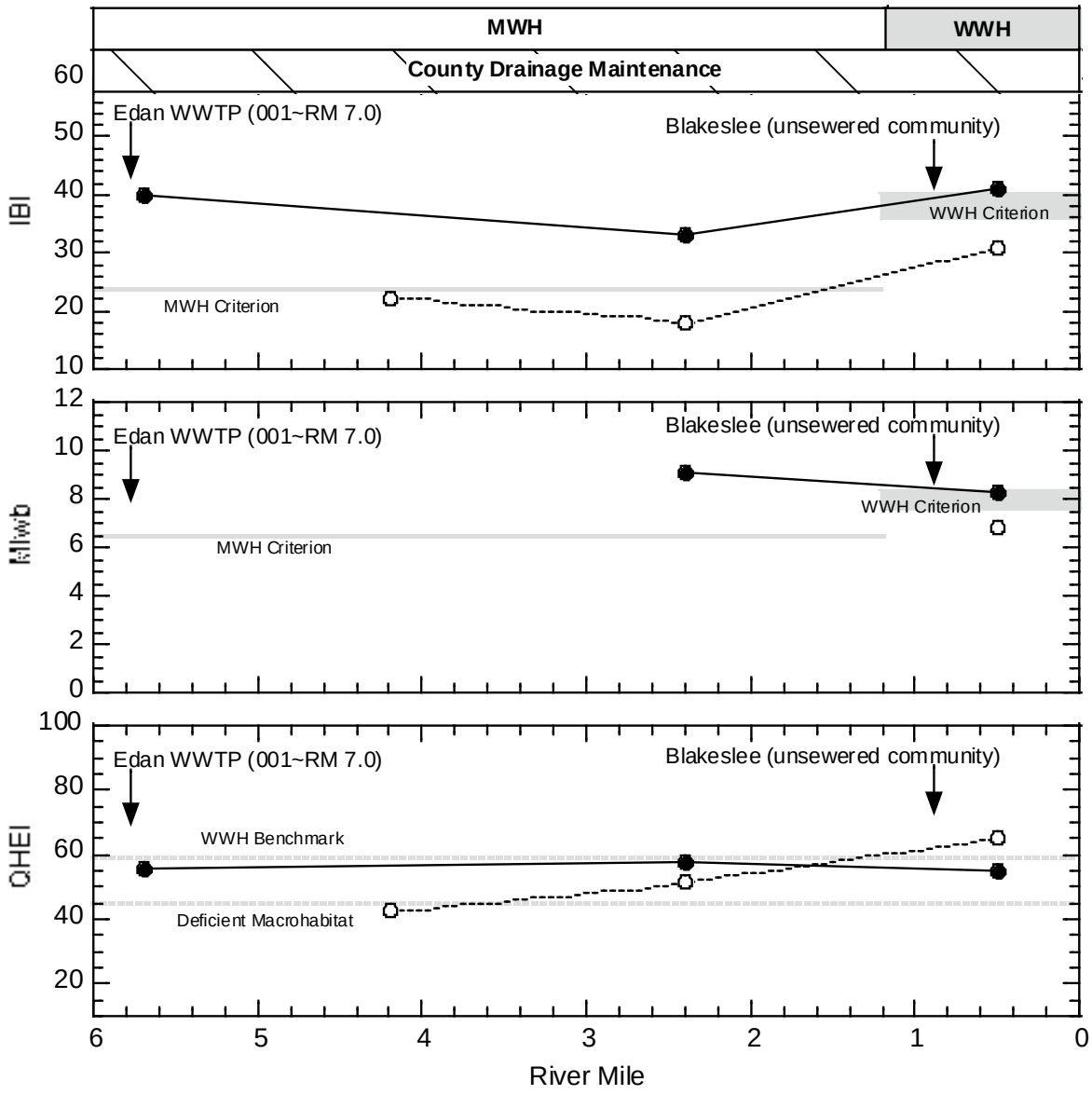

Figure 46. Longitudinal performance of the IBI, MIwb, and the QHEI, Bear Creek, 1992 and 2013. Grey-scale horizontal bars and solid lines represent the WWH biocriteria and areas of non-significant departure, and MWH biocriteria, respectively. Horizontal dashed lines indicate WWH benchmarks, and QHEI scores typical of significantly deficient or otherwise potentially limiting macrohabitat (Rankin 1989 and Rankin 1995). Arrows identify direct or diffuse points of discharge for the villages of Edon and Blakeslee, respectively. The remaining markers identify the suite of aquatic life use designations for Bear Creek (WWH and MWH). Presently, Bear Creek and its principal tributary are maintained by Williams County as open drains (Office of Williams County Engineer, pers. com. 2015). Bear Creek is contained wholly within the ECBP ecoregion (Omernik 1987, Omernik and Gallant 1988).

