Environmental Protection Agency

Biological and Water Quality Study of the Sandusky River Watershed and Muddy Creek

Crawford, Hardin, Huron, Marion, Richland, Sandusky, Seneca, and Wyandot counties

Ohio EPA Technical Report AMS/2022-SANDRV-2

Division of Surface Water

Assessment and Modeling Section

September 2025

TMDL DEVELOPMENT |

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List of Acronyms

AFO	animal feeding operation
ALU	aquatic life use
AWS	agricultural water supply
BNA	base neutralized acid
CAFO	concentrated animal feeding operation
CFR	Code of Federal regulations
cfs	cubic feet per second
cfu	colony forming units
CSO	combined sewer overflow
CW	coldwater
CWA	Clean Water Act
CWH	Coldwater Habitat
DA	drainage area
DC	direct current
DELT	deformities, erosions, lesions, tumors
DIN	dissolved inorganic nitrogen
DMR	Discharge Monitoring Report
DO	dissolved oxygen
ECBP	Eastern Corn Belt Plains
EPA	Environmental Protection Agency
EPT	ephemeroptera, plecoptera, trichoptera
ESL	ecological screening level
EWH	exceptional warmwater habitat
GHQW	general high-quality waters
GIS	geographic information system
GPS	global positioning system
HCB	hexachlorobenzene
HELP	Huron Erie Lake Plain
HHEI	headwater habitat evaluation index
HSTS	home sewage treatment system
HUC	hydrologic unit code

IBI	index of biotic integrity
ICI	invertebrate community index
IP	Interior Plateau
IPS	integrated prioritization system
IWS	industrial water supply
LEL	lowest effect level
LRAU	large river assessment unit
LRW	limited resource water
MGD	million gallons per day
MI	moderately intolerant
MIwb	Modified Index of well-being
MS4	Municipal Separate Storm System
MWH	modified warmwater habitat
MYA	million years ago
NEORSD	Northeast Ohio Regional Sewer District
NPDES	National Pollutant Discharge Elimination System
OAC	Ohio Administrative Code
ODA	Ohio Department of Agriculture
ODH	Ohio Department of Health
ODNR	Ohio Department of Natural Resources
OMZA	outside mixing zone average
OMZM	outside mixing zone minimum
ORC	Ohio Revised Code
OSW	outstanding state water
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCR	primary contact recreation
PEC	probable effects concentration
POTW	publicly owned treatment work
PTI	permit to install
PTO	permit to operate
PWS	public water supply

QHEI	Qualitative Habitat Evaluation Index
RM	river mile
RL	reporting limit
SCR	secondary contact recreation
SFFC	skin off fillet composite
SHQW	superior high-quality waters
SQGs	Sediment quality guidelines
SRV	sediment reference value
SRW	state resource water
SSH	seasonal salmonid habitat
SSO	sanitary sewer overflow
STV	statistical threshold value
SWMP	storm water management plan
TALU	tiered aquatic life use
TDS	total dissolved solids
TEC	threshold effects concentration
TKN	total Kjeldahl nitrogen
TL	trophic level
TMDL	total maximum daily load
TOC	total organic carbon
TP	total phosphorus
TSS	total suspended solids
UAA	use attainability analysis
USGS	United States Geological Survey
VOC	volatile organic compound
WAU	watershed assessment unit
WB	whole body (single fish)
WBC	whole body composite
WQS	water quality standards
WWH	warmwater habitat
WWTP	wastewater treatment plant

Executive Summary

Rivers and streams in Ohio support a variety of beneficial uses such as aquatic life, recreation, and water supply. Ohio EPA evaluates streams and rivers through a statewide, integrated monitoring program to determine appropriate beneficial use designations of these waterbodies and if current conditions are meeting the goals of the Federal Clean Water Act (33 U.S.C. §1251). In 2022, chemical, physical, and biological monitoring was conducted on 66 streams encompassing 115 sites throughout the Sandusky River and Muddy Creek watersheds using the integrated Ohio EPA assessment effort described in Appendix A. Results from seven sites in the large river portion of the Sandusky River mainstem were collected in 2021 as part of a state-wide large rivers survey and were included as part of this assessment.

All 14 locations (100%) on the Sandusky River mainstem met applicable aquatic life use (ALU) criteria during the current survey, while tributary sites were responsible for *partial* or *non-attainment* of aquatic life goals (Figure 1). Biological community quality at most Sandusky River mainstem sites was either *very good* or *exceptional* quality. Of the 99 tributary sampling stations assessed, 74 locations (75%) were in *full attainment*, 17 locations (17%) were in *partial attainment*, and eight (8%) were in *non-attainment* of applicable aquatic life use criteria.

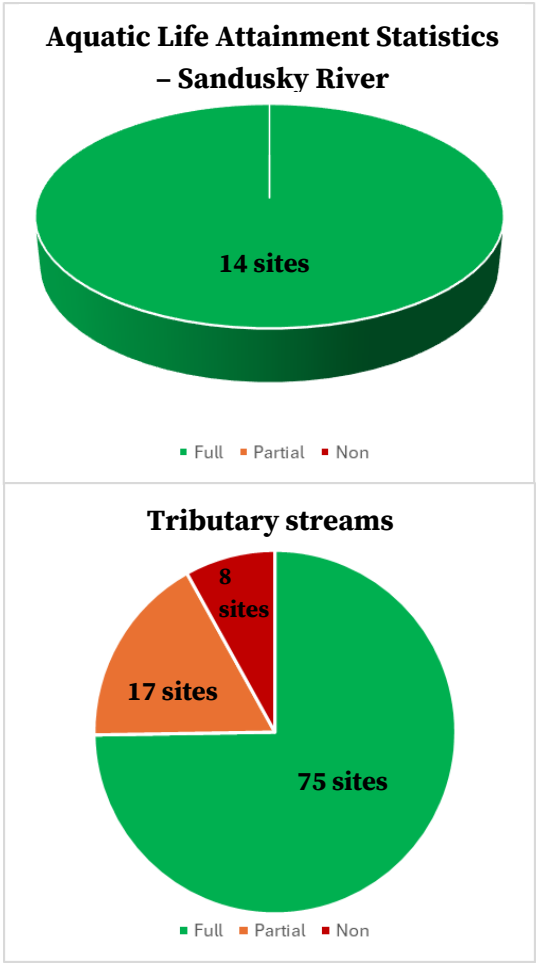


Figure 1 – Pie chart displaying the attainment status of sites for their respective aquatic life criteria from the current survey.

The current integrated water quality survey was one of several major efforts that have occurred in this watershed, though the entirety of the Sandusky River watershed had not been previously assessed comprehensively. Prior to 2022, the upper portion of the watershed was assessed in 2001, and the lower portion of the watershed in 2009. There were also numerous other smaller efforts scattered throughout the watershed since the mid-1980s. These previous Ohio EPA efforts had documented a watershed with most of its waters unable to achieve the baseline goals set forth in the Clean Water Act. Historically, the major sources of pollution included excessive siltation and nutrients from non-point sources, general habitat degradation, and negative water quality impacts point source discharges and combined sewer discharges (Ohio EPA 2003, 2011). Two Total Maximum Daily Loading plans were drafted for the upper and lower portions of the watershed to address issues identified during early water quality surveys (Ohio EPA 2004, 2014b).

The current survey documented substantial improvements compared to these historical efforts (Figure 2). Of the 113 sites sampled during the most recent survey, 102 sites had historical biological data with a prior ALU assessment. As water quality conditions in the watershed have improved over time, the number of sites in *full attainment* of the aquatic life use criteria increased from 40 sites (39%) in prior surveys to 81 sites (79%) in the 2022 assessment. There has also been a corresponding decrease in the number of sites in both partial and non-attainment since their previous assessment. The improved water quality conditions throughout the watershed can be attributed primarily to better treatment of permitted effluent and reductions in non-point source sediment and nutrient loadings related to modern tillage and agricultural soil conservation practices (Miltner 2015, Richards et. al 2009).

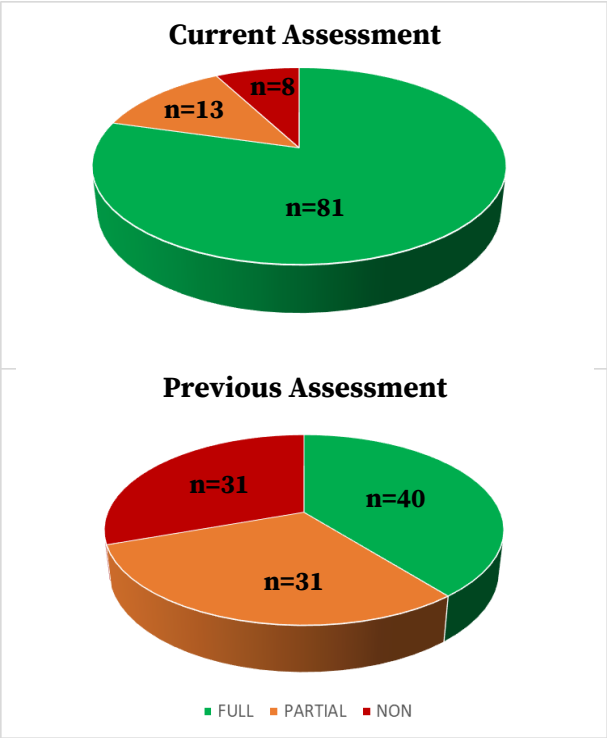


Figure 2 – Pie charts displaying the aquatic life use attainment status from sites in the current survey paired with their last full assessment (n=102).

The remaining impairments to biological communities documented during the current survey were more localized in tributary streams, including portions of the Broken Sword Creek, Little Sandusky, Tymochtee Creek, and Honey Creek sub-watersheds. There were also biological impairments in some other smaller, direct tributaries to the Sandusky River. Aquatic life impairments were related primarily to non-point source issues such as excessive siltation, flow regime alterations, and other general habitat alterations (Table 1). Several locations were also impacted by localized organic enrichment.

Unlike all other larger tributary streams, the Little Sandusky River has not shown any signs of recovery since the earliest Ohio EPA surveys. Both habitat quality and biological communities have changed little since 1995, and most index scores correspond to poor or fair quality. All sampling locations on the Little Sandusky River still failed to achieve baseline Clean Water Act goals (Table 1). Deficient instream habitat, pervasive siltation, and generally poor water quality continued to negatively impact this sub-watershed.

Aquatic life impairment related to ammonia fertilizer runoff from a local cooperative that resulted in acute ammonia toxicity and a complete fish kill were documented in Allen Run during the 2022 survey. A small dam near the mouth of Paramour Creek was limiting upstream fish passage, resulting in impaired fish communities.

Results and discussion of individual sampling collection types are discussed throughout the remaining sections of this document. An integrated discussion of all chemical, physical habitat, and aquatic life sampling results are contained in the ***Water Quality and Aquatic Life Impairment Discussion*** portion of this document.

Table 1 – Aquatic life use attainment status for stations sampled in the Sandusky River and Muddy Creek watersheds based on data collected June-October 2021-2023.

*Sites are presented by 12-digit Hydrologic Watershed Assessment Units (HUC-12s), while Table 18 lists sites and tributary streams upstream to downstream. These assessment units are consistent with those presented in the biannual **Ohio Integrated Water Quality Monitoring and Assessment Report**. The Index of Biotic Integrity (IBI), Modified Index of well-being (MIwb), and Invertebrate Community Index (ICI) are multi-metric index scores based on the performance of the biological communities. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat of the stream to support a biotic community. Portions of the survey area lie within both the Eastern Corn Belt Plains (ECBP) and the Huron Erie Lake Plains (HELP) ecoregion. If biological impairment has occurred, the cause(s) and source(s) of the impairment are noted. Sampling locations listed in the table represent the reaches evaluated with biological monitoring; chemical sampling may have occurred at an alternate sampling point for that station. All absolute sampling locations are reflected in each respective section of this document. Index scores surrounded by [brackets] indicate that samples were not collected in 2022.*

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi^2)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
04100011 03 01 (Brandywine Creek-Broken Sword Creek)												
U02G09	BROKEN SWORD CREEK @ ST. RT. 98	ECBP	WWH	29.52	10.9 [H]	44	-	G	55.00	**FULL**		
U02G07	BROKEN SWORD CREEK @ SCHWEMLEY RD.	ECBP	WWH	25.48	32.6 [W]	38[NS]	8.9	54	55.75	**FULL**		
201366	BROKEN SWORD CREEK NE OF BENTON @ ST. RT. 19/100	ECBP	WWH	19.70	42.0 [W]	34*	7.9[NS]	40	61.75	**PARTIAL**	Siltation/sedimentation	Agriculture
201372	RED RUN NEAR MOUTH @ HENRY COOPER RD.	ECBP	WWH(R)	0.42	8.0 [H]	39[NS]	-	MG[NS]	45.50	**FULL**		
302323	BRANDYWINE CREEK S OF BROKEN SWORD @ HOLMES CENTER RD.	ECBP	WWH(C)	0.45	11.1 [H]	30*	-	F*	65.00	**NON**	Siltation/sedimentation	Inappropriate waste disposal, Agriculture
											Direct habitat alterations, Flow regime alterations	Channelization
											Organic enrichment	Uknown source
04100011 03 02 (Indian Run-Broken Sword Creek)												
U02S23	BROKEN SWORD CREEK AT OCEOLA DST. U.S. RT. 30N	ECBP	WWH	12.30	69.1 [W]	46	9.8	50	75.00	**FULL**		
U02P47	BROKEN SWORD CREEK NEAR NEVADA @ CO. RD. 62	ECBP	WWH	0.87	93.3 [W]	49	9.8	54	72.75	**FULL**		
U02G12	INDIAN RUN NW OF NEVADA DST. TWP. RD. 137A	ECBP	WWH	0.75	8.5 [H]	36[NS]	-	G	53.75	**FULL**		
04100011 04 01 (Headwaters Paramour Creek-Sandusky River)												
U02P48[R]	PARAMOUR CREEK NE OF CRESTLINE @ FINNEGAN RD.	ECBP	WWH	6.15	5.1 [H]	36[NS]	-	MG[NS]	54.00	**FULL**		
U02P12	PARAMOUR CREEK DST. CRESTLINE @ NAZOR RD.	ECBP	WWH	1.50	26.0 [W]	30*	6.8*	36	58.00	**PARTIAL**	Barrier to fish passage	Dam/impoundment
U02S07[R]	TRIB. TO PARAMOUR CREEK (5.13) UPST PPG OUTFALL	ECBP	WWH	3.70	1.0 [H]	[38[NS]]	-	[MG[NS]]	[53.00]	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi^2)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
04100011 04 02 (Loss Creek-Sandusky River)												
U02P08	SANDUSKY R. NEAR LEESVILLE @ LOWER LEESVILLE RD.	ECBP	WWH	127.90	35.0 [W]	44	9.3	46	87.00	**FULL**		
U02G20	ALLEN RUN SE OF LEESVILLE DST. CRESTLINE RD.	ECBP	WWH	1.05	3.6 [H]	[27*]	-	[F*]	[59.50]	**NON**	Fish kills Total ammonia	Spills/runoff
201377	S.FK. LOSS CREEK AT MOUTH @ LOSS CREEK RD.	ECBP	WWH	0.10	6.7 [H]	42	-	G	75.25	**FULL**		
04100011 04 03 (Riley Reservoir-Sandusky River)												
U02G01	SANDUSKY R. @ LOCUST GROVE RD.	ECBP	WWH	120.70	67.2 [W]	38[NS]	9.2	56	78.25	**FULL**		
04100011 04 04 (Grass Run)												
U02G14	GRASS RUN ADJ. BUCYRUS-NEVADA RD.	ECBP	WWH(R)	8.36	9.1 [H]	38[NS]	-	G	57.00	**FULL**		
U02G13	GRASS RUN @ CRAWFORD/WYANDOT COUNTY LINE RD.	ECBP	WWH	3.42	18.3 [H]	50	-	E	77.25	**FULL**		
04100011 04 05 (Town of Wyandot-Sandusky River)												
U02P30	SANDUSKY R. DST. BUCYRUS WWTP @ KERSTETTER RD.	ECBP	WWH	110.43	88.9 [W]	50	9.1	38	83.50	**FULL**		
U02P33	SANDUSKY R. DST. BUCYRUS @ ST. RT. 231	ECBP	WWH	98.69	109.7 [W]	48	9.4	54	84.25	**FULL**		
04100011 05 01 (Prairie Run)												
U01W04	PRAIRIE RUN @ AGOSTA-MEEKER RD.	ECBP	MWH-C (R)	1.02	8.6 [H]	19*	-	F	29.50	**NON**	Siltation/sedimentation Low flows Flow regime alterations Direct habitat alterations Uknown cause	Agriculture Channelization Unknown source
04100011 05 02 (Headwaters Tymochtee Creek)												
U01W05	TYMOCHTEE CREEK SE OF MEEKER @ CRAMER RD.	ECBP	MWH-C (R)	51.43	6.4 [H]	26	-	F	42.50	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi²)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
U01G07	TYMOCHTEE CREEK AT MEEKER @ MASON RD. (CO. RD. 213A)	ECBP	WWH	49.44	16.1 [H]	34*	-	F*	49.75	**NON**	Siltation/sedimentation	Agriculture
											Direct habitat alterations	Channelization
											Flow regime alterations	
											Organic enrichment	Unsewered areas, Impacts from land application of wastes, Failing HSTS, Agriculture
04100011 05 03 (Carroll Ditch)												
U01G26	CARROLL DITCH NNW OF MEEKER @ OSBUN RD.	ECBP	MWH-C	0.66	10.3 [H]	32	-	G	37.75	**FULL**		
04100011 05 04 (Pawpaw Run)												
U01G25	PAWPAW RUN @HARDIN/MARION COUNTY LINE RD.	ECBP	WWH	6.13	8.2 [H]	38[NS]	-	G	59.50	**FULL**		
U01G24	PAWPAW RUN S OF MARSEILLES @ RUBINS RD.	ECBP	WWH	0.80	16.3 [H]	[37[NS]]	-	G	[70.90]	**FULL**		
04100011 05 05 (Pawpaw Run)												
U01G23	REEVHORN RUN 4.8 MI. W OF MARSEILLES @ CO. RD. 76	ECBP	WWH(C)	2.26	12.5 [H]	36[NS]	-	MG[NS]	61.50	**FULL**		
201432	PAWPAW RUN AT HOPEWELL CHURCH @ ST. RT. 67	ECBP	WWH(C)	1.10	5.6 [H]	32*	-	VG	36.75	**PARTIAL**	Direct habitat alterations	Channelization
											Flow regime alterations	
04100011 05 06 (Upper Little Tymochtee Creek)												
304302	L. TYMOCHTEE CREEK (UPPER) @ CO RD 205	ECBP	MWH-C	8.63	11.9 [H]	30	-	G	47.25	**FULL**		
04100011 05 07 (Lower Little Tymochtee Creek)												
U01G20	L. TYMOCHTEE CREEK (UPPER) NW OF MARSEILLES @ CO. RD. 93	ECBP	WWH	4.00	35.5 [W]	36[NS]	8.4	38	72.75	**FULL**		
04100011 05 08 (Warpole Creek)												
U01G18	WARPOLE CREEK @ TWP. RD. 58	ECBP	WWH(R)	1.52	18.8 [H]	36[NS]	-	G	56.00	**FULL**		
304296	ST. JAMES RUN NEAR MOUTH @ TWP. RD. 108	ECBP	WWH(C)	0.15	10.7 [H]	42	-	VG	58.50	**FULL**		
04100011 05 09 (Enoch Creek-Tymochtee Creek)												
U01G05	TYMOCHTEE CREEK S OF MARSEILLES @ DRY LANE RD. N.	ECBP	WWH	44.95	64.5 [W]	33*	7.3*	34[NS]	56.00	**PARTIAL**	Siltation/sedimentation	Agriculture
											Flow regime modification	Channelization
U01G04	TYMOCHTEE CREEK N OF MARSEILLES @ TWP. RD. 97	ECBP	WWH	33.99	146.2 [W]	36[NS]	8.2[NS]	48	65.00	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi²)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
U01W01	ENOCH CREEK @ DECLIFF RD, SOUTHERN MOST CROSSING	ECBP	MWH-C (R)	1.59	6.5 [H]	28	-	MG	54.50	**FULL**		
04100011 06 01 (Oak Run)												
U01G16	OAK RUN @ TWP. RD. 54	ECBP	WWH(C)	0.29	15.2 [H]	34*	-	G	64.50	**PARTIAL**	Siltation/sedimentation	Agriculture
											Flow regime alterations	Channelization
04100011 06 02 (Baughman Run-Tymochtee Creek)												
U01G03	TYMOCHTEE CREEK W OF UPPER SANDUSKY @ ST. RT. 53	ECBP	WWH	26.28	175.0 [W]	38[NS]	8.8	32[NS]	67.25	**FULL**		
U02P44	TYMOCHTEE CREEK NEAR UPPER SANDUSKY @ TWP. RD. 49	ECBP	WWH	19.45	204.3 [W]	38[NS]	8.1[NS]	42	74.00	**FULL**		
04100011 06 03 (Hart Ditch-Little Tymochtee Creek)												
U01G14	L. TYMOCHTEE CREEK (LOWER) NW OF UPPER SANDUSKY @ TWP RD 49	ECBP	MWH-C (R)	10.32	11.1 [H]	[24]	-	[F]	[39.25]	**FULL**		
U01G13	L. TYMOCHTEE CREEK (LOWER) SE OF CAREY @ ST. RT. 199	ECBP	WWH	6.33	18.5 [H]	34*	-	F*	35.75	**NON**	Siltation/sedimentation	Agriculture
											Direct habitat alterations	Channelization
											Flow regime alterations	
											Organic enrichment	Agriculture, Failing HSTS
U02P45	L. TYMOCHTEE CREEK (LOWER) NEAR CAREY @ TWP. HWY 106	ECBP	WWH	1.95	28.4 [W]	32*	6.8*	28*	58.00	**NON**	Siltation/sedimentation	Agriculture
											Direct habitat alterations	Channelization
											Flow regime alterations	
04100011 06 04 (Spring Run)												
U02P46	SPRING RUN DST. CAREY @ MOTT RD.	ECBP	WWH	1.71	16.9 [H]	38[NS]	-	G	73.00	**FULL**		
U01G10	POVERTY RUN NE OF CAREY @ POVERTY RUN RD. (TWP. RD. 11).	ECBP	WWH	2.99	9.3 [H]	40	-	VG	57.50	**FULL**		
04100011 06 05 (Mouth Tymochtee Creek)												
500850[R]	TYMOCHTEE CREEK AT CRAWFORD @ ST. RT. 199	ECBP	WWH	7.80	232.0 [W]	45	9.5	50	70.38	**FULL**		
U01G15	LICK RUN S OF CAREY @ CO. RD. 97	ECBP	WWH	0.83	7.9 [H]	40	-	G	53.25	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi^2)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
04100011 07 01 (Little Sandusky River)												
201361	L. SANDUSKY R. AT MORRAL @ GOODNOW RD.	ECBP	MWH-C (R)	10.40	6.9 [H]	22*	-	LF*	29.25	**NON**	Siltation/sedimentation	Agriculture
											Direct habitat alterations	Channelization
											Flow regime alterations	
U02G16	L. SANDUSKY R. @ WYANDOT/MARION COUNTY LINE RD.	ECBP	WWH	6.40/ 6.52	16.8 [H]	20*	-	F*	46.75	**NON**	Siltation/sedimentation	Agriculture
											Direct habitat alterations	Channelization
											Flow regime alterations	
U02W06	L. SANDUSKY R. NW OF MORRAL @ TWP. RD. 125	ECBP	WWH	3.71	21.5 [W]	26*	6.1*	34[NS]	42.5	**NON**	Siltation/sedimentation	Agriculture
											Flow regime alterations	Channelization
											Organic enrichment	Unsewered areas, Impacts from land application of wastes, Failing HSTS, Agriculture
U02W05	TRIB. TO L. SANDUSKY R. (8.93) SW OF MORRAL @ FORD	ECBP	MWH-C	0.78	5.9 [H]	32	-	F	30.75	**FULL**		
U02G18	HONEY RUN SE OF LITTLE SANDUSKY @ CO. RD. 126	ECBP	WWH	0.52	9.0 [H]	40	-	E	65.25	**FULL**		
04100011 07 02 (Town of Upper Sandusky-Sandusky River)												
U02G02	SANDUSKY R. DST. BROKEN SWORD CREEK @ CO. RD. 128	ECBP	WWH	93.76	232.2 [W]	44	9.4	54	72.00	**FULL**		
500860	SANDUSKY R. DST. UPPER SANDUSKY @ TWP. RD. 121	ECBP	WWH	78.09	295.5 [W]	42	9.9	56	75.00	**FULL**		
04100011 07 03 (Negro Run)												
U02S19	NEGRO RUN NE OF UPPER SANDUSKY @ CO. RD. 124	ECBP	WWH	0.52	13.1 [H]	50	-	VG	67.25	**FULL**		
04100011 07 04 (Rock Run)												
U02S20	ROCK RUN NE OF UPPER SANDUSKY @ TWP. RD. 122	ECBP	WWH	1.4	9.4 [H]	36[NS]	-	G	64.75	**FULL**		
04100011 07 05 (Sugar Run-Sandusky River)												
U02P38	SANDUSKY R. DST UPPER SANDUSKY @ TWP. RD. 40	ECBP	WWH	72.08	337.6 [W]	48	10.2	56	75.00	**FULL**		
201354	SUGAR RUN NEAR SMITHVILLE, UPST. ST. RT. 67, UPST. TRIB.	ECBP	WWH	0.60	4.6 [H]	40	-	MG[NS]	70.25	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi^2)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
04100011 08 01 (Brokenknife Creek)												
201405	BROKENKNIFE CREEK @ HURON/SENECA COUNTY LINE RD.	ECBP	WWH	1.05	18.6 H	38 NS	-	VG	65.50	**FULL**		
04100011 08 02 (Upper Honey Creek)												
U03G20	HONEY CREEK NW OF TIRO @ TIRO RD.	ECBP	WWH	41.66	10.4 H	38 NS	-	G	75.50	**FULL**		
U03G18 R	HONEY CREEK @ BIGHAM RD.	ECBP	WWH(R)	34.14	26.5 W	37 NS	8.4	48	47.50	**FULL**		
303862	CELERY CREEK @ WEIS RD. (RD. 84)	ECBP	MWH-C	0.45	13.4 H	36	-	LF*	33.00	**PARTIAL**	Siltation/sedimentation Direct habitat alterations Flow regime alterations	Agriculture Channelization
04100011 08 03 (Aicholz Ditch)												
U03G25	AICHOLZ DITCH E OF BLOOMVILLE @ CO. RD. 23	ECBP	MWH-C	3.72	9.4 H	32	-	F	42.25	**FULL**		
U03G24	AICHOLZ DITCH E OF BLOOMVILLE @ COOPER RD. (TWP. RD. 77)	ECBP	WWH	2.46	15.0 H	36 NS	-	MG NS	60.00	**FULL**		
04100011 08 04 (Silver Creek)												
U03G22	SILVER CREEK S OF BLOOMVILLE @ ST. RT. 19	ECBP	WWH	4.08	16.3 H	34*	-	G	45.50	**PARTIAL**	Siltation/sedimentation Direct habitat alterations Flow regime alterations	Agriculture Channelization
04100011 08 05 (Middle Honey Creek)												
U03S03	HONEY CREEK W OF ATTICA @ TWP. RD. 79	ECBP	WWH	25.03	84.4 W	36 NS	7.4*	44	61.25	**PARTIAL**	Siltation/sedimentation	Agriculture
04100011 08 06 (Lower Honey Creek)												
U03S02 R	HONEY CREEK AT MELMORE @ ST. RT. 67/100	ECBP	WWH	12.30	149.3 W	44	9.9	48	91.50	**FULL**		
500970 R	HONEY CREEK NEAR TIFFIN @ CO. RD. 19	ECBP	WWH(R)	0.20/ 1.10	179.3 W	46	9.2	58	46.75	**FULL**		
04100011 09 01 (Taylor Run)												
U03G04	TAYLOR RUN NW OF SYCAMORE @ TWP. RD. 16	ECBP	WWH	1.88	17.4 H	38 NS	-	F*	75.00	**PARTIAL**	Siltation/sedimentation Flow regime alterations	Agriculture Channelization

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi^2)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
304297	TRIB. TO TAYLOR RUN (2.49) NEAR MOUTH @ CO. RD. 37	ECBP	MWH-C	0.10	6.7 [H]	30	-	MG	61.00	**FULL**		
04100011 09 02 (Headwaters Sycamore Creek)												
U03G10	SYCAMORE CREEK E OF LYKENS @ KENNEDY RD.	ECBP	WWH(R)	18.92	18.2 [H]	40	-	G	63.25	**FULL**		
U03G13	SPRING CREEK (TRIB TO SYCAMORE CK. 12.92) @ ST. RT. 100	ECBP	WWH	1.88	8.8 [H]	40	-	MG[NS]	52.50	**FULL**		
04100011 09 03 (Greasy Run-Sycamore Creek)												
U03G08	SYCAMORE CREEK @ WYANDOT/CRAWFORD COUNTY LINE	ECBP	WWH	9.14	47.2 [W]	40	9.0	46	72.00	**FULL**		
U03P05	SYCAMORE CREEK NEAR MEXICO @ CO. RD. 37	ECBP	WWH	0.41	64.2 [W]	45	9.6	48	77.75	**FULL**		
04100011 09 04 (Thorn Run-Sandusky River)												
U03G03	THORN RUN AT MCCUTCHENVILLE @ ST. RT. 53	ECBP	WWH	0.70	9.1 [H]	34*	-	G	70.25	**PARTIAL**	Siltation/sedimentation Flow regime alterations	Agriculture Channelization
04100011 09 05 (Mile Run-Sandusky River)												
U03G14	MILE RUN N OF MEXICO @ CO. RD. 37	ECBP	WWH	0.30	6.4 [H]	40	-	E	72.25	**FULL**		
04100011 10 01 (East Branch East Branch Wolf Creek)												
U04G13	E. BR. OF EAST BRANCH WOLF CREEK @ CO. RD. 26	ECBP	WWH(C)	3.52	7.2 [H]	32*	-	MG[NS]	68.25	**PARTIAL**	Flow regime alterations Direct habitat alterations	Channelization
300682	E. BR. OF EAST BRANCH WOLF CREEK @ CO. RD. 48 (TWP. RD. 118)	ECBP	WWH(C)	1.48	19.7 [H]	44	-	52	71.50	**FULL**		
U04G14	M. BR. OF E. BR. OF EAST BRANCH WOLF CREEK @ CO. RD. 26	ECBP	WWH(C)	0.46	10.9 [H]	38	-	G	78.25	**FULL**		
04100011 10 02 (Town of New Riegel-East Branch Wolf Creek)												
300673	E. BR. WOLF CREEK @ N. TWP RD. 109	HELP	WWH(C)	19.13	20.3 [W]	34	7.8	G	56.25	**FULL**		
U04G15	E. BR. WOLF CREEK @ TWP. RD. 132	HELP	WWH(C)	13.63	33.2 [W]	42	8.6	42	73.00	**FULL**		
304299	EICHER DITCH NEAR MOUTH UPST. W. BEECH ST.	HELP	WWH(R)	0.01	9.3 [H]	34	-	MG[NS]	60.75	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi^2)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
04100011 10 03 (Snuff Creek-East Branch Wolf Creek)												
201338	E. BR. WOLF CREEK SW OF FORT SENECA @ TWP. RD. 150	HELP	WWH(C)	9.00	67.8 [W]	41	8.9	52	65.50	**FULL**		
U04P03	E. BR. WOLF CREEK NEAR BETTSVILLE @ GILMORE RD.	HELP	WWH(C)	0.86	82.0 [W]	43	10.3	E	77.75	**FULL**		
04100011 10 04 (Wolf Creek)												
201336	WOLF CREEK 0.2 MI. UPST. CO. RD. 592	HELP	WWH(C)	13.45	28.1 [W]	34	7.5	44	65.75	**FULL**		
U04S40	WOLF CREEK AT BETTSVILLE @ CEMETERY	HELP	WWH(C)	5.60	66.5 [W]	38	8.9	50	74.25	**FULL**		
U04G07	WOLF CREEK UPST. EAST BRANCH @ TOWNSHIP LINE RD.	HELP	WWH(C)	1.58	71.7 [W]	42	9.0	52	71.25	**FULL**		
U04G11	HARRISON CREEK E OF FOSTORIA @ CO. RD. 592	HELP	WWH(R)	0.38	9.1 [H]	46	-	G	44.00	**FULL**		
U04G09	PLUM RUN E OF FOSTORIA @ ST. RT. 635	HELP	WWH(R)	0.79	9.8 [H]	44	-	F*	49.25	**PARTIAL**	Siltation/sedimentation Direct habitat alterations Flow regime alterations	Agriculture Channelization
304298	TRIB. TO WOLF CREEK (8.10) @ ST. RT. 12	HELP	WWH(R)	0.17	6.7 [H]	42	-	VG	56.50	**FULL**		
04100011 11 01 (Rock Creek)												
U04G18	ROCK CREEK @ CO. RD. 43	ECBP	WWH	11.69	14.7 [H]	29*	-	MG[NS]	51.50	**PARTIAL**	Siltation/sedimentation Low streamflow Flow regime alterations	Agriculture Channelization
U04W06	ROCK CREEK AT TIFFIN @ REBECCA ST. NEAR USGS GAUGE	ECBP	WWH	0.75	34.5 [W]	44	8.4	54	73.25	**FULL**		
U04G03	EAST BRANCH ROCK CREEK @ CO. RD. 16	ECBP	WWH	0.47	6.4 [H]	36[NS]	-	F*	73.00	**PARTIAL**	Siltation/sedimentation Low streamflow Flow regime alterations	Agriculture Channelization
04100011 11 02 (Morrison Creek)												
U04G06	MORRISON CREEK NW OF REPUBLIC @ TWP. RD. 175	ECBP	MWH-C	9.34	9.3 [H]	30	-	G	54.75	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi^2)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
U04G05	MORRISON CREEK @ TWP. RD. 15	ECBP	WWH	2.05/ 2.36	16.4 [H]	32*	-	G	68.50	**PARTIAL**	Siltation/sedimentation	Agriculture
											Direct habitat alterations	Channelization, Loss of riparian habitat
											Flow regime alterations	
04100011 11 03 (Willow Creek-Sandusky River)												
U04W09	WILLOW CREEK AT TIFFIN @ MARKET ST.	ECBP	MWH-C	0.82	5.7 [H]	22*	-	F	50.00	**NON**	Siltation/sedimentation	Agriculture
												Stormwater runoff
											Flow regime alterations	Channelization
												Stormwater runoff
04100011 11 04 (Sugar Creek)												
U04Q10[R]	SUGAR CREEK NEAR TIFFIN @ TWP. RD. 76	ECBP	WWH(C)	3.20	8.6 [H]	44	-	50	75.00	**FULL**		
04100011 11 05 (Spicer Creek)												
U04Q11	SPICER CREEK N OF TIFFIN DST. CO. RD. 33	ECBP	WWH(C)	0.65	12.5 [H]	48	-	E	70.50	**FULL**		
04100011 13 01 (Muskellunge Creek)												
300674	MUSKELLUNGE CREEK @ ST. RT. 635	HELP	WWH	16.7	17.7 [H]	46	-	G	45.25	**FULL**		
201332	MUSKELLUNGE CREEK NEAR FREMONT @ SPIELDENNER RD.	HELP	WWH	5.40	35.7 [W]	42	7.9	48	63.50	**FULL**		
04100011 13 02 (Indian Creek-Sandusky River)												
500950	INDIAN CREEK S OF FREMONT @ HURDICK RD.	HELP	WWH(C)	0.62	12.0 [H]	36	-	VG	72.25	**FULL**		
04100011 13 03 (Yellow Swale-Sandusky River)												
300671	BARK CREEK @ KELLEY RD. (CR 245)	HELP	WWH	3.20	10.0 [H]	34	-	MG[NS]	47.00	**FULL**		
04100011 14 01 (Gries Ditch)												
U04Q16[R]	GRIES DITCH W OF FREMONT @ STAFF RD.	HELP	WWH	0.93	12.5 [H]	27[NS]	-	42	63.60	**FULL**		
04100011 14 02 (Town of Helena-Muddy Creek)												
201410[R]	MUDDY CREEK W OF FREMONT @ TWP. RD. 55	HELP	WWH	21.90	43.5 [W]	44	9.0	42	69.00	**FULL**		
U04S08[R]	S. BR. MUDDY CREEK @ SENECA CO. RD. 28	HELP	WWH	5.67	4.6 [H]	30	-	36	50.50	**FULL**		
300679	S. BR. MUDDY CREEK @ ANDERSON RD.	HELP	WWH	1.54	21.9 [W]	28	7.4	42	38.00	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi^2)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
04100011 14 03 (Little Muddy Creek)												
300677	L. MUDDY CREEK @ BOOKTOWN RD. (W. CO. RD. 89)	HELP	WWH	7.55	12.4 H	28	-	MG^{NS}	57.00	**FULL**		
300678	FISHING CREEK @ WEICKERT RD.	HELP	WWH	0.20	7.0 H	34	-	LF*	25.75	**PARTIAL**	Natural conditions	Natural sources – Lake Erie backwaters
04100011 14 04 (Town of Lindsey-Muddy Creek)												
U04S01	MUDDY CREEK DST. LINDSEY @ CO. RD. 153	HELP	WWH	9.79	72.8 W	40	9.2	38	53.60	**FULL**		
Sandusky River Large River Assessment Unit, Tymochtee Creek to Wolf Creek (OHLR041000119001)												
U03G01	SANDUSKY R. S OF MCCUTCHENVILLE @ CO. RD. 16	ECBP	EWH(R)	65.01	656.0 B	[52]	[9.8]	[50]	[83.00]	**FULL**		
U04S29	SANDUSKY R. NEAR MEXICO @ CO. RD. 9	ECBP	EWH(R)	57.34	760.1 B	[52]	[9.9]	[E]	[83.00]	**FULL**		
500830^{R}	SANDUSKY R. DST MEXICO @ CO. RD. 90	ECBP	EWH(R)	47.75	774.0 B	-	-	[E]	-	**-**		
500940^{R}	SANDUSKY R. UPST. TIFFIN @ U.S. RT. 224	ECBP	MWH-I	42.92	960.4 B	44	9.1	MG	50.50	**FULL**		
U04S28	SANDUSKY R. AT TIFFIN @ ELLA ST.	ECBP	EWH(R)	41.84	964.2 B	[54]	[10.5]	[E]	[84.25]	**FULL**		
500880	SANDUSKY R. DST. TIFFIN @ CO. RD. 38	ECBP	EWH(R)	36.50	1030.9 B	-	-	[E]	-	**-**		
500910^{R}	SANDUSKY R. DST TIFFIN @ ABBOTTS BRIDGE	ECBP	EWH(R)	30.85	1048.2 B	[54]	[11.4]	54	[79.00]	**FULL**		
U04Q06^{R}	SANDUSKY R. UPST. FREMONT, UPST. WOLF CREEK	HELP	EWH(R)	23.00	1072.0 B	[54]	[10.4]	[50]	[64.25]	**FULL**		
Sandusky River Large River Assessment Unit, Wolf Creek to Sandusky Bay (OHLR041000119902)												
U04S23	SANDUSKY R. AT FREMONT @ TIFFIN RD.	HELP	EWH(R)	16.80/ 18.00	1255.3 B	[46 ^{NS}]	[10.6]	44^{NS}	[84.50]	**FULL**		

a River Mile (RM) represents the sampling location of biological communities; other sampling types may be collected at an alternative location
b MIwb is not applicable to headwater streams with drainage areas ≤ 20 mi^2.
c A narrative evaluation of the qualitative sample was used when quantitative data was not available or was unable to be collected. VP=Very Poor; P=Poor, LF= Low Fair, F=Fair; MG=Marginally Good; G=Good; VG=Very Good; E=Exceptional.
d Attainment status is given for the proposed ALU designation when a change is recommended.
ns Nonsignificant departure from biocriteria (≤4 IBI or ICI units, or ≤0.5 MIwb units)

* Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range and would automatically place a site into non-attainment.
B Boat site.
H Headwater site.
W Wading site.
L Lacustary Site
R Reference Site

Integrated Water Quality Survey Overview

During 2022, Ohio EPA conducted a water quality assessment of 66 streams in the Sandusky River and Muddy Creek watersheds using integrated Ohio EPA assessment efforts described in Appendix A. This study included assessments of the biological, instream physical habitat, chemical condition, recreation (bacteriological) conditions, and fish tissue contamination. The free-flowing portion of the Sandusky River Large River Assessment Unit (LRAU) segment, extending from approximately river mile (RM) 65 through 17, was assessed in 2021 during the Statewide Large Rivers Survey at eight locations (Ohio EPA 2023a). Biological and chemical sampling also occurred at several tributary locations in 2023 based on observations from 2022.

Figure 3 – The Sandusky River and Muddy Creek watersheds in Ohio.

A total of 115 biological, 112 water chemistry, six sediment chemistry, 10 fish tissue, and 62 bacteria stations were sampled during the survey. The Sandusky watershed location in Ohio is shown in Figure 3. Sampling stations are displayed in Figure 4 and listed in Table 2. Please ***email*** us for biological, chemical or bacteria data requests.

Specific objectives of this integrated water quality survey were to:

- Ascertain the present biological conditions through the Sandusky River watershed by evaluating fish and macroinvertebrate communities
- Identify the relative levels of organic, inorganic, and nutrient parameters in the surface water and sediments
- Evaluate influences from National Pollutant Discharge Elimination System (NPDES) outfall discharges
- Assess physical habitat influences on stream biotic integrity
- Recommend beneficial use designations to undesignated streams, verify current beneficial use designations, or recommend revisions to designations where appropriate.
- Determine the attainment status of Aquatic Life Uses
- Determine recreational water quality
- Compare present results with historical conditions
- Verify and update fish tissue consumption advisories

The findings of this evaluation may factor into regulatory actions taken by Ohio EPA (for example, NPDES permits, Director's Final Findings and Orders or the Ohio Water Quality Standards – Ohio Administrative Code 3745-1) and may eventually be incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, Total Maximum Daily Loads (TMDLs), and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d] reports).

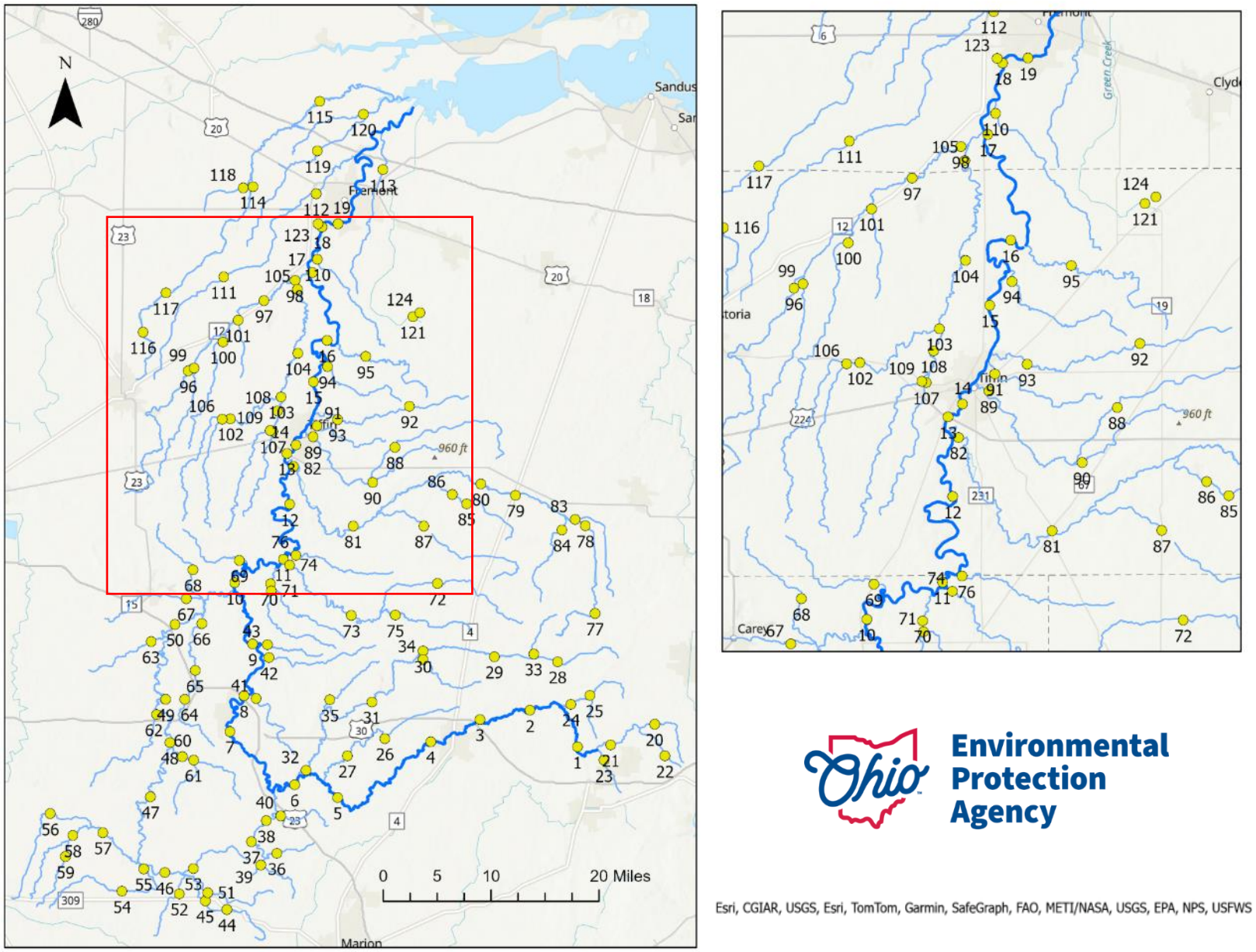


Figure 4 – Sampling locations for the 2022 Sandusky River. Site numbers correspond with Table 2.