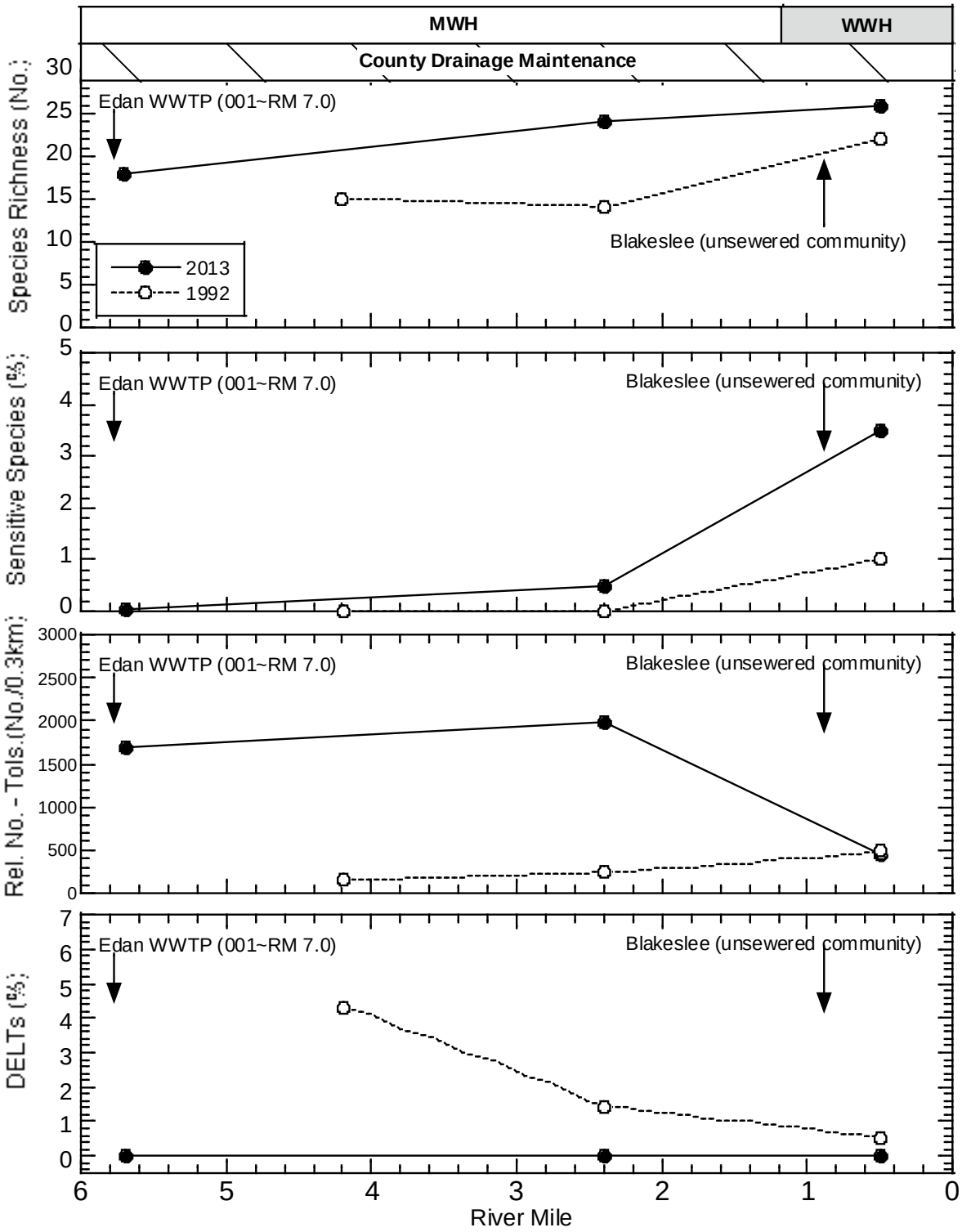

Figure 47. Longitudinal performance of the selected biometrics, Bear Creek, 1992 and 2013. Arrow identifies direct points of discharge for the major NPDES facilities on Bear Creek.

Fish Tissue Contamination

Ohio has been sampling streams annually for sport fish contamination since 1993. Fish are analyzed for contaminants that bioaccumulate in fish and that could pose a threat to human health if consumed in excessive amounts. Contaminants analyzed in Ohio sport fish include mercury, PCBs, DDT, mirex, hexachlorobenzene, lead, selenium, and several other metals and pesticides. Additional contaminants are occasionally analyzed if indicated by site-specific current or historic sources. For more information about the chemicals analyzed, how fish are collected, or the history of the fish contaminant program, see State Of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program, Ohio EPA, January 2010
(http://www.epa.state.oh.us/portals/35/fishadvisory/FishAdvisoryProcedure10.pdf).

Fish contaminant data are primarily used for three purposes: 1) to determine fish consumption advisories; 2) to determine attainment with the water quality standards; and 3) to examine trends in fish contaminants over time.

Fish consumption advisories
Fish contaminant data are used to determine a meal frequency that is safe for people to consume (e.g., two meals a week, one meal a month, do not eat), and a fish advisory is issued for applicable species and locations. Because mercury mostly comes from nonpoint sources, primarily aerial deposition, Ohio has had a statewide "one meal per week" advisory for most fish since 2001. Most fish are assumed to be safe to eat once a week unless specified otherwise in the fish advisory, which can be viewed at http://www.epa.state.oh.us/dsw/fishadvisory/index.aspx.

The minimum data requirement for issuing a fish advisory is three samples of a single species from within the past 10 years.