Table 2 – Sampling table list for the 2022 survey. Sites are presented upstream to downstream, starting with the Sandusky and then proceeding through the tributaries. The river mile and drainage areas displayed correspond to the biological sampling locations; chemical sampling may have occurred nearby at an alternative sampling location point.

Site number	Station	Station Name	River Mile	Drainage area (mi^2)	HUC 12 (04100011-)	Latitude	Longitude	Sampling (refer to key below)
1	U02P08	SANDUSKY R. NEAR LEESVILLE @ LOWER LEESVILLE RD.	127.90	35.0	04 02	40.798668	-82.809296	F2, MQ, CM, B, T
2	U02G01	SANDUSKY R. @ LOCUST GROVE RD.	120.70	67.2	04 03	40.835657	-82.873006	F, MQ, CM, B
3	U02P05	SANDUSKY R. UPST BUCYRUS @ BEECHGROVE RD.	115.42	82.1	04 03	40.826459	-82.940168	DW
4	U02P30	SANDUSKY R. DST. BUCYRUS WWTP @ KERSTETTER RD.	110.43	88.9	04 03	40.803732	-83.006103	F, MQ, CM, N
5	U02P33	SANDUSKY R. DST. BUCYRUS @ ST. RT. 231	98.69	109.7	04 05	40.747145	-83.130774	F, MQ, CMO1, B, T
6	U02G02	SANDUSKY R. DST. BROKEN SWORD CREEK @ CO. RD. 128	93.76	232.2	07 02	40.760257	-83.188316	F, MQ, CM
7	U02P41	SANDUSKY R. AT UPPER SANDUSKY @ CO. RD. 55	83.47	286.8	07 02	40.814121	-83.275081	DW
8	500860	SANDUSKY R. DST. UPPER SANDUSKY @ TWP. RD. 121	78.09	295.5	07 02	40.850407	-83.256121	F, MQ, CMO1, S, B, N
9	U02P38	SANDUSKY R. DST UPPER SANDUSKY @ TWP. RD. 40	72.08	337.6	07 05	40.902923	-83.244540	F, MQ, CMO2, B, N
10	U03G01	SANDUSKY R. S OF MCCUTCHENVILLE @ CO. RD. 16	65.01	656.0	09 04	40.964819	-83.268588	2021 LRAU
11	U04S29	SANDUSKY R. NEAR MEXICO @ CO. RD. 9	57.34	760.1	09 05	40.988818	-83.203749	2021 LRAU
12	500830-R	SANDUSKY R. DST MEXICO @ CO. RD. 90	47.75	774.0	09 05	41.044255	-83.194919	2021 LRAU
13	500940-R	SANDUSKY R. UPST. TIFFIN @ U.S. RT. 224	42.91	960.0	11 03	41.095655	-83.198820	F, MQ
14	U04S28	SANDUSKY R. AT TIFFIN @ ELLA ST.	41.84	964.0	11 03	41.103955	-83.186619	2021 LRAU, DW
15	500880	SANDUSKY R. DST. TIFFIN @ CO. RD. 38	36.50	1031.0	11 05	41.167716	-83.163044	2021 LRAU
16	500910-R	SANDUSKY R. DST TIFFIN @ ABBOTTS BRIDGE	30.85	1047.0	11 05	41.209690	-83.145172	2021 LRAU

Site number	Station	Station Name	River Mile	Drainage area (mi^2)	HUC 12 (04100011-)	Latitude	Longitude	Sampling (refer to key below)
17	U04Q06-R	SANDUSKY R. UPST. FREMONT, UPST. WOLF CREEK	23.00	1073.0	11 05	41.277958	-83.164730	2021 LRAU
18	304303	SANDUSKY RIVER @ FREMONT PWS INTAKE	19.10	1253.0	13 02	41.324000	-83.152000	2021 DW
n/a	304130	SANDUSKY R. JUST UPST HISTORIC BALLVILLE DAM (FREE FLOWING)	18.10	1255.2	13 02	41.326397	-83.137597	2021 LRAU
19	U04S23	SANDUSKY R. AT FREMONT @ TIFFIN RD.	16.80/ 18.00	1255.3	13 02	41.327097	-83.130412	2021 LRAU
20	U02P48-R	PARAMOUR CREEK NE OF CRESTLINE @ FINNEGAN RD.	6.15	5.1	04 01	40.821643	-82.706237	F, MQ, CM, T
21	U02P12	PARAMOUR CREEK DST. CRESTLINE @ NAZOR RD.	1.50	26.0	04 01	40.800558	-82.764863	F2, MQ, CMO1, B, S, N
22	U02S07-R	TRIB. TO PARAMOUR CREEK (5.13) UPST. OLD PPG OUTFALL	3.70	1.0	04 01	40.789511	-82.692228	F, Mq, CM
23	U02G20	ALLEN RUN SE OF LEESVILLE @ CRESTLINE RD.	1.05	3.6	04 02	40.785057	-82.773902	F, Mq, CM, S, B
24	U02G03	LOSS CREEK NW OF LEESVILLE @ BIDDLE RD.	0.96	11.7	04 02	40.841717	-82.818239	CM
25	201377	S.FK. LOSS CREEK AT MOUTH @ LOSS CREEK RD.	0.10	6.7	04 02	40.850796	-82.792609	F, Mq, CM
26	U02G14	GRASS RUN ADJ. BUCYRUS-NEVADA RD.	8.36	9.1	04 04	40.807091	-83.067388	F, Mq, CM
27	U02G13	GRASS RUN @ CRAWFORD/WYANDOT COUNTY LINE RD.	3.42	18.3	04 04	40.789557	-83.117814	F, Mq, CM, B
28	U02G09	BROKEN SWORD CREEK @ ST. RT. 98	29.52	10.9	03 01	40.884857	-82.836005	F, Mq, CM
29	U02G07	BROKEN SWORD CREEK @ SCHWEMLEY RD.	25.48	32.6	03 01	40.890157	-82.921008	F2, MQ, CM, N
30	201366	BROKEN SWORD CREEK NE OF BENTON @ ST. RT. 19/100	19.70	42.0	03 01	40.895857	-83.016611	F2, MQ, CM, B, T, N
31	U02S23	BROKEN SWORD CREEK AT OCEOLA DST. U.S. RT. 30N	12.30	69.1	03 02	40.844180	-83.085034	F2, MQ, CM, FCA, N
32	U02P47	BROKEN SWORD CREEK NEAR NEVADA @ CO. RD. 62	0.87	93.3	03 02	40.774844	-83.173040	F2, MQ, CMO2, B, FCA, N
33	201372	RED RUN NEAR MOUTH @ HENRY COOPER RD.	0.42	8.0	03 01	40.892857	-82.868206	F2, Mq, CM, T

Site number	Station	Station Name	River Mile	Drainage area (mi^2)	HUC 12 (04100011-)	Latitude	Longitude	Sampling (refer to key below)
34	302323	BRANDYWINE CREEK S OF BROKEN SWORD @ HOLMES CENTER RD.	0.45	11.1	03 01	40.887126	-83.016639	F, Mq, CM, N
35	U02G12	INDIAN RUN NW OF NEVADA @ TWP. RD. 137A	0.75	8.5	03 02	40.846351	-83.141082	F, Mq, CM
36	201361	L. SANDUSKY R. AT MORRAL @ GOODNOW RD.	10.40	6.9	07 01	40.690643	-83.212318	F, Mq, CM
37	U02G16	L. SANDUSKY R. @ WYANDOT/MARION COUNTY LINE RD.	6.40/ 6.52	16.8	06 01	40.702257	-83.246418	F, Mq, CM
38	U02W06	L. SANDUSKY R. NW OF MORRAL @ TWP. RD. 125	3.71	21.5	06 05	40.723727	-83.226388	F, MQ, CMO2, B, N
39	U02W05	TRIB. TO L. SANDUSKY R. (8.93) SW OF MORRAL @ FORD	0.78	5.9	07 01	40.678519	-83.233729	F, Mq, CM
40	U02G18	HONEY RUN SE OF LITTLE SANDUSKY @ CO. RD. 126	0.52	9.0	07 01	40.728653	-83.207131	F, Mq, CM, B
41	U02S20	ROCK RUN NE OF UPPER SANDUSKY @ TWP. RD. 122	1.40	9.4	07 03	40.847489	-83.240328	F, Mq, CM, B
42	U02S19	NEGRO RUN NE OF UPPER SANDUSKY @ CO. RD. 124	0.52	13.1	05 03	40.889027	-83.222687	F, Mq, CM, B, T
43	201354	SUGAR RUN NEAR SMITHVILLE, UPST. ST. RT. 67, UPST. TRIB.	0.60	4.6	07 05	40.902256	-83.224919	F, Mq, CM
44	U01W05	TYMOCHTEE CREEK SE OF MEEKER @ CRAMER RD.	51.43	6.4	05 02	40.633490	-83.279040	F, Mq, CM
45	U01G07	TYMOCHTEE CREEK AT MEEKER @ MASON RD. (CO. RD. 213A)	49.44	16.1	05 02	40.642132	-83.308261	F, Mq, CM, B, T, N
46	U01G05	TYMOCHTEE CREEK S OF MARSEILLES @ DRY LANE RD. N.	44.95	64.5	05 09	40.670995	-83.362172	F2, MQ, CM, B, N
47	U01G04	TYMOCHTEE CREEK N OF MARSEILLES @ TWP. RD. 97	33.99	146.2	05 09	40.747920	-83.381612	F, MQ, CM, B

Site number	Station	Station Name	River Mile	Drainage area (mi^2)	HUC 12 (04100011-)	Latitude	Longitude	Sampling (refer to key below)
48	U01G03	TYMOCHTEE CREEK W OF UPPER SANDUSKY @ ST. RT. 53	26.28	175.0	06 02	40.802924	-83.355781	F, MQ, CM, S
49	U02P44	TYMOCHTEE CREEK NEAR UPPER SANDUSKY @ TWP. RD. 49	19.45	204.3	06 02	40.846770	-83.361215	F, MQ, CM, B, N
50	500850-R	TYMOCHTEE CREEK AT CRAWFORD @ ST. RT. 199	7.80	232.0	06 05	40.922800	-83.348900	F2, MQ, CMO2, B, N
51	U01W04	PRAIRIE RUN @ AGOSTA-MEEKER RD.	1.02	8.6	05 01	40.650617	-83.304871	F2, Mq, CM, B
52	U01W01	ENOCH CREEK @ DECLIFF RD, SOUTHERN MOST CROSSING	1.59	6.5	05 09	40.649452	-83.342929	F, Mq, CM
53	U01G26	CARROLL DITCH NNW OF MEEKER @ OSBUN RD.	0.66	10.3	05 03	40.675286	-83.324103	F, Mq, CM, B
54	U01G25	PAWPAW RUN @HARDIN/MARION COUNTY LINE RD.	6.13	8.2	05 04	40.651971	-83.419688	F, Mq, CM, N
55	U01G24	PAWPAW RUN S OF MARSEILLES @ RUBINS RD.	0.80	16.3	05 04	40.674756	-83.390722	F2, Mq, CM, B
56	304302	L. TYMOCTHEE CREEK (UPPER) @ CO. RD. 205	8.63	11.9	05 06	40.730785	-83.515949	F2, Mq, CM, B, T
57	U01G20	L. TYMOCHTEE CREEK (UPPER) NW OF MARSEILLES @ CO. RD. 93	4.00	35.5	05 07	40.711593	-83.445240	F2, MQ, CM, B, N
58	U01G23	REEVHORN RUN 4.8 MI. W OF MARSEILLES @ CO. RD. 76	2.26	12.5	05 05	40.708755	-83.485725	F, Mq, CM, B
59	201432	PAWPAW RUN AT HOPEWELL CHURCH @ ST. RT. 67	1.10	5.6	05 05	40.687217	-83.495477	F, Mq, CM
60	U01G18	WARPOLE CREEK @ TWP. RD. 58	1.52	18.8	05 08	40.788587	-83.338610	F, Mq, CM, B
61	304296	ST. JAMES RUN NEAR MOUTH @ TWP. RD. 108	0.15	10.7	05 08	40.785260	-83.323690	F, Mq, CM
62	U01G16	OAK RUN @ TWP. RD. 54	0.29	15.2	06 01	40.831556	-83.373123	F, Mq, CM, B
63	U01G15	LICK RUN S OF CAREY @ CO. RD. 97	0.83	7.9	06 05	40.905355	-83.380923	F, Mq, CM
64	U01G14	L. TYMOCHTEE CREEK (LOWER) NW OF UPPER SANDUSKY @ TWP RD 49	10.32	11.1	06 03	40.847040	-83.335481	F, Mq, CM
65	U01G13	L. TYMOCHTEE CREEK (LOWER) SE OF CAREY @ ST. RT. 199	6.33	18.5	06 03	40.875956	-83.321822	F, Mq, CM, N

Site number	Station	Station Name	River Mile	Drainage area (mi^2)	HUC 12 (04100011-)	Latitude	Longitude	Sampling (refer to key below)
66	U02P45	L. TYMOCHTEE CREEK (LOWER) NEAR CAREY @ TWP. HWY 106	1.95	28.4	06 03	40.923705	-83.312760	F, MQ, CM, B, N
67	U02P46	SPRING RUN DST. CAREY @ MOTT RD.	1.71	16.9	06 04	40.948746	-83.333708	F, Mq, CM, B, S, N
68	U01G10	POVERTY RUN NE OF CAREY @ POVERTY RUN RD. (TWP. RD. 11).	2.99	9.3	06 04	40.978042	-83.324677	F, Mq, CM
69	U03G03	THORN RUN AT MCCUTCHENVILLE @ ST. RT. 53	0.70	9.1	08 04	40.987496	-83.262403	F, Mq, CM, B
70	U03G04	TAYLOR RUN NW OF SYCAMORE @ TWP. RD. 16	1.88	17.4	09 01	40.963856	-83.220819	F, Mq, CM, B
71	304297	TRIB. TO TAYLOR RUN (2.49) NEAR MOUTH @ CO. RD. 37	0.10	6.7	09 01	40.956638	-83.219906	F, Mq, CM
72	U03G10	SYCAMORE CREEK E OF LYKENS @ KENNEDY RD.	18.92	18.2	09 02	40.964256	-82.997211	F, Mq, CM, B, T
73	U03G08	SYCAMORE CREEK @ WYANDOT/CRAWFORD COUNTY LINE	9.14	47.2	09 03	40.931756	-83.112315	F2, MQ, CM, T FCA
74	U03P05	SYCAMORE CREEK NEAR MEXICO @ CO. RD. 37	0.41	64.1	09 03	40.982877	-83.195375	F2, MQ, CM, B, FCA, N
75	U03G13	SPRING CREEK (TRIB TO SYCAMORE CK, 12.92) @ ST. RT. 100	1.88	8.8	09 02	40.932057	-83.053513	F, Mq, CM, T
76	U03G14	MILE RUN N OF MEXICO @ CO. RD. 37	0.30	6.4	09 05	40.992701	-83.186760	F, Mq, CM
77	U03G20	HONEY CREEK NW OF TIRO @ TIRO RD.	41.66	10.4	08 02	40.933963	-82.786008	F, Mq, CM
78	U03G18-R	HONEY CREEK @ BIGHAM RD.	34.14	26.5	08 02	41.022556	-82.798904	F2, MQ, CM, B, T
79	U03P03	HONEY CREEK NEAR ATTICA @ ST. RT. 4	28.32	74.0	08 05	41.053356	-82.892408	DW
80	U03S03	HONEY CREEK W OF ATTICA @ TWP. RD. 79	25.03	84.4	08 05	41.064848	-82.938911	F2, MQ, CM, B, FCA, N, T
81	U03S02-R	HONEY CREEK AT MELMORE @ ST. RT. 67/100	12.30	149.3	08 06	41.022200	-83.109700	F2, MQ, CM, FCA, N
82	500970- R	HONEY CREEK NEAR TIFFIN @ CO. RD. 19	0.20/ 1.10	179.3	08 06	41.082465	-83.189785	F, MQ, CMO2, B, FCA

Site number	Station	Station Name	River Mile	Drainage area (mi²)	HUC 12 (04100011-)	Latitude	Longitude	Sampling (refer to key below)
83	303862	CELERY CREEK @ WEIS RD. (RD. 84)	0.45	13.4	08 02	41.028874	-82.812726	F, Mq, CM, T, N
84	201405	BROKENKNIFE CREEK @ HURON/SENECA COUNTY LINE RD.	1.05	18.6	08 01	41.018289	-82.830271	F, Mq, CM, B
85	U03G25	AICHOLZ DITCH E OF BLOOMVILLE @ CO. RD. 23	3.72	9.4	08 03	41.044813	-82.957944	F, Mq, CM, T
86	U03G24	AICHOLZ DITCH E OF BLOOMVILLE @ COOPER RD. (TWP. RD. 77)	2.46	15.0	08 03	41.053956	-82.977111	F2, Mq, CM, B
87	U03G22	SILVER CREEK S OF BLOOMVILLE @ ST. RT. 19	4.08	16.3	08 04	41.022256	-83.015513	F, Mq, CM, B
88	U04G18	ROCK CREEK @ CO. RD. 43	11.69	14.7	11 01	41.101786	-83.053908	F2, Mq, CM, T, N
89	U04W06	ROCK CREEK AT TIFFIN @ REBECCA ST. NEAR USGS GAUGE	0.75	34.5	11 01	41.112355	-83.163819	F, MQ, CM, B, T, N
90	U04G03	EAST BRANCH ROCK CREEK @ CO. RD. 16	0.47	6.4	11 01	41.066155	-83.084015	F, Mq, CM
91	U04W09	WILLOW CREEK AT TIFFIN @ MARKET ST.	0.82	5.7	11 03	41.123555	-83.158719	F, Mq, CM
92	U04G06	MORRISON CREEK NW OF REPUBLIC @ TWP. RD. 175	9.34	9.3	11 02	41.143155	-83.034515	F, Mq, CM, T
93	U04G05	MORRISON CREEK @ TWP. RD. 15	2.05/ 2.36	16.6	11 02	41.129668	-83.130987	F, Mq, CM, B, N
94	U04Q11	SPICER CREEK N OF TIFFIN @ CO. RD. 33	0.65	12.5	11 04	41.183240	-83.144207	F, Mq, CM, B, T
95	U04Q10-R	SUGAR CREEK NEAR TIFFIN @ TWP. RD. 76	3.20	8.6	10 04	41.193367	-83.093178	F, MQ, CM, B, T
96	201336	WOLF CREEK 0.2 MI. UPST. CO. RD. 592	13.45	28.1	10 04	41.178789	-83.330942	F, MQ, CM, N
97	U04S40	WOLF CREEK AT BETTSVILLE @ ST. RT. 12	5.60	65.3	10 04	41.249753	-83.229622	F, MQ, CM, B, S, N
98	U04G07	WOLF CREEK UPST. EAST BRANCH @ TOWNSHIP LINE RD.	1.58	71.7	10 04	41.270100	-83.188000	F, MQ, CMO2
99	U04G11	HARRISON CREEK E OF FOSTORIA @ CO. RD. 592	0.38	9.1	10 04	41.181529	-83.323391	F, Mq, CM
100	U04G09	PLUM RUN E OF FOSTORIA @ ST. RT. 635	0.79	9.8	10 04	41.208139	-83.284383	F, Mq, CM
101	304298	TRIB. TO WOLF CREEK (8.10) @ ST. RT. 12	0.17	6.7	10 04	41.230050	-83.264380	F, Mq, CM
102	300673	E. BR. WOLF CREEK @ N. TWP. RD. 109	19.13	20.3	10 02	41.130721	-83.274457	F, Mq, CM

Site number	Station	Station Name	River Mile	Drainage area (mi²)	HUC 12 (04100011-)	Latitude	Longitude	Sampling (refer to key below)
103	U04G15	E. BR. WOLF CREEK @ TWP. RD. 132	13.63	33.2	10 02	41.152700	-83.206400	F, MQ, CM, B
104	201338	E. BR. WOLF CREEK SW OF FORT SENECA @ TWP. RD. 150	9.00	67.8	10 03	41.196636	-83.183972	F2, MQ, CM, N
105	U04P03	E. BR. WOLF CREEK NEAR BETTSVILLE @ GILMORE RD.	0.86	82.0	10 03	41.261241	-83.184548	F2, MQ, CM, B, FCA
106	304299	EICHER DITCH NEAR MOUTH UPST. W. BEECH ST.	0.01	9.3	10 02	41.130112	-83.285796	F, Mq, CM
107	U04G13	E. BR. OF EAST BRANCH WOLF CREEK @ CO. RD. 26	3.52	7.2	10 01	41.117800	-83.217800	F, Mq, CM, N
108	300682	E. BR. OF EAST BRANCH WOLF CREEK @ CO. RD. 48 (TWP. RD. 118)	1.48	19.7	10 01	41.138267	-83.211215	F, MQ, CM, B, N
109	U04G14	M. BR. OF E. BR. OF EAST BRANCH WOLF CREEK @ CO. RD. 26	0.46	10.9	10 01	41.118543	-83.221431	F, Mq, CM
110	500950	INDIAN CREEK S OF FREMONT @ HURDICK RD.	0.62	12.0	13 02	41.291453	-83.158220	F, Mq, CM, B
111	300674	MUSKELLUNGE CREEK @ ST. RT. 635	16.70	17.7	13 01	41.273735	-83.283380	F, Mq, CM, N
112	201332	MUSKELLUNGE CREEK NEAR FREMONT @ SPIELDENNER RD.	5.40	35.7	13 01	41.357110	-83.159772	F, Mq, CM, B
113	300671	BARK CREEK @ KELLEY RD. (CR 245)	3.20	10.0	13 03	41.381388	-83.070230	F, Mq, CM, B, N
114	201410-R	MUDDY CREEK W OF FREMONT, DST. TWP. RD. 55	21.9	43.5	14 02	41.364423	-83.244500	F2, MQ, CM, B, T, FCA, N
115	U04S01	MUDDY CREEK DST. LINDSEY @ CO. RD. 153	9.79	72.8	14 04	41.450252	-83.154949	F2, MQ, CM, B, FCA, S
116	U04S08-R	S. BR. MUDDY CREEK @ SENECA CO. RD. 28	5.67	4.6	14 02	41.217925	-83.391690	F, MQ, CM
117	300679	S. BR. MUDDY CREEK @ ANDERSON RD.	1.54	21.9	14 02	41.257520	-83.361055	F, MQ, CM
118	U04Q16-R	GRIES DITCH W OF FREMONT @ STAFF RD.	0.90	12.5	14 01	41.363126	-83.257408	F2, MQ, CM, B, T
119	300677	L. MUDDY CREEK @ BOOKTOWN RD. (W. CO. RD. 89)	7.55	12.4	14 03	41.400314	-83.157824	F2, Mq, CM, B, N

Site number	Station	Station Name	River Mile	Drainage area (mi^2)	HUC 12 (04100011-)	Latitude	Longitude	Sampling (refer to key below)
120	300678	FISHING CREEK @ WEICKERT RD.	0.20	7.0	14 03	41.437347	-83.096631	F, Mq, CM, B, N
121	304305	BEAVER CREEK @ INTAKE, Adj Twp Rd 180	2.80	44.2	12 02	41.233502	-83.030085	DW
123	303353	Fremont Reservoir at L-1	---	---	13 01	41.326944	-83.156944	IL
124	U04K02	Beaver Creek Reservoir (Clyde)	---	---	12 03	41.237700	-83.020700	IL

Acronym Key - Sampling Types	
F or F2	Fish sampling (one or two sampling events) & habitat sampling
Mq	Qualitative macroinvertebrate sampling
MQ	Quantitative macroinvertebrate sampling
CM	Inorganic water chemistry with metals
B	Bacteria
CM	Chemistry metals + organics (O1 or O2 as below)
O1	Organics (sVOCs)
O2	Organics (Herbicides/Insecticides)
DW	Drinking water
S	Sediment
N	Nutrient (Sonde deployment and chlorophyll samples)
IL	Inland Lake Sampling
FCA	Fish Tissue (Fish Consumption Advisory samples)
T	Continuous temperature dataloggers
2021 LRAU	Sites sampled during 2021 Large River Assessment Unit survey. Sites will not be visited in 2022 unless otherwise noted.

Study Area Description

Introduction

The Sandusky River watershed encompasses over 1400 mi^2 and is one of the principal tributaries to Lake Erie. The Sandusky River below Tymochtee Creek drains more than 500 mi^2, the threshold for a Large River status in Ohio. The Sandusky River watershed begins near Crestline, OH, flowing west through Crawford County, before turning north in Wyandot County, draining much of Seneca and Sandusky Counties. The watershed ultimately empties to Sandusky Bay and through to Lake Erie (Figure 4). The watershed primarily drains Seneca (28.5% of county), Wyandot (20.0%), Sandusky (17.4%), and Crawford (16.6%) counties.

The entirety of the Sandusky River and Sandusky Bay watersheds (the Sandusky Hydrological Unit 04100011) drains approximately 1,165,000 acres, or 1,820 square miles. The Sandusky River at the most downstream site sampled at RM 17.70 (U04S23) drains 1,255 square miles, or about 69% of the entire hydrologic unit. The Sandusky River and Muddy Creek, along with Green Creek are the principal tributaries that comprise the Sandusky Bay. The sub-watershed "North Side Sandusky Bay Frontal" is a HUC-12 that that runs along the north side of Sandusky Bay that did not have any stream sampling sites located in it. This HUC-12 lacks any sizable enough streams that are not influenced by Sandusky Bay. Green Creek and Sandusky Bay tributaries to the east of the Sandusky River were evaluated during a separate project in 2023 (Ohio EPA 2023).

Principal tributaries to the Sandusky River, listed upstream to downstream, include Broken Sword Creek (93 mi^2), the Little Sandusky River (35 mi^2), Tymochtee Creek (304 mi^2), Sycamore Creek (64 mi^2), Honey Creek (179 mi^2), Rock Creek (34 mi^2), and Wolf Creek (156 mi^2). Paramour Creek is the functional extension of the Sandusky River upstream, draining about 28 mi^2 at its "confluence" with the Sandusky River. Nominally, the Sandusky River is formed from the confluence of Paramour Creek and Allen Run near RM 127.90 (Figure 4).

Previous comprehensive Ohio EPA sampling efforts in the watershed included a 2001 effort focused on the upper portions of the Sandusky River watershed upstream from the confluence of Wolf Creek (Ohio EPA 2003) and a 2009 effort focused on the lower Sandusky watershed and Sandusky Bay tributaries (Ohio EPA 2011). There were also smaller, targeted efforts throughout the basin, including: a small 1985 effort through the Paramour Creek sub-watershed; a 1990 survey encompassing most of the mainstem and the lower reaches of

Table 3 – Watershed drainage by county, Sandusky River and Bay watershed.

County	Percent of County in Sandusky watershed	Percent of Sandusky watershed in county
Crawford	75.2%	16.6%
Erie	44.6%	6.3%
Hancock	0.3%	0.1%
Hardin	9.4%	2.4%
Huron	5.0%	1.4%
Marion	19.8%	4.4%
Ottawa	10.7%	1.6%
Richland	3.5%	0.9%
Sandusky	76.6%	17.4%
Seneca	93.9%	28.5%
Wood	1.1%	0.4%
Wyandot	89.1%	20.0%

three tributaries (Ohio EPA 1991); extensive sampling through the Tymochtee basin in 1995 related to an enforcement case; a targeted survey through the Sycamore Creek basin in 1999 & 2000 related to a large tire fire (Ohio EPA 2000); and sampling through the upper Broken Sword and uppermost Sandusky watershed through the 2010s related to Great Lakes water quality restoration funding (Ohio EPA 2012 and 2022). Sporadic biological and chemistry sampling has also occurred beginning in the 1980s at reference sites, monthly ambient chemistry stations, and other areas through the watershed. This study area also has two existing TMDLs – one for the upper portion of the watershed (Ohio EPA 2004) and another for the lower (Ohio EPA 2014b).

Geology and Glacial History

Ohio was largely covered by a shallow tropical sea during the Ordovician (488–443 mya), Silurian (443–416 mya), and Devonian (416–359 mya) Periods, making it home to reef forming corals and other similar organisms. Bedrock limestone across most of the watershed dates to the latter two of these Periods. In the late Devonian, continents collided east of Ohio, resulting in the formation of the ancestral Appalachian Mountains. This mountain building event caused Eastern Ohio to drop, resulting in a deepening of the sea, bringing about an end to limestone deposition by these coral communities. Erosional forces on the mountains began to fill the sea, and by the close of the Devonian period, dry land had spread from the mountains across much of Ohio. Brief incursions of shallow seas during the Mississippian Period (359-321 mya) provided the only other limestone depositional period in the basin, in what is today, Crawford County. During the later Permian, Triassic, Jurassic, Cretaceous, and Tertiary Periods (251-2.6 mya) Ohio transitioned from a place of deposition to one of erosion. No locally formed rocks from these periods have been found in Ohio. During the Pleistocene Epoch beginning 2.6 mya, massive glaciers of ice made their way down from present day Canada, transforming the land and depositing glacial till (ODNR 2023a).

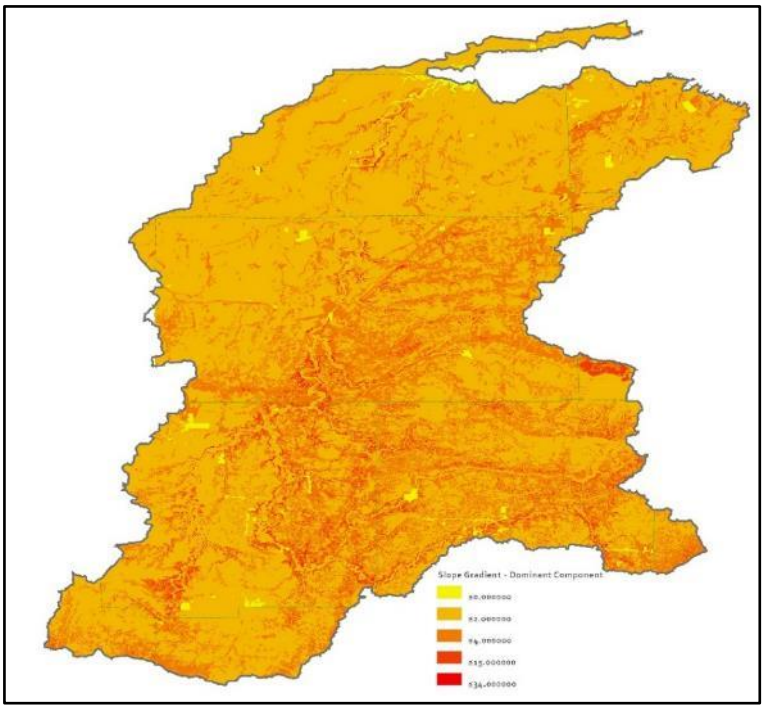


Figure 5 – Slope gradient, dominant component, Sandusky River & Bay Watershed

Two types of moraines, ground moraines and end moraines, are the primary landforms found at the surface today. Ground moraines are composed of glacial till deposited beneath a glacier and are well preserved in western central Ohio, where the underlying bedrock and pre-glacial landscape was relatively flat. End moraines are looping ridges composed of complex deposits of till, sand, and gravel in places where glaciers stopped moving across the landscape but continued to internally move sediment in front of the glacier (ODNR 2023b). Areas around these glacial end moraines are generally higher gradient (Figure 5). The Wabash, Fort

Wayne, Defiance, a small portion of the Mississinewa end moraines, and interspersed ground moraines are the predominant landscape features that form the upper Sandusky watershed (Figure 6). The upper Sandusky River, Broken Sword Creek, Honey Creek, and other smaller tributaries joining from the east are all formed around these features.

The lower Sandusky watershed is influenced by precursors to current-day Lake Erie and consists primarily of lake-planned tills and lacustrine silt/clay, with beach ridges dotted along what were once former shorelines of a receding lakebed (Figure 6). While not within the former Great Black Swamp, the Muddy Creek sub-watershed does border this area, and streams here are often very similar to those further west. Though some of these areas in the lower watershed have exposed bedrock, many are lower gradient and consist of finer grained sediments.

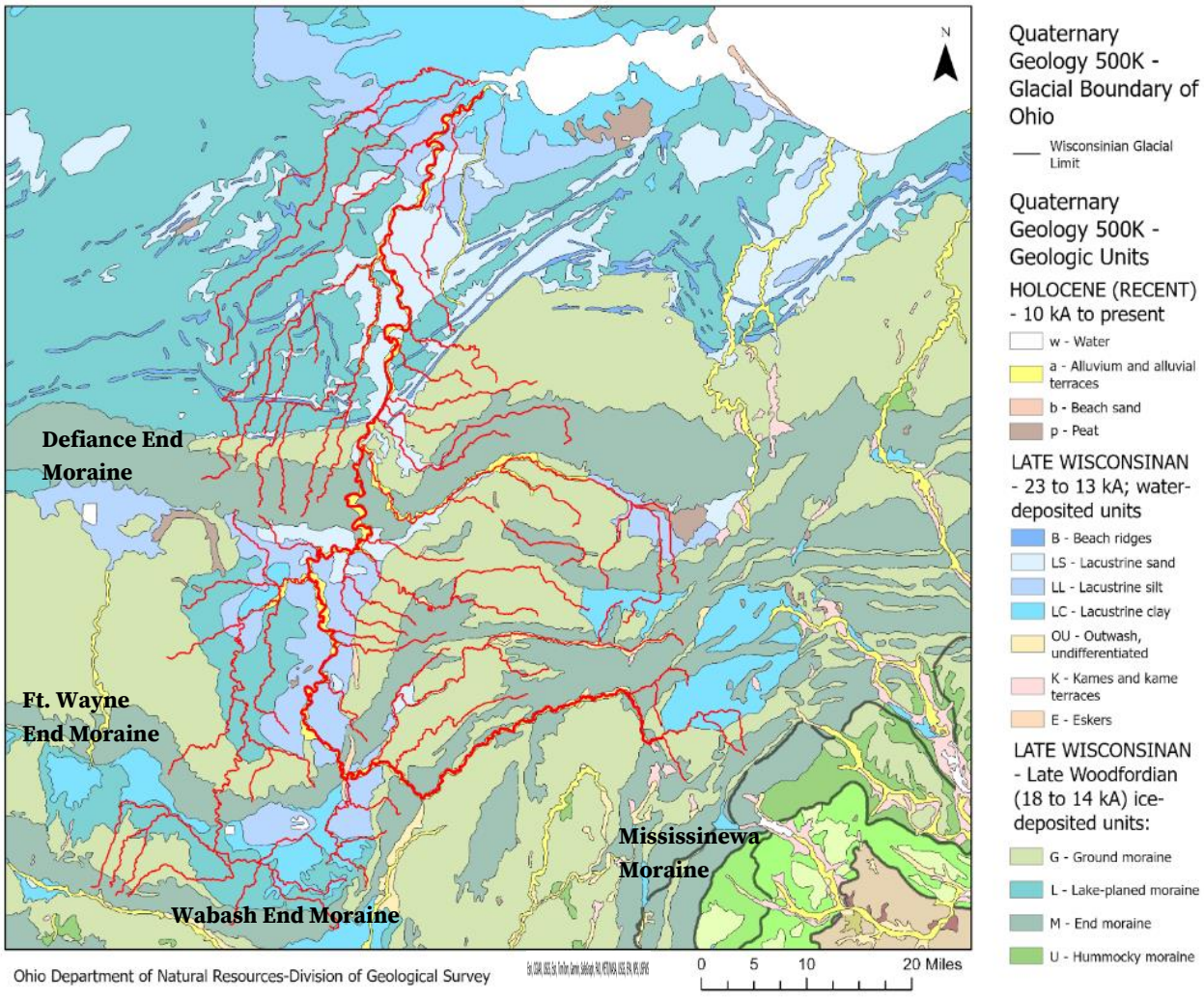


Figure 6 – Quaternary glacial geology of northwest Ohio. Streams sampled during the survey are pictured in red for contrast. The legend only contains an abbreviated list of all types relevant for the study area.

Portions of several tributary streams in the upper watershed are situated near a glacial end moraine but drain proglacial lakes and former wetlands (Figure 6). These include Tymochtee Creek, the Little Sandusky River, Paramour Creek, and upper Honey Creek. In these areas, the lower local relief and

fine-grained instream substrates more closely resembles streams in the northern portion of the study area. Most or all of these waterways have been heavily modified to facilitate drainage for agricultural production. Tymochtee Creek is comprised nearly entirely of these types of areas splayed between glacial end moraines.

Ecoregions

Glacial tills and shallow bedrock drive the physical nature of the stream network and land use across the basin. Limestone bedrock is often exposed in the riverbed, especially the mainstem north of Tiffin and other area tributaries. The upper watershed lies within Eastern Corn Belt Plains (ECBP) and is broadly defined by gently rolling till plains and end moraines. The lower watershed lies within the Huron/Erie Lake Plains (HELP) and is broadly characterized as being nearly flat with generally low relief and poor drainage (Figure 5, Figure 7, Omernick 1987). Fine grained sediments like lacustrine silts, clays, and lake-planned till materials are common in the HELP ecoregion. Larger, glacially deposited gravels, cobbles, and boulders are more common in the ECBP ecoregion. Both ecoregions are productive agricultural lands. The Defiance End Moraine broadly denotes the transition between the ECBP and HELP ecoregions (Figure 6). As discussed above, local physiography may also determine whether a particular stream exhibits the typical features of an ecoregion.

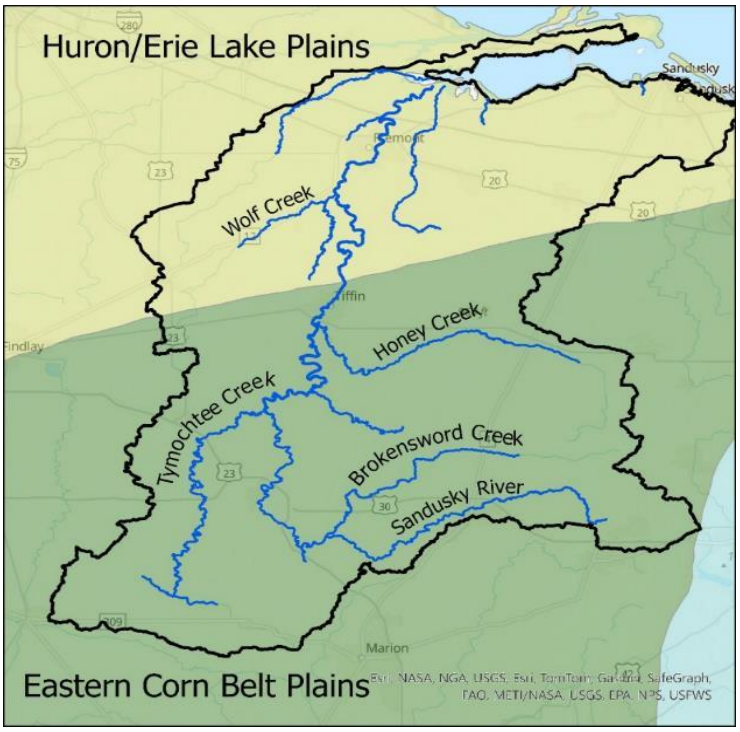


Figure 7 – Ecoregions of the Sandusky River and Sandusky Bay Watershed (Omernick 1987).

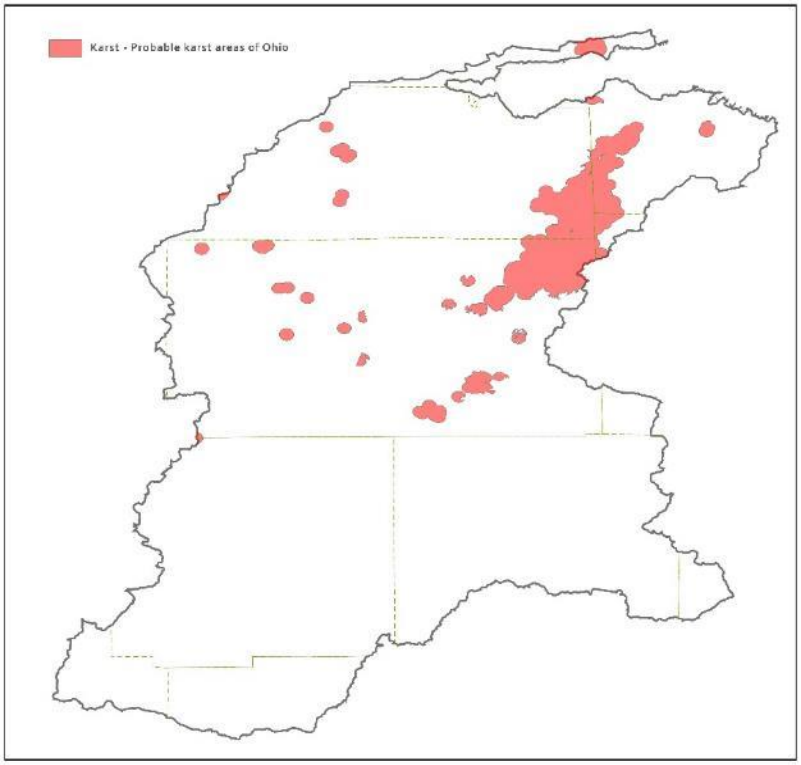


Figure 8 – Karst regions of the Sandusky River & Bay Watershed

Karst Region

Karst is a landform that develops on or in limestone, dolomite, or gypsum by dissolution and is characterized by the presence of diagnostic features such as sinkholes, underground (or internal) drainage through solution-enlarged fractures (joints), and caves. Pollutants entering sinkholes as surface drainage are conducted directly and quickly into the ground-water system and can cause threats to potable water supplies (ODNR 2016).

The Bellevue-Castalia Karst Plain is believed to contain more sinkholes than any of Ohio's other karst regions. Huge, irregularly shaped, closed depressions up to 270 acres in size and commonly enclosing smaller, circular-closed depressions 5 to 80 feet in diameter pockmark the land between the village of Flat Rock in northeastern Seneca County and Castalia in western Erie County. Surface drainage on the plain is very limited, and many of the streams which are present disappear into sinkholes called swallow holes (ODNR 2016).

Soils

Soil hydrologic groups provide a basic guide to water transmission by soils. Figure 9 illustrates the variation in these groups across with watershed, with A and B soils typically having 10-20% clay, with C or D soils being 20-40% (or more) clay and less than 50% sand. Soil types across the basin are fertile and lend themselves to agricultural production. Given the naturally poor drainage potential through most of the soils in the watershed, the assistance of intensive, systematic tiling is employed. Streams with the lowest drainage potential, D and C (pictured below), need the most intensive amount of hydromodifications to facilitate drainage for agriculture and development.

Land Use

Land use and land cover have an important influence on water quality conditions found in the watershed. Row crop agriculture was the dominant land use, comprising about 77% of the study area (Table 4, Figure 10). Along with deciduous forest (8.45%) and developed land (8.68% - all intensities), these three types account for almost 95% of the total land in the study area.

The combination of low gradients and poorly draining, but fertile ground predominantly used for agriculture, has made the watershed among the most intensely tile drained in the United States (Figure 11). Intensive tile drainage of large swaths of land leads to a significant change in the flow regime of entire stream systems. This change in flow patterns, with quicker rises to higher peaks, and quicker falls to lower valleys, is often detrimental to instream biota. The Richards-Baker (R-B) Index, a measure of relative flashiness of stream systems, was developed by researchers at the National Center for Water Quality Research. The R-B Index characterized Rock Creek, Honey Creek, and the Sandusky River mainstem as highly flashy (Baker 2004).

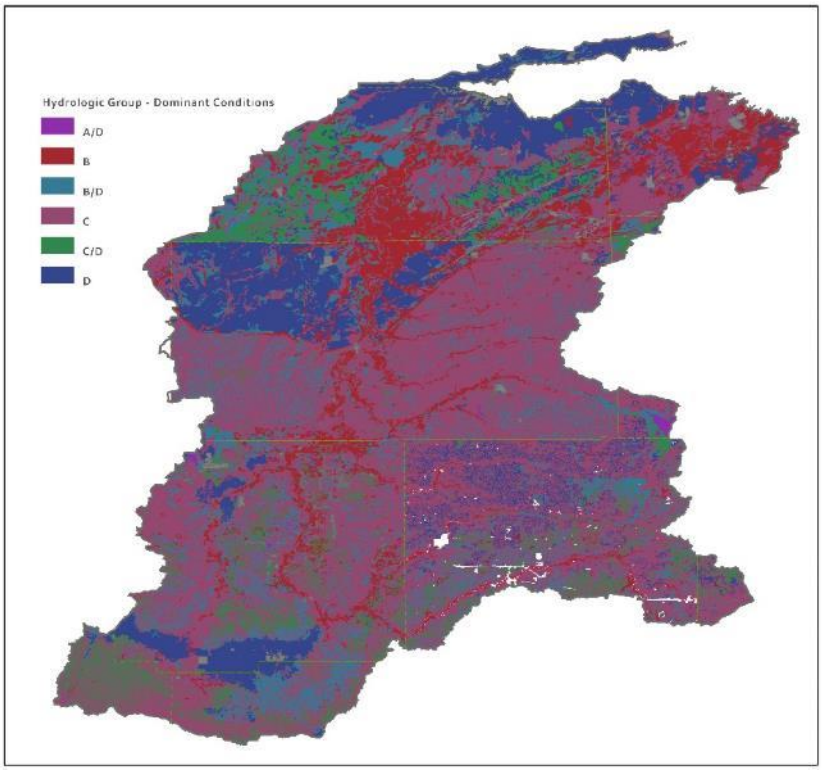


Figure 9 – Hydrologic soil groups, dominant conditions, Sandusky River & Bay Watershed

Table 4 – Land Use, Sandusky River watershed (NLCD 2019).

Land Use	Percent of Land
Open Water	0.73%
Developed, Open Space	3.16%
Developed, Low Intensity	3.35%
Developed, Medium Intensity	1.69%
Developed, High Intensity	0.48%
Barren Land	0.32%
Deciduous Forest	8.45%
Evergreen Forest	0.03%
Mixed Forest	0.24%
Shrub/Scrub	0.02%
Grasslands/Herbaceous	0.42%
Pasture/Hay	2.28%
Cultivated Crops	77.16%
Woody Wetlands	0.60%
Emergent Herbaceous Wetlands	1.08%

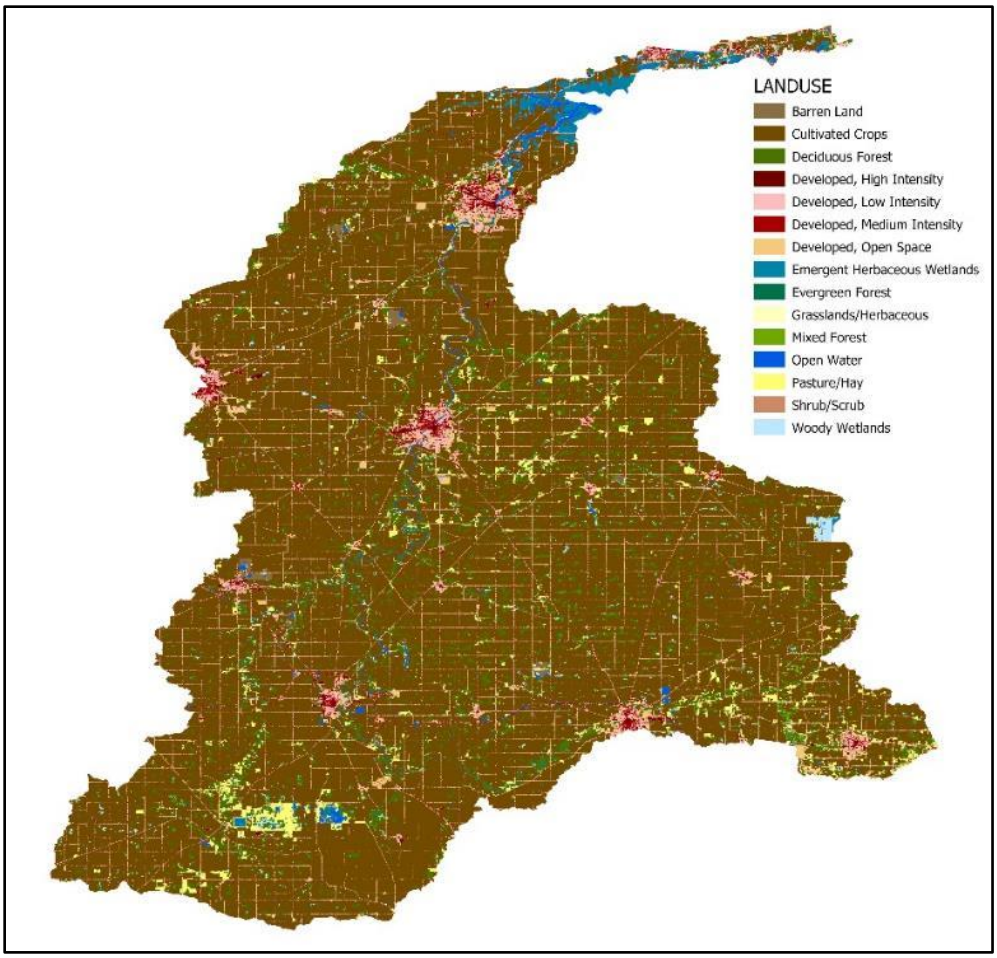


Figure 10 – Land Use Sandusky River Watershed, National Land Cover Dataset, 2019.

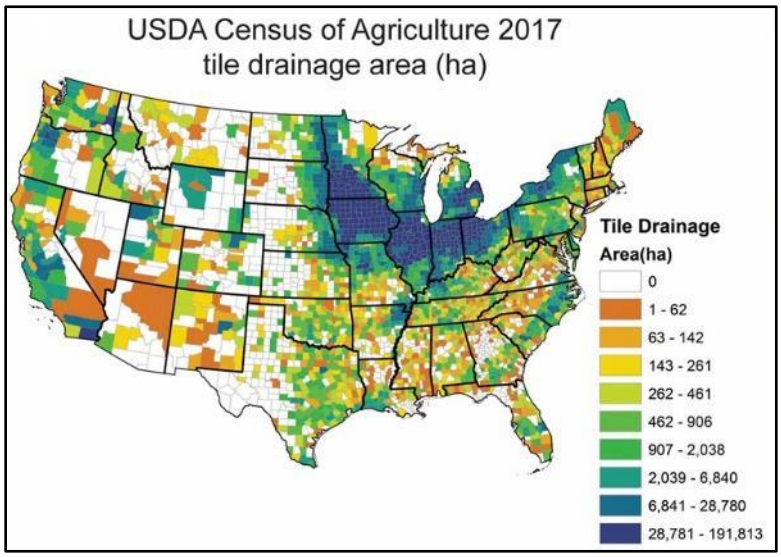


Figure 11 – USDA Census of agriculture, tile drainage area (Valayamkunnath 2020).

Census Data

According to the 2020 census, the study area is home to approximately 140,000 people, with approximately 60,000 living outside of the cities and villages (Table 5). Population densities range from under 40 people/mi^2 in most of the rural areas to more than 6,000 people/mi^2 in the most urban census tract in the City of Fremont (Figure 12).

As detailed in Table 5, nearly all cities and villages that were over 1,000 residents in 2000, have seen a population decrease as of the US Census 2020. Upper Sandusky is the only city that saw a population increase over this time. This trend remains true across the primary counties in the study area (Table 6).

Table 5 – Population change, cities and villages with over 1,000 residents.

City/Village	County	Population, 2000*	Population, 2020[Y]	Population Change
Tiffin	Seneca	18,530	17,953	-3.1%
Fremont	Sandusky	18,133	15,930	-12.1%
Bucyrus	Crawford	13,198	11,684	-11.5%
Fostoria	Seneca	11,007[z]	9,554[z]	-12.1%
Upper Sandusky	Wyandot	6,148	6,698	8.9%
Crestline	Crawford	5,021	4,525	-9.9%
Carey	Wyandot	3,788	3,565	-5.9%
Attica	Seneca	1,040	873	-16.1%
New Washington	Crawford	1,028	873	-15.1%
Bloomville	Seneca	1,027	867	-15.6%
Total		78,920	72,522	-8.11%

*Source: SRWC, 2001.[Y]Source: US Census, 2020. [z] Population estimates for portion in watershed.

Table 6 – Population change, primary counties in the Sandusky River watershed[Y].

County	Population, 2000	Population, 2010	Population, 2020	Population Change
Crawford	46,966	43,784	42,025	-10.5%
Sandusky	61,792	60,944	58,896	-4.7%
Seneca	58,683	56,745	55,069	-6.2%
Wyandot	22,908	22,615	21,900	-4.4%

[Y]Source: US Census Bureau data, 2000, 2010, 2020.

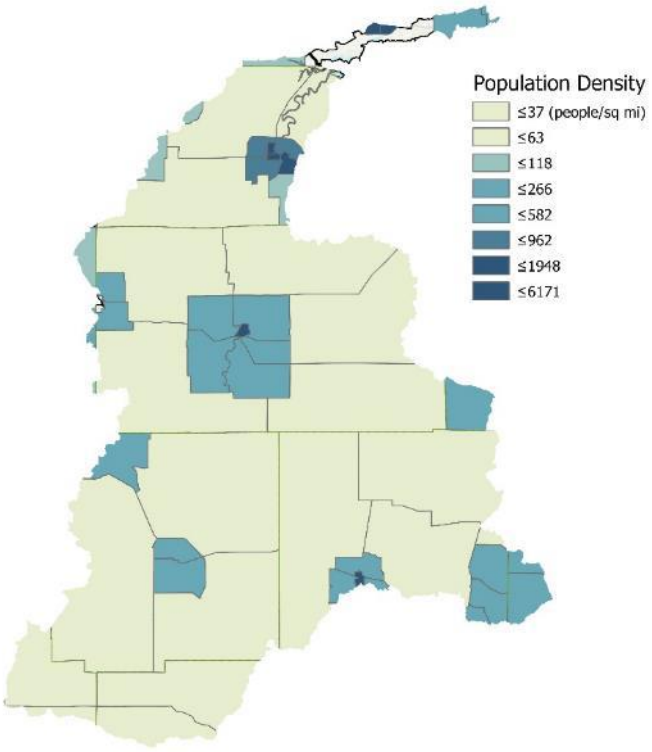


Figure 12 – Population Densities, Sandusky River Watershed, US Census 2020.

Watershed Stakeholders

The Sandusky River Watershed has countless stewards that collaborate to restore, conserve, and protect the valued natural resources in this watershed. Collaborators featured below are just some of the many watershed stakeholders working to protect and improve the watershed and beyond. Their websites are provided for more information on the water quality improvements, partnerships, land stewardship, and community improvements their organizations foster.

National Center for Water Quality Research (NCWQR)*:** Originally founded in 1969, the NCWQR's Tributary Loading Program has collected one of the most robust water quality data sets in the world, including multiple stations in the Sandusky River Watershed. More information can be found on their ***website.

Local Park Districts: County Park districts protect and manage natural resources as well as educate residents and visitors on the natural, rural, historical, and cultural aspects of local communities. Local park districts within the Sandusky River Watershed include ***Crawford Park District***, ***Sandusky County Park District***, ***Seneca Parks***, ***Wyandot County Parks***, along with several city park districts.

Sandusky River Watershed Coalition (SRWC)*:** Formed in 1997, the SRWC aims to "leadership for the conservation and enhancement of the Sandusky River watershed and its natural resources through community-based planning, education, and action (SRWC, 2023)." More information can be found on their ***website.

Soil and Water Conservation Districts (SWCD): Largely established in the late 1940s, SWCD's are locally organized self-governing bodies chartered by the State (of Ohio). Through voluntary action and cooperation of landowners (and other stakeholders), Conservation Districts work to conserve land, water, forest, wildlife and other related resources for the benefit of all (Crawford SWCD, 2023). The Conservation Districts serving the four primary counties draining to the Sandusky River are ***Crawford***, ***Sandusky***, ***Seneca***, and ***Wyandot*** county *SWCD*.

Scenic Rivers Program

A 65-mile stretch of the Sandusky River between Upper Sandusky and Fremont is designated as a State Scenic River. Many areas are open to the public for various recreational opportunities, including canoeing, kayaking, hunting and fishing. Similar to the Maumee River, the Sandusky is noted for its annual walleye run. Other popular catches along the Scenic River include catfish, Smallmouth Bass (*Micropterus dolomieu*) and White Bass (*Morone chrysops*) (ODNR Scenic Rivers, 2023).

Details on the Scenic Rivers program and public access points can be found ***here***.

Wastewater Discharge Overview

A total of 92 National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge sanitary wastewater, industrial process water and/or industrial storm water into the Sandusky 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 Ohio EPA in a Discharge Monitoring Report (DMR).

Certain NPDES facilities are considered major dischargers based on the volume (more than one million gallons per day, or MGD) and type of waste they discharge. All other individual NPDES permitted facilities are considered minor dischargers. All major NPDES facilities in the Sandusky River watershed, as well as some minor dischargers that were bracketed with biological monitoring sites, are listed in Appendix B. Through our website, Ohio EPA provides an ***interactive map*** with NPDES facility locations. Once a facility is selected within the map, the user will have access to basic information about the facility, such as a links to the associated NPDES permit and compliance information through U.S. EPA's website.

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*** encompassed under each type of general permit is also located on the Ohio EPA website. There are also ***several types of general permits specific to storm water***, including, but not limited to, small Municipal Separate Storm Systems (MS4s), construction sites, industries and marinas.

Water Chemistry Sampling Results

Surface water chemistry samples were collected from the Sandusky River watershed study area from June 2021 through September 2022 at 118 locations (Table 2). Stations were established in free-flowing sections of the streams. Samples were collected directly from the stream or from bridge crossings. Surface water samples were collected in appropriate containers, preserved, and delivered to either Ohio EPA's Environmental Services laboratory or a contract laboratory, if appropriate. Collected water was preserved using appropriate methods, as outlined in Ohio EPA's *Surface Water Field Sampling Manual* (Ohio EPA 2021).

A subset of 44 sites that were sampled for chemistry were also sampled with water quality sondes. Sondes collect hourly readings of temperature, dissolved oxygen (DO), pH, and specific conductance (conductivity) to evaluate diel (24-hour) patterns in water quality. Sonde preparation, deployment, and data evaluation followed procedures outlined in Appendix II of Ohio EPA's *Surface Water Field Sampling Manual* (Ohio EPA 2021).

Temperature, DO, and pH are influenced by diel (24-hour) patterns. These diel patterns have the greatest impact on streams during a critical condition that includes stable, low stream flow. Specific conductance is not influenced by the same diel triggers but is monitored to evaluate water quality exceedances and as an indicator of changes in stream flow. The water quality sondes collect readings hourly to monitor these parameters throughout the diel cycle. Grab readings differ because they only represent one point on the diel cycle. While they are effective at characterizing water quality parameters that change based on hydrologic regime or season, they can miss or not fully characterize parameters that exhibit diel patterns.

Dissolved oxygen fluctuates in a stream due to biological activity, flow, reaeration, pollution and temperature. During summer months, flow is decreased, pollutant sources are less diluted, water temperatures are higher and biological activities increase. Streams with impacts such as low flow, limited reaeration, or organic enrichment will see depressed DO throughout the diel cycle. These are scenarios where grab readings during the day will capture minimum DO exceedances and sondes will capture 24-hour average exceedances in addition to the minimum exceedances. Large diel swings in DO are observed

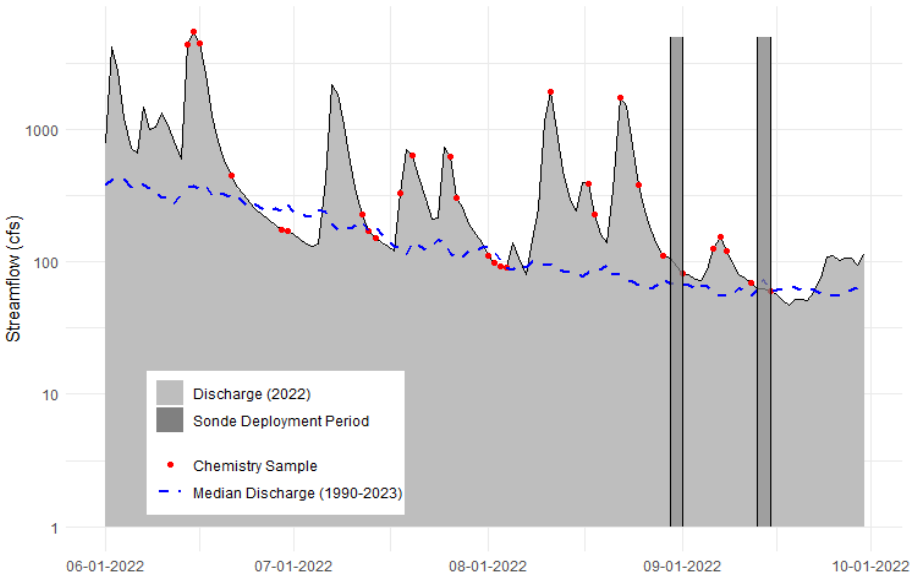


Figure 13 — Daily average flow conditions in the Sandusky River watershed at the USGS gage at Sandusky River near Fremont, OH (04198000) in 2022 (USGS, 2024). Chemistry sampling activities and sonde deployments are indicated on the plot.

in streams with increased biological activity due to eutrophic factors of excessive primary production and respiration. Photosynthetic production and instream oxygen concentration peaks during the day with available solar radiation. The depletion of stream DO due to respiration occurs at a relatively steady rate. Therefore, minimum DO concentrations are generally observed in overnight sonde measurements due to the lack of solar radiation.

USGS gage data from Sandusky River near Fremont, OH (04198000) were used to show flow trends in the Sandusky River watershed during the 2022 survey (Figure 13) and 2023 follow-up sampling (Figure 14). The surface chemistry sampling and sonde deployment dates are noted on the figure. Flow conditions during both the 2022 and 2023 sampling period were generally higher than the historic median. In 2022, a wetter than normal spring resulted in flow conditions that remained high throughout much of the summer. Low-flow conditions were recorded mid-June to early July, early August, and throughout the month of September. Streamflow in 2023 was still mostly above median values. However, spring was relatively dry in 2023, and critical low-flow conditions occurred in early June. Similar low-flow periods occurred in late July and early August 2023 (Figure 14). The 2023 sonde data was collected in September after very high flow events in late August.

Water samples captured a variety of flow conditions in the study area during the field season. Critical conditions for temperature and DO are times when flows are low, temperatures are high, and days are long. These are the times when instream productivity is greatest, and the stream ecosystem is most sensitive to organic and nutrient enrichment. To capture these conditions, sondes are typically deployed during low-flow conditions once or twice between June and September. Sondes were deployed at 29 sites in this study area from August 30 to September 1, 2022, and at 5 sites from September 13-15, 2022 (Appendix K, Figure 13). Sondes were deployed again in 2023 at 6 locations from September 12 -14 (Figure 14).

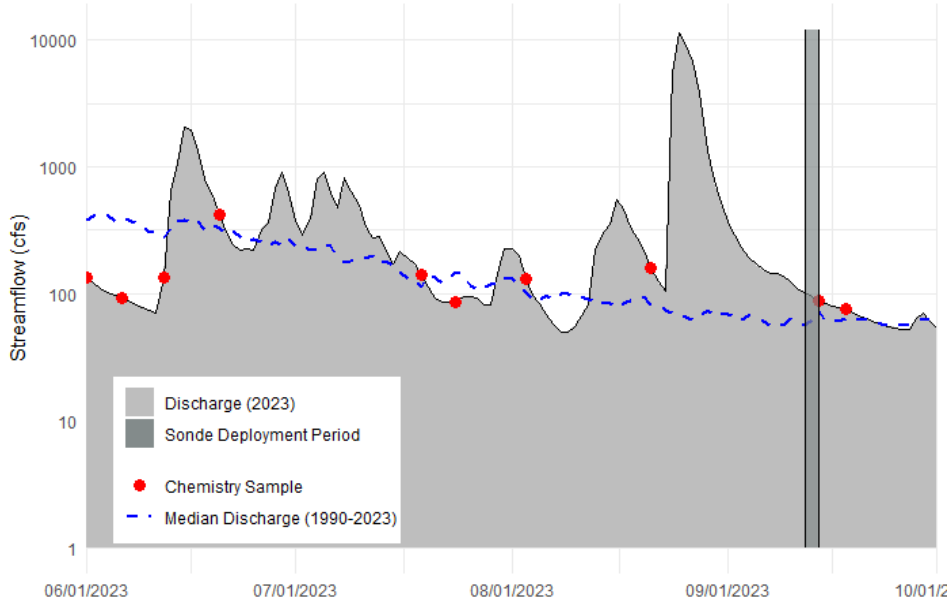


Figure 14 — Daily average flow conditions in the Sandusky River watershed at the USGS gage at Sandusky River near Fremont, OH (04198000) in 2023 (USGS, 2024). Chemistry sampling activities and sonde deployments are indicated on the plot.

Water Quality Exceedances

Water Grab Sampling Exceedances

Surface water samples were analyzed for metals, nutrients, semi-volatile organic compounds, organic pesticides, and suspended and dissolved solids (Appendix I & J). Additionally, surface water samples were analyzed for bacteria (*E. coli*) from 62 stations. Results can be found in the ***Recreation Beneficial Use – Results and Discussion*** section of this document and data are displayed in Appendix N. Instantaneous readings of temperature, pH, conductivity, and DO were measured in the field with every chemistry sample. Parameters that exceeded criteria in the Ohio WQS are reported in Table 7. Water quality sondes were placed at 36 locations to monitor hourly levels of DO, pH, temperature, and conductivity over multiple days (Appendix K). Water quality exceedances observed with the sondes are reported in Table 8.

Field meter instantaneous DO concentrations were below the minimum water quality criteria at four sites a total of four times (Table 7). All four DO levels below the minimum criteria occurred in August and September. Three of the sites have small drainages (Paramour Creek - 4.5 mi^2, Fishing Creek - 7 mi^2, and Tymochtee Creek - 6.1 mi^2).

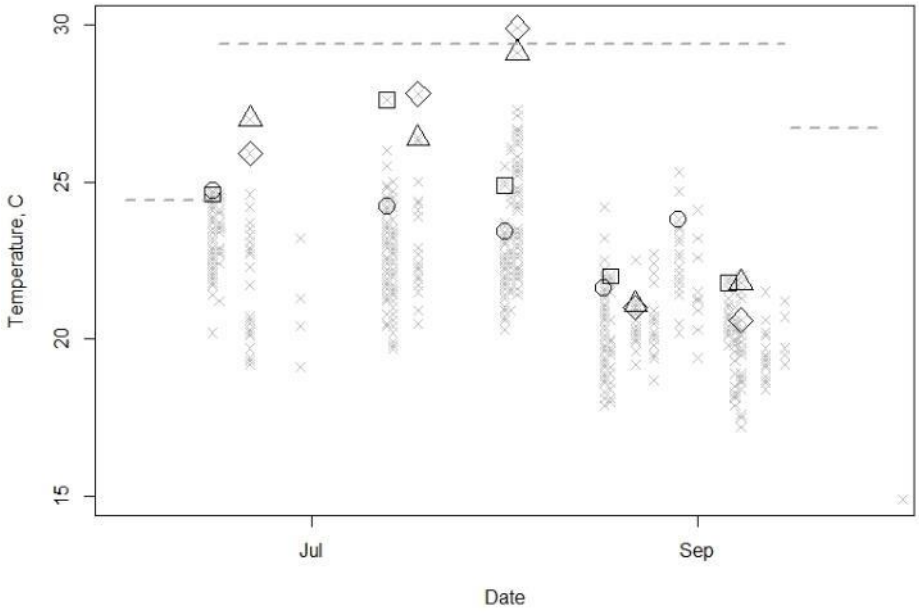


Figure 15 – Scatter plot displaying results from field surface water temperature data collected during the summer of 2023. Water quality standards are displayed by the dotted lines. Values from selected sites are shows in open polygons - South Branch Muddy Creek RM 5.67 (diamonds) and RM 1.54 (triangles), Carroll Ditch RM 1.59 (squares), and Broken Sword Creek RM 19.70 (circles).

Temperature values exceeded water quality criteria four instances at four locations – South Branch Muddy Creek RM 5.67 (U04S08), Carrol Creek RM 0.66 (U01G26), Pawpaw Run RM 6.13 (U01G25), and Broken Sword Creek RM 19.70 (201366). South Branch Muddy Creek consistently had among the highest temperatures recorded during sampling that occurred in June, July, and early August. Figure 15 displays temperature grab samples from the entire survey area, with sites from South Branch Muddy Creek at RM 5.67 displayed as diamonds and RM 1.54 (300679) as triangles. South Branch

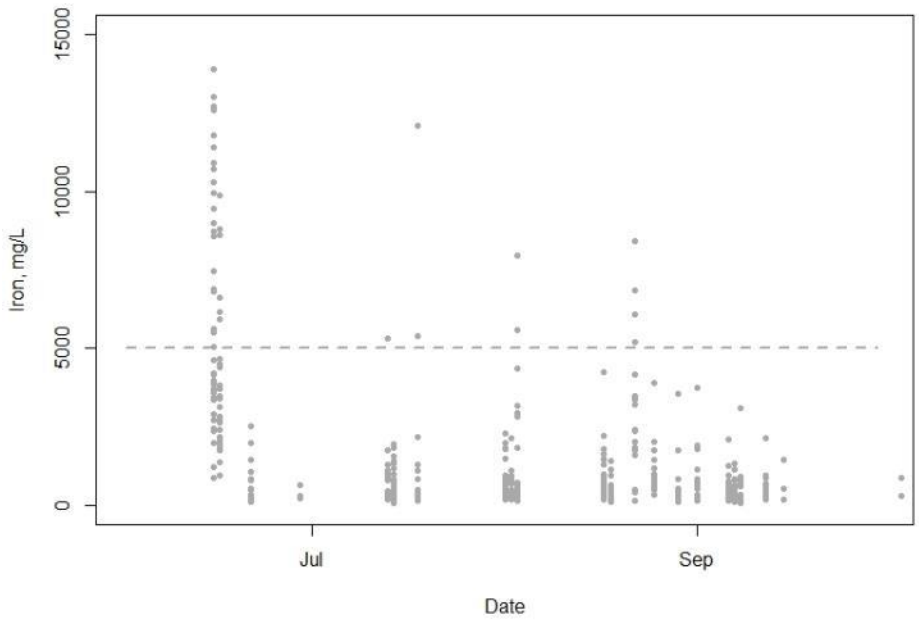


Figure 16 – Scatter plot displaying iron results from grab samples collected during the current survey. Water quality standards are displayed by the dotted lines.

Muddy Creek RM 5.67 is a smaller drainage (4.6 mi^2) site with a heavily modified channel and no overhead tree canopy. Carrol Ditch, displayed as squares in Figure 15, had a similar tendency to be among the highest values recorded during any given day of sampling. Broken Sword Creek (circles) had an exceedance (24.7 °C) of the temperature criteria (24.4 °C) on June 15, 2023. This stream here was wide at the bridge, had sluggish flows, and had limited tree cover. All these factors contributed to the increased temperature observed here. Subsequent visits to the site yielded results more similar to other sampling sites throughout the basin (Figure 15). Pawpaw Creek RM 6.13 had a temperature exceedance that exceeded the standard by 0.1 °C on June 15, 2022.

The most numerous exceedances of WQS were iron levels above the criteria for the protection of the agricultural water supply use (Figure 16, Table 7). These exceedances primarily occurred in June after a significant rainfall event across much of the watershed. The source of the isolated iron exceedances was most likely suspended soil particles or sediment washed instream during the rainfall event. During water sample chemical analysis, metals associated with clay particles are released into solution, resulting in elevated metals concentrations in the water.

Ammonia concentrations at two stations were markedly higher than others across the study area. Figure 17 displays total ammonia concentrations from all survey area sites, highlighting the two sites of interest. Tymochtee Creek downstream from Meeker at RM 49.44 (U01G07) had the highest geometric mean value (0.806 mg/L) of all sites over five visits. Allen Run RM 1.18 (U02G20) had a somewhat lower geometric mean of 0.714 mg/L. For comparison, the site with the next highest total ammonia concentration had a station geometric mean that was decidedly lower (0.256 mg/L) than the sites on either Tymochtee Creek or Allen Run.

Allen Run RM 1.18 had an exceedance of the ammonia standard observed during the survey, with a single sample result of 33.0 mg/L on 7/13/2022. Ammonia concentrations of this magnitude far exceed

the acute toxicity threshold for aquatic life (USEPA 2013). This toxic ammonia concentration was the result of inappropriate management of fertilizer storage tanks and a documented fertilizer release from the stormwater pond of an agricultural cooperative that discharges into a tributary to Allen Run just upstream from this site. This event and a subsequent fish kill are discussed further in the **Water Quality and Aquatic Life Impairment Discussion** section of this document. Though maximum values in Tymochtee Creek RM 49.44 were not as high as those observed in Allen Run, the higher geometric mean here would suggest that the elevated ammonia concentrations here were more of a chronic stressor. Prairie Run RM 1.02 (U01W04) also had an exceedance of the ammonia water quality standard. This stream has been heavily channelized in the past, and low or interstitial flows were observed during the summer of 2022. This site is also lower gradient and drains old wetland and lake deposited sediments (Figure 6). Habitat sampling also noted a profuse amount of detritus and silts comprising the instream substrates and the present of emergent wetland plants. This combination of factors likely resulted in the higher ammonia values observed in this stream.

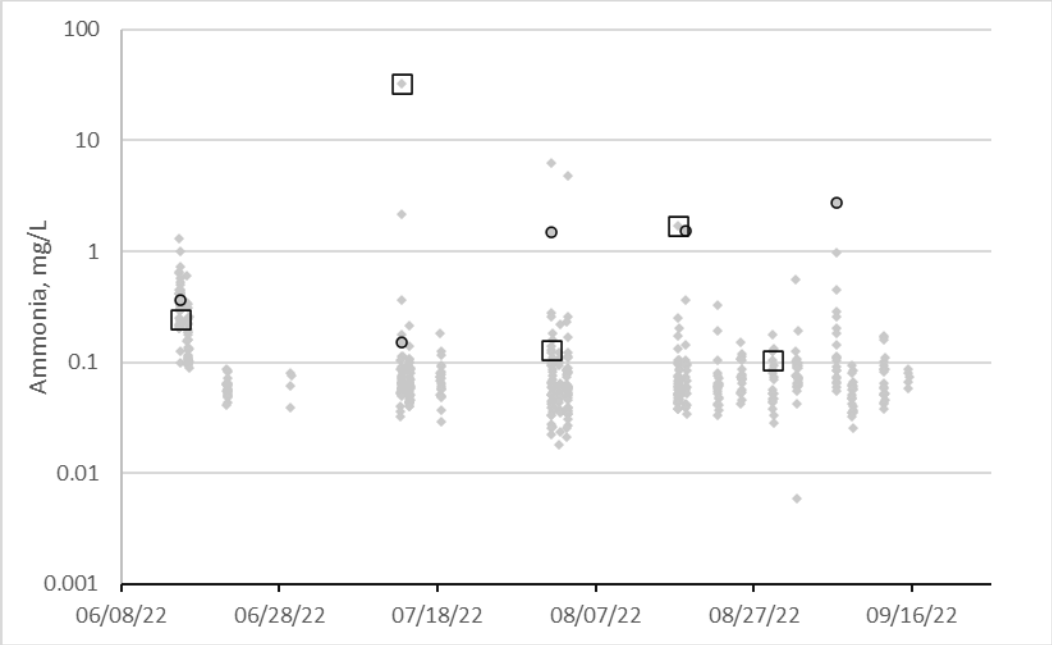


Figure 17 – Scatter plot of total ammonia concentrations in surface water grab samples displayed by date from sites all survey sites, 2022. Samples from Allen Run RM 1.18 and Tymochtee Creek RM 49.44 are displayed by open squares and circles, respectively.

Table 7 — Exceedances of Ohio EPA WQS criteria (OAC 3745-1) for chemical and physical water parameters measured in grab samples taken from the Sandusky River watershed study area, 2022[d].

Water parameters are assessed based on water quality criteria for the recommended ALU designations. Refer to Beneficial Use Designations and Recommendations within this report for details about use recommendations.

Stream (Stream Code) use designations [a]			
Station	**12-digit AU [b]**	**RM**	**Parameter (value) – (units are µg/L for metals, C° for temperature, and mg/L for DO and Ammonia)**
Sandusky River mainstem (05-001-000) *EWH – PCR-B – AWS – IWS*			
304130[d]	13-02	18.10	Iron: (857; 2700; 1250; 897; 509)
Sandusky River mainstem (05-001-000) *WWH – PCR-B – AWS – IWS*			
U02P33	04-05	98.69	Iron (11,400) ∞
U02G02	07-02	93.76	Iron (13,000)
U02P38	07-05	72.09	Iron (8,790)
Paramour Creek (05-042-000) *WWH – PCR-B – AWS – IWS*			
U02P48	04-01	6.31	DO (3.62‡)
U02P12	04-01	1.50	DO (3.96‡)
Allen Run (05-043-000) *WWH – PCR-B – AWS – IWS*			
U02G20	04-02	1.18	Ammonia (33.0**, 16.6*, 16.57*)
Loss Creek (05-041-000) *WWH – PCR-B – AWS – IWS*			
U02G03	04-02	0.96	Iron (5,050)
Broken Sword Creek (05-035-000) *WWH – PCR – AWS – IWS*			
201366	03-01	19.70	Temperature (24.7) **
U02P47	03-02	0.87	Iron (13,900)
Little Sandusky River (05-033-000) *MWH – SCR – AWS – IWS*			
201361	07-01	10.40	Iron (7,460)
Little Sandusky River (05-033-000) *WWH – PCR-B – AWS – IWS*			
U02G16	07-01	6.52	Iron (9,460)
Tributary to Little Sandusky River (8.93) (05-033-003) *MWH – SCR – AWS – IWS*			
U02W05	07-01	0.78	Iron (8,710)
Honey Run (05-034-000) *WWH – PCR-B – AWS – IWS*			
U02G18	07-01	0.52	Iron (8,550)
Tymochtee Creek (05-300-000) *MWH – SCR – AWS – IWS*			
U01W05	05-02	51.43	DO (3.2‡)
Tymochtee Creek (05-300-000) *WWH – PCR-B – AWS – IWS*			
U01G07	05-02	49.44	Ammonia (1.63*, 2.13*)
U01G04	05-09	33.99	Iron (12,600)
U01G03	06-02	26.28	Iron (6,610)
U02P44	06-02	19.45	Iron (9,870; 5,580)
500850	06-05	8.06	Iron (7,950)
Prairie Run (05-300-007) *MWH – PCR-B – AWS – IWS*			
U01W04	05-01	1.02	Iron (5,500), Ammonia (3.13*, 3.14*)
Carroll Ditch (05-300-004) *MWH – SCR – AWS – IWS*			
U01G26	05-03	0.66	Iron (12,700), Temperature (24.6) **
Pawpaw Run (05-319-000) *WWH – PCR-B – AWS – IWS*			
U01G25	05-04	6.13	Temperature (24.5) **
U01G24	05-04	0.57	Iron (10,300)
Little Tymochtee Creek (Lower) (05-304-000) *WWH – PCR-B – AWS – IWS*			
U01G13	06-03	6.87	Ammonia (2.43*, 1.70*)

Stream (Stream Code) use designations [a]			
Station	**12-digit AU [b]**	**RM**	**Parameter (value) – (units are µg/L for metals, C° for temperature, and mg/L for DO and Ammonia)**
Sycamore Creek (05-021-000) *WWH – PCR-B – AWS – IWS*			
U03G10	06-04	2.99	Iron (5,620)
Honey Creek (05-200-000) *WWH – PCR-B – AWS – IWS*			
U03G20	08-02	41.66	Iron (6,790)
U03G18	08-02	34.14	Iron (10,900)
U03S03	08-05	25.03	Iron (11,800)
U03S02	08-06	12.30	Iron (5,920)
500970	08-06	1.10	Iron (8,600)
Celery Creek (05-200-003) *MWH – PCR-B – AWS – IWS*			
303862	08-02	0.45	Iron (10,700; 5,310)
Brokenknife Creek (05-209-000) *WWH – PCR-B – AWS – IWS*			
201405	08-01	1.05	Iron (6,880)
Aicholz Ditch (05-203-000) *MWH – PCR-B – AWS – IWS*			
U03G25	08-03	3.72	Iron (8,990)
Aicholz Ditch (05-203-000) *WWH – PCR-B – AWS – IWS*			
U03G24	08-03	2.46	Iron (9,960)
Rock Creek (05-014-000) *WWH – PCR-B – AWS – IWS*			
U04G18	11-01	11.69	Iron (6,150)
U04W06	11-01	1.05	Iron (6,620)
Spicer Creek (05-011-000) *WWH – PCR-B – AWS – IWS*			
U04Q11	11-05	0.80	Iron (12,100; 5,200)
East Branch Wolf Creek (05-006-000) *WWH – PCR-B – AWS – IWS*			
201338	10-03	9.00	Iron (8,400)
U04P03	10-03	0.86	Iron (6,840)
Muddy Creek (05-219-000) *WWH – PCR-B – AWS – IWS*			
201410	14-02	21.10	Iron (6,070)
South Branch Muddy Creek (05-222-000) *WWH – PCR-B – AWS – IWS*			
U04S08	14-02	5.67	Temperature (29.9) **
Fishing Creek (05-220-001) *WWH – PCR-B – AWS – IWS*			
300678	14-03	0.20	Iron (5,380); DO (3.62‡)

a Use designations:

Aquatic Life Habitat	Water Supply	Recreation
EWH - exceptional warmwater habitat	IWS - industrial water supply	PCR - primary contact
WWH - warmwater habitat	AWS - agricultural water supply	SCR - secondary contact
CWH - coldwater habitat	PWS - public water supply	BWR - bathing water
MWH - modified warmwater habitat		
LRW - limited resource water		

b Assessment Unit within 8-digit watershed assessment unit 04100011.

c Undesignated [WWH criteria apply to 'undesignated' surface waters].

‡ Exceedance of the applicable minimum DO criterion (EWH – 5.0 mg/L; WWH – 4.0 mg/L; MWH – 3.0 mg/L).

** Exceedance of OMZM (outside mixing zone maximum) numerical criteria for prevention of acute toxicity.

* Exceedance of OMZA (outside mixing zone average) numerical criteria for prevention of chronic toxicity, 30-day avg value listed.

∞ Iron values, exceedance of agricultural water supply criterion (applies to all listed iron exceedances).

d Site sampled in 2021 as part of Large River Assessment Unit study.

Continuous Sonde Sampling Exceedances

The data collected during sonde deployments are sufficient to evaluate exceedances of the standards for the protection of aquatic life for: maximum daily temperature; minimum DO; 24-hour average DO; pH; and specific conductivity. Absolute minimum or maximum exceedances are compared directly to hourly readings reported from the water quality sondes. The 24-hour average for DO is calculated as a rolling 24-hour average of the hourly data. A summary of the exceedances is presented in Table 8.

Sonde data documented no temperature exceedances of the general Lake Erie basin standards. Additionally, no pH or specific conductivity exceedances were documented at any sonde sampling locations.

There were eight sonde sampling locations with DO exceedances documented. All stream reaches with DO exceedances were designated WWH ALUs. The exceedances are listed below:

- Brandywine Creek RM 0.45 (302323) exceeded the minimum DO criterion and 24-hour average for the whole duration of the sonde deployment, lasting 47 consecutives reading hours.
- Little Sandusky River RM 3.71 (U02W06) had three different periods where DO dropped below the minimum criterion, one of which lasted 15 hours. The 24-hour DO average criterion exceeded at this site throughout the whole sonde deployment.
- Minimum and 24-hour average DO exceedances were observed at two sites on Tymochtee Creek: RM 49.44 and 19.45 (U01G07 and U02P44, respectively). At RM 49.44, there were three separate, non-consecutive hours where the DO dropped below the minimum criterion and the 24-hour DO average criterion was in exceedance throughout the whole sonde deployment. At RM 19.45, 20 of 23 daily averaging periods exceeded the DO criterion. There were no hours where DO concentrations dropped below the minimum criterion.
- Little Tymochtee Creek (lower) RM 6.87 (U01G13) exceeded the minimum DO criterion for 8 hours and 24-hour DO average criteria for 5 consecutive 24-hour periods.
- All 24-hour averaging periods during the first 2022 Honey Creek RM 25.03 (U03S03) deployment and 20 consecutive reading hours exceeded the average and minimum DO criterion, respectively. Dissolved oxygen during the final hours of the first deployment dropped to almost 0 mg/L. During retrieval, the sonde was pulled from being stuck in the silty, mucky substrates present at this site. The low DO readings from this first deployment were very likely influenced by the probe being submerged in the mucky stream bottom. There were no exceedances during the second sonde deployment in 2022 and the DO profile documented was more representative of typical conditions, like those documented in chemistry grab sampled.
- Little Muddy Creek RM 7.55 (300677) had 5 non-consecutive 24-hour periods where DO average concentrations fell below the criterion. The DO concentrations also dropped below the minimum criterion for 4 hours.
- Fishing Creek RM 0.2 (300678) saw two separate periods where DO concentrations dropped below the minimum criterion, with one occurrence being 11 hours in duration. The 24-hour DO average criterion was exceeded for 9 consecutive 24-hour periods during the sonde deployment. This stream site is within a shallow Lake Erie backwater and had no discernable flows during sampling. Oxygen depletion here is likely the result of the natural conditions present here.

Table 8 — Exceedances of Ohio WQS criteria (OAC 3745-1) for chemical and physical parameters derived from diel monitoring in the Sandusky River watershed study area, 2022.

Sonde parameters are assessed based on criteria for the recommended ALU designations. Refer to Beneficial Use Designations and Recommendations within this report for details about use recommendations. All exceedances are identified in bold. 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 DO criterion. The duration is the count of consecutive hours that exceeded for the minimum criterion or count of 24-hour periods in exceedance for the average concentration. The magnitude of exceedance is presented as the most extreme value measured that exceeds the criterion. The duration is presented first, followed by the magnitude in parenthesis.

Sondes were deployed at 44 sites, with some of the sites being sampled twice. 8 sondes that were deployed in the Sandusky River mainstem during the 2021 Large Rivers Assessment Unit project are included in this exceedance evaluation to help assess nutrient impacts on the mainstem. The first 2022 Sandusky survey deployment was 8/30-9/1/2022 and between 39-55 hours of data were collected at each of the 29 sites. The second 2022 deployment was 9/13-15/2022 resulting in 50 hours of data at each of the 5 sites. A third round of deployments were completed the following year, from 9/12-14/2023, with between 47-49 hours of data at each of the 6 sites. Four sites were sampled during the first and second 2022 surveys (Bark Creek at Kelley Rd., Paramour Creek dst. Crestline @ Nazor Rd., Broken Sword Creek at Oceola at U.S. Rt. 30N, and Honey Creek W of Attica at Twp. Rd. 79). All other sites were sampled once.