For the mainstem of the St. Joseph River, four species met this requirement as of 2013. Prior to 2013, the only advisory for the mainstem was a "one meal per month" advisory for channel catfish due to mercury and PCBs. The 2013 sampling confirmed the advisory due to mercury but PCB levels were below the advisory threshold and may be removed as a cause of the advisory after a confirmatory round of sampling. There was also sufficient data to assess rock bass and northern pike, both of which need a "one meal per month" advisory published due to mercury, as well as common carp, which does not need an advisory (due to mercury and PCB contamination in line with the statewide, "one meal per week" advisory).

The West Branch St. Joseph River had no previous advisories, and sufficient samples to assess common carp and catfish—both of which are in line with the statewide advisory of "one meal per week" due to mercury and PCBs.

Fish Creek had no previous advisories and enough data to assess rock bass, which should have a "one meal per month" advisory due to mercury.

Nettle Creek had no previous advisories and insufficient data to assess any species.
Nettle Lake had no previous advisories and insufficient data to assess any species.

The East Branch of the St. Joseph River and St. Joseph Lake were not sampled in 2013 and were not assessed for this summary.

For a listing of fish tissue data collected from the St. Joseph River mainstem in support of the advisory program, and how the data compare to advisory thresholds, see Appendix I.

Fish tissue/human health use attainment

In addition to determining safe meal frequencies, fish contaminant data are also used to determine attainment with the human health water quality criteria pursuant to OAC Rules 3745-1-33 and 3745-1-34. The human health water quality criteria are presented in water column concentrations of µg/Liter, and are then translated into fish tissue concentrations in mg/kg. [See Ohio's 2010 Integrated Report, Section E (http://www.epa.state.oh.us/portals/35/tmdl/2010IntReport/Section%20E.pdf) for further details of this conversion.]