Station	12-digit assessment unit	RM	Parameter: duration (magnitude) Units are C° for temperature**, mg/L for DO min‡ and avg‡‡, s.u. for pH Δ, and µS/cm for specific conductance~.
Sandusky River (05-001-000) *WWH – PCR – AWS – IWS*			
U02P30	04 05	110.43	None detected in one survey
500860	07 02	78.09	None detected in one survey
U02P38	07 05	72.09	None detected in one survey
U03G01[d]	09 04	65.01	None detected in one survey
U04S29[d]	09 05	57.34	None detected in one survey
500830[d]	09 05	47.75	None detected in one survey
U04S28[d]	11 03	41.84	None detected in one survey
500880[d]	11 05	36.50	None detected in one survey
500910[d]	11 05	30.85	None detected in one survey
U04Q06[d]	11 05	23.00	None detected in one survey
304130[d]	13 02	18.10	None detected in one survey
Paramour Creek (05-042-000) *WWH – PCR – AWS – IWS*			
U02P12	04 01	1.50	None detected in two surveys
Broken Sword Creek (05-035-000) *WWH – PCR – AWS – IWS*			
U02G07	03 01	25.48	None detected in one survey
201366	03 01	19.70	None detected in one survey
U02S23	03 02	12.41	None detected in two surveys
U02P47	03 02	0.87	None detected in one survey
Brandywine Creek (05-037-000) *WWH – PCR – AWS – IWS*			
302323	03 01	0.45	**DO min: 47 (1.7)** ‡ Sept. 12-14, 2023 survey **DO avg: 24 (2.9)** ‡‡ Sept. 12-14, 2023 survey
Little Sandusky River (05-033-000) *WWH – PCR – AWS – IWS*			
U02W06	07 01	3.71	**DO min: 3 (3.0); 15 (3.6); 4(3.9)** ‡ Aug. 30-Sept. 1, 2022 survey **DO avg: 29 (3.8)** ‡‡ Aug. 30-Sept. 1, 2022 survey

Station	12-digit assessment unit	RM	Parameter: duration (magnitude) Units are C° for temperature**, mg/L for DO min‡ and avg‡‡, s.u. for pH Δ, and µS/cm for specific conductance~.
Tymochtee Creek (05-300-000) *WWH – PCR – AWS – IWS*			
U01G07	05 02	49.44	**DO min: 1 (3.9); 1 (3.8); 1 (3.9)** ‡ Sept. 12-14, 2023 survey **DO avg: 24 (4.2)** ‡‡ Sept. 12-14, 2023 survey
U01G05	05 09	42.83	None detected in one survey
U02P44	06 02	19.45	**DO avg: 20 (4.8)** ‡‡ Aug. 30-Sept. 1, 2022 survey
500850	06 05	8.06	None detected in one survey
Pawpaw Run (05-319-000) *WWH – PCR – AWS – IWS*			
U01G25	05 04	6.13	None detected in one survey
Little Tymochtee Creek (Upper) (05-316-000) *WWH – PCR – AWS – IWS*			
U01G20	05 07	4.00	None detected in one survey
Little Tymochtee Creek (Lower) (05-304-000) *WWH – PCR – AWS – IWS*			
U01G13	06 03	6.87	**DO min: 8 (3.7)** ‡ Aug. 30-Sept. 1, 2022 survey **DO avg: 5 (4.6)** ‡‡ Aug. 30-Sept. 1, 2022 survey
U02P45	06 03	0.90	None detected in one survey
Spring Run (05-301-000) *WWH – PCR-– AWS – IWS*			
U02P46	06 04	1.71	None detected in one survey
Sycamore Creek (05-021-000) W*WH – PCR – AWS – IWS*			
U03P05	09 03	0.41	None detected in one survey
Honey Creek (05-200-000) W*WH – PCR – AWS – IWS*			
U03S03	08 05	25.03	*Results from first deployment were not used to determine exceedances due to sonde probe being buried in bottom substrates None detected in the second survey
U03S02	08 06	12.30	None detected in one survey
Celery Creek (05-200-003) M*WH – PCR – AWS – IWS*			
303862	08 02	0.45	None detected in one survey
Rock Creek (05-014-000) *WWH – PCR – AWS – IWS*			
U04G18	11 01	11.69	None detected in one survey
U04W06	11 01	1.05	None detected in one survey
Morrison Creek (05-012-000) *WWH – PCR – AWS – IWS*			
U04G05	11 02	2.36	None detected in one survey
Wolf Creek (05-005-000) *WWH – PCR – AWS – IWS*			
201336	10 04	13.60	None detected in one survey
U04S40	10 04	5.15	None detected in one survey
East Branch Wolf Creek (05-006-000) *WWH – PCR – AWS – IWS*			
201338	10 03	9.00	None detected in one survey
East Branch of East Branch Wolf Creek (05-008-000) *WWH – PCR – AWS – IWS*			
U04G13	10 01	3.52	None detected in one survey
300682	10 01	1.48	None detected in one survey
Muskellunge Creek (05-003-000) *WWH – PCR – AWS – IWS*			
300674	13 01	16.70	None detected in one survey
Bark Creek (05-002-000) *WWH – PCR – AWS – IWS*			
300671	13 03	3.20	None detected in two surveys (no DO data on one survey)
Muddy Creek (05-219-000) *WWH – PCR – AWS – IWS*			
201410	14 02	21.1	None detected in one survey

Station	12-digit assessment unit	RM	Parameter: duration (magnitude) Units are C° for temperature**, mg/L for DO min‡ and avg‡‡, s.u. for pH Δ, and µS/cm for specific conductance~.
Little Muddy Creek (05-220-000) *WWH – PCR – AWS – IWS*			
300677	14 03	7.55	**DO min: 4 (3.9)** ‡ Aug. 30-Sept. 1, 2022 survey **DO avg: 1 (4.9); 4 (4.9)** ‡‡ Aug. 30-Sept. 1, 2022 survey
Fishing Creek (05-220-001) *WWH – PCR-B – AWS – IWS*			
300678	14 03	0.20	**DO min: 9 (2.6); 11 (1.1)** ‡ Aug. 30-Sept. 1, 2022 survey **DO avg: 9 (4.6)** ‡‡ Aug. 30-Sept. 1, 2022 survey

b Assessment Unit within 8-digit watershed assessment unit 04100011.

‡ Exceedance of the applicable minimum DO criterion (EWH – 5.0 mg/L; WWH – 4.0 mg/L; MWH – 3.0 mg/L).

‡‡ Exceedance of the applicable minimum 24-hour average DO criterion (EWH – 6.0 mg/L; WWH – 5.0 mg/L; MWH – 4.0 mg/L).

d Site sampled in 2021 as part of Large River Assessment Unit study.

Weight of Evidence Nutrient Assessment

Nutrients were measured at each water chemistry sampling location, including ammonia, nitrate + nitrite, total Kjeldahl nitrogen (TKN), total phosphorus, and orthophosphate. Total phosphorus and dissolved inorganic nitrogen (ammonia and nitrate + nitrite), or DIN, are presented in Table 9 as geometric means over the index period (June 15 – October 15) and are summarized by risk categories for instream nutrient enrichment (Ohio EPA 2015). These risk categories are not the sole tool used to determine the degree of impact from nutrient over-enrichment but, rather, are used as one of several lines of evidence that can help describe instream conditions along a spectrum of eutrophication (oligotrophic to hyper-eutrophic). The purpose of the nutrient sampling summarized below is to consider the effect of nutrients on the biological conditions in the local streams.

In addition to nutrient monitoring, measurements were taken at a subset of locations to represent the algal biomass and associated primary productivity or DO production and consumption. Chlorophyll-α concentrations from benthic algae (attached to bottom substrates) are measured as a proxy for algal community biomass in wadeable streams and small rivers, while chlorophyll-α concentrations measured from sestonic algae (suspended in the water column) serve as a proxy for algal abundance in large rivers. Physical factors such as width-depth ratio, time of travel, and longitudinal gradient though determine whether sestonic or benthic algae drive production and respiration through a given stream reach. However, sestonic algae typically predominate in streams defined as large rivers, and benthic algae typically predominate in smaller streams.

Miltner (2010) identified benthic chlorophyll-α levels that broadly demarcate enrichment status of streams relative to conditions found in Ohio. Streams with an algal density of less than 90 mg/m^2 can be considered least disturbed and atypical for Ohio. Benthic chlorophyll-α levels between 90-183 mg/m^2 are typical for Ohio streams with modest amounts of agriculture or wastewater loadings. Levels between 183-320 mg/m^2 are typical of streams draining agricultural landscapes or that are effluent dominated. Chlorophyll-α levels exceeding 320 mg/m^2 characterize over-enrichment or nuisance conditions. A review of studies on sestonic chlorophyll-α by Dodds (2006), which included some Midwestern streams, suggest that concentrations of 40-100 µg/l sestonic chlorophyll-α identify eutrophic conditions while concentrations >100 µg/l indicate hyper-eutrophic conditions.

Ohio and other states have been developing nutrient reduction strategies in recent years to address cultural eutrophication (Miltner 2018, U.S. EPA 2015, Ohio EPA 2015, Ohio EPA 2014a, Miltner 2010, Heiskary and Markus 2003). Wide diel (24-hour) DO ranges associated with eutrophication are caused by excessive photosynthesis (O_2 production) during daylight hours and respiration (O_2 consumption) at night. The most recent investigations by Ohio EPA have identified a diel DO range of 6.5 mg/L as a threshold generally protective of biological and stream quality. Diel DO ranges greater than 6.5 mg/L are indicative of eutrophic, over-enriched conditions in Ohio streams (Ohio EPA 2014a).

Results

Figure 18, Figure 19, and Figure 20 display a representation of the nutrient assessment data collected from all Sandusky assessment sites that received at least one full sonde deployment in the watershed during the current survey or 2021 Statewide Large Rivers survey. The top plot in each figure displays the distribution of DO values from the 24-hour period with widest range for each site. The dot within

each DO distribution range shows the average DO value for the sonde deployment. Distributions that have a 24-hour DO range that is greater than 6.5 mg/L are shaded in red to indicate they are in exceedance of the maximum DO range threshold. The next two plots display the benthic and sestonic chlorophyll-α results for each site. Only chlorophyll-α samples taken during the sonde deployment presented in the top plot are shown. This pairs the DO readings taken during the 24-hour period with the algal community present during the sonde deployment. Benthic and/or sestonic chlorophyll samples were unable to be collected at all sonde sites; a lack of suitable substrates (e.g. sand, silt, hardpan, etc.) or high turbidity are common reasons why chlorophyll data are unable to be collected. The two bottom panels show the distribution of dissolved inorganic nitrogen (DIN), or the sum of nitrate+nitrite and total ammonia, and total phosphorus (TP) for each assessment site from June through September. The DIN and TP geometric mean concentration for each site are also indicated.

Dissolved oxygen and chlorophyll data were collected between three surveys in the Sandusky River watershed area study from Aug. 30– Sept. 1 and Sept. 13-15, 2022, and Sept. 12 – 14, 2023. For assessment sites that were revisited, DO and chlorophyll-α results from the deployment with the greatest DO 24-hour range are presented. Figure 18 displays a longitudinal representation of the nutrient assessment data collected from the Sandusky River mainstem. Each sonde deployment is organized by RM in a descending order from its headwaters to the mouth. Plotting data from the entire Sandusky mainstem longitudinally highlights the large stretch of data reaching from Bucyrus to Fremont collected from 2021-2022. Most sites are between five to ten RMs apart from one another. Figure 19 and Figure 20 displays data from all tributary sites assessed with sondes in the study area from 2022 and 2023. Both the tributary streams and individual sites are presented from upstream to downstream.

Sandusky River - Mainstem

Total phosphorus geometric mean concentrations from the mainstem Sandusky River were in the low- or moderate-risk categories for nutrient enrichment (Table 9). All sites that were in moderate-risk category were only slightly higher than the low-risk threshold. The greatest TP geometric mean occurred downstream from the Bucyrus WWTP at Kerstetter Road (RM 110.43 - U02P30), with a concentration of 0.181 mg/L. This value was 0.050 mg/L above the low-risk threshold. All DIN seasonal geometric mean vales were in the low-risk category.

Three Sandusky River mainstem sites had diel DO concentration range above the threshold of 6.5 mg/L— downstream from Upper Sandusky at Twp. Rd. 121 (RM 78.09 - 500860), downstream from Tiffin at Co. Rd. 38 (RM 36.50 - 500880), and upstream from Fremont and Wolf Creek (RM 23.00 – U04Q06). Benthic chlorophyll concentrations at these sites, where able to be collected, were in the low range. Sestonic algae concentrations were in the low range through much of the upper mainstem, while values were in the moderate or high range (Figure 18). Additionally, much of the middle and lower Sandusky River is shallower and flows over limestone bedrock which limits vertical scour and can leave these reaches potentially more prone to becoming over-enriched. All three of these locations have bedrock as a dominant substrate and the sites at RMs 23.00 and 78.09 were particularly shallow reaches of the Sandusky River.

Despite some indications of nutrient over-enrichment through certain segments of the Sandusky River mainstem, aquatic community quality through the entire mainstem achieved water quality goals and

most biological index scores were either very good or exceptional (Table 1). Nutrient enrichment is likely not an imminent threat or chronic issue impacting biological communities throughout the Sandusky River mainstem. A comprehensive, integrated discussion of biological, chemical, and physical habitat sampling results is contained in the **Water Quality and Aquatic Life Impairment Discussion** portion of this document.

Tributaries

The TP geometric mean concentration from all Sandusky River tributaries considered for this nutrient assessment were in the low- or moderate-risk categories. All sites in Figure 19 were contained within the ECBP ecoregion. Numerically, there are more assessment sites in the moderate-risk category among these upper tributaries compared to the lower tributaries, displayed in Figure 20. Total phosphorus concentrations in the moderate-risk category are typical for a working, agricultural stream in the ECBP ecoregion. Figure 20 displays sites that transition into the HELP ecoregion. More sites in this portion of the watershed had TP concentrations in the low-risk category. Like the Sandusky River mainstem sites, all DIN values were in the low-risk category.

All sites in Figure 19 had benthic chlorophyll concentrations in the low range. Results from benthic chlorophyll in Figure 20 were also generally low to moderate, except for Little Muddy Creek at Booktown Rd. (RM 7.55 - 300677) which was in the high range. Sestonic algae was also in the low range at all tributary assessment locations, except for Tymochtee Creek at Meeker at Mason Rd. (RM 49.44 – U01G07) which had concentrations in the moderate range.

Diel DO ranges greater than 6.5 mg/L were documented at seven tributary sites — Broken Sword Creek at Schwemley Rd. (RM 25.48 – U02G07), Little Tymochtee Creek (upper) NW of Marseilles at Co. Rd. 93 (RM 4.00 – U01G20) shown in Figure 19; Celery Creek at Weis Rd. (RM 0.45 - 303862), Wolf Creek upstream Co. Rd. 592 (RM 13.60 - 201336), Muskellunge Creek at St. Rt. 635 (RM 16.70 - 300674), Bark Creek at Kelley Rd. (RM 3.20 - 300671), and Fishing Creek at Weickert Rd. (RM 0.20 - 300678) shown in Figure 20.

The 2023 sonde deployment at Brandywine Creek at Holmes Center Rd. (RM 0.45 - 302323) documented DO values low enough that minimum criteria exceedances were noted every hour observed and in every 24-hour window (Figure 19). Dissolved oxygen saturation at this location never reached 100%. This assessment site has good forest cover and good buffer areas downstream from the bridge, with mixed rural residential/agricultural and some construction upstream. Benthic algal collections were not sampled at this site because of the predominantly fine-grained sands and small gravels present. Sestonic chlorophyll-α concentrations were low likely due to elevated suspended sediments in the water column and the presence of riparian shading. Chronically low DO values, coupled with lack of DO fluctuations or high algal biomass suggest that water quality impacts here stemmed from organic enrichment or another oxygen demanding source, rather than impacts from nutrient over-enrichment. This stream reach has a low gradient, and the instream substrates are dominated by fine-grained sediments. This combination of factors can result in the build-up of organic or other material(s) which spurs microbial activity that consumes oxygen through increased respiration as materials decompose or are processed. Additionally, excessive sediments or chemicals in the water can also create an additional oxygen demand (e.g., sediment oxygen demand - SOD, chemical oxygen demand – COD). This site was in the moderate-risk category for nutrient impairment

with current stressors including organic enrichment, sedimentation, and habitat alterations (Table 1). However, these data did not indicate nutrient enrichment here during the survey.

Tymochtee Creek at Meeker at Mason Rd. (RM 49.44 - U01G07) also exhibited extremely low DO concentrations throughout the sonde deployment (Figure 19). This portion of Tymochtee Creek has been heavily channelized and drained for agricultural use. Also, most streams in this area are lower gradient and finer-grained sandy, silty substrates are predominant. Overall, the Tymochtee watershed is the largest tributary system feeding to the Sandusky River and its headwaters have been heavily modified to facilitate drainage. Despite being heavily modified, Tymochtee Creek and many of its tributaries retain forested riparian buffers and relatively large tracts of woods that are not as common further north in the HELP ecoregion. The generally low gradient and sluggish nature of this entire stream system influences the delivery rates, settlement, and decomposition of sediment and organic materials into the stream and influences its overall chemical profile. Sonde data from 2023 documented exceedances of the minimum and 24-hour average DO criteria (Table 8). The low DO profile was most likely caused by respiration from the decomposition of excessive organic material delivered to this assessment site and the general lack of reaeration through this reach. Benthic algal collections were not possible at this assessment site because of the fine-grained sediments present. Sestonic chlorophyll-α sample results were in the moderate range at this site. Organic enrichment, along with excessive sedimentation and habitat alterations appear to be the primary stressors at this location. This site is in the moderate-risk category for eutrophication; however, nutrient enrichment was not impacting the assessment site during the survey.

Little Tymochtee Creek (lower) at RM 6.87 (U01G13) had DO concentrations throughout deployment that never exceeded 100% saturation and fell below the minimum criterion for 8 hours (Table 8). Benthic and sestonic chlorophyll-α sample results were low at this site (Table 9), likely due to the silty, mucky substrates noted in the stream at the time of sampling. The habitat characteristics at this site allow for organic materials to enter the system, while the low gradient nature of the system limits the ability to process and export the materials. This data coupled with the observations of habitat modification and excessive sediment provides evidence that organic enrichment is impacting this stretch of river. Though this site was in the moderate-risk category for nutrient enrichment, data from the current survey suggests that this site was primarily impacted by other factors.

Sondes in the Little Sandusky River at RM 3.71 (U02W06) had minimum DO exceedances for all 24-hour average periods and 22 reading hours below the minimum criterion (Figure 19, Table 8). This assessment site was lower gradient with silt substrates predominant and active erosion where sondes were deployed. Excess organic inputs coupled with these generally limiting habitat conditions exacerbate chemical signatures from excess inputs to this section of the river. Benthic algal collections were not possible at this assessment site because of the lack of suitable substrates and sestonic chlorophyll-α concentrations were very low (Table 9). The lack of suitable habitat and indicators of organic enrichment here place this site in a moderate-risk category for nutrient enrichment.

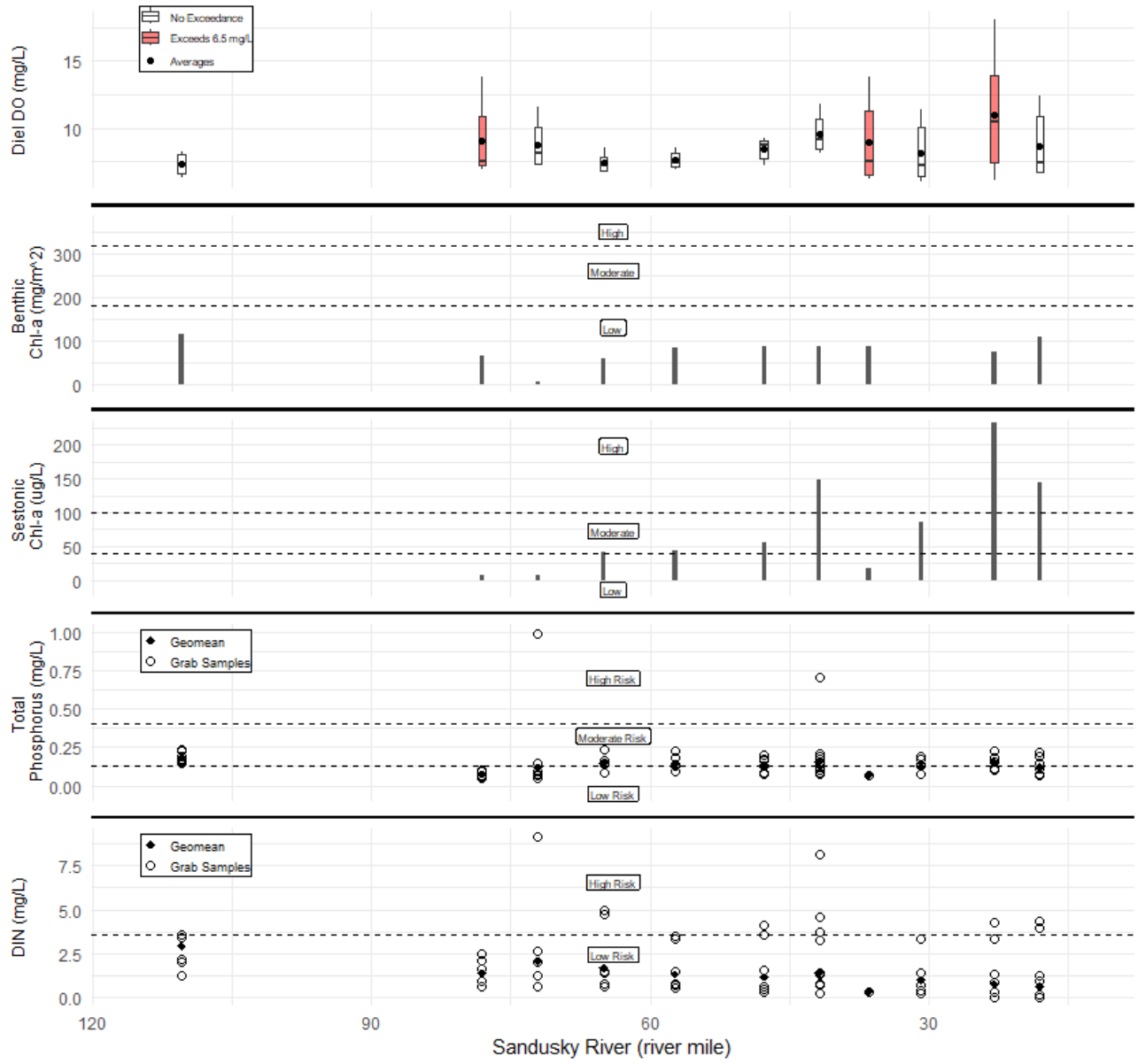


Figure 18 – Longitudinal representation of diel DO, benthic/sestonic chlorophyll-α, TP, and DIN used to evaluate the impact of nutrients on the Sandusky River from RM 110.43 near Bucyrus to RM 18.00 near Fremont.

Benchmarks for chlorophyll-a and nutrients (Dodds 2006, Miltner 2010, Ohio EPA 2014a, Ohio EPA 2015) are presented within their respective plots. Boxes on DO plots are shaded red if the diel range exceeds the 6.5 mg/L benchmark (Miltner 2010). The diel DO and chlorophyll data were collected from Sept. 7-9, 2021, between RM 18.00 and 65.01 as part of the Large Rivers Assessment Unit Study (8 sites), Aug. 30-Sept. 1, 2022, between RM 72.09 and 78.09 and Sept. 13-15, 2022, at RM 110.43 during the 2022 survey. Chemistry grab samples from the 2021 Large Rivers survey and 2022 Sandusky survey are from the period of June 2021– September 2023.

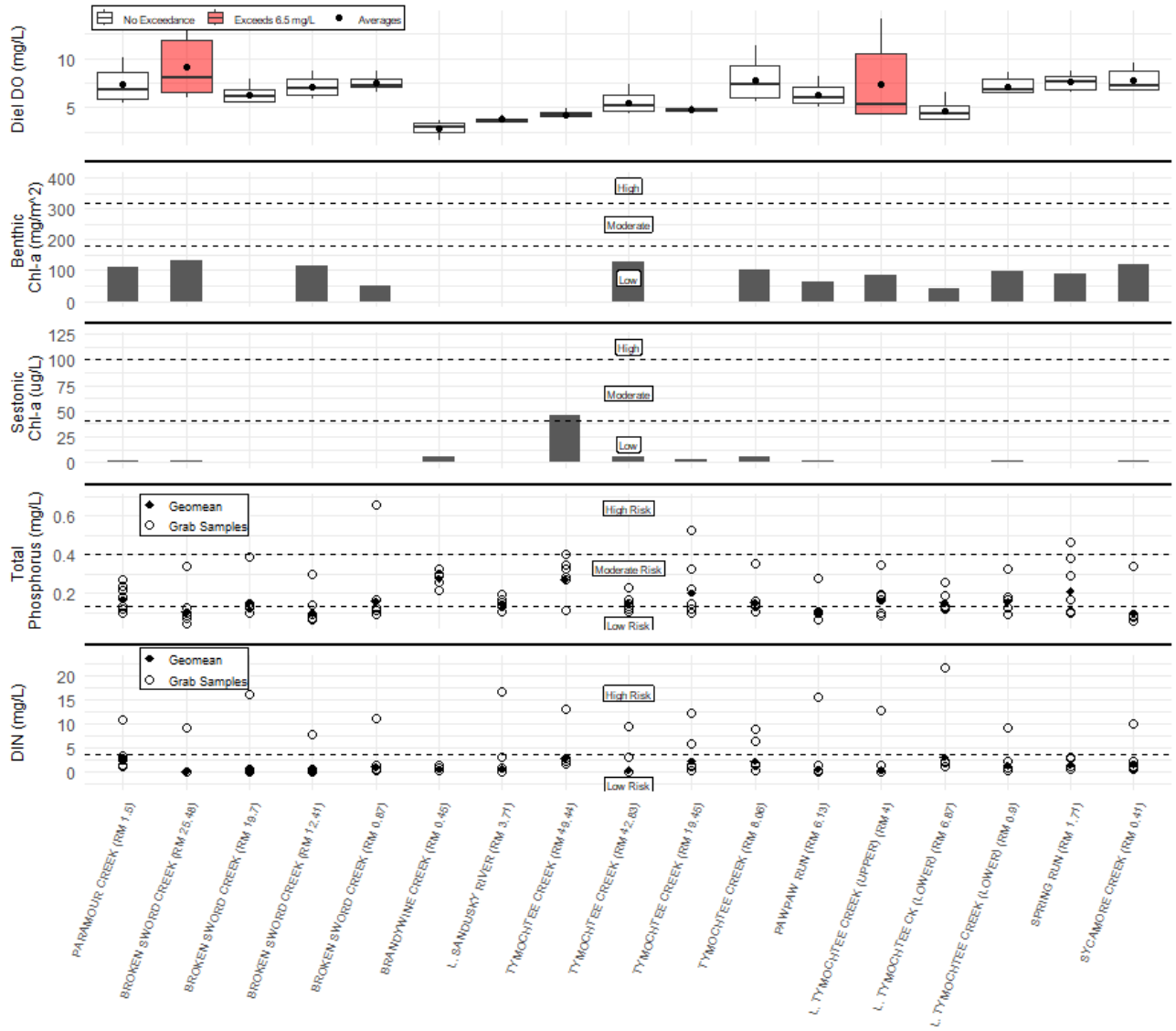


Figure 19 – Representation of diel DO, benthic/sestonic chlorophyll-α, TP, and DIN used to evaluate the impact of nutrients on tributaries to the Sandusky River.

Benchmarks for chlorophyll-a and nutrients (Dodds 2006, Miltner 2010, Ohio EPA 2014a, Ohio EPA 2015) are presented within their respective plots. Boxes on DO plots are shaded red if the diel range exceeds the 6.5 mg/L benchmark (Miltner 2010). The DO and chlorophyll data were collected between three surveys in the Sandusky River watershed area study from Aug. 30– Sept. 1 and Sept. 13-15, 2022, and Sept. 12 – 14, 2023. Chemistry grab samples are from the period of June 15, 2022 – Sept. 18, 2023.

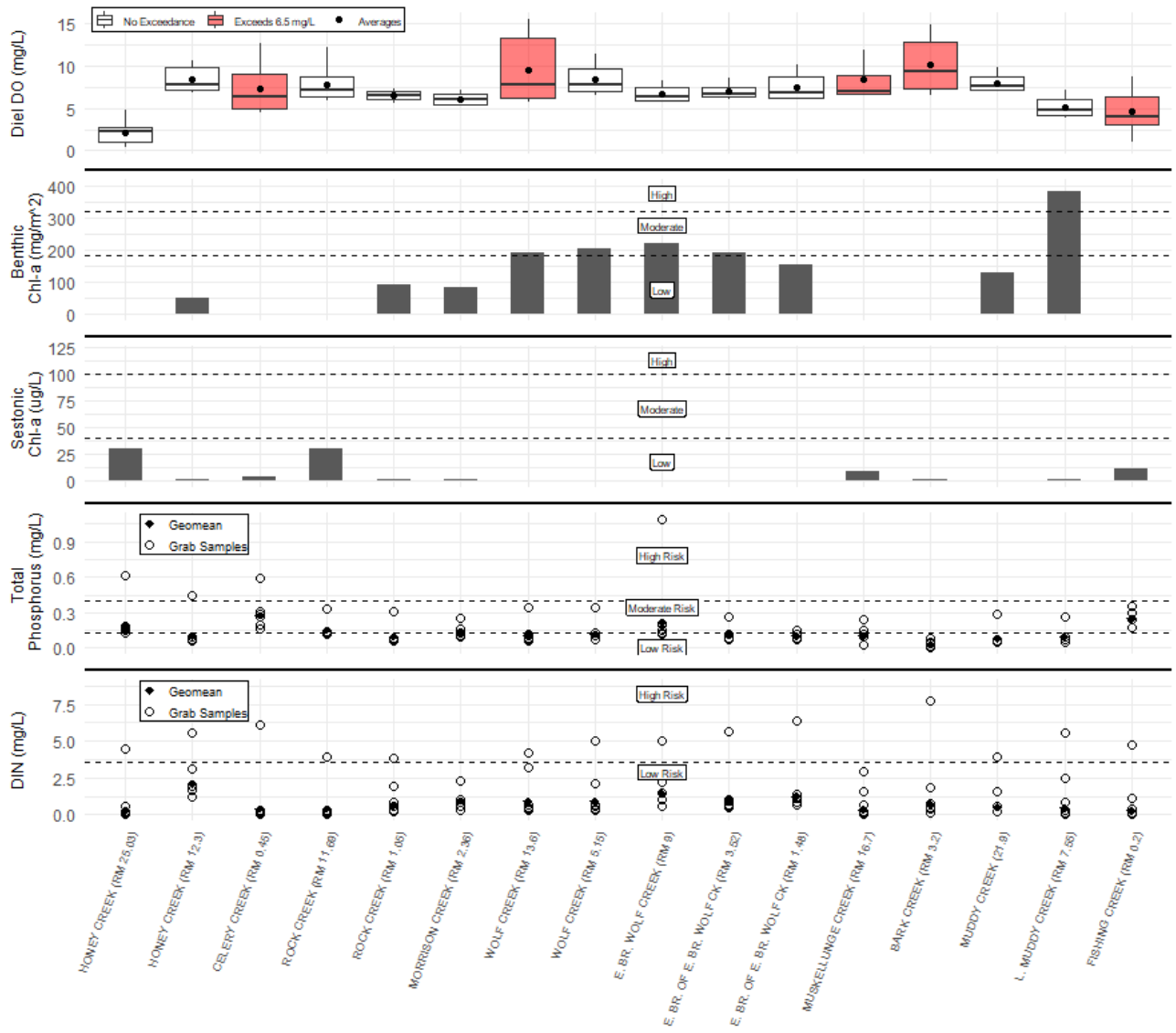


Figure 20 – Representation of diel DO, benthic/sestonic chlorophyll-α, TP and DIN used to evaluate the impact of nutrients on tributaries to the Sandusky River.

Benchmarks for chlorophyll-a and nutrients (Dodds 2006, Miltner 2010, Ohio EPA 2014a, Ohio EPA 2015) are presented within their respective plots. Boxes on DO plots are shaded red if the diel range exceeds the 6.5 mg/L benchmark (Miltner 2010). The DO and chlorophyll data were collected between three surveys in the Sandusky River watershed area study from Aug. 30– Sept. 1 and Sept. 13-15, 2022, and Sept. 12 – 14, 2023. Chemistry grab samples are from the period of June 15, 2022 – Sept. 18, 2023.

Table 9 — Nutrient sampling results in the Sandusky River watershed, summer (June 15 – October 15) 2022 and 2023.

The seasonal geometric mean for each site was used to assign a site to a risk category (Ohio EPA 2015). The risk categories do not directly translate to cause/source determinations for ALU impairment. Rather, this data serves as one of many lines of evidence in the cause/source determination process. However, this information does give one a general sense of how individual site nutrient levels compare to statewide data.

Stream (Stream Code)				Total Phosphorus		DIN (Ammonia + Nitrate + Nitrite)		
Station	RM	Assessment Unit[a]	Drainage Area (mi^2)	Samples (#)	Geometric Mean	Samples (#)	Geometric Mean	Risk Category [b]
Sandusky River Mainstem (05-001-000)								
U02P08	127.80	04 02	35.0	5	0.083	5	1.540	L
U02G01	120.82	04 03	67.1	5	0.114	5	1.259	L
U02P05	115.42	04 03	82.1	5	0.160	5	1.160	M
U02P30	110.43	04 05	88.9	7	0.181	6	2.927	M
U02P33	98.69	04 05	109.7	5	0.170	5	2.819	M
U02G02	93.76	07 02	232.2	5	0.149	5	2.136	M
U02P41	83.47	07 02	286.8	5	0.118	4	2.105	L
500860	78.09	07 02	295.5	6	0.075	5	1.387	L
U02P38	72.09	07 05	337.6	6	0.121	5	2.079	L
U03G01[d]	65.01	09 04	656.0	6	0.149	6	1.698	M
U04S29[d]	57.34	09 05	760.1	6	0.144	6	1.332	M
500830[d]	47.75	09 05	774.0	6	0.131	6	1.834	M
U04S28[d]	41.84	11 03	964.2	11	0.159	11	1.435	M
500880[d]	36.50	11 05	1030.9	1	0.069	1	0.352	L
500910[d]	30.85	11 05	1048.2	6	0.123	6	1.016	L
U04Q06[d]	23.00	11 05	1072.0	6	0.152	6	0.799	M
304303	19.10	13 02	1254.6	5	0.135	5	1.225	M
304130[d]	18.10	13 02	1255.2	6	0.122	6	0.681	L
Paramour Creek (05-042-000)								
U02P48	6.31	04 01	5.0	5	0.107	5	0.595	L
U02P12	1.50	04 01	26.0	7	0.146	7	2.894	M
Tributary to Paramour Creek (05-042-003)								
U02S07	3.70	04 01	1.0	3	0.220	3	2.156	M
Allen Run (05-043-000)								
U02G20	1.18	04 02	3.6	9	0.156	9	4.346	H
Loss Creek (05-041-000)								
U02G03	0.96	04 02	11.7	5	0.091	5	0.997	L
Grass Run (05-039-000)								
U02G14	8.36	04 04	9.1	5	0.067	4	2.116	L
U02G13	3.42	04 04	18.3	5	0.071	4	2.253	L
Broken Sword Creek (05-035-000)								
U02G09	30.31	03 01	9.4	5	0.051	5	0.228	L
U02G07	25.48	03 01	32.6	6	0.101	6	0.198	L
201366	19.70	03 01	42.0	6	0.153	6	0.600	M
U02S23	12.41	03 02	69.1	7	0.094	6	0.570	L

Stream (Stream Code)				Total Phosphorus		DIN (Ammonia + Nitrate + Nitrite)		
Station	RM	Assessment Unit[a]	Drainage Area (mi^2)	Samples (#)	Geometric Mean	Samples (#)	Geometric Mean	Risk Category [b]
U02P47	0.87	03 02	93.3	6	0.158	6	1.106	M
Red Run (05-038-000)								
201372	0.42	03 01	8.0	5	0.124	5	0.282	L
Brandywine Creek (05-037-000)								
302323	0.45	03 01	11.1	5	0.225	5	0.677	M
Indian Run (05-036-000)								
U02G12	0.94	03 02	8.0	5	0.083	4	4.460	H
Little Sandusky River (05-033-000)								
201361	10.40	07 01	6.9	5	0.187	5	0.638	M
U02G16	6.52	07 01	16.8	5	0.245	5	0.592	M
U02W06	3.71	07 01	21.5	6	0.146	6	0.803	M
Tributary to Little Sandusky River (05-033-003)								
U02W05	0.78	07 01	5.9	5	0.596	5	3.222	H
Honey Run (05-034-000)								
U02G18	0.52	07 01	9.0	4	0.106	5	0.694	L
Rock Run (05-032-000)								
U02S20	0.80	07 04	10.2	4	0.098	4	0.620	L
Negro Run (05-027-000)								
U02S19	0.52	07 03	13.1	5	0.028	4	0.254	L
Sugar Run (05-026-000)								
201354	0.60	07 05	4.6	5	0.058	4	1.018	L
Tymochtee Creek (05-300-000)								
U01W05	51.43	05 02	6.4	5	0.140	5	0.320	M
U01G07	49.44	05 02	16.7	6	0.269	6	2.956	M
U01G05	44.95	05 09	64.5	6	0.146	6	0.479	M
U01G04	33.99	05 09	146.2	5	0.199	5	1.770	M
U01G03	26.28	06 02	175.0	5	0.168	4	2.970	M
U02P44	19.45	06 02	204.3	6	0.201	5	2.278	M
500850	8.06	06 05	231.8	6	0.149	5	2.340	M
Prairie Run (05-300-007)								
U01W04	1.02	05 01	8.6	5	0.249	5	2.171	M
Enoch Ditch (05-300-006)								
U01W01	1.59	05 09	6.5	5	0.098	5	0.357	L
Carroll Ditch (05-300-004)								
U01G26	0.66	05 03	10.3	4	0.094	5	0.238	L
Pawpaw Run (05-319-000)								
U01G25	6.13	05 04	8.2	5	0.103	6	0.676	L
U01G24	0.57	05 04	16.3	5	0.113	5	1.302	L
Little Tymochtee Creek (Upper) (05-316-000)								
304302	8.63	05 06	11.9	5	0.158	5	1.336	M
U01G20	4.00	05 07	35.5	6	0.160	6	0.464	M
Reevhorn Run (05-317-000)								
U01G23	2.26	05 05	12.5	5	0.172	5	2.114	M

Stream (Stream Code)				Total Phosphorus		DIN (Ammonia + Nitrate + Nitrite)		
Station	RM	Assessment Unit[a]	Drainage Area (mi^2)	Samples (#)	Geometric Mean	Samples (#)	Geometric Mean	Risk Category [b]
Pawpaw Run (05-318-000)								
201432	1.10	05 05	5.6	4	0.155	5	1.287	M
Warpole Creek (05-314-000)								
U01G18	1.52	05 08	18.8	5	0.114	4	1.497	L
St. James Run (05-315-000)								
304296	0.15	05 08	10.7	5	0.079	4	1.936	L
Oak Run (05-312-000)								
U01G16	0.29	06 01	15.2	5	0.139	4	2.090	M
Lick Run (05-308-000)								
U01G15	0.83	06 05	7.9	5	0.091	4	0.951	L
Little Tymochtee Creek (Lower) (05-304-000)								
U01G14	10.32	06 03	11.1	5	0.263	5	1.031	M
U01G13	6.87	06 03	18.2	6	0.151	5	3.136	M
U02P45	0.90	06 03	31.0	6	0.156	5	1.387	M
Spring Run (05-301-000)								
U02P46	1.71	06 04	16.9	6	0.210	5	1.568	M
Poverty Run (05-302-000)								
U01G10	2.99	06 04	9.3	5	0.057	4	6.357	H
Thorn Run (05-024-000)								
U03G03	0.70	09 04	9.1	5	0.020	5	1.086	L
Taylor Run (05-023-000)								
U03G04	1.88	09 01	17.4	3	0.109	4	2.093	L
Tributary to Taylor Run (05-023-001)								
304297	0.10	09 01	6.7	5	0.093	5	1.671	L
Sycamore Creek (05-021-000)								
U03G10	18.92	09 02	18.2	5	0.072	5	0.188	L
U03G08	9.14	09 03	47.2	5	0.097	4	1.416	L
U03P05	0.41	09 03	64.2	6	0.010	6	1.709	L
Mile Run (05-020-000)								
U03G14	0.30	09 05	6.4	5	0.063	5	2.185	L
Honey Creek (05-200-000)								
U03G20	41.66	08 02	10.4	5	0.109	5	0.835	L
U03G18	34.14	08 02	26.5	5	0.084	5	0.351	L
U03P03	28.32	08 05	74.0	5	0.310	5	0.251	M
U03S03	25.03	08 05	84.4	8	0.188	8	0.200	M
U03S02	12.30	08 06	149.3	6	0.102	6	2.087	L
500970	1.10	08 06	179.3	5	0.140	5	1.495	M
Celery Creek (05-200-003)								
303862	0.45	08 02	13.4	6	0.225	6	0.236	M
Brokenknife Creek (05-209-000)								
201405	1.05	08 01	18.6	5	0.115	5	0.489	L
Aicholz Ditch (05-203-000)								
U03G25	3.72	08 03	9.4	5	0.173	5	0.524	M

Stream (Stream Code)				Total Phosphorus		DIN (Ammonia + Nitrate + Nitrite)		
Station	RM	Assessment Unit[a]	Drainage Area (mi^2)	Samples (#)	Geometric Mean	Samples (#)	Geometric Mean	Risk Category [b]
U03G24	2.46	08 03	15.0	5	0.152	5	0.607	M
Silver Creek (05-202-000)								
U03G22	4.08	08 04	16.3	5	0.188	5	0.481	M
Rock Creek (05-014-000)								
U04G18	11.69	11 01	14.7	6	0.150	6	0.375	M
U04W06	1.05	11 01	34.4	6	0.099	6	0.739	L
East Branch Rock Creek (05-015-000)								
U04G03	0.47	11 01	6.4	5	0.109	5	1.171	L
Willow Creek (05-013-000)								
U04W09	0.82	11 03	5.7	5	0.204	5	1.178	M
Morrison Creek (05-012-000)								
U04G06	9.34	11 02	9.3	5	0.272	5	0.773	M
U04G05	2.36	11 02	16.4	6	0.132	6	0.924	M
Spicer Creek (05-011-000)								
U04Q11	0.80	11 05	12.3	5	0.074	5	0.881	L
Sugar Creek (05-010-000)								
U04Q10	3.11	11 04	8.7	5	0.074	5	0.564	L
Wolf Creek (05-005-000)								
201336	13.60	10 04	27.9	6	0.109	6	0.908	L
U04S40	5.15	10 04	66.5	5	0.119	6	0.904	L
U04G07	1.58	10 04	71.7	5	0.135	5	0.889	M
Harrison Creek (05-005-004)								
U04G11	0.38	10 04	9.1	5	0.105	5	1.026	L
Plum Run (05-005-003)								
U04G09	0.79	10 04	9.8	5	0.086	5	1.259	L
Tributary to Wolf Creek (05-005-002)								
304298	0.17	10 04	6.7	5	0.063	5	2.204	L
East Branch Wolf Creek (05-006-000)								
300673	19.65	10 02	19.0	5	0.316	5	2.517	M
U04G15	13.63	10 02	33.2	5	0.194	5	1.706	M
201338	9.00	10 03	67.8	6	0.216	6	1.433	M
U04P03	0.86	10 03	82.0	5	0.142	5	1.622	M
Eicher Ditch (05-006-004)								
304299	0.01	10 02	9.3	5	0.124	5	1.041	L
East Branch of East Branch Wolf Creek (05-008-000)								
U04G13	3.52	10 01	7.2	4	0.115	6	1.001	L
300682	1.48	10 01	19.7	6	0.103	6	1.236	L
Middle Branch of East Branch Wolf Creek (05-009-000)								
U04G14	0.46	10 01	10.8	5	0.129	5	2.392	L
Indian Creek (05-004-000)								
500950	0.62	13 02	12.0	5	0.021	5	2.809	L
Muskellunge Creek (05-003-000)								
300674	16.70	13 01	17.7	6	0.102	6	0.335	L
201332	5.40	13 01	35.7	5	0.083	5	0.572	L

Stream (Stream Code)				Total Phosphorus		DIN (Ammonia + Nitrate + Nitrite)		
Station	RM	Assessment Unit[a]	Drainage Area (mi^2)	Samples (#)	Geometric Mean	Samples (#)	Geometric Mean	Risk Category [b]
Bark Creek (05-002-000)								
300671	3.20	13 03	10.0	7	0.043	7	0.725	L
Muddy Creek (05-219-000)								
201410	21.10	14 02	44.1	5	0.079	6	0.508	L
U04S01	9.79	14 04	72.8	5	0.087	5	0.568	L
South Branch Muddy Creek (05-222-000)								
U04S08	5.67	14 02	4.60	5	0.038	5	1.579	L
300679	1.54	14 02	21.9	5	0.036	5	0.587	L
Gries Ditch (05-223-000)								
U04Q16	0.93	14 01	12.5	5	0.028	5	0.955	L
Little Muddy Creek (05-220-000)								
300677	7.55	14 03	12.4	6	0.096	6	0.449	L
Fishing Creek (05-220-001)								
300678	0.20	14 03	7.0	6	0.251	6	0.261	M

a Assessment Unit within 8-digit watershed assessment unit 04100011.

b Risk categories are based on Ohio EPA (2015).

d Site sampled in 2021 as part of Large River Assessment Unit study.

Risk category	Total phosphorus	DIN
L (Low)	<0.131	<3.6
M (Medium)	≥0.131 and <0.4	<3.6
H (High)	≥0.4	≥3.6

Organic Surface Water Chemistry

Organic parameters, including organochlorine pesticides, acid- and chlorinated-acid herbicides, and glyphosate, were additionally measured at six sampling locations not designated as drinking water supply intakes. Organics were analyzed during two visits to each site across the field sampling season. Results are displayed in Table 10.