In order to be considered in attainment of the Ohio Water Quality Standards, the sport fish caught within a HUC12 in the Lake Erie basin must have a weighted average concentration of the geometric means for all species below 0.35 mg/kg for mercury, and below 0.023 mg/kg for PCBs.

Within the St. Joseph River study area, fish tissue data were only adequate to determine attainment status for three of the seven HUC12s which were sampled. At least two samples from each trophic level 3 and 4 are needed for assessment. PCBs were detected in the St. Joseph River mainstem and West Branch but not in Fish Creek, Nettle Creek, or Nettle Lake. All HUCs with sufficient data for assessment were found to be impaired for PCBs, and some for mercury. These results are summarized in Table 21.

Stream	HUC12	HUC name	2014 status	Previous data current?	Cause	Sufficient data to reassess?	Changes
Mainstem	04100003 03 02	Cogswell Cemetery-St Joseph River	Impaired	No	Not given	No	NA
	04100003 03 03	Eagle Creek	Impaired	No	Not given	Yes	Impaired for PCBs
	04100003 03 05	Bear Creek	Impaired	No	Not given	Yes	Impaired for mercury and PCBs
	04100003 03 06	West Buffalo Cemetery-St Joseph River	Impaired	No	Not given	No	NA
W Branch	04100003 02 04	West Branch St Joseph River	Unimpaired	No	NA	Yes	Impaired for mercury and PCBs
Fish Creek	04100003 04 06	Cornell Ditch-Fish Creek	Insufficient data	NA	NA	No	NA
Nettle Creek	04100003 03 01	Nettle Creek	Unimpaired	No	NA	No	NA

Table 21. Existing and updated impairment status of the human health (fish contaminants) use for St. Joseph River survey watersheds.

Fish contaminant trends

Fish contaminant levels can be used as an indicator of pollution in the water column at levels lower than laboratory reporting limits for water concentrations but high enough to pose a threat to human health from eating fish. Most bioaccumulative contaminant concentrations are decreasing in the environment because of bans on certain types of chemicals like PCBs, and because of stricter permitting limits on dischargers for other chemicals. However, data show that PCBs continue to pose a risk to humans who consume fish, and mercury concentrations have been increasing in some locations because of increases in certain types of industries for which mercury is a byproduct that is released to air and/or surface water.

For this reason, it is useful to compare the results from the survey presented in this report with the results of the previous survey(s) done in the study area. Recent data can be compared against historical data to determine whether contaminant concentrations in fish tissue appear to be increasing, decreasing, or staying the same in a water body or watershed.

One major challenge in assessing fish tissue trends is the large number of factors other than time which influence contaminant uptake, including fish species, location, age, and size. This is often further complicated in that many water bodies are sampled infrequently, sample sizes are often small, and different species may be sampled in different years. The use of 3D graphs offer one way to tease apart the factors of interest, but in the case of the St. Joseph River, the data is not highly informative.

As shown in Figure 48, channel catfish PCB concentrations were high in 1995 and relatively low in 2006 and 2013, following the general trend for PCB contamination in Ohio's waters. Rock bass PCBs were similar in 1995 and 2013. Yellow bullhead, largemouth bass, and bluegill had samples taken in multiple years and PCBs were not detected in each year.

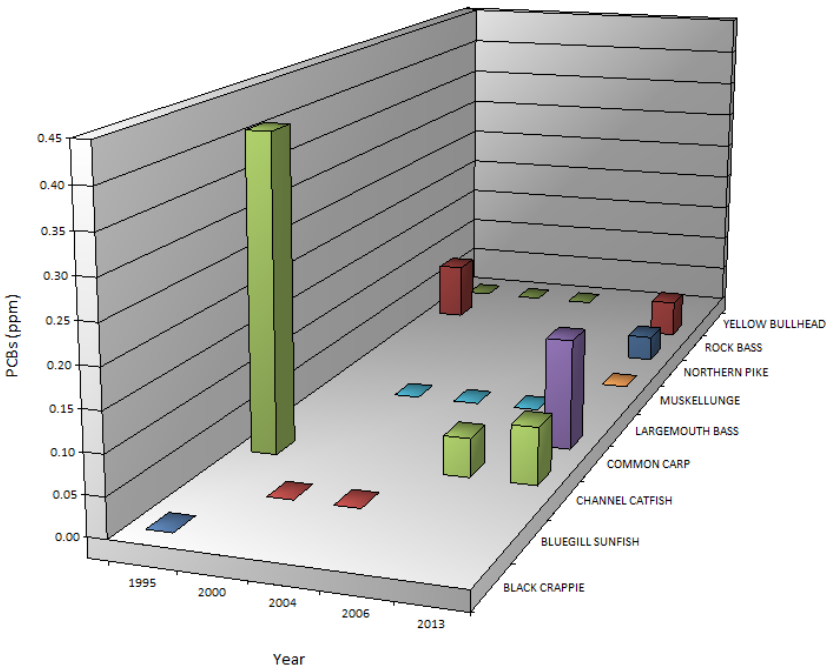

Figure 48: PCB concentrations across time by species in the St. Joseph River mainstem.

The mercury data for the St. Joseph River covers more species than the PCB data, due to the fact that mercury was assessed in 1974 across nine species while PCBs were not (Figure 49). Many of those species were never sampled upon return visits. For those species with multiple assessment years, no clear trend emerges, except that mercury concentrations give some appearance of being generally stable, with fluctuations between years (which may be highly influenced by the high inter-sample variability of mercury contamination and small sample sizes, leading to a fair degree of noise among the data points).

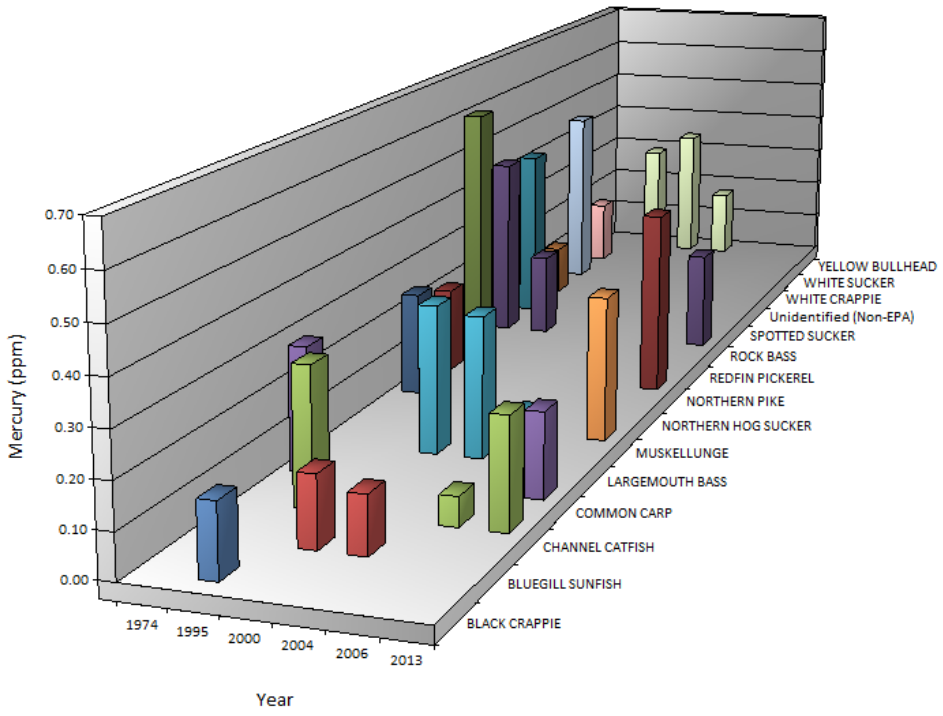

Figure 49: Mercury concentrations across time by species in the St. Joseph River mainstem.

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*Some of the references not in the report can be found in the Appendix Table E which includes Methods, Biosurvey Background Information, and Notice to Users.