Alachlor was detected at one site, Broken Sword Creek at RM 0.87 (U02P47). Alachlor is an herbicide used for weed control on corn, soybeans, sorghum, peanuts, and beans. There are various liquid, dry flowable, microencapsulated, and granular formulations of this herbicide. Monitoring studies show that alachlor levels in surface water can result in effects on aquatic plants and indirectly on aquatic animals (US EPA 1998a). There are no applicable water quality criteria for alachlor outside of designated public water supplies (OAC 33745-1-33 A, Table 33-1).

Atrazine, detected in each of the twelve samples collected, is a systemic herbicide used to selectively control preemergent annual grasses and broadleaf weeds. Pesticide products containing atrazine are used on agricultural crops including corn and wheat, as well as non-agricultural uses such as nursery/ornamental and turf (USEPA 2022a). Atrazine is the second most widely used herbicide in the U.S., with 75% of corn treated annually (USEPA 2019). “It can reduce primary production in aquatic communities by inhibiting photosynthesis, has been linked to adverse reproductive effects in amphibians and other wildlife, and is currently being studied as a potential endocrine disruptor and carcinogen to both aquatic and human life (USEPA 2022b).” There are no applicable water quality criteria for atrazine outside of designated public water supplies (OAC 33745-1-33 A, Table 33-1).

Endrin was detected in four samples across three sites. Endrin was used as a pesticide to control insects, rodents, and birds. It was last produced and sold for general use in the United States in 1986. Endrin is not particularly water soluble. It is commonly found attached to the bottom sediments of rivers, lakes, and other bodies of water. Endrin can build up bioaccumulate in the tissues of aquatic organisms. Endrin breaks down to form endrin aldehyde and other substances. There are no applicable water quality criteria for Endrin aldehyde outside of designated public water supplies in the Lake Erie basin (OAC 33745-1-33 A, Table 33-1).

Metolachlor was detected in all twelve samples. Metolachlor is a broad-spectrum herbicide used primarily on corn, soybeans, lawns and turf, ornamental plants, trees, shrubs and vines, rights of way, fence rows and hedgerows, and in forestry. Liquid or granular ground application is most common, although aerial, irrigation, and chemigation application methods also are permitted. Metolachlor is moderately acutely toxic to freshwater fish. It is slightly acutely toxic to aquatic invertebrates. It also impacts non-target aquatic plants (USEPA 1995). There are no applicable water quality criteria for metolachlor.

Metribuzin was detected in nine samples across 5 sites. Metribuzin is an herbicide used to control broadleaf weeds and grassy weed species on vegetable, grain, turf grass, and non-crop settings. It is slightly toxic to practically non-toxic to freshwater fish on an acute basis, moderately to slightly toxic to aquatic invertebrates on an acute basis, and highly toxic to nontarget plants (USEPA 1998b). Propachlor was detected in one sample. Propachlor is an herbicide used to control grasses and broadleaf weeds, it is applied once, early in the season. Propachlor is slightly to moderately toxic to

most non-target organisms (USEPA 1998c). There are no applicable water quality criteria for Metribuzin or Propachlor.

Simazine, detected in two samples across two sites, is used to control a wide variety of annual broadleaf weeds on agricultural crops and ornamental plantings. It is toxic to aquatic invertebrates (USEPA 2021). There are no applicable water quality criteria for simazine.

Of note, Honey Creek at County Road 19 (500970, RM 1.1) is 2.9 RMs upstream from the City of Tiffin's drinking water intake at Ella Street. An outside mixing zone average criteria for atrazine of 3.0 µg/l applies at the intake. Atrazine values at Ella Street ranged from 0.5 to 1.35 µg/l. Discussion of drinking water sites can be found in that section of this report.

Table 10 — Organics detected in the Sandusky River watershed during 2021-2022.

Station	12-digit WAU 04100001-	River Mile	Parameter (value) (µg/l)
Broken Sword Creek			
U02P47	03 02	0.87	Alachlor (0.426) Atrazine (1.050, 0.242) Metolachlor (1.270, 0.732) Metribuzin (0.487) Propachlor (0.262)
Tymochtee Creek			
500850	06 05	8.06	Atrazine (2.57, 6.87) Endrin aldehyde (0.0073, 0.0085) Metolachlor (8.030, 6.870) Metribuzin (0.698, 0.686) Simazine (0.367)
Little Sandusky River			
U02W06	07 01	3.71	Atrazine (3.610, 1.540) Endrin aldehyde (0.0189) Metolachlor (8.660, 6.530) Metribuzin (0.547)
Sandusky River			
U02P38	07 05	72.09	Atrazine (1.280, 0.344) Endrin aldehyde (0.0089) Metolachlor (2.540, 0.718)
Honey Creek			
500970	08 06	1.10	Atrazine (22.800, 1.030) Metolachlor (10.700, 1.400) Metribuzin (1.16, 0.473)
Wolf Creek			
U04G07	10 04	1.58	Atrazine (1.400, 1.080) Metolachlor (1.550, 0.905) Metribuzin (0.304, 0.447) Simazine (0.267)

Sediment Chemistry Quality

Ohio EPA collected instream sediment samples in the Sandusky River study area on September 28, October 3 and 11, 2022. Samples were analyzed for percent solids, TOC, TP, metals, pesticides, PCBs, and s-VOCs (Polycyclic Aromatic Hydrocarbons, or PAHs). Sampling locations were selected in the study plan to determine background sediment quality, assess the impact from point sources and urban non-point runoff, and evaluate downstream transport and recovery. Samples were collected following the *Sediment Sampling Guide and Methodologies,* 3rd Edition (Ohio EPA 2012b). The goal is to collect a representative sample that is composed of more than 30% silt and clay particles. 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.

Many of the streams in the Sandusky River study area contain little in the way of fine-grained sediment in large enough volumes to have much of an ecological impact. Fine particles are predominantly washed downstream at higher flows. Exceptions to this include impounded segments, isolated eddies and in the headwater where feeder streams are channelized. Fine-grained sediments in large enough quantities for collection could not be found at sites on Broken Sword Creek (U02P47), Sandusky River (U02P30), Honey Creek (U03S02), Sycamore Creek (U03P05) and East Branch Wolff Creek (U04P03).

A total of seven sediment samples were collected. Samples were collected in the Sandusky River downstream Upper Sandusky at Twp. Rd. 121 (500860), Tymochtee Creek at State Route 53 (U01G03), Allen Run at Crestline Road (U02G20), Paramour Creek at Nazor Road (U02P12), Spring Run at Mott Road (U02P46), Muddy Creek at Co. Rd. 153 (U04S01), and Wolf Creek at State Route 12 (U04S40). Chemical parameters tested in the sediment and the analytical results are listed in Appendix M.

Sediment sample results were evaluated using Tier I procedures for aquatic life described in the *Guidance on Evaluating Sediment Contaminant Results* (Ohio EPA 2010) and *Sediment Sampling Data Quality Objectives for Biological and Water Quality Studies*, Version 1.0 located in Appendix III – Section B of the *Surface Water Field Sampling Manual* (Ohio EPA 2021). Numeric sediment quality guidelines (SQGs) used include Ohio sediment reference values (SRVs) for metals contained in the *Ecological Risk Assessment Guidance* (Ohio EPA 2018). The consensus-based sediment guidelines define two levels of ecotoxic effects. A threshold effect concentration (TEC) is a level of sediment chemical quality below which harmful effects are unlikely to be observed. A probable effect concentration (PEC) indicates a level above which harmful effects are likely to be observed.

Two options exist when contaminants are at concentrations above the PEC — either appropriate treatment options should be explored to remediate the source, or consideration should be given to investigate if bioavailability affects toxicity. This would likely require further investigation and studies. Harmful effects are unlikely below the TEC and more likely above the PEC. A summary of parameters measured above SQGs is presented in Table 11. Metals that were above their TEC, but that did not exceed their sediment reference value SRV are not displayed.

Table 11 — Chemical parameters measured above the Sediment Quality Guideline (SQG) in surficial sediment samples collected by Ohio EPA in the Sandusky River study area during 2022. Bold and highlighted parameters exceed the respective SQG.

Parameter	Result (mg/kg)	SRV (mg/kg)	TEC (mg/kg)	PEC (mg/kg)	
HUC 12 (04100011-07-02)					
500860 - SANDUSKY R. DST. UPPER SANDUSKY @ TWP. RD. 121					ECBP
Dieldrin (µg/kg)	2.24	NA	**1.9**	61.8	
Total PAH (mg/kg)	5.33	NA	**1.6**	22.8	
HUC 12 (04100011-06-02)					
U01G03 - TYMOCHTEE CREEK W OF UPPER SANDUSKY @ ST. RT. 53					ECBP
Dieldrin (µg/kg)	2.24	NA	**1.9**	61.8	
Total PAH (mg/kg)	2.53	NA	**1.6**	22.8	
HUC 12 (04100011-04-02)					
U02G20 - ALLEN RUN SE OF LEESVILLE @ CRESTLINE RD.					ECBP
Total PAH (mg/kg)	7.02	NA	**1.6**	22.8	
HUC 12 (04100011-04-01)					
U02P12 - PARAMOUR CREEK DST. CRESTLINE @ NAZOR RD.					ECBP
Zinc (mg/kg)	143.0	160	**121**	459	
Total PCB (µg/kg)	101.4	NA	**59.8**	676.0	
Total PAH (mg/kg)	3.56	NA	**1.6**	22.8	
HUC 12 (04100011-06-04)					
U02P46 - SPRING RUN DST. CAREY @ MOTT RD.					ECBP
Anthracene (PAH) (mg/kg)	1.25	NA	**0.057**	**0.845**	
Total PAH (mg/kg)	4.14	NA	**1.6**	22.8	
HUC 12 (04100011-10-04)					
U04S40 - WOLF CREEK AT BETTSVILLE @ ST. RT. 12					ECBP
Total PAH (mg/kg)	3.51	NA	**1.6**	22.8	

All parameters at all sites were below the PEC except for Anthracene in Spring Run. Anthracene is an individual PAH that exceeded the PEC, however, when included with all other PAH parameters the PEC for Total PAH is not exceeded.

Physical Habitat Sampling Results


Sandusky River RM 41.6 (U04S28) downstream from Ella Street looking downstream. 2021.

Stream physical habitat is evaluated using the Qualitative Habitat Evaluation Index (QHEI). The QHEI is a rapid, visual habitat assessment method correlated with fish community condition (Ohio EPA 2006a, 1989). Stream reaches with mean QHEI values of at least 60 indicate a level of macrohabitat quality that is typically sufficient to fully support an assemblage of aquatic organisms found in warmwater streams, while areas with average values greater than 75 typically have a greater potential to support exceptional assemblages (Ohio EPA 1989, Rankin 1995). Stream reaches with average QHEI values between 45 and 60 indicate that instream habitat may begin limit overall biological performance. Average values below 45 within a system indicate a higher probability of aquatic life use impairment related to aspects on the instream habitat.

However, average QHEI score values should not be viewed as being solely determinant of biological condition. In some instances, factors other than habitat quality (e.g., land use type, geology, hydrology, pollution sources, etc.) may exert more of a controlling force on the structure of biological assemblages. These positive or negative factors may cause stream biology to either "over- "or "under-perform" relative to available instream habitat, both at a particular site or through a stream reach. For example, smaller stream systems with extreme stormwater surges may still generally have good or even excellent QHEI scores, but biological performance may still fall short of expectations.

Streams with higher habitat quality will have more capacity to process excess pollutants and will also generally be associated with better quality biological assemblages. As habitat quality shifts from a natural to a more modified state, attendant water quality issues, like nutrient or organic enrichment, in a stream system can be exacerbated. For example, if a stream already has deficient instream habitat (reduced riparian shading, fair/poor stream development, etc.), excess nutrients may not adequately assimilate. This condition can result in more severe instream enrichment and negative impacts to biological communities compared to a similar pollutant load into a more natural stream system. Conversely, a more natural stream system is generally able to process various pollutants like nutrients or sediment more effectively, and thus, a similar pollutant load may not have as drastic an impact on instream conditions.

Results

As part of the survey efforts, stream physical habitat was evaluated at 112 sampling locations encompassing 120 individual QHEI assessments. Overall, QHEI scores throughout the study area ranged from very poor to excellent and most scores fell within the good to exceptional range (Table 12).

Habitat scores are displayed by drainage area in Figure 21 and are parsed by site attainment status and the existing or recommended ALU. Most sites in the study area had QHEI scores sufficient to fully support an assemblage of aquatic organisms found in warmwater streams. There were some areas where QHEI scores fell below 45; most of these scores were associated with either sub-use goal stream segments or sites that had one or more organism group failing to achieve WWH criteria. There are also a good number of areas where limiting habitat features may be present (QHEI between 60 or 55, and 45). Habitat influences may play a primary or secondary role in limiting biological performance at sites in this range (Figure 21). These influences of habitat on biotic assemblages are discussed more thoroughly in the ***Beneficial Use Designations and Recommendations*** section.

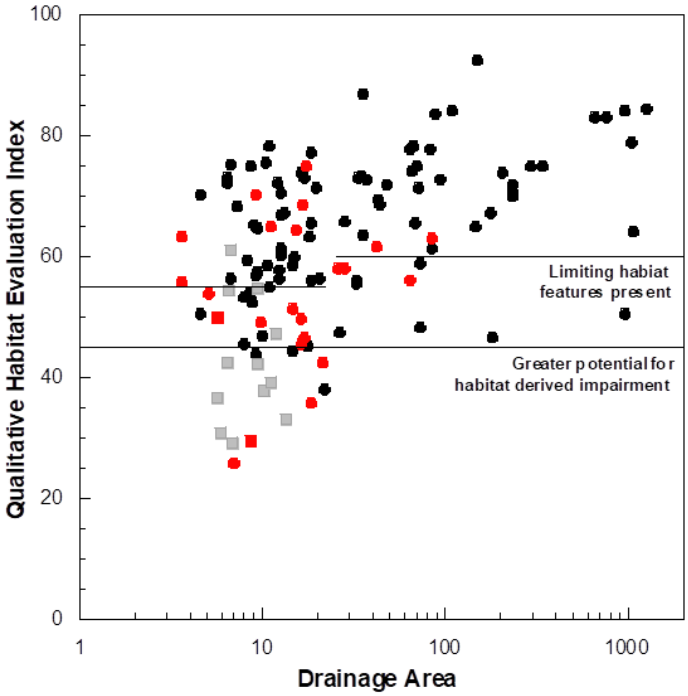


Figure 21 – QHEI scores displayed by drainage area from the current Sandusky survey, 2021-2023. Sites with one or more organism groups failing to achieve requisite criterion are identified in red. Sites with sub-use CWA aquatic life use designations (MWH or LRW) are indicated by grey squares.

QHEI scores through the mainstem indicated generally good to excellent habitat quality, with an average value (77.4) indicating excellent overall habitat quality. The site exhibiting fair habitat quality (RM 42.92, 500940) was within the Ella Street Dam pool, resulting in a lower QHEI score compared to surrounding reaches. All the other mainstem reaches evaluated had generally high-quality habitat and had QHEI scores that were mostly excellent (Table 12).

Tributaries to the upper portions of the Sandusky River drain a mosaic of agricultural farmlands and the occasional small city or town. Many of these streams drain from glacial end moraines that comprise the uppermost Sandusky River watershed (Figure 6). In addition to providing cool groundwater, these glacial features result in a generally higher gradient and more power compared to streams draining more low-gradient lacustrine deposits. These factors give a stream the ability to more quickly recover from habitat disturbances and more efficiently purge excessive silts/fines from the system.

QHEI scores in the upper tributaries (Allen Run, Paramour Creek, South Fork Loss Creek, Grass Run) were higher quality, except for Paramour Creek. QHEI scores at both locations in Paramour Creek were in the fair range, compared to good or excellent habitat in the other areas (Table 12). Much of Paramour Creek drains older lacustrine silts/fines deposited by proglacial lakes formed at the base of retreating glaciers, resulting in the need for more channelization and drainage through this sub-basin to facilitate agriculture and development. The two Paramour Creek sampling locations had the lowest channel sub-metric scores of these upper tributaries (Table 12).

Habitat quality through Broken Sword Creek ranged from fair to excellent, with an average QHEI score (64.0) indicating good overall habitat. QHEI scores were highest at the two lowest locations in Broken Sword Creek and gradually decreased in an upstream progression as the amount of channelization and hydromodifications increases in this tributary system. Tributaries to Broken Sword Creek had fair or good QHEI scores, with average values trending toward the fair range (Table 12). Channelization and habitat modifications were pervasive through the smallest drainages in this sub-basin.

Deficient instream habitat was present through much of the Little Sandusky River sub-watershed - the average QHEI score (42.9) indicated poor habitat quality through the watershed. Substrate sub-metric scores were, collectively, among the lowest in the survey and thick blankets of silt covering the stream bottom plagued much of this sub-basin. Honey Run downstream from County Road 126 (RM 0.50, U02G18) was the lone exception. A good QHEI score was noted, and pervasive siltation was not present here (Table 12). Much of this sub-watershed drains older lacustrine deposited silts/fines from former glacial lakes that formed at the base of retreating glaciers.

Little Sandusky River RM 6.52 (U02G16). Note the lack of stream development and heavy siltation.

All other smaller tributaries through the middle mainstem (Rock Run, Negro Run, Sugar Run, Thorn Run, Taylor Run, Trib. to Taylor Run (2.49), Sycamore Creek, Mile Run) had generally high-quality habitat and QHEI scores were either good or excellent (Table 12). Like some of the other area streams, Thorn Run and Taylor Run also drain mostly older lacustrine deposits, and finer grained sediments were pervasive in these streams despite generally good overall habitat.

Tymochtee Creek near RM 33.99 (U01G04). Note the sluggish flows and finer grained sediments. This reach has not been formerly channelized.

The Tymochtee Creek sub-basin also drains mostly all areas of finer grained lacustrine sands and silts splayed between the adjacent glacial moraines that outline this tributary system (Figure 6). It is a generally sluggish, low-gradient stream system with profuse amounts of large woody debris and finer grained sediments like pea gravel, sand, and silt. Instream habitats often resemble typical streams in the Huron-Erie Lake Plains ecoregion. Habitat scores through Tymochtee Creek mainstem were good through the lower and middle reaches, and fair to poor in the upper reaches (Table 12). Several tributary segments in the upper reaches of Tymochtee Creek had QHEI scores in the range where habitat may be limiting and would have a higher potential for habitat derived impairment – these stream segments included Prairie Run, Enoch Creek, Carroll Ditch, the upper reaches of Little Tymochtee Creek (upper), and Pawpaw Run. Most tributaries draining to lower Tymochtee Creek had generally good QHEI scores, except for Little Tymochtee Creek (lower). Fair to poor quality habitat persisted in this stream and pervasive siltation through the upper reaches lowered habitat quality.

The Honey Creek sub-watershed encompasses a diverse array of habitats from its headwaters near Tiro to its confluence with the Sandusky in Tiffin. Honey Creek is the last major tributary system that joins the Sandusky River before the watershed transitions into the HELP ecoregion (Figure 7). Its headwaters drain glacial end moraines and are higher gradient with excellent habitat quality for a headwater-sized stream (Table 12). The middle portions of the sub-basin are lower gradient and drain flat ground moraines (Figure 6); habitat quality through this reach of the sub-watershed ranged from poor to good. Celery Creek near Celeryville, OH drains to Honey Creek upstream from RM 34.14 (U03G18). The area around Celeryville is a former glacial lake that was a shallow finger of prehistoric Lake Erie. This shallow, marshy portion of the former glacial lake gradually filled and became dominated by bog type plants, eventually resulting in the peat deposits that characterize the area (ODNR Div. of Wildlife). Much of this area has been drained extensively and is now very productive agricultural land able to sustain specialty crops such as peppers, cucumbers, summer squash, zucchini (Gwirtz 2021). Further downstream, Honey Creek at RM 12.30 (U03S02) had excellent quality habitat and is higher gradient, coursing through exposed limestone bedrock and coarse tills. The lowermost portions of Honey Creek are affected by the Ella Street Dam pool on the Sandusky River, with fair overall habitat quality noted at RM 1.10 (500970). QHEI scores were in the range that can limit biological community performance at several areas through the Honey Creek sub-watershed – specifically Celery Creek RM 0.45 (303862), Aicholz Ditch RM 3.72 (U03G25), and Silver Creek RM 4.08 (U03G22). Though overall habitat quality was good at Honey Creek RM 25.03 (U03S03), this reach was sluggish with poor development and pervasive siltation. Large woody debris constrictions formed the only semblances of a riffle here; there were no true riffles with coarse substrates.

Several of the smaller tributaries in the greater Tiffin area drain the last set of glacial moraines as the watershed transitions to the HELP ecoregion (Figure 6, Figure 7). These include Rock Creek, Willow Creek, Morrison Creek, Spicer Creek, and Sugar Creek.

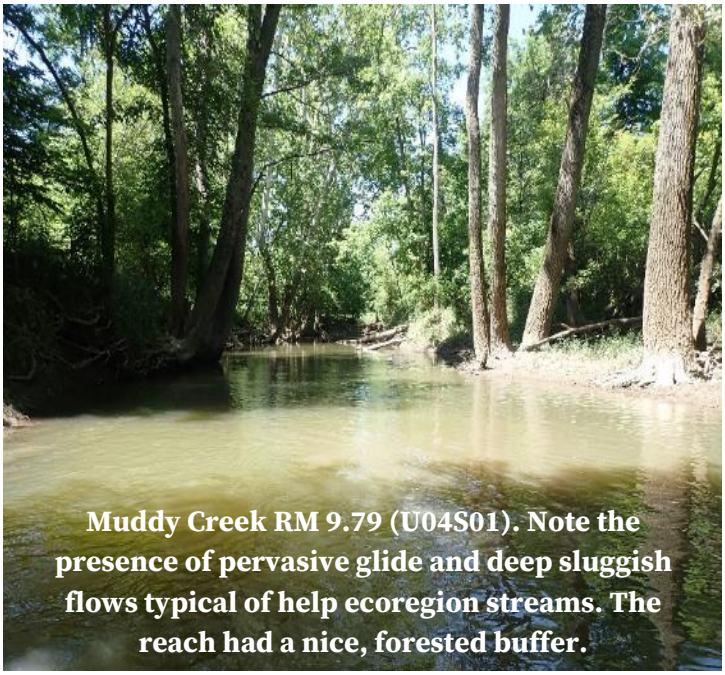
Rock Creek RM 0.75 (U02G16) in Tiffin. Note the bedrock substrates and good shallows habitat.

Habitat quality at Rock Creek RM 11.69 (U04G18) was fair (Table 12). Interstitial flows were observed during sampling on 9/15/2022 and heavy blankets of siltation were noted during both sampling events. Some portions were also scoured to hardpan. Though this segment of Rock Creek maintains some natural habitat features, much of this portion of the watershed was extensively drained to facilitate agriculture and the surrounding development. Habitat quality at Rock Creek RM 0.75 (U04W06) was much better overall. Conditions here were decidedly different from the upper reaches, being higher gradient and flowing over exposed limestone bedrock (pictured above).

Habitat quality in Willow Creek RM 0.82 (U04W09) was only fair and thick blankets of silt smothered the reach evaluated (Table 12). Most of the lower reaches that were evaluated have been formerly channelized and had poor/fair channel development, with the stream contained within its incised banks. The upper portion of the evaluation zone was more natural, but the riparian understory was overgrown with various invasive plant species. Though the habitat quality here was only fair, this stream reach has a higher gradient and cold groundwater inputs from the adjacent moraines were evident during sampling (Figure 6).

The overall habitat quality at Morrison Creek RM 2.05 (U04W05) was good; however, the overly deep pools through this reach suggest some modified/flashy hydrology. There were only moderate amounts of siltation and embeddedness, but there were still too many fines overall. Although this reach of Morrison Creek had many natural habitat features, the upstream reaches have been heavily modified, and several segments were channelized in recent years (Figure 22).

The northernmost tributaries are located mostly in the HELP ecoregion. Most stream habitats through the HELP ecoregion are characterized by generally flat plains, some stream segments in this portion of the watershed were higher gradient and drained exposed limestone bedrock. These sites included Wolf Creek RM 5.15 (U04S40) and RM 1.58 (U04G07), East Branch Wolf Creek RM 1.58 (U04P03), and Gries Ditch RM 0.93 (U04Q16).



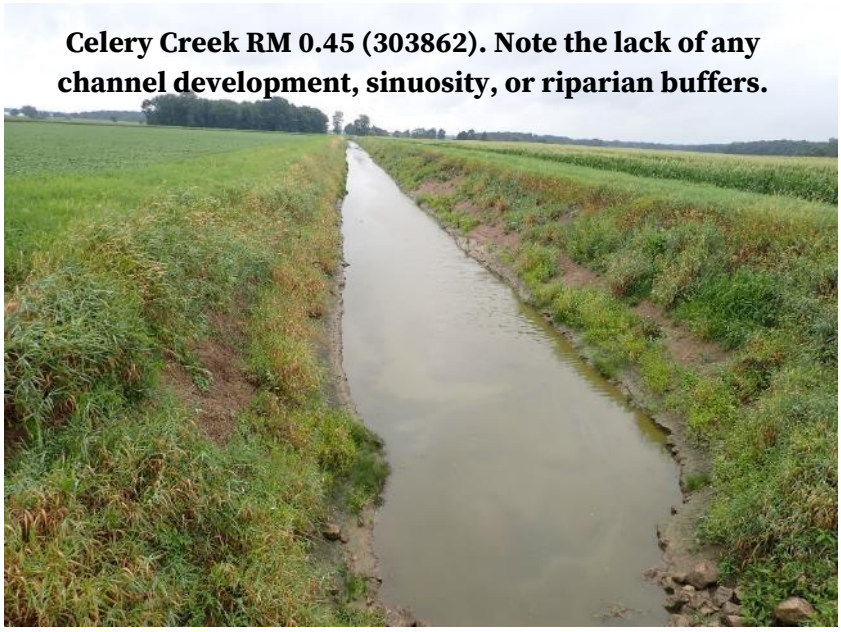
Muddy Creek RM 9.79 (U04S01). Note the presence of pervasive glide and deep sluggish flows typical of help ecoregion streams. The reach had a nice, forested buffer.

Other tributary sites in this portion of the study area were more typical of HELP ecoregion streams, with most being formerly channelized and having finer grained, lacustrine sediments as the dominant substrate type. Habitat quality ranged from very poor to excellent (Table 12). Plum Run RM 0.79 (U04G09) had a QHEI score in the fair range and siltation was pervasive throughout the reach evaluated. Though the East Branch of East Branch Wolf Creek RM 3.52 (U04G13) had a good QHEI score, this stream segment was formerly channelized and confined within its incised banks where sampled. This stream segment lies close to the ecoregion boundary and has some coarser substrates (boulders and cobbles) strewn through the zone. Fishing Creek RM 0.20 had very poor habitat quality, and the site was within a Lake Erie backwater area. Thick organic material and silt were the dominant substrates and there were no lotic stream features at this site (Appendix H).

Figure 22 – Time-lapse aerial imagery displaying segments of upper Morrison Creek.

Note the fresh channelization, removal of riparian buffers, and formerly retired lands now being put back into agricultural production (left).

Sandusky River RM 98.67 (U02P33). Note the presence of coarse substrates, good riparian buffers, and good deep riffles.



Celery Creek RM 0.45 (303862). Note the lack of any channel development, sinuosity, or riparian buffers.

Comparisons between the QHEI and IBI have resulted in a list of critical, often natural, habitat features strongly associated with WWH and EWH fish assemblages (warmwater habitat attributes) and a list of features that are more often associated with degraded communities (negative habitat attributes) (Rankin 1989, Rankin 1995). Certain negative habitat attributes have substantially higher impacts to biological assemblages than others. These are collectively referred to as moderate- and high-influence negative habitat attributes. As the number of negative habitat attributes begin to accumulate, both at a site and within a stream system, the potential for habitat quality to limit biological performance increases. As the ratio of negative to warmwater attributes increases above 2:1, the potential for instream habitat to cause biological impairment increases. A complete list of positive and negative habitat features is presented in Appendix H.

Deep riffles flowing through coarse substrates and wide riparian areas (pictured above) are two examples of positive, natural habitat features, while many negative habitat features are pictured in Celery Creek (right).

Stream sites that had high-influence MWH/WWH attribute rations greater than 2:1 included Tymochtee Creek RM 51.40 (U01W05), Prairie Run RM 1.00 (U01W04), Carroll Ditch RM 0.70 (U01G26), Little Tymochtee Creek (lower) RM 10.30 (U01G14), Celery Creek RM 0.45 (303862), and South Branch Muddy Creek RM 5.70 (U04S08). Habitat quality was like a primary factor limiting biological performance at these locations.

Additionally, there were numerous other stream sites that had moderate-influence ratios greater than 2:1. Several streams had moderate-influence rations greater than 3:1 including the Little Sandusky River RM 10.40 (301361), Trib. to Little Sandusky River (8.93) RM 0.80 (U02W05), Tymochtee Creek RM

49.30 (U01G07), Prairie Run RM 1.02 (U01W04), Enoch Creek RM 1.59 (U01W01), Carroll Ditch RM 0.66 (U01G26), Pawpaw Run RM 1.10 (201432), Little Tymochtee Creek (lower) RM 10.32 (U01G14) and RM 6.33 (U01G13), Celery Creek RM 0.45 (303862), Morrison Creek RM 9.34 (U04G06), Muddy Creek RM 9.79 (U04S01), and South Branch Muddy Creek RM 5.67 (U04S08) and RM 1.50 (300679). There are likely components of habitat that are limiting biological performance at these sites.

Table 12 – Summary of QHEI scores and individual metric breakdowns from streams within the current survey, 2021-23.

Values were averaged if multiple QHEI scores were collected at the same location. River miles displayed are for the actual sampling locations.

Station	River Mile	Drainage Area	Substrate	Instream Cover	Channel	Riparian	Pool	Riffle	Gradient	QHEI	Narrative Evaluation
Sandusky River (05-001-000)											
U02P08	127.90	35.5	19	15	18	8	10	7	10	87.00	Excellent
U02G01	120.70	67.1	16	16	15	8.75	10	4.5	8	78.25	Excellent
U02P30	110.43	88.9	20	16	16	6.5	11	6	8	83.50	Excellent
U02P33	98.69	109.7	18	16	16.5	5.75	12	6	10	84.25	Excellent
U02G02	93.76	232.2	14.5	17	14	4.5	10	2	10	72.00	Good
500860	78.09	295.5	13	17	16	6	9	6	8	75.00	Excellent
U02P38	72.09	337.6	15	15	16	6	7	6	10	75.00	Excellent
U03G01	65.01	656.0	15	16	18	8	11	5	10	83.00	Excellent
U04S29	57.34	760.1	15	18	18	8	11	5	8	83.00	Excellent
500940	42.92	960.4	5	14	12	5.5	8	0	6	50.50	Fair
U04S28	41.60	964.3	19	15	17	7.25	9	7	10	84.25	Excellent
500910	30.90	1048.2	15	15	18	8	10	5	8	79.00	Excellent
U04Q0	23.00	1072.0	11	10	14	7.25	10	4	8	64.25	Good
U04S23	16.80	1257.6	16.5	14	18	8	11	7	10	84.50	Excellent
Paramour Creek (05-042-000)											
U02P48	6.15	5.1	11	13	8.5	3.5	10	2	6	54.00	Fair
U02P12	1.50	26.0	12.5	13	8.5	3	10	5	6	58.00	Fair
Trib to Paramour Creek (5.13) (05-042-003)											
U02S07	3.70	1.0	7.5	10	14	6	5	0.5	10	53.00	Fair
Allen Run (05-043-000)											
U02G20	1.05	3.6	12.25	10	17	5.75	6	2.5	6	59.55	Good

Station	River Mile	Drainage Area	Substrate	Instream Cover	Channel	Riparian	Pool	Riffle	Gradient	QHEI	Narrative Evaluation
South Fork Loss Creek (05-041-001)											
201377	0.10	6.7	16	16	16	5.25	9	5	8	75.25	Excellent
Grass Run (05-039-000)											
U02G14	8.36	9.1	16	15	10.5	1.5	8	0	6	57.00	Good
U02G13	3.42	18.3	17	16	13.5	5.75	11	4	10	77.25	Excellent
Broken Sword Creek (05-035-000)											
U02G09	29.52	10.9	12	9	11	2	7	4	10	55.00	Good
U02G07	25.48	32.6	12.25	14.5	10.25	3	9.5	2.25	4	55.75	Fair
201366	19.70	42.0	12	17	9	5.75	8	4	6	61.25	Good
U02S23	12.30	69.1	13	15	16	6	10	7	8	75.00	Excellent
U02P47	0.60	93.5	17	16	12	3.75	10	6	8	72.75	Good
Red Run (05-038-000)											
201372	0.42	8.0	12.5	12	9	2	6	0	4	45.50	Fair
Brandywine Creek (05-037-000)											
302323	0.40	11.2	10	14	12	6.5	8	4.5	10	65.00	Good
Indian Run (05-036-000)											
U02G12	0.75	8.5	13.5	12	10.5	4.75	5	2	6	53.75	Fair
Little Sandusky River (05-033-000)											
201361	10.40	6.9	0	9	6	6.25	4	0	4	29.25	Very Poor
U02G16	6.40	16.9	6.5	5	14	7.25	5	3	6	46.75	Fair
U02W06	3.71	21.5	0.5	13	13	6	4	0	6	42.50	Poor
Trib. To Little Sandusky River (8.93) (05-033-003)											
U02W05	0.78	5.9	0	5	9.5	4.25	5	3	4	30.75	Poor
Honey Run (05-034-000)											
U02G18	0.52	9.0	13	14	14	6.75	5	4.5	8	65.25	Good

Station	River Mile	Drainage Area	Substrate	Instream Cover	Channel	Riparian	Pool	Riffle	Gradient	QHEI	Narrative Evaluation
Rock Run (05-032-000)											
U02S20	1.40	9.4	12	13	13.5	5.25	7	6	8	64.75	Good
Negro Run (05-027-000)											
U02S19	0.52	13.1	15	15	10.5	3.75	9	4	10	67.25	Good
Sugar Run (05-026-000)											
201354	0.60	4.6	15	14	17	6.75	6	3.5	8	70.25	Excellent
Tymochtee Creek (05-300-000)											
U01W05	51.43	6.4	4	11	8.5	5.5	5	2.5	6	42.50	Poor
U01G0	49.44	16.1	9	12	9	5.75	9	1	4	49.75	Fair
U01G05	44.95	64.5	13	10	11	5.5	6	4.5	6	56.00	Fair
U01G04	33.99	146.2	13	15	11.5	6.5	11	2	6	65.00	Good
U01G03	26.28	175.0	12.5	16	13.5	5.75	10	1.5	8	67.25	Good
U02P44	19.45	204.3	10.5	17	16	7	12	5.5	6	74.00	Good
500850	7.60	232.2	12.25	14.5	15	6.625	7	5	10	70.4	Good
Prairie Run (05-300-007)											
U01W04	1.02	8.6	1	10	5	4.5	3	0	6	29.50	Very Poor
Enoch Creek (05-300-006)											
U01W01	1.59	6.5	13	13	9	4.5	5	2	8	54.50	Fair
Carroll Ditch (05-300-004)											
U01G26	0.66	10.3	4	8	10.5	4.75	4	2.5	4	37.75	Poor
Pawpaw Run (05-319-000)											
U01G25	6.13	8.2	9	18	12	4.5	6	4	6	59.50	Good
U01G24	0.80	16.3	14	17	12	6.75	10	4	10	73.75	Excellent
Little Tymochtee Creek (Upper) (05-316-000)											
304302	8.63	11.9	7.5	8	10	4.75	6	5	6	47.25	Fair

Station	River Mile	Drainage Area	Substrate	Instream Cover	Channel	Riparian	Pool	Riffle	Gradient	QHEI	Narrative Evaluation
U01G20	3.95	37.1	15	15	15	6.75	6	5	10	72.75	Good
Reevhorn Run (05-317-000)											
U01G23	2.26	12.5	14.5	14	12	5	6	6	4	61.50	Good
Pawpaw Run (05-318-000)											
201432	1.10	5.6	5	6	10	2.75	5	2	6	36.75	Poor
Warpole Creek (05-314-000)											
U01G18	1.55	18.4	9	11	10	3	8	5	10	56.00	Good
St. James Run (05-315-000)											
304296	0.15	10.7	12.5	12	14.5	3	7	3.5	6	58.50	Good
Oak Run (05-312-000)											
U01G16	0.29	15.2	7.5	13	14.5	6.5	10	3	10	64.50	Good
Lick Run (05-308-000)											
U01G15	0.83	7.9	11.5	8	13	4.25	6	2.5	8	53.25	Fair
Little Tymochtee Creek (Lower) (05-304-000)											
U01G14	10.32	11.1	2	9	10	4.25	5	3	6	39.25	Poor
U01G13	6.33	18.5	0	5	8.5	3.75	6	2.5	10	35.75	Poor
U02P45	1.95	28.4	10.5	13	9.5	5.5	10	3.5	6	58.00	Fair
Spring Run (05-301-000)											
U02P46	1.71	16.9	13.5	16	13	6	10	4.5	10	73.00	Excellent
Poverty Run (05-302-000)											
U01G10	2.99	9.3	11.5	14	11.5	3.5	7	4	6	57.50	Good
Thorn Run (05-024-000)											
U03G03	0.70	9.1	9.5	15	16	5.25	10	4.5	10	70.25	Excellent
Taylor Run (05-023-000)											
U03G04	1.88	17.4	12.5	15	16	7.5	10	4	10	75.00	Excellent

Station	River Mile	Drainage Area	Substrate	Instream Cover	Channel	Riparian	Pool	Riffle	Gradient	QHEI	Narrative Evaluation
Trib. To Taylor Run (2.49) (05-023-001)											
304297	0.10	6.7	8	13	15	6	6	3	10	61.00	Good
Sycamore Creek (05-021-000)											
U03G10	18.92	18.2	15	13	11	6.25	6	6	6	63.25	Good
U03G08	9.14	47.2	11	15	16	7	9	6	8	72.00	Good
U03P05	0.41	64.2	15	15	16	5.25	11	5.5	10	77.75	Excellent
Spring Creek (05-021-002)											
U03G13	1.88	8.8	13.5	9	12.5	5	5	1.5	6	52.50	Fair
Mile Run (05-020-000)											
U03G14	0.30	6.4	13	16	17	5.25	8	3	10	72.25	Excellent
Honey Creek (05-200-000)											
U03G20	41.66	10.4	13.5	16	17	5.5	9	4.5	10	75.50	Excellent
U03G18	34.14	26.5	14	8	11	1.5	6	3	4	47.50	Fair
U03S03	25.03	84.4	11.5	16	12	6.75	8	3	4	61.25	Good
U03S02	12.30	149.3	20	20	19	6.5	12	7	8	92.50	Excellent
500970	0.20	179.3	5	13	11	5.75	8	0	4	46.75	Fair
Celery Creek (05-200-003)											
303862	0.45	13.4	2	5	6.5	1.5	6	2	10	33.00	Poor
Brokenknife Creek (05-209-000)											
201405	1.05	18.6	14.5	16	14	3	9	3	6	65.50	Good
Aicholz Ditch (05-203-000)											
U03G25	3.72	9.4	1	14	8.5	4.75	8	0	6	42.25	Poor
U03G24	2.46	15.0	13	9	11	6.5	6	4.5	10	60.00	Good
Silver Creek (05-202-000)											
U03G22	4.08	16.3	5	8	10.5	5.5	6	4.5	6	45.50	Fair

Station	River Mile	Drainage Area	Substrate	Instream Cover	Channel	Riparian	Pool	Riffle	Gradient	QHEI	Narrative Evaluation
Rock Creek (05-014-000)											
U04G18	11.69	14.7	5.5	13	12	5.75	4	1.25	10	51.50	Fair
U04W06	0.75	34.5	16	14	15	4.75	8	5.5	10	73.25	Good
East Branch Rock Creek (05-015-000)											
U04G03	0.47	6.4	16.5	14	15.5	8	5	4	10	73.00	Excellent
Willow Creek (05-013-000)											
U04W09	0.82	5.7	6	10	11	4.5	6	4.5	8	50.00	Fair
Morrison Creek (05-012-000)											
U04G06	9.34	9.3	13.5	8	10.5	5.75	4	3	10	54.75	Fair
U04G05	2.05	16.4	11.5	16	13	5	10	3	10	68.50	Good
Spicer Creek (05-011-000)											
U04Q11	0.65	12.5	16.5	12	14	6	6	6	10	70.50	Excellent
Sugar Creek (05-010-000)											
U04Q10	3.20	8.6	14.5	15	16	8.5	8	3	10	75.00	Excellent
Wolf Creek (05-005-000)											
201336	13.45	28.1	14.5	17	9	4.25	9	6	6	65.75	Good
U04S40	5.15	66.5	12	16	17	6.25	7	6	10	74.25	Good
U04G07	1.58	71.7	15	11	17	6.25	6	6	10	71.25	Good
Harrison Creek (05-005-004)											
U04G11	0.38	9.1	13.5	10	8.5	2	4	0	6	44.00	Fair
Plum Run (05-005-003)											
U04G09	0.79	9.8	11	9	10.5	4.75	5	3	6	49.25	Fair
Trib. To Wolf Creek (8.11) (05-005-002)											
304298	0.17	6.7	10.5	13	13	4	6	4	6	56.50	Good

Station	River Mile	Drainage Area	Substrate	Instream Cover	Channel	Riparian	Pool	Riffle	Gradient	QHEI	Narrative Evaluation
East Branch Wolf Creek (05-006-000)											
300673	19.65	19.0	12.5	12	8.5	6.25	5	2	10	56.25	Good
U04G15	13.63	33.2	15.5	18	16	6.5	10	5	2	73.00	Good
201338	9.00	67.8	12.5	16	11.5	5	9	5.5	6	65.50	Good
U04P03	0.86	82.0	16	15	17	5.25	8	6.5	10	77.80	Excellent
Eicher Ditch (05-006-004)											
304299	0.01	9.3	7	15	10.5	4.25	8	5	10	60.75	Good
East Branch East Branch Wolf Creek (05-008-000)											
U04G13	3.40	7.3	13.5	16	13	6.25	11	4.5	4	68.25	Good
300682	1.48	19.7	17	15	14	4	6	5.5	10	71.50	Excellent
Middle Branch of the East Branch of the East Branch Wolf Creek (05-009-000)											
U04G14	0.46	10.8	13	16	13.5	9.25	10	6.5	10	78.25	Excellent
Indian Creek (05-004-000)											
500950	0.62	12.0	10	15	14.5	5.75	10	7	10	72.25	Excellent
Muskellunge Creek (05-003-000)											
300674	16.70	17.7	5	9	11	5.25	6	3	6	45.25	Fair
201332	5.40	35.7	15.5	13	13	4.5	6	5.5	6	63.50	Good
Bark Creek (05-002-000)											
300671	3.20	10.0	2	10	9.5	2	9	4.5	10	47.00	Fair
Muddy Creek (05-219-000)											
201410	21.90	43.5	14.25	17.5	10.5	5.75	10	5	6	69.00	Good
U04S01	9.79	72.8	8.75	14	9	6.875	7	0	8	53.65	Fair
South Branch Muddy Creek (05-222-000)											
U04S08	5.67	4.6	14.5	7	10	4	4	3	8	50.50	Fair
300679	1.54	21.9	9	8	9	2	4	0	6	38.00	Poor

Station	River Mile	Drainage Area	Substrate	Instream Cover	Channel	Riparian	Pool	Riffle	Gradient	QHEI	Narrative Evaluation
Gries Ditch (05-223-000)											
U04Q16	0.93	12.5	13.5	9.5	14.5	3.125	7	6	10	63.65	Good
Little Muddy Creek (05-220-000)											
300677	7.55	12.4	8.25	14.5	12.5	2.25	6.5	3	10	57.05	Good
Fishing Creek (05-220-001)											
300678	0.20	7.0	0	7	9	3.75	4	0	2	25.75	Very Poor

Fish Community Sampling Results

Approximately 93,300 individual fish representing 63 unique species, 6 invasive or non-native species, and several hybrids were collected during the current survey. Primary sampling occurred in 2022, while limited follow up sampling occurred in 2023. The large river portion of the Sandusky River (RM 65 to 17) was evaluated in 2021 as part of a statewide survey of Ohio's large rivers (Ohio EPA 2020).

This survey included 137 fish sampling events from 113 locations and represents one of several major efforts in this watershed since the early 1980s. Comparisons to historical sampling activities are contained in the following trends section.

Relative numbers, biomass, species collected per location, and distribution maps are presented in Appendix E and Appendix F. IBI, MIwb, and IBI metric scores are contained in Appendix G. Fish numbers and biomass are standardized by distance – 0.3 km for headwater and wading sites, and 1 km for boat sites. These standardized values are referred to as "relative abundance" and "relative biomass". Sampling sites were spread between the Eastern Corn Belt Plains (ECBP) and the Huron-Erie Lake Plain ecoregions (Figure 7). Sampling locations were evaluated using either the WWH, MWH-I or MWH-C, and the EWH biocriteria for the IBI and MIwb (if applicable). Fish species summary information is contained in (Table 13).

Of the 113 fish sampling locations, 93 (82.3%), including all mainstem locations, achieved all applicable fish community criteria. Only 20 locations (17.7%) failed to achieve requisite criteria (Table 13). Fish index scores through the Sandusky River mainstem ranged from good to exceptional, while scores through the tributaries were more variable but generally achieved expectations (Table 13).

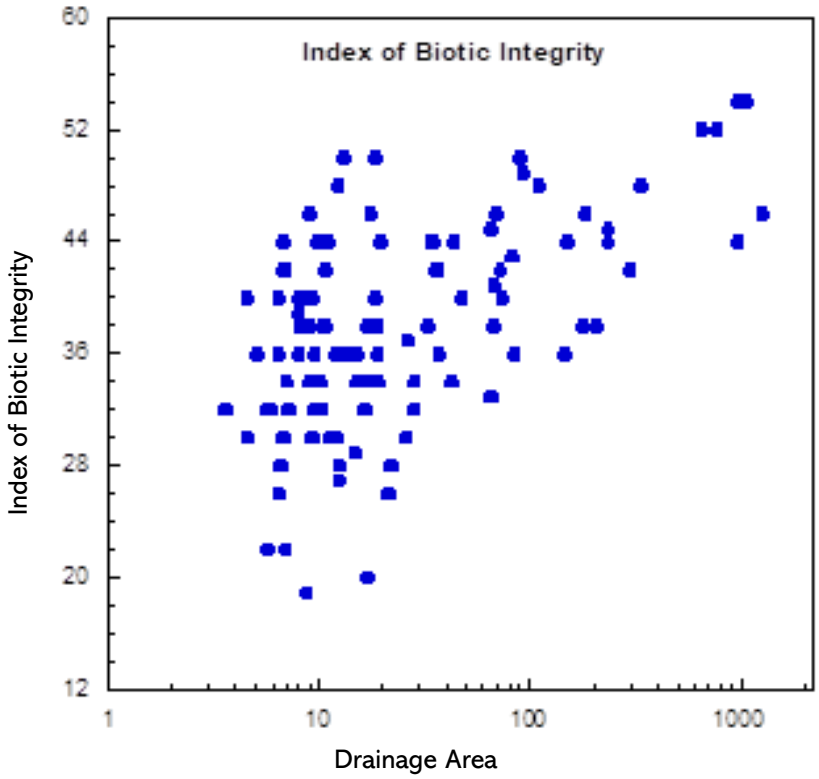


Figure 23 – Scatter plot of all IBI scores displayed by drainage area from the Sandusky River survey, 2021 & 2022.

IBI scores tended to show a generally positive correlation to stream size. The largest drainages had generally the highest IBI scores, while scores were most variable in the headwater sized streams. There was also some variability in scores in the wading and smaller river-sized areas, but the headwater-sized sites had the most variability by far (Figure 23). IBI scores were generally highest in the Sandusky mainstem, while the Little Sandusky sub-basin had the

decidedly lowest overall scores. Collectively, IBI scores were also high in the Sycamore and Wolf Creek sub-basins (Figure 24).

The proportions of sensitive species, insectivorous species, and simple lithophilic species all displayed a positive correlation with drainage area (Figure 25). Higher portions of these species are generally also associated with higher IBI scores (Figure 23). The proportions of all these groups were highest in the largest drainages. However, the proportion of sensitive species was generally low, and less variable compared to insectivorous and simple lithophilic species in the smallest waterbodies sampled. Insectivorous and simple lithophilic species were also more broadly distributed through the smaller drainages in this study area. Conversely, the proportions of highly tolerant, omnivorous, and pioneering species are all generally associated with lower IBI scores. Sites with the highest proportions of these species generally typically have the lowest community index scores.

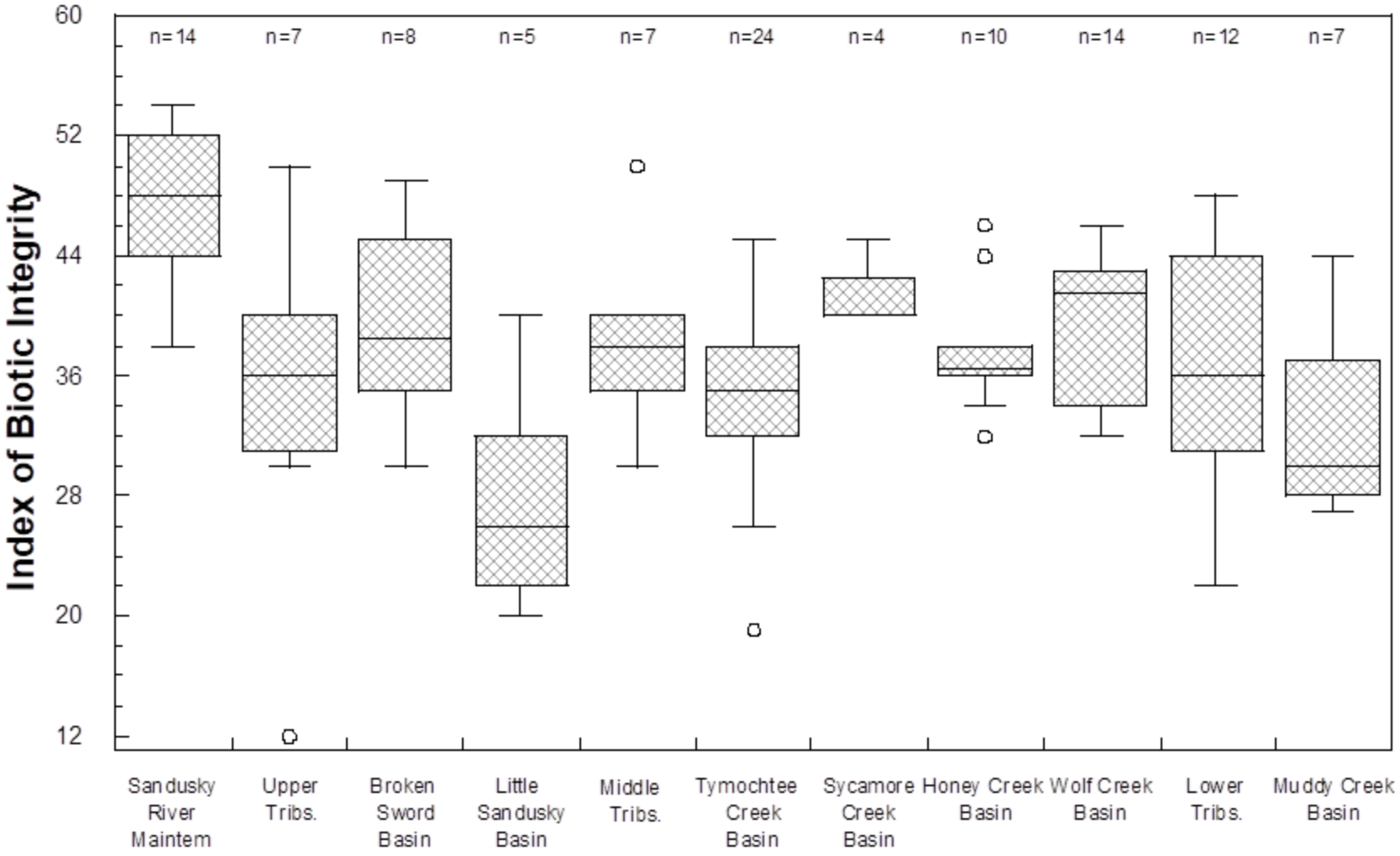


Figure 24 – Box plot of IBI scores from all survey sites parsed by major drainage basin, 2021 & 2022. Multiple IBI scores from a given location within a single year are averaged. IBI scores from both passes on Allen Run RM 1.05 (U02G20) were displayed because a fish kill occurred between the two fish passes.

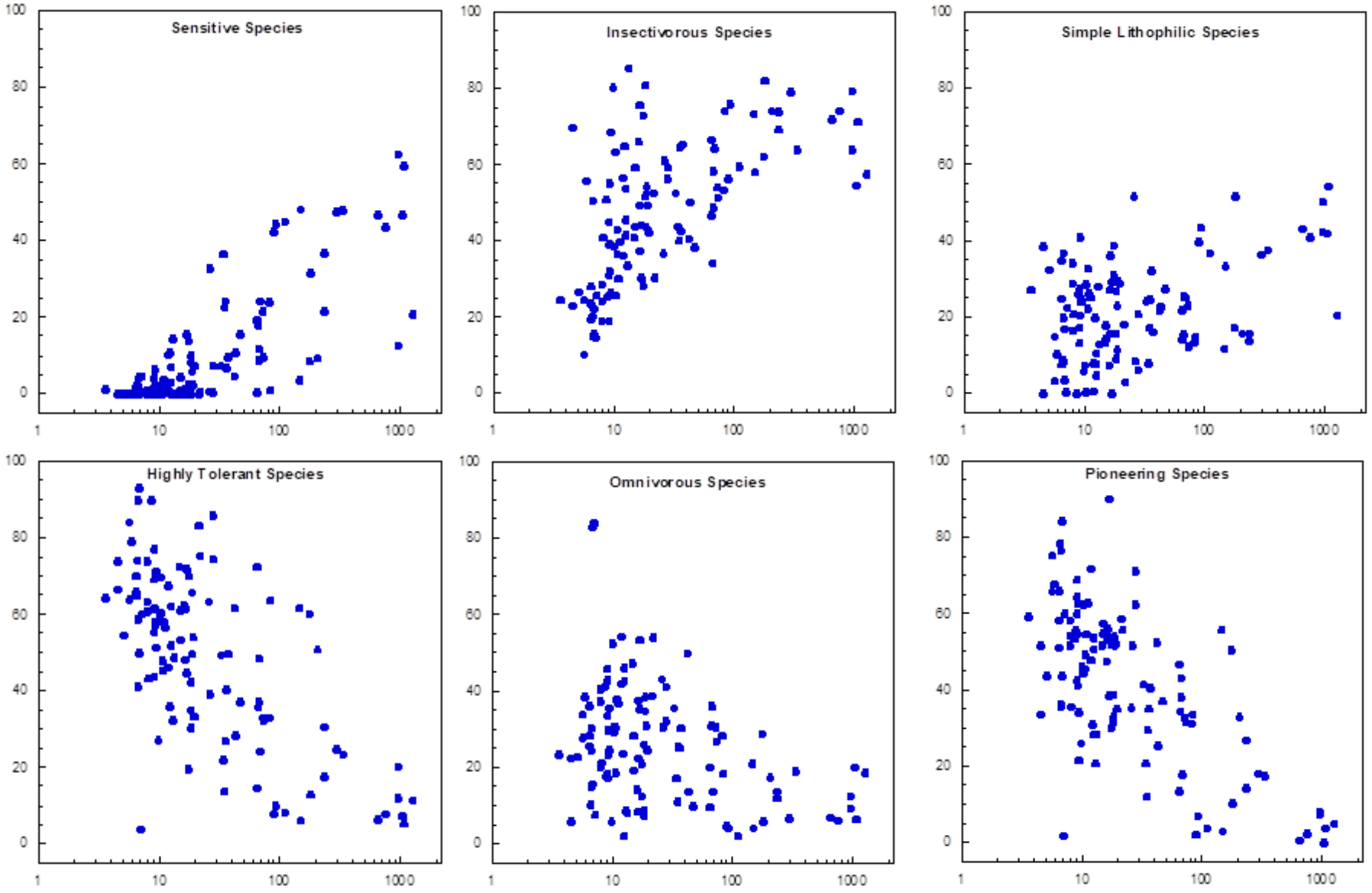


Figure 25 – Scatter plots displaying the portions of the fish assemblage (Y-axis) comprised by major categories by drainage area (X-axis) from the Sandusky survey, 2021 & 2022.

Sandusky River mainstem

Fish assemblages were evaluated at 14 locations along the Sandusky River mainstem – the seven lowermost sites (RM 65.01 – RM 16.80) were sampled in 2021 as part of Ohio EPA's statewide large rivers survey, while the remaining seven sites in the upper watershed (RM 127.90 – RM 72.09) were sampled in 2022.

The Sandusky River mainstem supported very high-quality fish communities. Most fish index scores from the mainstem exceeded WWH expectations and many were in the very good or exceptional range. Collectively, IBI scores from the Sandusky mainstem were among the highest of the survey (Figure 24). IBI and MIwb scores from the upper mainstem (RM 127.90 - RM 72.09) ranged from good to exceptional, while most scores from the large river segments (RMs 65.01-16.80) were almost all in the exceptional range. MIwb scores throughout the mainstem were mostly in the exceptional range and displayed a slight decreasing trend in an upstream progression (Figure 26, Table 13). Overall, 53 native species, four exotic/non-native, and several hybrid species were collected from the Sandusky mainstem during the most recent survey.

Redhorse suckers (Golden – *Moxostoma erythrurum*, Black – *M. duquesnei*, Silver – *M. anisurum*, Shorthead – *M. macrolepidotum*, River – *M. carinatum*, Greater – *M. valenciennesi*) were a dominant component of the fish assemblage at all mainstem locations (Appendix F), ranging from 5% of fish biomass at RM 17.70 near Lake Erie to over 62% of biomass at RM 23.00. Redhorse sucker abundances at most mainstem locations was around 40-50% of fish biomass. The Sandusky River basin is one of one of the only watersheds in Ohio that supports both the state-listed Greater Redhorse (threatened) and River Redhorse (species of concern) (ODNR 2020, Yoder and Beaumier 1986). Sportfish like Smallmouth Bass and Channel Catfish (*Ictalurus punctatus*) were also well-represented through the Sandusky River mainstem.

Though the Ella Street dam presented a barrier for some native fish that could persist upstream like Smallmouth Buffalo (*Ictiobus bubalus*), Longnose Gar (*Lepisosteus osseus*), Flathead Catfish (*Pylodictis olivaris*), and Northern Sunfish (*Lepomis peltastes*), other species distributions through the watershed did not appear limited by this structure. Fish index scores from the Ella Street Dam pool were lower than surrounding reaches but still achieved WWH criteria. There were no declines in fish community performance observed downstream from either the Tiffin, Upper Sandusky, or Bucyrus WWTPs (Figure 26).

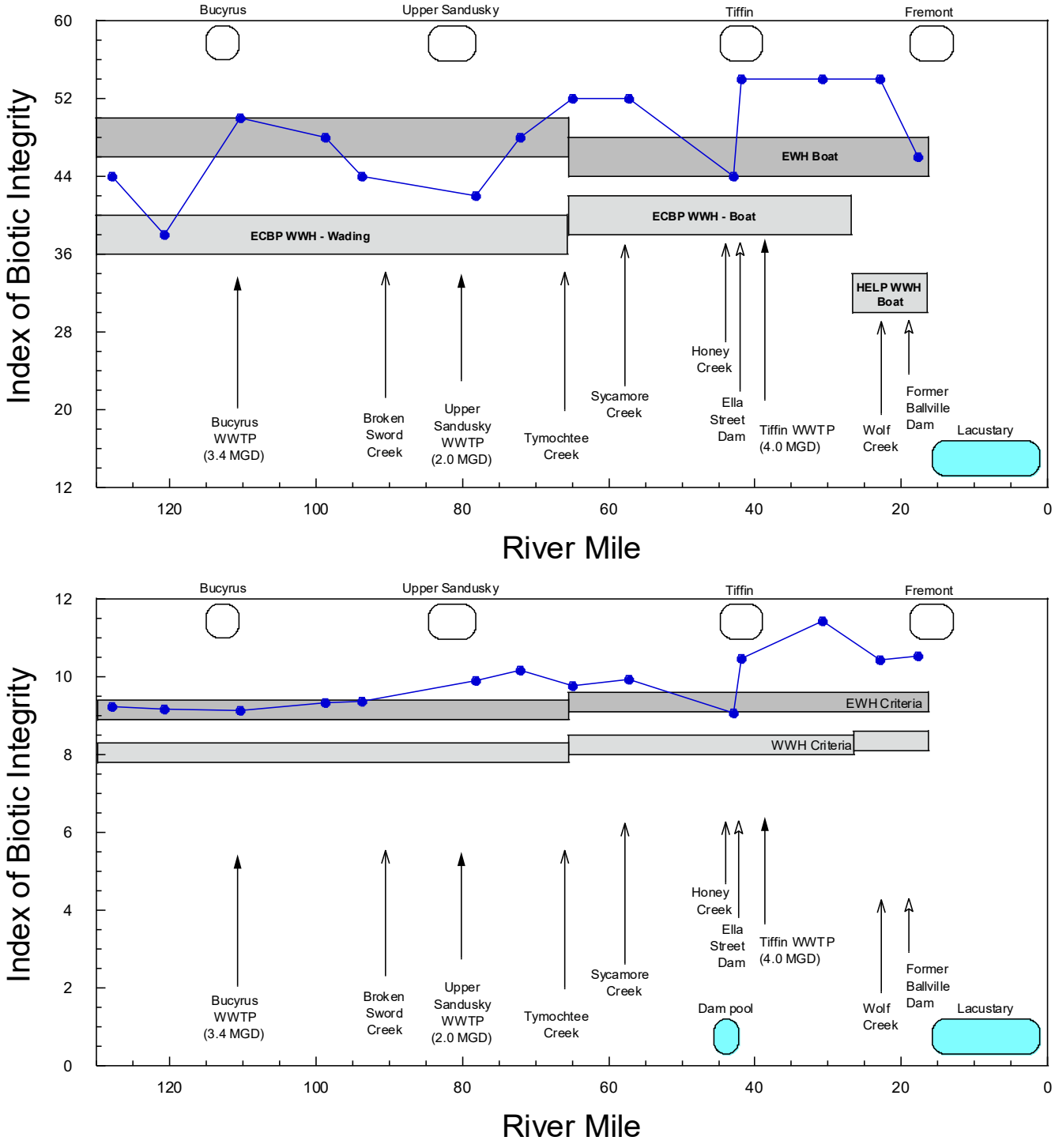


Figure 26 – Longitudinal display of IBI (top) and MIwb (bottom) scores from the Sandusky River mainstem, 2021-22.

Sites are displayed upstream to downstream. The grey shaded bars represent EWH and WWH criteria and the areas of non-significant departure for the sampling type used. Tributaries, point source discharges, and dam (current or former) are listed along position on mainstem by arrows. Lacustuary zone and dam pools are denoted by blue shaded boxes.

Upper Sandusky River Tributaries

Tributary streams in the upper Sandusky watershed evaluated during the survey included Paramour Creek, Tributary to Paramour Creek (5.13), Allen Run, South Fork Loss Creek, and Grass Run (Table 13).

Fish index scores in Paramour Creek fell short of WWH expectations at the lower location (RM 1.50 U02P12) and marginally met expectations at the upper location (RM 6.15, U02P48). Lower Paramour Creek and the Sandusky River at RM 127.90 (U02P08) are very similar in drainage area and are close spatially, but the fish assemblages observed were distinctly different. Only 12 total fish species were collected from Paramour Creek RM 1.50 and over 63% of the fish assemblage here was comprised by highly tolerant individuals. In comparison, 20 species were collected downstream on the Sandusky River at RM 127.90 and only 13% of the assemblage was comprised by highly tolerant fish species. There is a small dam near the mouth of Paramour Creek just before joining Allen Run to form the Sandusky River. This structure presents a barrier to upstream fish passage that limits recolonization. The upper site on Paramour Creek at RM 6.15 drains much less area than the downstream site and is also a modified reference site (Table 13). The IBI score here marginally met WWH expectations.

Fish assemblages in Allen Run were sampled twice at RM 1.05 (U02G20) in 2022. The first sampling event on 7/19/22 yielded only a fair quality fish community. The second sampling event 9/15/22 occurred after a documented fish kill and yielded no fish. Additional follow-up sampling occurred during the summer of 2023 to document the extent of recovery after the event. An IBI of 36 was recorded and marginally met WWH expectations. The fish community still displayed signs of recovery though. Many juveniles were observed, including an abundance of small White Sucker (*Catostomus commersonii*), while the adult fish were present in few numbers. If no further fish kills occur, more substantial recovery and stability should eventually be observed in the fish assemblages here.

Grass Run and South Fork Loss Creek both supported fish assemblages that achieved WWH expectations.

Broken Sword Creek basin

Fish assemblages in this sub-basin were assessed at five locations in Broken Sword Creek and at one site in each of its three principal tributaries. Fish index scores achieved WWH expectations at four of five locations on Broken Sword Creek and two of three locations of tributaries (Table 1).

The average IBI score from Broken Sword Creek at RM 19.70 (201366) fell just short of WWH criteria, while the MIwb score marginally achieved expectations. Omnivorous fish species comprised nearly 50% of the overall assemblage here and nearly 80% of fish biomass – by far the highest proportions compared to similar sized survey sites (Figure 25). The portion fish biomass comprised by omnivorous species here (79%) was much higher than values for the other sampling locations on Broken Sword Creek (29%, 16%, 5%) (Appendix G). This site also had the highest proportion of fish biomass comprised by omnivores for the entire survey, followed by the Little Sandusky RM 3.70 (201366) and Honey Creek RM 25.03 (U03S03) at 76% and 71%, respectively.

The IBI score from Brandywine Creek fell just short of WWH expectations. Fish assemblages had good numbers of native taxa observed, including 3 darters and 9 different minnow species, however most proportional IBI metrics (% tolerant, % omnivore, % pioneering) and the number of sensitive species

all scored low (Appendix G). Fish IBI scores in the other two tributaries were somewhat better and did not fall below WWH expectations (Table 13).

Little Sandusky River basin

Fish assemblages were assessed at three locations on the Little Sandusky River and one location on each of its two largest tributaries. Fish index scores from the Little Sandusky River were among the lowest values observed during the survey (Figure 24). Most scores in the Little Sandusky River corresponded to poor quality assemblages and highly tolerant species predominated throughout the basin (Table 13, Appendix E).

Fish community quality from tributary streams was incrementally higher, including a fair quality community in the tributary to the Little Sandusky River (8.93) and a good quality community in Honey Run. The higher quality fish communities found in Honey Run compared to the rest of this sub-watershed demonstrates the potential for this system to have fish communities that are consistent with WWH criteria.

Tymochtee Creek basin

Fish assemblages were evaluated at 24 locations throughout the Tymochtee Creek basin, including 7 locations along the mainstem and 17 locations in 14 tributary streams. Fish index scores through the basin ranged from very poor in the uppermost headwaters to exceptional near its confluence with the Sandusky River.

Both IBI and MIwb scores through the Tymochtee mainstem display a gradually decreasing trend in an upstream progression. Index scores from the reference area at RM 8.06 (500850) were the highest in the basin and gradually decreased upstream (Figure 27). Fish assemblages through lower Tymochtee Creek (RMs 8.06-33.99) achieved WWH expectations, while assemblages from the uppermost reaches (RMs 44.95-51.43) mostly fell short of WWH expectations (Table 13). Fish assemblage quality in tributary streams ranged from very poor to good, with most scores being in the fair to marginally good range.

Index scores displayed distinct differences between sites located up- and downstream from the moraine complex that bisects the

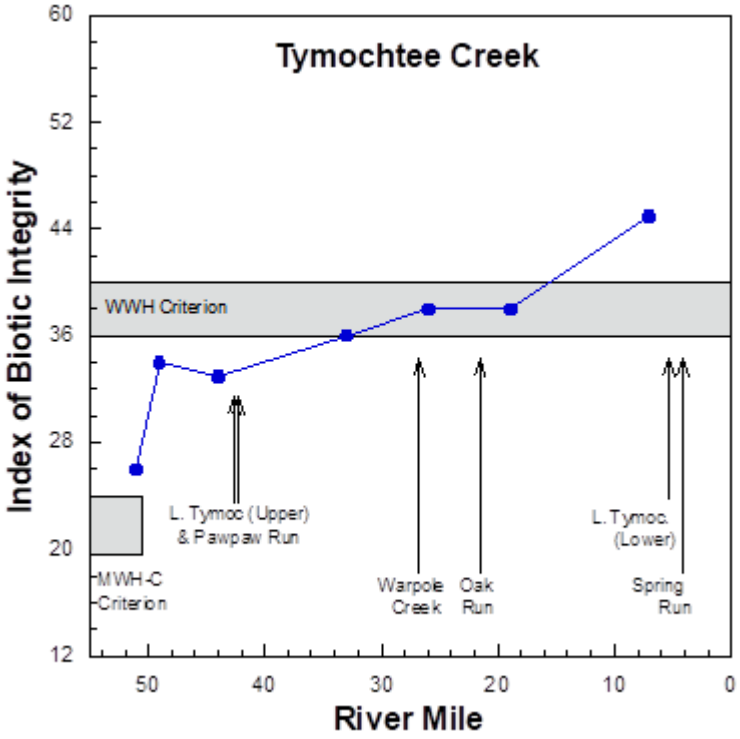


Figure 27 – Longitudinal display of IBI scores from the Tymochtee Creek mainstem, 2022.

Sites are displayed upstream to downstream. The grey shaded bars represent WWH and MWH criteria and the areas of non-significant departure for the sampling type used. Tributary streams are displayed with arrows relative to position along mainstem.

Tymochtee Creek sub watershed north of Marseilles, OH. Fish assemblages achieved WWH expectations at nine of 12 locations (75%) downstream from this moraine, while only three of 12 sites (25%) had fish assemblages that achieved WWH criteria upstream. The uppermost reaches of Tymochtee Creek and these tributaries have been heavily channelized in the past to facilitate drainage through this formerly swampy area. These sites, collectively, supported among the lowest overall proportions of sensitive and simple lithophilic spawning species of all sites in the survey (Figure 25).

The fish communities through much of the Tymochtee basin tended to reflect the sluggish nature of this stream system. Fish species that prefer pool habitats like Yellow Bullhead (*Ameiurus natalis*), Black Bullhead (*Ameiurus melas*), Golden Shiner (*Notemigonus crysoleucas*), and Spotted Sucker (*Minytrema melanops*) were abundant through this system, while the abundance of sensitive species and simple lithophilic spawners were low compared to other Sandusky River tributary systems (Figure 25, Appendix G). Northern Pike (*Esox lucius*) were also present at most sites through middle and lower Tymochtee Creek highlighting the presence of both high-quality pools and cool groundwater inputs from the adjacent moraines (Appendix F).

Sycamore Creek basin

Sycamore Creek joins the Sandusky River from the east and drains just over 64 square miles at its mouth. Fish assemblages in this sub-watershed were evaluated at 3 locations on Sycamore Creek and one location near the mouth of Spring Creek. Fish index scores met WWH criteria at all sites evaluated and IBI scores were among the higher values observed among all tributaries (Figure 24). Index scores were highest near the mouth and similar between the upper sub-watershed locations (Table 13).

Other Middle Sandusky River tributaries

Several other smaller streams that join the Sandusky mainstem from Broken Sword Creek downstream to the dam pool in Tiffin, OH were evaluated. These included: Rock Run, Negro Run, Sugar Run, Thorn Run, Taylor Run, tributary to Taylor Run (2.49), and Mile Run. Fish assemblages were assessed at one location in each stream. Most all these streams had IBI scores that achieved or exceeded WWH criteria. The IBI score from Negro Run was among the highest scores for all headwater tributaries in the survey. The IBI score from Thorn Run fell just short of WWH expectations. The numbers of darter, minnow, and total native species were all high, but low proportions of insectivorous and sensitive species coupled with high abundances of tolerant, pioneering, and omnivorous species depressed the IBI score here (Appendix G).

Honey Creek basin

Fish assemblages were evaluated at 10 locations, including five on Honey Creek and five in four tributary streams. Fish community performance at individual locations ranged from fair to exceptional, with most scores in the marginally good range (Table 13). Fish index scores in Honey Creek were highest at the two lowermost sampling locations (Table 13). Fish assemblage quality in Honey Creek at RM 0.20 (500970) was in the very good range, despite pooled conditions from the Ella Street Dam pool through the sampling zone. Fish index scores achieved WWH criteria at four of five sampling locations, while the MIwb score fell short of expectations at RM 25.03 (U03S03). Sensitive species were nearly absent from this location, comprising less than 1% of the assemblage; the proportions of simple lithophilic spawners was also low (15%), and the proportion of highly tolerant

species (64%) was elevated compared to other similarly sized sites (Figure 25). However, the proportion of insectivorous fish (74%) and omnivorous fish (18%) were still favorable, and this reach had similar species diversity compared to surrounding areas.

IBI scores fell just short of achieving WWH expectations at two of five locations in tributaries to Honey Creek. Overall fish abundances in all Honey Creek tributaries were generally low. Aside from Brokenknife Creek, total relative abundance values (including highly tolerant species) were among the lowest values observed during the survey (Table 13). Simple lithophilic species were also only found in generally low abundances through the tributaries to Honey Creek (Figure 25).

Wolf Creek basin

Fish assemblages were evaluated at 14 locations, including seven locations in Wolf Creek and the East Branch and seven locations among six different tributaries. Individual index scores ranged from marginally good to excellent, and scores were generally among the higher values observed during the survey (Figure 24, Table 13). All sites had fish assemblages that achieved WWH criteria for the HELP ecoregion. Sizable populations of six different darter species were present throughout this sub watershed. Two other intolerant species, Stonecat Madtom (*Noturus flavus*) and Mimic Shiner (*Paranotropis volucellus*), and an additional madtom species, the Tadpole Madtom (*Noturus gyrinus*), were collected in Wolf Creek and East Branch Wolf Creek. The natural escarpment near the mouth of East Branch Wolf Creek at RM 0.90 does not seem to have a profound influence on fish distribution through this system. Both the Tadpole Madtom and Mimic Shiner were not found upstream from this escarpment, while Stonecat Madtom were found at several locations upstream. Most other common species were present upstream and downstream from this escarpment. Cold groundwater from the adjacent glacial end moraines was evident during fish sampling, especially in the uppermost reaches of these streams.

Fish assemblage quality ranged from fair to very good at the seven sites in smaller tributaries to Wolf Creek and East Branch. Six of seven sites achieved expectations for either HELP or ECBP warmwater streams. The East Branch of East Branch of Wolf Creek RM 3.52 (U04G13) had an IBI score that fell just below ECBP expectations. In comparison, the nearby Middle Branch of East Branch of East Branch Wolf Creek RM 0.46 (U04G14) had an IBI score 12 points higher. Both sites were about the same size and were located very close to each other. However, Middle Branch supported several more, relatively common species including more darters, minnows, and other pool associated fish species. The presence of many more pool-associated fish species in the Middle Branch, despite sufficient pool depths through East Branch RM 3.52 may reflect impacts from hydrologic or habitat modifications.

Lower Tributaries

Tributaries in the lowermost portion of the watershed were all generally located around the divide between the lacustrine deposited sediments of the HELP and the newest Wisconsin-aged glacial formations that roughly form the ECBP/HELP eco-region divide. Streams in this portion of the watershed generally displayed a mix of features between the ECBP and HELP ecoregions.

These streams had the widest range of IBI scores compared to all other groups of tributaries (Figure 24). Higher-quality assemblages that met expectations were documented through lower Rock Creek, East Branch Rock Creek, Spicer Creek, Sugar Creek, Plum Run, Indian Creek, Muskellunge Creek, and

Bark Creek. Fish assemblages that did not achieve WWH expectations were documented in upper Rock Creek, Willow Creek, and Morrison Creek.

Rock Creek displayed distinct differences in fish assemblage quality and composition between RM 0.75 (U04W06) and RM 11.69 (U04G18). Conditions consisted of more sluggish, silty pool habitat at RM 11.69, while shallow bedrock and other course substrates predominated at RM 1.05. Fish assemblages reflected the differences in habitat – species that tended to prefer pooled conditions (Yellow and Black Bullhead, Largemouth Bass (*Micropterus salmoides*), crappie and sunfishes, Golden Shiner) comprised over 35% of the assemblage at RM 11.69, while species that prefer lotic systems and course substrates predominated at RM 1.05. The proportion of omnivorous species at RM 11.69 (47%) was also among the higher values for similarly sized streams in the survey (Figure 25).

Willow Creek is a small stream that is channelized over much of its length. Its lower reaches encompass a small portion of Tiffin, while its upper reaches are mostly agricultural. The fish assemblage at RM 0.82 (U04W09) was comprised nearly entirely of highly tolerant fish species (84%) and lacked any other insectivorous fish other than Johnny Darters (*Etheostoma nigrum*) and Green Sunfish (*Lepomis cyanellus*) (10%). The fish IBI score recorded at this location fell short of even MWH-C expectations (Table 13, Appendix G).

Morrison Creek had fair IBI scores at both locations sampled (Table 13). The IBI score of 32 at RM 2.05 (U04G05) was among the lowest values of all similarly sized survey sites and fell short of WWH expectations for the ECBP ecoregion (Figure 23).

Muddy Creek basin

Streams in the Muddy Creek basin drain mostly lower gradient, lake deposited sediments originating entirely within the HELP ecoregion. There are some streams that flow through areas of shallow, exposed limestone bedrock, however, most streams have relatively simplified habitat and consist of finer grained sands and silts

Fish assemblages were collected from two sites along Muddy Creek mainstem and at five locations on four tributary streams. Fish index scores were generally good through Muddy Creek mainstem and fair in its tributaries; scores met expectations at all locations assessed (Table 13). Muddy Creek supported over 20 native species, including a diverse array of native minnows, darters, sunfish, suckers, bass, and even Northern Pike.

Table 13 – Fish community summaries based on pulsed D.C. electrofishing conducted by Ohio EPA in the Sandusky River and Muddy Creek watersheds, 2021-2023.

Sampling through the large river segment of the Sandusky River was monitored in 2021 as part of a statewide large rivers survey. All remaining tributary data was collected mostly in 2022, while information from select areas was collected in 2023. IBI and MIwb scores followed by an asterisk (*) indicate scores failed to meet biocriteria for the existing or recommended aquatic life use and "ns" is in non-significant departure of the existing or recommended ALU; individual scores are averaged to determine overall site attainment for each index value. Superscript letters correspond to Table 1.

Station	River Mile		Drainage Area	Total Native Species	Sensitive Species	Relative Number – all species	Relative Number minus tolerants	Relative biomass – all species (kg)	Relative Biomass minus Tol. (kg)	QHEI	IBI	MIwb	Narrative Evaluation (IBI : MIwb)	
Sandusky River (05-001-000)														
U02P08	127.90	W	35.2	20	5	1668	1438	24.2	17.1	-	44	9.5	Good	: Exceptional
U02P08	127.90	W	35.2	18	5	1087	942	24.8	16.1	87.00	44	9.0	Good	: Very Good
U02G01	120.70	W	67.2	24	6	1169	602	30.7	15.3	78.25	38[NS]	9.2	Marg. Good	: Very Good
U02P30	110.43	W	88.9	21	8	504	465	49.6	42.6	83.50	50	9.1	Exceptional	: Very Good
U02P33	98.69	W	109.7	23	8	447	411	39.5	33.2	84.25	48	9.4	Very Good	: Exceptional
U02G02	93.76	W	232.2	22	8	813	672	109.0	49.7	72.00	44	9.4	Good	: Exceptional
500860	78.09	W	295.5	22	9	782	588	123.7	96.7	75.00	42	9.9	Good	: Exceptional
U02P38	72.09	W	337.6	28	12	563	432	120.6	94.7	75.00	48	10.2	Very Good	: Exceptional
U03G01	65.01	B	656.0	19	7	720	674	247.0	190.1	83.00	52	9.8	Exceptional	: Exceptional
U04S29	57.34	B	760.1	27	10	616	568	170.0	127.8	83.00	52	9.9	Exceptional	: Exceptional
500940	42.92	B	960.4	15	2	336	268	104.1	67.6	50.50	44	9.1	Very Good	: Very Good
U04S28	41.60	B	964.3	25	11	698	614	164.6	138.6	84.25	54	10.5	Exceptional	: Exceptional
500910	30.90	B	1048.2	25	10	650	602	684.8	554.8	79.00	54	11.4	Exceptional	: Exceptional
U04Q06	23.00	B	1072.0	24	11	376	356	179.6	169.8	64.25	54	10.4	Exceptional	: Exceptional
U04S23	16.80	B	1257.6	26	7	612	542	369.2	257.9	84.50	46	10.5	Very Good	: Exceptional
Paramour Creek (05-042-000)														
U02P48	6.15	H	5.1	10	0	3036	1380	-	-	54.0	36	-	Marg. Good	: -
U02P12	1.50	W	26.0	12	2	654	267	27.5	5.7	-	32*	6.6*	Fair	: Fair

Station	River Mile		Drainage Area	Total Native Species	Sensitive Species	Relative Number – all species	Relative Number minus tolerants	Relative biomass – all species (kg)	Relative Biomass minus Tol. (kg)	QHEI	IBI	MIwb	Narrative Evaluation (IBI : MIwb)	
U02P12	1.50	W	26.0	10	1	982	332	25.2	6.2	58.00	28*	6.9*	Fair	: Fair
Trib. to Paramour Creek (5.13) (05-042-003)														
U02S07	3.70	H	1.0	11	0	1194	420	-	-	53.00	38[NS]	-	Marg. Good	: -
Allen Run (05-043-000)														
U02G20	1.05	H	3.6	0	0	0	0	-	-	-	12*	-	Very Poor	: -
U02G20	1.05	H	3.6	10	1	970	348	-	-	63.25	32*	-	Fair	: -
South Fork Loss Creek (05-041-001)														
201377	0.10	H	6.7	14	1	2220	1114	-	-	75.25	42	-	Good	: -
Grass Run (05-039-000)														
U02G14	8.36	H	9.1	18	2	2622	814	-	-	57.00	38[NS]	-	Marg. Good	: -
U02G13	3.42	H	18.3	22	4	1112	776	-	-	77.25	50	-	Exceptional	: -
Broken Sword Creek (05-035-000)														
U02G09	29.52	H	10.9	23	3	2526	1058	-	-	55.00	44	-	Good	: -
U02G07	25.48	W	32.6	20	3	1188	651	32.1	17.1	55.50	42	9.1	Good	: Very Good
U02G07	25.48	W	32.6	20	3	2029	984	20.6	13.5	56.00	34*	8.7	Fair	: Good
201366	19.70	W	42.0	22	3	1418	550	79.7	10.6	-	36[NS]	7.9[NS]	Marg. Good	: Marg. Good
201366	19.70	W	42.0	20	3	1912	731	53.8	9.7	61.75	32*	7.8[NS]	Fair	: Marg. Good
U02S23	12.30	W	69.1	23	6	1264	1005	26.4	20.8	-	50	10.0	Exceptional	: Exceptional
U02S23	12.30	W	69.1	18	6	1028	735	25.9	20.1	75.00	42	9.6	Good	: Exceptional
U02P47	0.60	W	93.5	27	9	543	483	42.7	39.9	-	50	9.8	Exceptional	: Exceptional
U02P47	0.60	W	93.5	21	8	755	687	78.5	75.0	72.75	48	9.7	Very Good	: Exceptional
Red Run (05-038-000)														
201372	0.42	H	8.0	16	0	2184	940	-	-	-	38[NS]	-	Marg. Good	: -
201372	0.42	H	8.0	21	3	1598	550	-	-	45.50	40	-	Good	: -

Station	River Mile		Drainage Area	Total Native Species	Sensitive Species	Relative Number – all species	Relative Number minus tolerants	Relative biomass – all species (kg)	Relative Biomass minus Tol. (kg)	QHEI	IBI	MIwb	Narrative Evaluation (IBI : MIwb)	
Brandywine Creek (05-037-000)														
302323	0.40	H	11.2	19	2	1314	570	-	-	65.00	30*	-	Fair	: -
Indian Run (05-036-000)														
U02G12	0.75	H	8.5	18	0	3304	1218		-	53.75	36^{NS}	-	Marg. Good	: -
Little Sandusky River (05-033-000)														
201361	10.40	H	6.9	12	0	1778	126		-	29.25	22*	-	Poor	: -
U02G16	6.40	H	16.9	8	0	184	52	-	-	46.75	20*	-	Poor	: -
U02W06	3.71	W	21.5	17	0	477	81	23.4	3.3	42.50	26*	6.1*	Poor	: Fair
Trib. To Little Sandusky River (8.93) (05-033-003)														
U02W05	0.78	H	5.9	14	0	1850	390	-	-	30.75	32	-	Fair	: -
Honey Run (05-034-000)														
U02G18	0.52	H	9.0	15	1	1300	580	-	-	65.25	40	-	Good	: -
Rock Run (05-032-000)														
U02S20	1.40	H	9.40	17	1	1958	956	-	-	64.75	36^{NS}	-	Marg. Good	: -
Negro Run (05-027-000)														
U02S19	0.52	H	13.1	19	3	1450	982	-	-	67.25	50	-	Exceptional	: -
Sugar Run (05-026-000)														
201354	0.60	H	4.6	12	0	1608	424	-	-	70.25	42	-	Good	: -
Tymochtee Creek (05-300-000)														
U01W05	51.43	H	6.4	13	0	288	102	-	-	42.50	26	-	Poor	: -
U01G07	49.44	H	16.1	16	0	740	278	-	-	49.75	34*	-	Fair	: -
U01G05	44.95	W	64.5	23	0	921	260	42.7	11.0	-	36^{NS}	7.8^{NS}	Marg. Good	: Marg. Good
U01G05	44.95	W	64.5	19	0	550	149	32.8	5.5	56.00	30*	6.8*	Fair	: Fair
U01G04	33.99	W	146.2	25	1	621	239	22.2	10.3	65.00	36	8.2	Marg. Good	: Marg. Good

Station	River Mile		Drainage Area	Total Native Species	Sensitive Species	Relative Number – all species	Relative Number minus tolerants	Relative biomass – all species (kg)	Relative Biomass minus Tol. (kg)	QHEI	IBI	MIwb	Narrative Evaluation (IBI : MIwb)	
U01G03	26.28	W	175.0	27	4	581	233	53.3	28.3	67.25	38	8.8	Marg. Good	: Good
U02P44	19.45	W	204.3	26	6	456	225	61.4	22.4	74.00	38	8.1	Marg. Good	: Marg. Good
500850	7.60	W	232.2	26	7	789	537	37.4	32.4	70.00	46	9.7	Very Good	: Exceptional
500850	7.60	W	232.2	25	7	677	482	29.7	25.9		44	9.3	Good	: Very Good
Prairie Run (05-300-007)														
U01W04	1.02	H	8.6	7	0	286	26	-	-	-	26*	-	Poor	: -
U01W04	1.02	H	8.6	3	0	10	4	-	-	29.50	12*	-	Very Poor	: -
Enoch Creek (05-300-006)														
U01W01	1.59	H	6.5	10	0	1236	322	-	-	54.50	28*	-	Fair	: -
Carroll Ditch (05-300-004)														
U01G26	0.66	H	10.3	13	0	1720	680	-	-	37.75	32	-	Fair	: -
Pawpaw Run (05-319-000)														
U01G25	6.13	H	8.2	16	0	1752	996	-	-	59.50	38^{NS}	-	Marg. Good	: -
U01G24	0.80	H	16.3	17	1	660	252	-	-	73.75	34*	-	Fair	: -
Little Tymochtee Creek (Upper) (05-316-000)														
304302	8.63	H	11.9	16	1	2138	684	-	-	-	28	-	Fair	: -
304302	8.63	H	11.9	18	1	2086	700	-	-	47.25	32	-	Fair	: -
U01G20	3.95	W	37.1	18	2	1079	695	21.7	9.3	-	40	8.6	Good	: Good
U01G20	3.95	W	37.1	19	3	947	327	26.4	12.6	72.75	32*	8.2^{NS}	Fair	: Marg. Good
Reevhorn Run (05-317-000)														
U01G23	2.26	H	12.5	11	0	339	163	-	-	61.50	36^{NS}	-	Marg. Good	: -
Pawpaw Run (05-318-000)														
201432	1.10	H	5.6	17	0	2730	984	-	-	36.75	32	-	Fair	: -

Station	River Mile		Drainage Area	Total Native Species	Sensitive Species	Relative Number – all species	Relative Number minus tolerants	Relative biomass – all species (kg)	Relative Biomass minus Tol. (kg)	QHEI	IBI	MIwb	Narrative Evaluation (IBI : MIwb)	
Warpole Creek (05-314-000)														
U01G18	1.55	H	18.4	16	0	3294	1662	-	-	56.00	36[NS]	-	Marg. Good	: -
St. James Run (05-315-000)														
304296	0.15	H	10.7	17	0	2329	1215	-	-	58.50	42	-	Good	: -
Oak Run (05-312-000)														
U01G16	0.29	H	15.2	17	1	570	222	-	-	64.50	34*	-	Fair	: -
Lick Run (05-308-000)														
U01G15	0.83	H	7.9	16	1	2300	606	-	-	53.25	40	-	Good	: -
Little Tymochtee Creek (Lower) (05-304-000)														
U01G14	10.32	H	11.1	10	0	1532	410	-	-	39.25	24	-	Poor	: -
U01G13	6.33	H	18.5	10	0	792	514	-	-	35.75	34	-	Fair	: -
U02P45	1.95	W	28.4	17	1	795	114	26.7	8.9	58.00	32*	6.8*	Fair	: Fair
Spring Run (05-301-000)														
U02P46	1.71	H	16.9	18	4	620	342	-	-	73.00	38[NS]	-	Marg. Good	: -
Poverty Run (05-302-000)														
U01G10	2.99	H	9.3	14	1	2010	866	-	-	57.50	42	-	Good	: -
Thorn Run (05-024-000)														
U03G03	0.70	H	9.1	17	1	1810	416	-	-	70.25	34*	-	Fair	: -
Taylor Run (05-023-000)														
U03G04	1.88	H	17.4	17	2	1490	446	-	-	75.00	38[NS]	-	Marg. Good	: -
Trib. to Taylor Run (2.49) (05-023-001)														
304297	0.10	H	6.7	12	0	854	86		-	61.00	30	-	Fair	: -

Station	River Mile		Drainage Area	Total Native Species	Sensitive Species	Relative Number – all species	Relative Number minus tolerants	Relative biomass – all species (kg)	Relative Biomass minus Tol. (kg)	QHEI	IBI	MIwb	Narrative Evaluation (IBI : MIwb)	
Sycamore Creek (05-021-000)														
U03G10	18.92	H	18.2	17	2	740	428	-	-	63.25	40	-	Good	: -
U03G08	9.14	W	47.2	24	6	1697	1242	39.9	24.1	-	42	9.6	Good	: Exceptional
U03G08	9.14	W	47.2	19	4	1626	846	29.4	12.3	72.00	38[NS]	8.3	Marg. Good	: Good
U03P05	0.41	W	64.2	27	7	840	719	18.8	16.2	-	44	9.6	Good	: Exceptional
U03P05	0.41	W	64.2	27	8	1347	1148	17.9	15.5	77.75	46	9.6	Very Good	: Exceptional
Spring Creek (05-021-002)														
U03G13	1.88	H	8.8	16	1	2533	984	-	-	52.50	40	-	Good	: -
Mile Run (05-020-000)														
U03G14	0.30	H	6.4	18	3	1336	454	-	-	72.25	40	-	Good	: -
Honey Creek (05-200-000)														
U03G20	41.66	H	10.4	17	2	2338	706	-	-	75.50	38[NS]	-	Marg. Good	: -
U03G18	34.14	W	26.5	23	4	1055	722	6.9	2.6	-	36[NS]	8.4	Marg. Good	: Good
U03G18	34.14	W	26.5	23	4	1982	1130	16.5	5.0	47.50	38[NS]	8.4	Marg. Good	: Good
U03S03	25.03	W	84.4	19	0	601	220	69.3	10.5	-	36[NS]	7.6*	Marg. Good	: Fair
U03S03	25.03	W	84.4	18	3	426	154	50.0	8.2	61.25	36[NS]	7.2*	Marg. Good	: Fair
U03S02	12.30	W	149.3	21	8	731	686	50.4	37.6		42	9.8	Good	: Exceptional
U03S02	12.30	W	149.3	21	8	990	929	51.9	40.3	92.50	46	9.9	Very Good	: Exceptional
500970	0.20	B	179.3	19	4	418	364	96.6	80.0	46.75	46	9.2	Very Good	: Very Good
Celery Creek (05-200-003)														
303862	0.45	H	13.4	15	0	472	242	-	-	33.00	36	-	Marg. Good	: -
Brokenknife Creek (05-209-000)														
201405	1.05	H	18.6	22	2	1024	352	-	-	65.50	38[NS]	-	Marg. Good	: -

Station	River Mile		Drainage Area	Total Native Species	Sensitive Species	Relative Number – all species	Relative Number minus tolerants	Relative biomass – all species (kg)	Relative Biomass minus Tol. (kg)	QHEI	IBI	MIwb	Narrative Evaluation (IBI : MIwb)	
Aicholz Ditch (05-203-000)														
U03G25	3.72	H	9.4	13	0	406	156	-	-	-	32	-	Fair	: -
U03G25	3.72	H	9.4	14	0	394	76	-	-	42.25	32	-	Fair	: -
U03G24	2.46	H	15.0	16	1	466	218	-	-	60.00	36[NS]	-	Marg. Good	: -
Silver Creek (05-202-000)														
U03G22	4.08	H	16.3	16	1	332	172	-	-	45.50	34*	-	Fair	: -
Rock Creek (05-014-000)														
U04G18	11.69	H	14.7	17	0	1834	444	-	-	44.50	26*	-	Poor	: -
U04G18	11.69	H	14.7	15	0	736	270	-	-	58.50	32*	-	Fair	: -
U04W06	0.75	W	34.4	20	7	698	545	17.7	14.7	73.25	44	8.4	Good	: Good
East Branch Rock Creek (05-015-000)														
U04G03	0.47	H	6.4	15	1	972	292	-	-	73.00	36[NS]	-	Marg. Good	: -
Willow Creek (05-013-000)														
U04W09	0.82	H	5.7	8	0	956	154	-	-	50.00	22*	-	Poor	: -
Morrison Creek (05-012-000)														
U04G06	9.34	H	9.3	11	0	1770	680	-	-	54.75	30	-	Fair	: -
U04G05	2.36	H	16.4	15	1	1340	520	-	-	68.50	32*	-	Fair	: -
Spicer Creek (05-011-000)														
U04Q11	0.80	H	12.3	18	5	442	284	-	-	70.50	48	-	Very Good	: -
Sugar Creek (05-010-000)														
U04Q10	3.20	H	8.6	15	2	2056	852	-	-	75.00	44	-	Good	: -
Wolf Creek (05-005-000)														
201336	13.60	W	27.9	24	4	1899	488	29.0	2.9	65.75	34	7.5	Marg. Good	: Marg. Good

Station	River Mile		Drainage Area	Total Native Species	Sensitive Species	Relative Number – all species	Relative Number minus tolerants	Relative biomass – all species (kg)	Relative Biomass minus Tol. (kg)	QHEI	IBI	MIwb	Narrative Evaluation (IBI : MIwb)	
U04S40	5.15	W	66.5	23	5	2433	1562	15.3	10.5	74.25	38	8.9	Good	: Very Good
U04G07	1.58	W	71.7	23	8	2099	1409	9.7	7.0	71.25	42	9.0	Good	: Very Good
Harrison Creek (05-005-004)														
U04G11	0.38	H	9.1	23	3	3776	2120	-	-	44.00	46	-	Very Good	: -
Plum Run (05-005-003)														
U04G09	0.79	H	9.8	15	1	376	274	-	-	49.25	44	-	Good	: -
Trib. to Wolf Creek (8.10) (05-005-002)														
304298	0.17	H	6.7	20	3	754	444	-	-	56.50	42	-	Good	: -
East Branch Wolf Creek (05-006-000)														
300673	19.13	W	20.3	19	2	1376	633	16.3	3.4	56.25	34	7.8	Marg. Good	: Marg. Good
U04G15	13.63	W	33.2	25	6	1133	678	16.1	7.2	73.00	42	8.6	Good	: Good
201338	9.00	W	67.8	24	4	875	527	20.6	16.6	-	38	9.3	Good	: Very Good
201338	9.00	W	67.8	22	4	745	493	26.8	11.3	65.50	44	8.5	Good	: Good
U04P03	0.86	W	82.0	29	9	2001	1315	39.0	33.8	-	42	10.1	Good	: Exceptional
U04P03	0.86	W	82.0	29	10	2133	1458	41.7	35.9	77.75	44	10.4	Good	: Exceptional
Eicher Ditch (05-006-004)														
304299	0.01	H	9.3	13	0	1080	454	-	-	60.75	34	-	Fair	: -
East Branch of East Branch Wolf Creek (05-008-000)														
U04G13	3.40	H	7.3	11	1	1178	472	-	-	68.25	32*	-	Fair	: -
300682	1.48	H	19.7	17	3	2626	1756	-	-	71.50	44	-	Good	: -
Middle Branch of East Branch of East Branch Wolf Creek (05-009-000)														
U04G14	0.46	H	10.8	18	2	1362	748	-	-	78.3	38	-	Marg. Good	: -

Station	River Mile		Drainage Area	Total Native Species	Sensitive Species	Relative Number – all species	Relative Number minus tolerants	Relative biomass – all species (kg)	Relative Biomass minus Tol. (kg)	QHEI	IBI	MIwb	Narrative Evaluation (IBI : MIwb)	
Indian Creek (05-004-000)														
500950	0.62	H	12.0	16	2	1224	660	-	-	72.3	36	-	Marg. Good	: -
Muskellunge Creek (05-003-000)														
300674	16.70	H	17.7	15	2	1008	810	-	-	45.3	46	-	Very Good	: -
201332	5.40	W	35.7	17	3	1544	1130	6.1	3.7	63.5	42	7.8	Good	: Marg. Good
Bark Creek (05-002-000)														
300671	3.20	H	10.0	17	1	1236	498	-	-	47.0	34	-	Fair	: -
Muddy Creek (05-219-000)														
201410	21.90	W	43.5	20	4	462	339	22.3	14.8	69.50	44	8.9	Good	: Very Good
201410	21.90	W	43.5	23	4	510	357	14.3	11.3	68.50	44	9.0	Good	: Very Good
U04S01	9.79	W	72.8	24	4	1163	686	13.5	10.1	48.25	36	8.7	Marg. Good	: Good
U04S01	9.79	W	72.8	22	4	1181	903	28.4	25.1	59.00	44	9.6	Good	: Exceptional
South Branch Muddy Creek (05-222-000)														
U04S08	5.67	H	4.6	10	0	376	126	-	-	50.50	30	-	Fair	: -
300679	1.54	H	21.9	20	1	1203	297	28.3	10.4	38.00	28[NS]	7.4	Fair	: Marg. Good
Gries Ditch (05-223-000)														
U04Q16	0.93	H	12.5	10	0	1550	510	-	-	67.00	24[NS]	-	Fair	: -
U04Q16	0.93	H	12.5	10	0	582	296	-	-	60.25	30	-	Fair	: -
Little Muddy Creek (05-220-000)														
300677	7.55	W	12.4	13	1	420	86		-	57.75	24[NS]	-	Fair	: -
300677	7.55	H	12.4	14	1	960	438		-	56.25	32	-	Fair	: -
Fishing Creek (05-220-001)														
300678	0.20	W	7.0	19	1	2248	2164	-	-	25.8	34	-	Fair	: -

Fish Community Trends

Since 1979, the Ohio EPA fish evaluation unit has sampled more than 118 total river miles of streams included in this survey. These efforts have yielded over 336,000 individual fish. The 2022 survey was one of several comprehensive sampling efforts in the Sandusky basin streams since 2001. The 2001 survey focused mostly on the upper portions of the Sandusky River and tributaries upstream from the confluence with Wolf Creek, while the 2009 effort was focused on the lower Sandusky watershed from Wolf Creek downstream and other Sandusky Bay tributaries. There were other smaller, more targeted efforts throughout the basin, including: a small 1985 effort through the Paramour Creek sub-watershed, a 1991 survey encompassing most of the mainstem and the lower reaches of three tributaries, extensive sampling through the Tymochtee basin in 1995 related to an enforcement case, a targeted survey through the Sycamore Creek basin in 1999 and 2000 related to the a large tire fire, and sampling through the upper Broken Sword and uppermost Sandusky watershed through the 2010s related to Great Lakes water quality restoration funding. Sporadic sampling has also occurred at the many reference sites scattered throughout the study area since the early 1980s.

Historical fish index score information from streams sampled during the current survey and displayed in Table 14, Table 15, and Figure 28 through Figure 31.

Previous assessments of the Sandusky River mainstem occurred in 1979, 1981, 2001, and 2009. The 1979 and 2001 sampling were mostly confined to the portions of the Sandusky mainstem upstream from Tiffin, Ohio, while the 1981 and 2009 surveys mostly covered the lower Sandusky River mainstem downstream from Tiffin. IBI and MIwb scores are aggregated by the upper and large river portions of the mainstem in Figure 28 and are displayed longitudinally in Figure 29. Overall, both IBI and MIwb scores have gradually improved through time, indicating both the improved structural (diversity, numbers, and biomass) and functional components (proper species mix and proportions) of fish assemblages throughout the Sandusky River.

IBI scores through the upper mainstem were similar between 1979 and 1990, while scores gradually improved during both the 2001 and the 2022 surveys. Meanwhile, the MIwb scores from the upper mainstem increased in a stepwise fashion through all survey periods (Figure 28). This indicates that fish community function (types and proportions of species present) as indicated by the IBI was generally similar through the two earliest periods of record and has gradually improved over the last several decades, while the structural components of the fish assemblage (diversity, numbers, and biomass of fish present) have gradually improved through all survey periods. Numbers, biomass, and diversity have gradually improved through time, but only during the recent evaluation periods has there been additional improvements related to fish community function.

Improved fish community performance was especially evident downstream from the Bucyrus WWTP (Figure 29). Substantial declines in both IBI and MIwb scores were observed downstream from this facility as recently as 2001 and not much recovery had occurred prior to the recent survey. Sampling from a targeted mini survey in 2013 suggested improved conditions compared to 2001, with good to very good fish assemblages noted. Further recovery has occurred since 2013, and fish community performance is now in the very good to exceptional range. This reach of the Sandusky River saw the greatest degree of improvement, by far, of all Sandusky River mainstem sites since 2001 and fish

assemblages through this reach are now among the highest quality in the upper mainstem. Recovery has also occurred around both the Tiffin and Upper Sandusky WWTPs.

Like the upper Sandusky mainstem, fish index scores through the lower mainstem have dramatically improved since the earliest sampling by Ohio EPA (Figure 28). IBI scores have improved since 1979/81 and have remained similar between the later survey periods, while MIwb scores through the lower mainstem displayed the same gradually increasing trend that was observed in the upper mainstem (Figure 29). This suggests that fish community function improved rather quickly through the lower mainstem and has plateaued somewhat through the last several reporting cycles, while the fish abundance and biomass continued to gradually increase over time. The basin wide improved biological condition through time can be attributed primarily to habitat improvements related to reduced siltation and modern soil conservation practices (Miltner 2015, Richards et. al 2009), and other reductions in non-point source nutrient loadings.

The removal of the Ballville Dam in 2018 eliminated an impediment to fish passage and now over 44 miles of the Sandusky River from Tiffin, Ohio to Lake Erie is free flowing. Previous external surveys have documented two new species, White Bass and Flathead Catfish, upstream from the former Ballville Dam and there have also been verified reports of Lake Sturgeon (*Acipenser fulvescens*) in tributaries upstream from this structure (Great Lakes Now 2022, Sasak 2021). The current survey also documented several additional new species upstream from the former Ballville Dam, including Smallmouth Buffalo, Bigmouth Buffalo (*Ictiobus cyprinellus*), and Emerald Shiners (*Notropis atherinoides*).

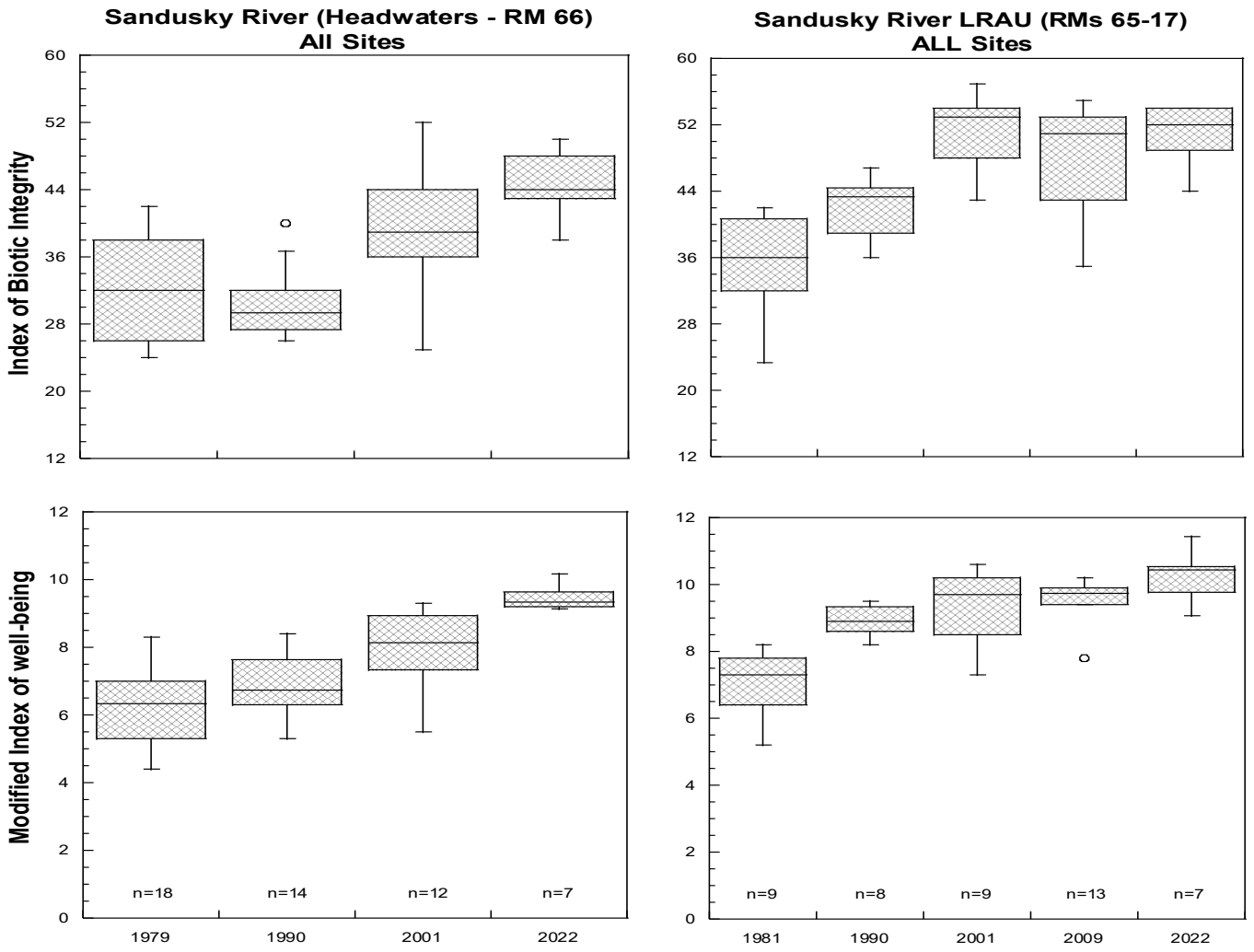


Figure 28 – Aggregated IBI (top) and MIwb (bottom) scores from indicated years in the upper (left) and lower (right) portions of the Sandusky River.

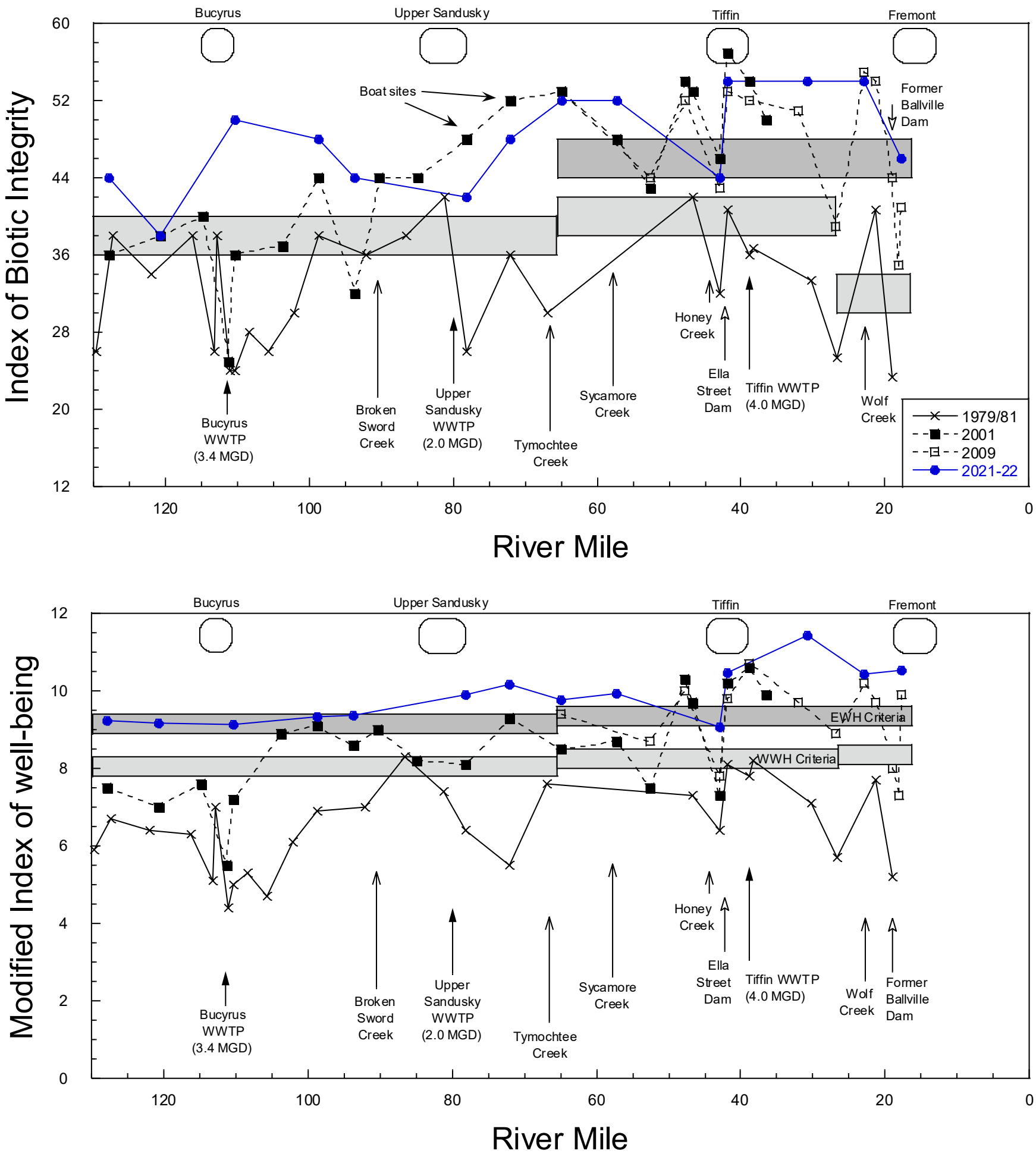


Figure 29 – Longitudinal display of IBI (top) and MIwb (bottom) scores from the Sandusky River mainstem from 2021/22, 2009, 2001, and 1979/81. Scores are displayed upstream to downstream.

Tributaries

Overall

A comprehensive list of all current and historical IBI and MIwb scores from streams in this survey are provided in Table 14 and Table 15. These tables contain information for all the major survey efforts described above and all other minor collection efforts that have occurred in these streams since 1979.

The most recent basin wide assessments of tributaries to the Sandusky River occurred in 2001 and 2009. The 2001 survey was focused on mainly the upper portions of the Sandusky watershed upstream from Wolf Creek. The 2009 survey was focused mostly on Muddy Creek and the lower portions of Sandusky watershed from Wolf Creek downstream, along with other nearby Sandusky Bay tributaries not included in this survey.

Like much of the Sandusky River mainstem, fish assemblage quality in tributaries to the Sandusky River have improved over time. Figure 30 displays IBI scores from paired tributary sampling locations comparing results from the 2001 and 2009 surveys to the 2022 survey. Clear improvements were observed between the two datasets. The average IBI score increased just over five points from 2001-2022 and the range of values was greatly reduced. The Wilcoxon-Mann Whitney non-parametric treatment suggested improvements over this period were statistically significant (p=<0.0001).

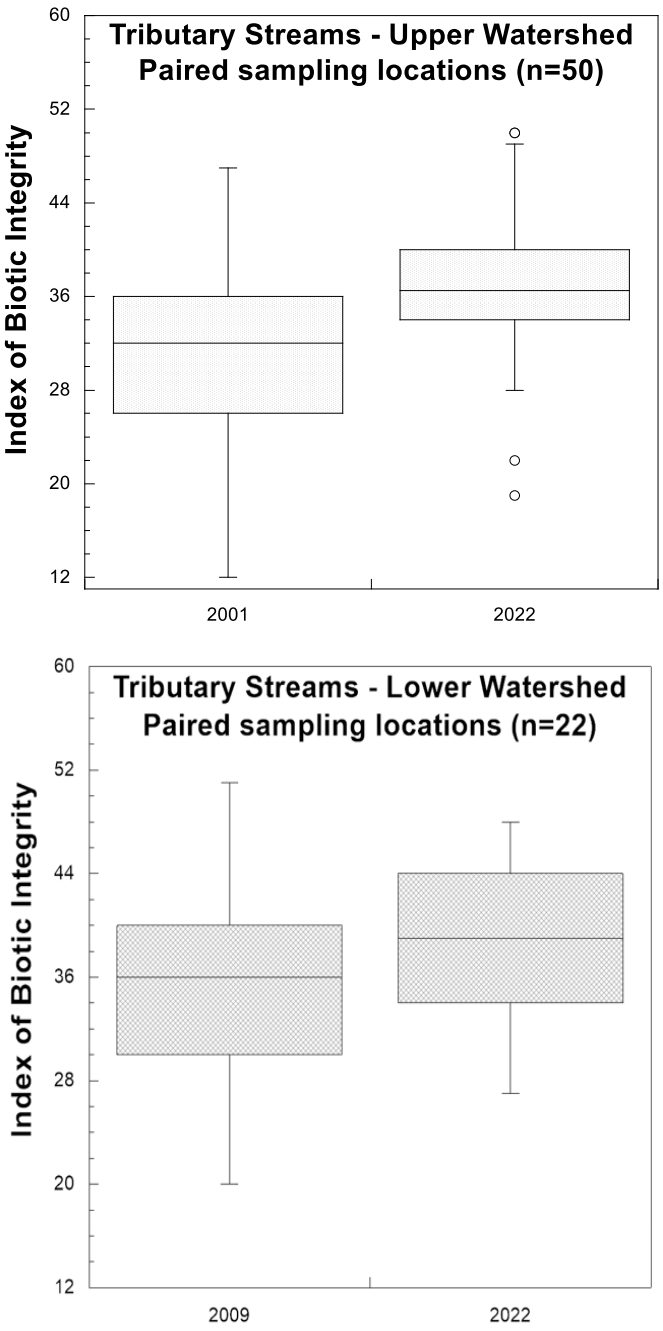


Figure 30 – Index of Biotic Integrity scores from paired sampling locations during the previous major surveys in the upper and lower portions of the watershed – 2001, 2009, and 2022.

While the improvements were less pronounced from 2009 to 2022 in the lower tributaries, the average IBI score still increased nearly three points and scores were higher overall in 2022. The shorter duration between surveys in the 2009 dataset may explain the differences between these datasets. The 2009 survey marked the first sampling efforts in many of these tributaries and some recovery would have likely occurred already by the time these areas were first sampled in 2009.

Individual Waterbodies

Most smaller tributaries in the upper watershed had generally stable to improved fish community quality (Table 14, Table 15). Both **South Fork Loss Creek** and **Grass Run** had similar or improved IBI scores compared to previous sampling.

Fish community scores were also higher in **Paramour Creek**, especially through the lower reaches. The impoundment near the mouth of Paramour has seemingly excluded fish recolonization from the Sandusky River. An analysis of all Ohio EPA data from 1979 to 2023 from the upper Sandusky mainstem and the Paramour sub-basin identified many common native fish species that would otherwise thrive or persist in lower Paramour Creek in the absence of an impoundment, including Rock Bass (*Ambloplites rupestris*), Smallmouth Bass (*Micropterus dolomieu*), Northern Hog Sucker (*Hypentelium nigricans*), Golden Redhorse, Common Logperch (*Percina caprodes*), Greenside Darter (*Etheostoma blennioides*), Fantail Darter (*Etheostoma flabellare*), Silverjaw Minnow (*Ericymba buccata*), and Spotfin Shiner (*Cyprinella spiloptera*).

Allen Run has seen declines in fish community performance over time, including being completely fishless in 2022 after a documented fish kill. The issues depressing fish community performance appear to be chronic, with scores declining into the fair to poor range over three evaluation periods since 2012 (Table 14).

Fish community performance has also improved throughout **Broken Sword Creek** and its tributaries (Table 15). Fish index scores from Broken Sword Creek have improved over time and both the IBI and MIwb scores were higher across all locations sampled compared to any prior years (Figure 31, Table 15). Despite general improvements through the system, there was still a decline in both indices at RM 19.70 (201366) in 2022 like those observed historically. IBI scores in **Red Run** and **Indian Run** were higher than historical values, while results from lower **Brandywine Creek** were similar to historical values.

The **Little Sandusky River** collectively had the lowest index scores of the 2022 survey and there has been no discernable recovery through time (Table 14, Table 15). Fish index scores still are generally in the poor range and remain unchanged compared to the conditions documented in 1995 and 2001-02. In contrast to the Little Sandusky River, the IBI scores from the **unnamed tributary (8.93)** and **Honey Run** have notably improved. The two sampling locations on these streams yielded a combined 39-point improvement in their overall IBI scores compared to the previous survey. Improvements in fish community performance were most evident in Honey Run, with good quality communities observed in 2022.

Fish index scores were improved in **Negro Run, Sugar Run, Thorn Run, Taylor Run,** and **Mile Run** compared to the 2001 survey, while scores were similar in **Rock Run**.

Tymochtee Creek had vastly improved IBI and MIwb scores compared to the previous survey (Figure 31, Table 14, Table 15). Fish performance in the tributaries to Tymochtee Creek were more variable. Most streams in the upper Tymochtee Creek watershed had similar IBI scores to those observed during the previous survey; incrementally higher scores were noted in the **Pawpaw Run** (Table 14). Despite only slightly higher IBI scores in **Little Tymochtee Creek (upper)** RM 4.0 (U01G20), the MIwb score was 3 full points higher than the value recorded in 2001 – this was the single highest improved

MIwb score from the entire survey (Table 15). While fish community function only improved incrementally, fish numbers, biomass, and overall assemblage diversity improved dramatically. Several tributaries in the lower Tymochtee Creek basin had improved IBI scores, including **Lick Run, Little Tymochtee Creek (lower), and Spring Run,** while scores were similar in other tributaries.

Fish community performance through lower **Sycamore Creek** has generally been stable since the previous survey in 2001, while an improved IBI score was documented at the uppermost sampling location.

Fish assemblages throughout **Honey Creek** have improved over time, with the most discernable improvements occurring during the most recent survey (Table 14, Table 15). Both IBI and MIwb scores were generally similar between historical survey periods, while scores from 2022 were decidedly higher than any of those scores recorded historically at these locations. Improved IBI scores were especially pronounced in the more upstream reaches of Honey Creek (Figure 31). IBI scores have also improved in the tributaries to Honey Creek since 2001, including in lower **Brokenknife Creek,** upper **Aicholz Ditch,** and lower **Silver Creek.**

Fish IBI scores in **Rock Creek, East Branch Rock Creek, Willow Creek,** and **Sugar Creek** were generally similar between 2001 and 2022. The IBI scores from **Spicer Creek, Indian Creek,** and **Bark Creek** were decidedly improved compared to the previous surveys in 2001 and 2009. **Muskellunge Creek** also had both improved IBI and MIwb scores compared to the previous survey (Table 14, Table 15). IBI scores declined slightly since 2001 at both locations sampled in **Morrison Creek**.

Both the IBI and MIwb scores from **Wolf Creek** were similar to 2009 in the upper reaches and slightly improved near the mouth at RM 1.58 (Table 14). IBI scores were decidedly improved in **Harrison Creek,** while similar values were observed in **Plum Run.** IBI scores were mostly improved through the upper and middle reaches of **East Branch Wolf Creek**, while the average IBI score dropped several points at the lowermost location between RMs 0.86 and 0.50; RM 0.50 has much deeper pools and supported a different type of assemblage than that encountered at RM 0.86. The MIwb score at this site, however, was similar between these two locations (Table 15). IBI scores in tributaries to the East Branch of Wolf Creek were generally similar to previous values documented.

Muddy Creek had IBI scores that have improved dramatically from the early 1980s to 2009 (Table 14). IBI scores from lower Muddy Creek have remained relatively stable since 2009, while scores have improved somewhat in the upstream reaches that were evaluated. MIwb scores have also followed this general pattern (Table 15). Most tributaries to Muddy Creek had IBI scores that were similar to values documented previously. Some recovery has occurred since the 1980s, while general stability was documented since the 2009 survey.

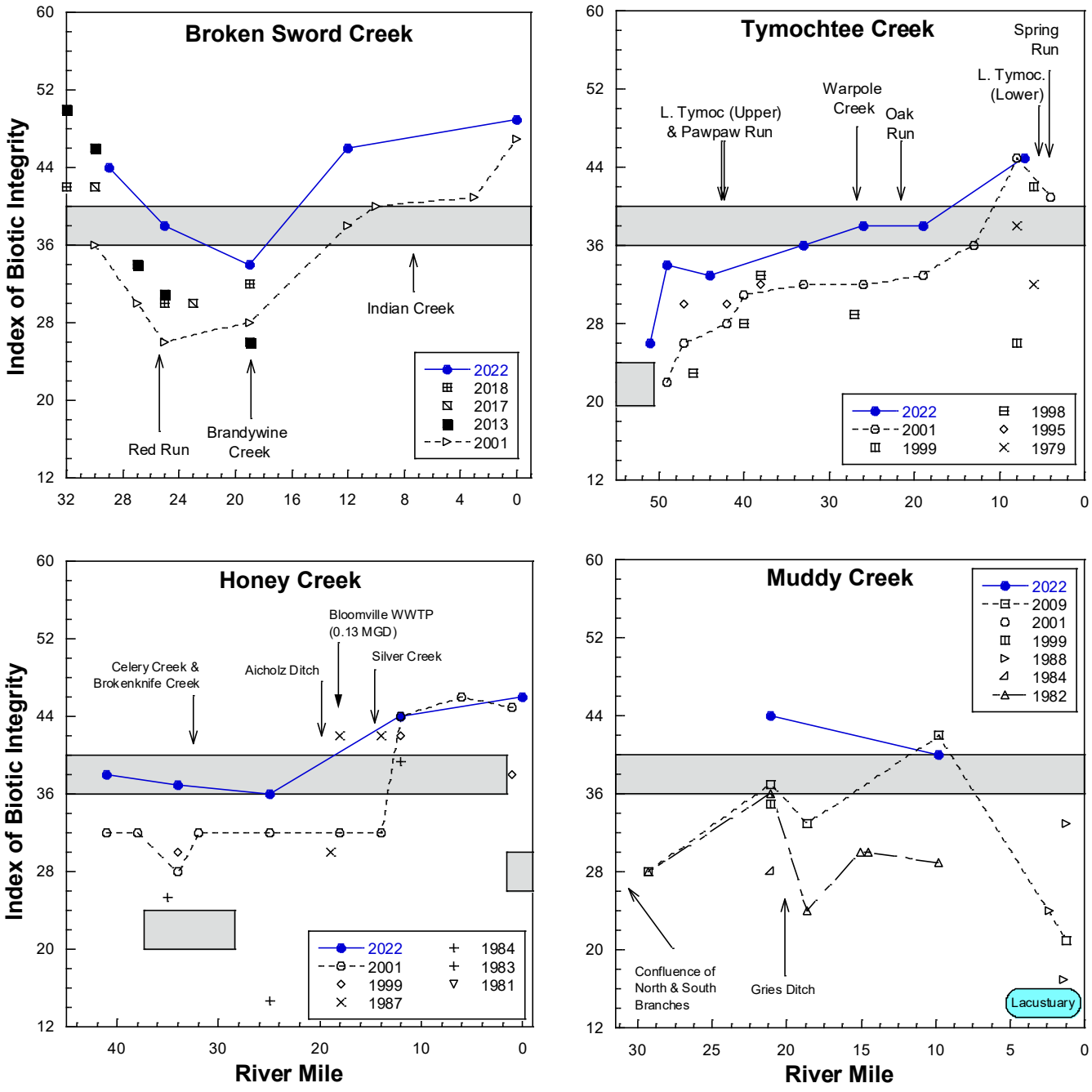


Figure 31 – Longitudinal display of IBI scores from select Sandusky River tributaries from the indicated years. Adjoining tributary streams and WWTPs (if present) are denoted by arrows.

Table 14 – Fish IBI scores collected by Ohio EPA from Sandusky River tributary streams.

Streams and sampling locations are displayed upstream to downstream, by their location longitudinally within the watershed. Multiple scores from within the same year are displayed as an average. Only streams sampled during 2022 and that had historical IBI scores were displayed.

Stream & River Mile	1979-1982	1983-1989	1990-1999	2000-2001	2009-2011	2012-2013	2016-2018	2022
Paramour Creek (05-042-000)								
6.31[R]		34	30	26				36
4.78		27		28				
2.99	20	22						
2.30	20	24						
1.50	12	20		20				30
0.23	14	22						
0.15	36	34						
Allen Run (05-043-000)								
2.30						32		
1.18				42	50	30	30	32/12
South Fork Loss Creek (05-041-001)								
0.01				38	46		30	42
Grass Run (05-039-000)								
10.60				26				
8.36				34				38
3.42				46				50
Broken Sword Creek (05-035-000)								
32.60								
30.31				36		50	42	44
27.96				30		46	42	
25.48				26		34	34	38
23.30						31	30	
19.70				28			30	34
12.41				38		26	32	46
10.55				40				
3.90				41				
0.87			44	47				49
Red Run (05-038-000)								
2.65						24	22	
0.42						38	30	39
Brandywine Creek (05-037-000)								
3.30				12		38	26	
1.60				24		30	36	
0.45						30	36	30
Indian Run (05-036-000)								
3.50				26				
0.94				26				36
Little Sandusky River (05-033-000)								
10.40			18	23				22
9.44				24				
8.60				20				

Stream & River Mile	1979-1982	1983-1989	1990-1999	2000-2001	2009-2011	2012-2013	2016-2018	2022
6.52				23				20
3.71			29	21				26
1.45				26				
0.30				26				
0.20				32				
Tributary to the Little Sandusky River (8.93) (05-033-003)								
2.40				19				
0.78			24	21				32
Honey Run (05-034-000)								
0.52				12				40
Rock Run (05-032-000)								
4.00				34				36
0.80			36	30				
Negro Run (05-027-000)								
2.91				44				
0.52			42	42				50
Sugar Run (05-026-000)								
0.60				34				40
Tymochtee Creek (05-300-000)								
51.43			21					26
49.44				22				34
47.15			30	26				
46.11			23					
44.95								33
42.83			30	28				
40.76			28	31				
38.90			33					
33.99				32				36
27.90			29					
26.28				32				38
19.45				33				38
13.73				36				
8.06[R]	38		26	45				50
6.10[R]	32		42					
4.64				41				
Prairie Run (05-300-007)								
5.60			32					
1.02			24	26				12/26
Enoch Ditch (05-300-006)								
1.59				28				28
1.40			32					
Carroll Ditch (05-300-004)								
0.66			20	26				28
Pawpaw Run (05-319-000)								
9.00				28				
6.13				22				38

Stream & River Mile	1979-1982	1983-1989	1990-1999	2000-2001	2009-2011	2012-2013	2016-2018	2022
4.25			30					
4.00			22					
0.57			27	26				34
Upper Little Tymochtee Creek (05-316-000)								
13.50				30				
9.77				30				
8.63								30
7.41				26				
5.50			32					
4.00				34				36
Warpole Creek (05-314-000)								
1.52				36				36
Lick Run (05-308-000)								
0.83				32				40
Lower Little Tymochtee Creek (05-304-000)								
6.87				26				34
0.90				24				32
Spring Run (05-301-000)								
5.29				28				
3.68				20				
1.71								38
Poverty Run (05-302-000)								
2.99				42				40
Thorn Run (05-024-000)								
2.90				22				
0.70				26				34
Taylor Run (05-023-000)								
5.30				22				
3.62				24				
1.88				30				38
Sycamore Creek (05-021-000)								
22.02				28				
18.92				26				40
14.26				38				
9.14			38	39				40
7.34				37				
6.40			24					
6.20			12	42				
5.10			29	42				
3.47			31	45				
2.61			18	46				
0.41			35	44				45
Spring Creek (05-021-000)								
5.70				40				
1.88								40

Stream & River Mile	1979-1982	1983-1989	1990-1999	2000-2001	2009-2011	2012-2013	2016-2018	2022
Mile Run (05-020-000)								
3.50				38				
0.30				32				40
Honey Creek (05-200-000)								
41.66				32				38
38.34				32				
34.14[R]		25	30	28				37
32.23				32				
25.03		15		32				36
19.31		30						
18.05		42		32				
14.80		42		32				
12.30[R]		39	42	44				46
6.68				46				
1.10[R]	27		38	45				46
Celery Creek (05-200-003)								
4.54							30	
0.45							36	36
Brokenknife Creek (05-209-000)								
5.08				30				
1.05				30				38
Aicholz Ditch (05-203-000)								
3.72				28				32
2.46				38				36
Silver Creek (05-202-000)								
7.75				36				
4.08				28				34
Rock Creek (05-014-000)								
11.69								29
8.31				32				
3.96				40				
0.75								44
East Branch Rock Creek (05-015-000)								
0.47				34				36
Willow Creek (05-013-000)								
3.00				22				
0.82								22
Morrison Creek (05-012-000)								
9.34				34				30
2.36				34				32
Spicer Creek (05-011-000)								
0.80				34				48
Sugar Creek (05-010-000)								
3.11[R]		45	34		42			44
2.90		28						
2.37		49						

Stream & River Mile	1979-1982	1983-1989	1990-1999	2000-2001	2009-2011	2012-2013	2016-2018	2022
1.05		50			44			
0.10		36						
Wolf Creek (05-005-000)								
13.60			32		36			34
12.10			36					
11.16			34					
5.15					40			38
1.58					36			42
0.04					46			
Harrison Creek (05-005-004)								
0.38					32			46
Plum Run (05-005-003)								
0.79					42			44
East Branch Wolf Creek (05-006-000)								
18.90					26			34
13.63					36			42
9.00					37			41
0.86								43
0.50					51			
East Branch of East Branch Wolf Creek (05-008-000)								
3.52					30			32
1.48					48			44
Middle Branch of East Branch of East Branch Wolf Creek (05-009-000)								
0.46					38			38
Indian Creek (05-004-000)								
0.62					30			36
Muskellunge Creek (05-003-000)								
16.70					44			46
5.40					37			42
1.23					37			
Bark Creek (05-002-000)								
3.20					20			34
Muddy Creek (05-219-000)								
29.36	28				28			
21.10[R]	36	28	35		37			44
18.68	24				33			
15.06	30							
14.50	30							
9.79	29				42			40
2.40		24						
1.40		17						
1.23		33			21			
South Branch Muddy Creek (05-222-000)								
5.67[R]	26		31					30
1.54					34			28

Stream & River Mile	1979-1982	1983-1989	1990-1999	2000-2001	2009-2011	2012-2013	2016-2018	2022
Gries Ditch (05-223-000)								
4.72					30			
0.93[R]		16	20		28			27
Little Muddy Creek (05-220-000)								
7.55					26			28
2.50					20			
1.75		12						
0.50		21						
Fishing Creek (05-220-001)								
0.20					32			34

[R] Reference Site

Table 15 – Fish MIwb scores collected by Ohio EPA from Sandusky River tributary streams.

Streams and sampling locations are displayed upstream to downstream, by their location longitudinally within the watershed. Multiple scores from within the same period are displayed as an average. Only streams sampled during 2022 and that had historical scores were displayed.

Stream & River Mile	1979-1982	1983-1989	1990-1999	2000-2001	2009-2011	2012-2013	2016-2018	2022
Paramour Creek (05-042-000)								
1.50		1.2						6.8
0.23		4.2						
0.15		8.8						
Broken Sword Creek (05-035-000)								
27.96						8.2	8.6	
25.48				6.8		6.7	8.2	8.9
23.30							6.0	
19.70				7.4		6.5	7.7	7.9
12.41				8.8				9.8
10.55				8.1				
3.90				7.6				
0.87			9.5	9.1				9.8
Little Sandusky River (05-033-000)								
3.71			5.8	5.1				6.1
1.45				5.0				
0.30				4.7				
0.20				7.1				
Tymochtee Creek (05-300-000)								
47.15			6.0	5.7				
46.11			5.2					
42.83			6.7	5.2				7.3
40.76			5.8	7.1				
38.90			6.8					
33.99				7.3				8.2
27.90			5.9					
26.28				7.0				8.8
19.45				7.3				8.1
13.73				6.6				
8.06	7.7		7.5	9.1				9.5
6.10	5.7		8.2					
4.64				8.3				
Upper Little Tymochtee Creek (05-316-000)								
4.00				5.1				8.4
Lower Little Tymochtee Creek (05-304-000)								
0.90				5.5				6.8
Sycamore Creek (05-021-000)								
14.26				7.5				
9.14			8.1	7.0				9.0
7.34				7.4				
6.40			4.6					
6.20			0.0	7.8				

Stream & River Mile	1979-1982	1983-1989	1990-1999	2000-2001	2009-2011	2012-2013	2016-2018	2022
5.10			5.0	7.0				
3.47			3.6	8.3				
2.61			2.7	7.4				
0.41			7.8	8.6				9.6
Honey Creek (05-200-000)								
34.14	6.0		7.4	7.3				8.4
32.23				6.7				
25.03		0.3		5.1				7.4
19.31		8.3						
18.05		8.8		6.7				
14.80		8.9		7.6				
12.30	8.6		8.4	9.2				9.9
6.68				9.3				
1.10	5.5		8.3	7.3				9.2
Rock Creek (05-014-000)								
3.96				8.1				
0.75								8.4
Wolf Creek (05-005-000)								
13.60			7.7		7.5			7.5
12.10			8.5					
11.16			8.9					
5.15					8.1			8.9
1.58					7.1			9.0
0.04					10.0			
East Branch Wolf Creek (05-006-000)								
18.90					6.0			7.8
13.63					7.2			8.6
9.00					7.4			8.9
0.86								10.3
0.50					9.7			
Muskellunge Creek (05-003-000)								
5.40					6.9			7.9
1.23					9.1			
Muddy Creek (05-219-000)								
29.36					7.2			
21.10		6.7	7.1		7.1			9.0
18.68					7.5			
15.06								
14.50								
9.79					7.4			9.2
2.40		7.9						
1.40		5.8						
1.23		7.8			6.8			
South Branch Muddy Creek (05-222-000)								
1.54					8.5			

Macroinvertebrate Community Sampling Results

Macroinvertebrate assemblages were evaluated at 115 locations throughout the study area. Most macroinvertebrate community samples were collected over the summer of 2022, while several areas had additional sampling occur in 2023. Macroinvertebrate communities at most locations through the large river portion of the Sandusky River were evaluated in 2021 as part of a statewide survey (Ohio EPA 2023a). Approximately 388 unique macroinvertebrate taxa were collected during the current survey, including 78 EPT (Ephemeroptera, Plecoptera and Trichoptera) taxa.

The macroinvertebrate sampling effort for the current survey included 116 samples across 115 sites (Table 16). Qualitative sampling was conducted at all sampling locations, while quantitative sampling was collected at 44 sites using Hester-Dendy artificial substrates. ICI scores were not used at five additional sites due to insufficient current velocity, suspected disturbance, or loss of the artificial substrate.

The macroinvertebrate taxa list associated with each site are presented in Appendix C and the ICI and metric scores are displayed in Appendix D. This survey represented one of several major efforts in this watershed since the early 1980s. Comparisons to historical sampling activities are contained in the following trends section. Sampling sites were spread between the Eastern Corn Belt Plains (ECBP) and the Huron-Erie Lake Plain ecoregions (Figure 7). Sampling locations were evaluated using either the WWH, MWH-C, and the EWH biocriteria for the ICI or equivalent narrative evaluation (if applicable). Macroinvertebrate taxa summary information is presented in Table 16.

Of the 115 sites where macroinvertebrate data were collected during the current survey, only 12 sites (10.4%) had communities that failed to achieve ALU goals (Table 1). Macroinvertebrate assemblages at the remaining 103 sites achieved their goals, including all sites on the Sandusky River mainstem (Figure 32).

Sandusky River mainstem

Macroinvertebrate assemblages were evaluated at 16 stations on the Sandusky River from river miles 127.80 to 17.70; no samples were collected from the lacustuary portions of the mainstem. Macroinvertebrate community quality ranged from marginally good to exceptional, with most sites supporting exceptional quality macroinvertebrate assemblages (Table 16). The sites on the Sandusky River mainstem generally yielded the highest numbers of EPT, sensitive taxa, and total taxa of the survey. Approximately 241 unique total taxa, 59 EPT, and 81 sensitive taxa were collected from the Sandusky mainstem alone.

Mayflies and caddisflies were well represented on the Hester-Dendy artificial substrates at the majority of the mainstem sites, in terms of both the proportions and overall diversity (Appendix D). The percentage of tolerant organisms was notably low across all the mainstem sites making up roughly 1.0% of the community on the artificial substrates.
The site downstream from Bucyrus WWTP at RM 110.43 (U02P30) was the lone outlier, where

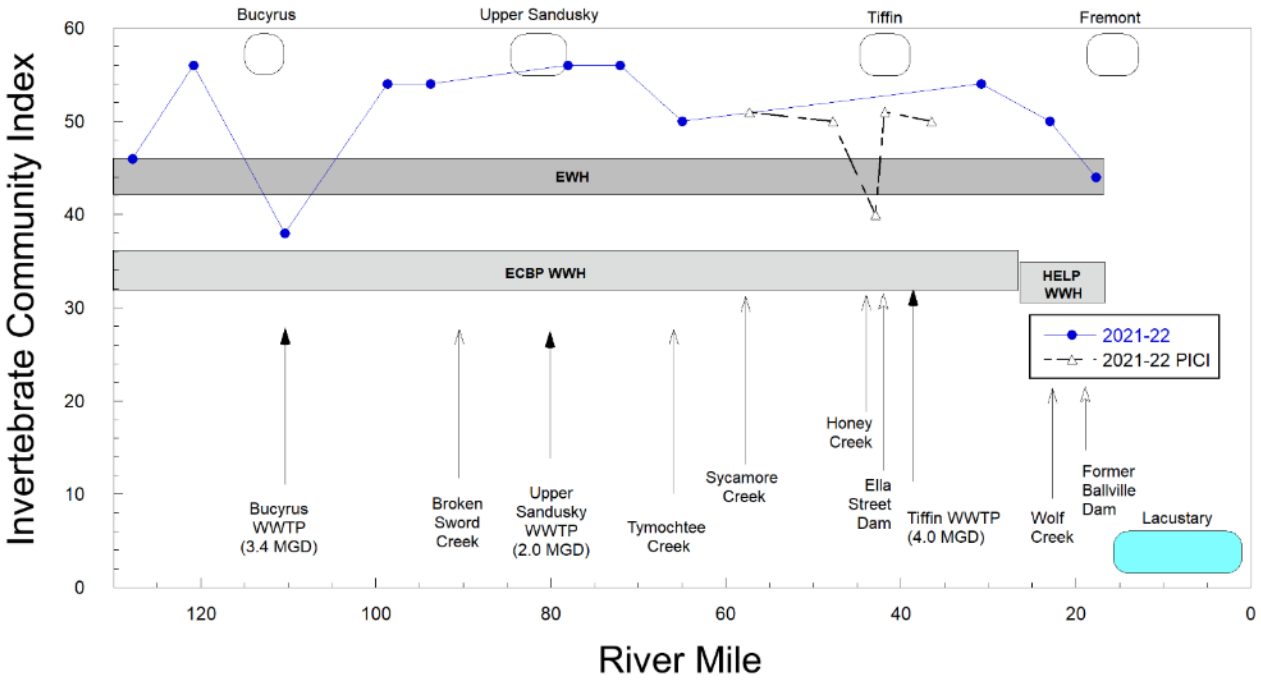


Figure 32 – Longitudinal macroinvertebrate ICI scores from the Sandusky River mainstem, 2021-2022. The predicted ICI was used where an ICI score wasn't available.

11.61% of the organisms were tolerant. The ICI score at this site was also somewhat lower than the surrounding areas, though still achieved WWH expectations (Figure 32).

The first records of *Paracloeodes minutus*, a Small Minnow-Mayfly, were noted in the Sandusky River mainstem in 2022. There were five collections made as part of the survey between RMs 41.84 to 72.09. This mayfly has been found in other high-quality streams through Ohio, but these records are the first for the entire Sandusky River mainstem (Bolton 2010).

During the qualitative sampling process, a passive search for living or fresh-dead mussels was conducted. Across the 16 mainstem Sandusky sites, freshwater mussels were found at 10 and 11 unique mussel taxa were identified (Table 17). Several of the mussel taxa found are state-listed species of concern in Ohio, including the Creek Heelsplitter (*Lasmigona compressa*), Elktoe (*Alasmidonta marginata*), and Purple Wartyback (*Cyclonaias tuberculata*). The habitat conditions at RM 93.76 were well suited for freshwater mussels, with 10 unique taxa found and healthy populations of numerous live mussels.

Upper Sandusky River tributaries

Macroinvertebrate community performance was variable across the tributaries that drain the uppermost portion of the Sandusky watershed. Fair quality communities were documented in **Allen Run** both in 2022 and 2023 (Table 16). Macroinvertebrate community quality was similar during both years, though the number of tolerant taxa was higher in 2023 (18) than in 2022 (12). The numbers of sensitive and EPT taxa were also low compared to similarly sized streams in

the watershed (Figure 33). Water quality issues documented during the summer of 2022 negatively impacted community quality here. This is discussed more thoroughly in the **Water Quality and Aquatic Life Impairment Discussion** section. Macroinvertebrate community quality through the remaining tributary sites was marginally good to good, with exceptional quality communities documented in lower **Grass Run**.

Broken Sword Creek and tributaries

Macroinvertebrate community quality throughout **Broken Sword Creek** was generally high (Table 16). Community quality in Broken Sword Creek at RM 29.52 (U02G09) and RM 19.70 (201366) was good, while the remaining three locations were exceptional quality. All sites achieved warmwater expectations, though relative underperformance at RM 29.52 and RM 19.70 may indicate some impacts to communities at these locations. Eight different mussel species were observed at three locations on Broken Sword Creek (Table 17).

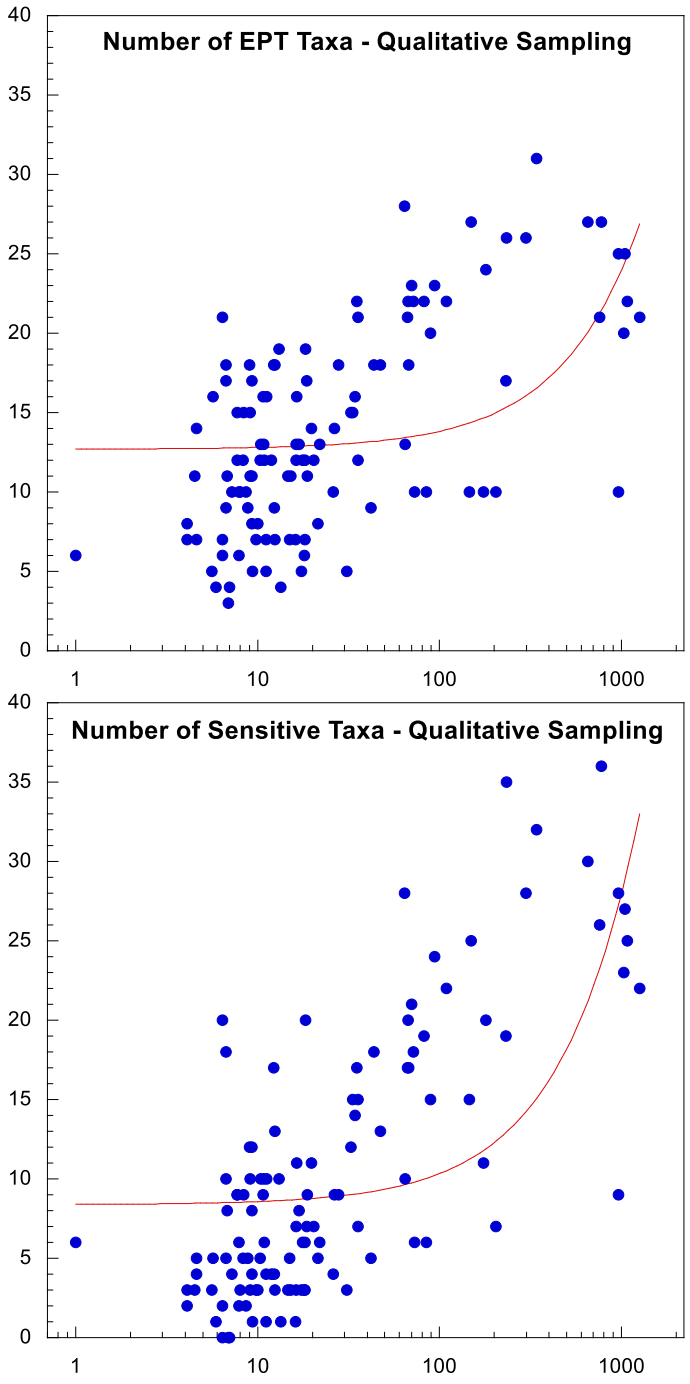


Figure 33 – Numbers of different sensitive and EPT taxa collected at each sampling location displayed by drainage area.

Macroinvertebrate community quality in **Brandywine Creek** at RM 0.40 (302343) was only fair and failed to achieve WWH expectations (Table 16). Facultative midges and flatworms were the predominant organisms here and the number of sensitive and EPT taxa (4, 5) was among the lower values for similarly sized streams in the study area (Figure 33). **Red Run** and **Indian Run** had marginally good and good quality assemblages, respectively, and both achieved WWH expectations.

Little Sandusky River sub-basin

Macroinvertebrate community performance in the **Little Sandusky River** ranged from low-fair to marginally good and was lower, overall, compared to other streams in the watershed. Community quality was fair at RM 6.52 (U02G16) and low-fair at RM 10.40 (201361) (Table 16). Both locations had communities that failed to achieve WWH expectations and RM 10.40 failed to even achieve MWH-C expectations (Table 1). Macroinvertebrate community quality in the Little Sandusky River at RM 10.40 was among the lowest of the survey, and was one of two sites that did not have any EPT taxa present. The ICI score in the Little Sandusky River only improved to marginally good further downstream at RM 3.71 (U02W06). The numbers of EPT (3, 6, 8) and sensitive taxa (0, 3, 5) at all three locations on the Little Sandusky River were among the lowest values in the survey compared to other similarly sized stream sites (Table 16, Figure 33).

Macroinvertebrate communities in the **tributary to the Little Sandusky (8.93)** were comparable to other sites in the upper portion of this sub-watershed. In stark contrast to other portions of the Little Sandusky sub-basin, community quality in **Honey Run** at RM 0.52 (U02G18) was exceptional. The numbers of EPT (18) and sensitive (12) were much higher than other sites in this sub-watershed (Figure 33, Table 16). There were twice the number of sensitive taxa collected here compared to the number of tolerant taxa (6).

Tymochtee Creek sub-basin

Macroinvertebrate assemblages were evaluated at seven locations along the length of **Tymochtee Creek** (Table 16). The uppermost two locations had fair quality communities that did not achieve WWH expectations. Flatworms and midges were the predominant organisms found here. Macroinvertebrate community quality through the rest of Tymochtee Creek ranged from marginally good to exceptional at the reference site near the mouth at RM 7.80 (500850). Eleven different mussel species were collected across all Tymochtee Creek sites, including eight at RM 33.99 (U01G04), alone. Two state listed species, the state-listed Round Pigtoe and Kidneyshell mussels (species of concern), were among the taxa collected here (Table 17). Lower gradient conditions, finer grained sediments, and pervasive hydromodifications through much of Tymochtee Creek limits the overall upside of macroinvertebrate community quality somewhat in this sub-watershed.

Macroinvertebrate community quality at most tributary sites was good or very good, while some were marginally good or fair (Table 16). Three different species of freshly dead mussels were collected in **Warpole Creek** at RM 1.52 (U01G18), including the state listed (species of concern) Creek Heelsplitter.

Planorbid Snails and tolerant midges were the predominant organisms in **Prairie Run** at RM 1.02 (U01W04) and community quality here was only fair. Planorbid Snails are lung breathing freshwater snails and their predominance at this site may indicate that this stream experiences low flows or has flow limitations.

Little Tymochtee Creek (lower) had fair quality macroinvertebrate assemblages at all three locations assessed (Table 16). Tolerant midges, flatworms, and snails predominated across all three locations and the numbers of EPT (7, 7, 5) and sensitive (1, 3, 3) taxa at these sites were among the lowest values of all other similarly sized streams sites in the survey (Figure 33). The number of tolerant taxa collected (24, 20, 12) far outnumbered the number of sensitive and EPT taxa, combined, across all three sampling locations (Table 16).

Middle Sandusky River tributaries

Macroinvertebrate community quality ranged from fair to exceptional across all other smaller tributaries to the Sandusky River mainstem between the Little Sandusky River and Honey Creek. Fair quality macroinvertebrate assemblages were documented in **Taylor Run** RM 1.88 (U03G04), with tolerant and facultative midges predominant. Only 39 overall taxa were collected here, with 13 of those being tolerant (Table 16).

Sycamore Creek drains just over 60 square miles at its confluence with the Sandusky River and had good to exceptional quality communities present at all three sampling locations. Mayflies were among the most predominant organisms on natural substrates (Table 16). Despite high quality macroinvertebrate assemblages being found throughout Sycamore Creek, no live for fresh dead mussels were collected from this stream (Table 17). Given the presence of various common mussel species throughout Broken Sword Creek and other area streams, prior fish kills in the system may have also eliminated the extant mussel fauna here (Ohio EPA 2000).

Honey Creek sub-basin

The five sites on **Honey Creek** had generally high macroinvertebrate community quality, ranging from good to exceptional. Mayflies were predominant at most locations sampled and there was also generally good community diversity throughout Honey Creek (Table 16). The upper two locations at RM 41.66 (U03G20) and RM 34.14 (U03G18) had EPT and sensitive taxa numbers that were near the median values of sites in the study draining similar a similar drainage area (Figure 33). Comparatively, the site at RM 25.03 (U03S03) was at the lower range for similarly sized streams, while the sites at RM 12.40 (U03S02) and RM 1.10 (500970) were at the higher range. Taken together, this suggests that macroinvertebrate community performance at RM 25.03 is slightly lower than expected compared to this rest of the watershed even though the ICI score at this site achieved WWH expectations. The numbers of EPT and

sensitive taxa in the uppermost reaches of Honey Creek were comparable to other similarly sized streams. The lower reaches of Honey Creek had exceptional quality macroinvertebrate assemblages.

Macroinvertebrate community quality in **Celery Creek** RM 0.45 (303862) was low-fair and failed to achieve MWH-C expectations (Table 16). The numbers of EPT and sensitive taxa were among the lowest values observed during the survey (Figure 33). Tolerant midges and snails predominated here, and overall community quality coincided with the silty substrates and heavily modified habitat present through this portion of the Honey Creek sub-watershed.


Wabash Pigtoe – Muskellunge Creek RM 5.40 (201332)

Aicholz Ditch at RM 3.72 had fair quality assemblages that achieved expectations for the existing MWH-C use. Macroinvertebrate community quality in the remaining Honey Creek tributary sites was marginally good to very good and all sites achieved WWH expectations.

Lower Sandusky River tributaries

Rock Creek and East Branch Rock Creek were evaluated at three locations total. **Rock Creek** at RM 0.75 (U04W06) had much higher macroinvertebrate community quality compared to the upstream site at RM 11.69 (U04G18). The site at RM 0.75 had exceptional quality assemblages, while those at RM 11.69 were only marginally good. An abundance of boulders, cobbles, and bedrock contributed to the high-quality habitat features present at RM 0.75. Upper Rock Creek and East Branch Rock Creek both supported lower quality macroinvertebrate communities. **East Branch Rock Creek** at RM 0.47 (U04G03) only had fair quality assemblages that failed to achieve WWH expectations, despite generally excellent habitat being noted (Table 12). No sensitive taxa were collected at RM 0.47 and only 7 EPT taxa were present here, both being among the lower values for similarly sized survey streams (Figure 33).

Willow Creek at RM 0.82 (U04W09) had fair macroinvertebrate assemblage quality that achieved expectations for its existing MWH-C use. There were three sensitive and five EPT taxa collected here (Table 16). Macroinvertebrate community quality in the remaining tributaries to the lower Sandusky River ranged from marginally good to exceptional and all achieved WWH expectations. A live Wabash Pigtoe mussel (pictured right), a species of concern in Ohio, was observed in **Muskellunge Creek** at RM 5.40 (201332).

Wolf Creek sub-basin

Wolf Creek and **East Branch Wolf Creek** supported high-quality macroinvertebrate communities throughout, with all site narratives ranging from good to exceptional. All seven

sites on these two streams had assemblages that achieved WWH expectations. The lowermost reaches of both Wolf Creek and East Branch Wolf Creek had exceptional quality assemblages.

Tributary streams in this sub-basin also had macroinvertebrate assemblages that mostly achieved WWH expectations. **Plum Run** at RM 0.79 (U04G09) only had fair quality macroinvertebrate communities, with midges, flatworms, and snails predominant. The numbers of EPT and sensitive taxa collected here were decidedly lower than other Wolf Creek tributaries and the proportion of tolerant to overall taxa is highest here (Table 16). The presence of some EPT and sensitive taxa, along with a high proportion of tolerant taxa and low overall organism density suggests that habitat related stressors are likely limiting macroinvertebrate communities in Plum Creek.

Muddy Creek sub-basin

All stream sites within the Muddy Creek sub-basin are in the HELP ecoregion. All four locations on **Muddy Creek** and **South Branch Muddy Creek** had ICI scores in the good range that achieved expectations for streams in this ecoregion (Table 16). The habitat conditions and macroinvertebrate communities present at these sites were typical for streams of the HELP ecoregion. **Gries Ditch** at RM 0.93 (U04Q16) also had a good ICI score, but the number of EPT and sensitive taxa were among the higher values compared to other similarly sized survey sites, regardless of ecoregion (Figure 33). Exposed limestone bedrock here, along with other larger till materials provide a diversity of clean, coarse substrates that benefit aquatic macroinvertebrates. **Fishing Creek** at RM 0.20 (300678) was affected by heavy siltation from Lake Erie backwater conditions and the low-fair quality macroinvertebrate communities present reflected this.

Table 16 – Macroinvertebrate taxa summary information.

Station	River Mile	Drainage Area (mi^2)	Taxa Count (Qual./Total)		EPT Taxa (Qual./Total)		Sensitive Taxa (Qual./Total)		Tolerant Taxa (Qual./Total)		Density (Organism/ Sq. Ft.)	Coldwater Taxa	Predominant Organisms on the Natural Substrates with Tolerance Category(ies)	ICI/Narrative Evaluation
Sandusky River (05-001-000)														
U02P08	127.90	35.0	63	71	22	22	17	19	11	11	620	0	Baetid (F-MI) & Heptageniid mayflies (F), Tanytarsini midges (F)	46
U02G01	120.70	67.2	79	94	22	25	20	25	13	13	645	0	Elmid Beetles (F), Caenis (F) & Heptageniid mayflies (F)	56
U02P30	110.43	88.9	70	88	20	20	15	16	12	15	458	0	Tanytarsini (F) & (F) midges, Scuds (MT-F), Isopods (T)	38
U02P33	98.69	109.7	72	89	22	23	22	25	11	12	544	0	Heptageniid (F-MI) & Baetid mayflies (F), Tanytarsini midges (F)	54
U02G02	93.76	233.0	90	97	26	26	35	37	11	12	899	0	*Protoptila sp.* caddisflies (MI), Heptageniid mayflies (MI), Midges (F-MI)	54
500860	78.00	298.0	88	106	26	28	28	33	19	20	1134	0	Midges (F), Heptageniid mayflies (F-MI), Hydrosychid caddisflies (F-MI)	56
U02P38	72.09	341.0	88	108	31	33	32	38	13	16	1124	0	Heptageniid mayflies (MI), Hydrosychid (F-MI) & Polycentropid caddisflies (MI)	56
U03G01	65.10	655.0	85	97	27	31	30	37	13	13	998	0	Heptageniid (F-MI), Riffle & margin Baetid mayflies (F-MI)	50
U04S29	57.30	760.0	74	-	21	-	26	-	12	-	-	0	Baetid mayflies (F-MI), Hydropsychid caddisflies (F), midges (F)	E
500830	47.75	774.0	71	-	27	-	36	-	6	-	-	0	*Petrophila sp.* moths (MI), Baetid mayflies (F-MI), Hydropsychid caddisflies (F-MI), blackflies (F)	E
500940	42.92	960.0	54	59	10	11	9	9	20	23	582	0	Midges (T-MT), Corixids (F-MT)	MG
U04S28	41.84	964.0	74	-	25	-	28	-	10	-	-	0	*Petrophila sp.* moths (MI), Baetid mayflies (F-MI), Hydropsychid caddisflies (F-MI), *Rheotanytarsus sp.* midges (MI)	E
500880	36.50	1031.0	62	-	20	-	23	-	11	-	-	0	Baetid mayflies (F-MI), Hydropsychid caddisflies (F-MI), *Elimia sp.* snails (MI)	E

Station	River Mile	Drainage Area (mi²)	Taxa Count (Qual./Total)		EPT Taxa (Qual./Total)		Sensitive Taxa (Qual./Total)		Tolerant Taxa (Qual./Total)		Density (Organism/ Sq. Ft.)	Coldwater Taxa	Predominant Organisms on the Natural Substrates with Tolerance Category(ies)	ICI/Narrative Evaluation
500910	31.15	1047.0	83	89	25	26	27	28	15	15	1980	0	Heptageniid and Ephemerid mayflies (F-MI), midges (F-MI), *Nectopsyche sp.* caddisflies (MI), *Argia sp.* damselflies (F)	54
U04Q06	23.00	1073.0	69	78	22	25	25	28	11	11	1445	0	Baetid mayflies (F-MI), *Petrophila sp.* moths (MI), Hydropsychid and *Protoptila sp.* caddisflies (F-I)	50
U04S23	18.00	1255.0	59	65	21	24	22	25	8	9	3756	0	Baetid (F-MI) & Heptageniid mayflies (F), Hydropsychid caddisflies (F-MI), Turbellaria (F)	44
Paramour Creek (05-042-000)														
U02P48	6.15	5.1	67	72	11	11	3	3	19	20	437	1	Midges (MT-F)	MG
U02P12	1.50	26.0	66	74	10	11	4	5	19	21	1194	0	Tanytarsini (F) & (T-F) midges, Isopods (T), Heptageniid mayflies (F)	36
Tributary to Paramour Creek (05-042-003)														
U02S07	3.70	1.0	47	-	6	-	6	-	11	-	Mod. -	4	Midges (F-MT), Sphaerid Clams (F), Physid Snails (T)	MG
Allen Run (05-043-000)														
U02G20	1.05	4.1	53	-	8	-	3	-	12	-	Mod. -	1	Midges (F)	F
U02G20	1.05	4.1	52	-	7	-	2	-	18	-	Mod. -	1	Midges (F), Hydrosychid caddisflies (F), Physid snails (T)	F
South Fork Loss Creek (05-041-001)														
201377	0.10	6.7	57	-	11	-	8	-	9	-	Mod. +	1	Midges (F), Hydrosychid (F) & Philopotamid caddisflies (MI)	G
Grass Run (05-039-000)														
U02G14	8.36	7.7	65	-	15	-	9	-	16	-	Mod.	0	Midges (F), Helicopsychid caddisflies (MI), Elmid Beetles (F)	G
U02G13	3.42	18.3	85	-	19	-	20	-	10	-	Mod. +	1	Tanytarsini (F) & (F) midges, Helicopsychid (MI) & *Neophylax sp.* caddisflies (MI)	E
Broken Sword Creek (05-035-000)														
U02G09	29.52	10.9	75	-	12	-	6	-	19	-	High -	0	Midges (F), Baetid mayflies (F-MI)	G

Station	River Mile	Drainage Area (mi²)	Taxa Count (Qual./Total)		EPT Taxa (Qual./Total)		Sensitive Taxa (Qual./Total)		Tolerant Taxa (Qual./Total)		Density (Organism/ Sq. Ft.)	Coldwater Taxa	Predominant Organisms on the Natural Substrates with Tolerance Category(ies)	ICI/Narrative Evaluation
U02G07	25.48	32.6	61	76	15	17	12	14	13	13	1584	1	Damselflies (F), Midges (MT-F), Asian clams (F), *Physella sp.* snails (T)	54
201366	19.70	42.0	54	69	9	9	5	9	19	19	287	0	Midges (MT-F), Baetid mayflies (F-MI), Snails (MT)	40
U02S23	12.30	70.0	79	88	23	23	21	24	12	12	899	0	Tanytarsini midges (F), Caenis (F), Heptageniid (F), & Baetid mayflies (F)	50
U02P47	0.60	94.0	64	79	23	25	24	28	10	10	579	0	Midges (F), Hydrosychid caddisflies (F-MI)	54
Red Run (05-038-000)														
201372	0.42	8.0	52	-	10	-	3	-	13	-	Mod.	0	Midges (F), Damselflies (F)	MG
Brandywine Creek (05-037-0000														
302323	0.40	11.1	43	-	5	-	4	-	14	-	Mod. -	0	Midges (F), Turbellaria (F)	F
Indian Run (05-036-000)														
U02G12	0.75	8.5	67	-	12	-	9	-	13	-	Mod.	0	Hydrosychid caddisflies (F), Midges (F)	G
Little Sandusky River (05-033-000)														
201361	10.40	6.9	31	-	3	-	0	-	19	-	Mod -	0	Midges (T-MT), Snails (MT-F)	LF
U02G16	6.52	18.0	50	-	6	-	3	-	12	-	Low +	0	Midges (MT)	F
U02W06	3.71	21.5	46	62	8	8	5	6	17	18	319	0	Midges (MT-F), Elmid Beetles (F), Damselflies (F)	34
Tributary to Little Sandusky River (05-033-003)														
U02W05	0.78	5.9	37	-	4	-	1	-	16	-	Low +	0	Midges (T)	F
Honey Run (05-034-000)														
U02G18	0.52	9.0	50	-	18	-	12	-	6	-	Mod. +	0	Midges (MT-F), *Elimia sp.* snails (MI), Hydrosychid caddisflies (F), Baetid (F-MI) mayflies	E
Rock Run (05-032-000)														
U02S20	1.40	9.4	60	-	12	-	5	-	15	-	Low +	0	Midges (F), Snails (T-MT)	G
Negro Run (05-027-000)														
U02S19	0.52	13.1	62	-	19	-	10	-	16	-	Mod. +	0	Midges (T-F), Baetids mayflies (F-MI), Hydrosychid caddisflies (F-MI)	VG

Station	River Mile	Drainage Area (mi²)	Taxa Count (Qual./Total)		EPT Taxa (Qual./Total)		Sensitive Taxa (Qual./Total)		Tolerant Taxa (Qual./Total)		Density (Organism/ Sq. Ft.)	Coldwater Taxa	Predominant Organisms on the Natural Substrates with Tolerance Category(ies)	ICI/Narrative Evaluation
Sugar Run (05-026-000)														
201354	0.60	4.6	47	-	7	-	4	-	7	-	Low	2	Elmid Beetles (F), Tanytarsini (F-MI) & (F) midges	MG
Tymochtee Creek (05-300-000)														
U01W05	51.43	6.4	50	-	6	-	2	-	22	-	Mod.	0	Midges (T-F), Turbellaria (F)	F
U01G07	49.44	16.1	41	-	7	-	1	-	16	-	Low +	0	Midges (T-F)	F
U01G05	44.95	64.5	71	80	13	14	10	11	19	20	600	0	Midges (F-MT), Damselflies (F), *Caenis sp.* mayflies (F)	34
U01G04	33.99	146.2	70	89	10	13	15	18	16	18	493	0	Midges (T-MT), Heptageniid mayflies (F)	48
U01G03	26.28	175.0	63	76	10	12	11	13	18	19	265	0	Midges (MT-F), Elmid Beetles (F), Damselflies (F)	32
U02P44	19.45	204.3	60	73	10	10	7	7	15	17	424	0	Midges (F), Elmid Beetles (F), Damselflies (F)	42
500850	7.80	231.8	78	94	17	21	19	24	20	21	417	0	Snails (F-MI), Heptageniid mayflies (F), *Petrophila sp.* moths (MI)	50
Prairie Run (05-300-007)														
U01W04	1.02	7.9	45	-	6	-	2	-	20	-	Mod.	0	Planorbid Snails (MT), Midges (T-F)	F
Enoch Ditch (05-300-006)														
U01W01	1.59	8.6	47	-	10	-	2	-	18	-	Mod.	0	Midges (F), Snails (MT)	MG
Carroll Ditch (05-300-004)														
U01G26	0.66	8.3	51	-	12	-	5	-	19	-	High -	0	Snails (T-MT), Beetles (MT-F), Midges (MT)	G
Pawpaw Run (05-319-000)														
U01G25	6.13	8.4	67	-	15	-	9	-	20	-	Mod.	0	Midges (F-T), Turbs (F), Hydropsychid caddisflies (F)	G
U01G24	0.80	16.3	58	-	13	-	7	-	16	-	Mod. -	0	Beetles (F), Midges (F), Heptageniids (F)	G
Little Tymochtee Creek (Upper) (05-316-000)														
304302	8.63	11.9	60	-	12	-	4	-	22	-	Mod. -	0	Midges (MT), Corixids (MT)	G

Station	River Mile	Drainage Area (mi^2)	Taxa Count (Qual./Total)		EPT Taxa (Qual./Total)		Sensitive Taxa (Qual./Total)		Tolerant Taxa (Qual./Total)		Density (Organism/ Sq. Ft.)	Coldwater Taxa	Predominant Organisms on the Natural Substrates with Tolerance Category(ies)	ICI/Narrative Evaluation
U01G20	4.00	35.5	74	83	12	13	7	7	21	23	Mod. +	0	Tanytarsini (F-MI) & (F) Midges, Turbellaria (F), Hydroptilid caddisflies (F)	38
Reevhorn Run (05-317-000)														
U01G23	2.26	12.5	54	-	7	-	3	-	22	-	Mod. +	0	Corixids (MT), Isopods (MT), Tanytarsini (F) & (T) midges	MG
Pawpaw Run (05-318-000)														
201432	1.10	5.6	55	-	16	-	5	-	19	-	Mod. +	0	Baetid mayflies (F-MI), Water Mites (F), Snails (MT), Midges (T-F)	VG
Warpole Creek (05-314-000)														
U01G18	1.52	18.8	67	-	11	-	9	-	18	-	Mod. -	0	Midges (T-F), Snails (T-MT)	G
St. James Run (05-315-000)														
304296	0.15	10.7	65	-	16	-	9	-	12	-	Mod.		Baetids (F-MI), Midges (F), Turbs (F)	VG
Oak Run (05-312-000)														
U01G16	0.29	15.2	57	-	11	-	3	-	22	-	Low +	0	Midges (T), Elmid Beetles (F), Water Mites (F)	G
Lick Run (05-308-000)														
U01G15	0.83	7.9	53	-	10	-	6	-	13	-	Low +	2	*Elimia sp.* snails (MI), Midges (F)	G
Little Tymochtee Creek (Lower) (05-304-000)														
U01G14	10.32	11.1	49	-	7	-	1	-	24	-	Mod. +	0	Turbellaria (F), Planorbid Snails (T), Midges (MT-T)	F
U01G13	6.33	18.2	54	-	7	-	3	-	20	-	Mod. -	0	Snails (T-MT), Midges (T-MT)	F
U02P45	1.95	31.0	49	57	5	5	3	3	12	12	549	0	Midges (MT-F)	28
Spring Run (05-301-000)														
U02P46	1.71	16.9	66	-	13	-	8	-	14	-	High -	0	Tanytarsini (F) & (T) midges, Baetid mayflies (F), Elmid Beetles (F)	G
Poverty Run (05-302-000)														
U01G10	2.99	9.3	57	-	17	-	12	-	9	-	Mod.	0	*Elimia sp.* snails (MI), Helicopsychid caddisflies (MI), Midges (F)	VG

Station	River Mile	Drainage Area (mi²)	Taxa Count (Qual./Total)		EPT Taxa (Qual./Total)		Sensitive Taxa (Qual./Total)		Tolerant Taxa (Qual./Total)		Density (Organism/ Sq. Ft.)	Coldwater Taxa	Predominant Organisms on the Natural Substrates with Tolerance Category(ies)	ICI/Narrative Evaluation
Thorn Run (05-024-000)														
U03G03	0.70	9.1	66	-	15	-	10	-	18	-	Low +	2	Snails (T-MT), Midges (T-F)	G
Taylor Run (05-023-000)														
U03G04	1.88	17.4	39	-	5	-	3	-	13	-	Low +	0	Midges (T-F)	F
Tributary to Taylor Run (05-023-001)														
304297	0.10	6.7	48	-	9	-	5	-	10	-	Low +	1	Tanytarsini (MI-F) & (F) midges, Heptageniid mayflies (F)	MG
Sycamore Creek (05-021-000)														
U03G10	18.92	18.2	58	-	12	-	6	-	11	-	Mod. +	0	Amphipods (F), Midges (MT-F)	G
U03G08	9.14	47.2	69	87	18	22	13	19	13	14	1049	0	Tanytarsini midges (F), *Caenis* (F) & Heptageniid mayflies (F), Helicopsychid caddisflies (MI)	46
U03P05	0.41	64.2	96	106	28	28	28	29	14	16	861	1	Baetid mayflies (F-MI), Tanytarsini (F-MI) & (F) midges, *Petrophila* sp. moths (MI)	48
Spring Creek (05-021-002)														
U03G13	1.88	8.8	63	-	9	-	5	-	15	-	Mod. -	0	Tanytarsini (F) & other midges (F), Baetid mayflies (F-MI)	MG
Mile Run (05-020-000)														
U03G14	0.30	6.4	74	-	21	-	20	-	17	-	Mod. -	0	Tanytarsini (F-MI) & other midges (F), Helicopsychid caddisflies (MI), Heptageniid mayflies (F-MI)	E
Honey Creek (05-200-000)														
U03G20	41.66	10.4	60	-	13	-	10	-	9	-	Mod.	0	Midges (F), Baetid mayflies (F-MI)	G
U03G18	34.14	26.5	62	77	14	16	9	12	12	14	1062	0	Midges (F), Turbellaria (F)	48
U03S03	25.03	84.4	58	65	10	10	6	6	17	18	434	0	Damselflies (F), Heptageniid mayflies (F), Midges (F)	44
U03S02	12.40	149.3	84	97	27	29	25	27	16	16	270	1	Heptageniid (F-MI) & Baetid mayflies (F), *Neophylax* caddisflies (MI)	48
500970	1.10	179.3	65	84	24	27	20	25	11	12	603	0	Midges (F), Water mites (F), *Tricorythodes sp.* (MI) & Baetid mayflies (F-MI)	58

Station	River Mile	Drainage Area (mi²)	Taxa Count (Qual./Total)		EPT Taxa (Qual./Total)		Sensitive Taxa (Qual./Total)		Tolerant Taxa (Qual./Total)		Density (Organism/ Sq. Ft.)	Coldwater Taxa	Predominant Organisms on the Natural Substrates with Tolerance Category(ies)	ICI/Narrative Evaluation
Celery Creek (05-200-003)														
303862	0.45	13.4	50	-	4	-	1	-	27	-	High -	0	Midges (T-MT), Snails (T-MT)	LF
Brokenknife Creek (05-209-000)														
201405	1.05	18.6	67	-	17	-	7	-	17	-	Mod.	0	Midges (T-F), Caenidae (F) & Baetid mayflies (F), Water mites (F)	VG
Aicholz Ditch (05-203-000)														
U03G25	3.72	9.4	45	-	5	-	1	-	20	-	Mod. -	0	Midges (T-MT), Amphipods (F)	F
U03G24	2.46	15.0	58	-	7	-	5	-	20	-	Mod. -	0	Tanytarsini (F) & other midges (F), Amphipods (F), Heptageniid mayflies (F)	MG
Silver Creek (05-202-000)														
U03G22	4.08	16.3	57	-	12	-	3	-	13	-	Mod.	0	Tanytarsini (MI) & other midges (T-F), Baetid mayflies (F-MI), Hydropsychid caddisflies (F), Turbellaria (F)	G
Rock Creek (05-014-000)														
U04G18	11.69	14.7	57	-	11	-	3	-	23	-	Mod.	0	Sphaeriid Clams (F), Amphipods (F), Midges (MT-F)	MG
U04W06	0.75	34.5	74	86	16	17	14	17	14	14	Mod. -	0	Baetid mayflies (F), Hydropsychid caddisflies (F-MI), Midges (F)	54
East Branch Rock Creek (05-015-000)														
U04G03	0.47	6.4	42	-	7	-	0	-	13	-	Mod. -	1	Tanytarsini (F) & other midges (F), Crayfish (F), Heptageniid mayflies (F)	F
Willow Creek (05-013-000)														
U04W09	0.82	5.6	50	-	5	-	3	-	14	-	Low +	2	Midges (T-F), Turbellaria (F)	F
Morrison Creek (05-012-000)														
U04G06	9.34	9.3	54	-	11	-	8	-	16	-	Low +	1	Midges (T-F), Helicopsychid caddisflies (MI), Heptageniid mayflies (F)	G
U04G05	2.36	16.4	51	-	16	-	11	-	11	-	Low +	0	Tanytarsini (F) & other midges (F), Heptageniid mayflies (F)	G

Station	River Mile	Drainage Area (mi^2)	Taxa Count (Qual./Total)		EPT Taxa (Qual./Total)		Sensitive Taxa (Qual./Total)		Tolerant Taxa (Qual./Total)		Density (Organism/ Sq. Ft.)	Coldwater Taxa	Predominant Organisms on the Natural Substrates with Tolerance Category(ies)	ICI/Narrative Evaluation
Spicer Creek (05-011-000)														
U04Q11	0.65	12.5	74	-	18	-	17	-	9	-	Mod.	2	Midges (F), Helicopsyche (F), *Neophylax* (MI), & Hydropsychid caddisflies (F-MI)	E
Sugar Creek (05-010-000)														
U04Q10	3.20	8.6	71	88	18	18	18	22	11	13	111	2	Heptageniid mayflies (F), Helicopsychid caddisflies (MI), Midges (F), *Elimia sp.* snails (MI)	50
Wolf Creek (05-005-000)														
201336	13.45	28.1	75	88	18	18	9	10	21	21	333	0	*Caenis sp.* mayflies (F), Midges (F-MI)	44
U04S40	5.60	66.5	72	82	21	22	17	20	14	15	802	0	*Elimia sp.* (snails) (MI), Midges (F-MI), Baetid mayflies (MI)	50
U04G07	1.58	71.7	70	84	22	23	18	18	13	14	410	0	*Elimia sp.* snails (MI), Baetid mayflies (F-MI), *Petrophila sp.* moths (MI)	52
Harrison Creek (05-005-004)														
U04G11	0.38	9.1	59	-	11	-	3	-	18	-	Mod.	0	Midges (F), Baetid mayflies (F)	G
Plum Run (05-005-003)														
U04G09	0.79	9.8	50	-	7	-	3	-	17	-	Low +	0	Midges (T-F), Turbellaria (F), Snails (T-MT)	F
Tributary to Wolf Creek (05-005-002)														
304298	0.17	6.70	64	-	17	-	10	-	23	-	Mod. +	0	Caenidae (F) & Baetid mayflies (MI), Helicopsychid caddisflies (MI)	VG
East Branch Wolf Creek (05-006-000)														
300673	19.13	20.3	69	-	12	-	7	-	21	-	Low +	0	Midges (F-MI), Water mites (F)	G
U04G15	13.63	33.2	74	80	15	15	15	15	9	9	210	0	Midges (F-MI), *Neophylax sp.* caddisflies (MI)	42
201338	9.00	67.8	79	89	18	20	17	19	15	15	338	0	Midges (MI), Damselflies (F), Elmid Beetles (F)	52
U04P03	0.86	82.0	82	-	22	-	19	-	22	-	Mod +	0	*Elimia sp.* snails (MI), Midges (F), Neophylax caddisflies (MI)	E
Eicher Ditch (05-006-004)														
304299	0.01	9.3	57	-	8	-	4	-	17	-	Low +	0	Midges (T-F)	MG

Station	River Mile	Drainage Area (mi²)	Taxa Count (Qual./Total)		EPT Taxa (Qual./Total)		Sensitive Taxa (Qual./Total)		Tolerant Taxa (Qual./Total)		Density (Organism/ Sq. Ft.)	Coldwater Taxa	Predominant Organisms on the Natural Substrates with Tolerance Category(ies)	ICI/Narrative Evaluation
East Branch of East Branch of Wolf Creek (05-008-000)														
U04G13	3.52	7.2	48	-	10	-	4	-	12	-	Low +	0	Midges (F), Heptageniid mayflies (F)	MG
300682	1.48	19.7	56	68	14	16	11	12	9	9	361	0	*Neophylax* caddisflies (MI), Midges (F-MI), *Petrophila sp.* moths (MI)	52
Middle Branch of East Branch Wolf Creek (05-009-000)														
U04G14	0.46	10.8	65	-	13	-	10	-	13	-	Low +	0	Midges (F-MI), Elmid Beetles (F)	G
Indian Creek (05-004-000)														
500950	0.62	11.2	58	-	16	-	10	-	9	-	Low +	0	Tanytarsini (MI) & (F) midges, Damselflies (F), Hydropsychid caddisflies (F)	VG
Muskellunge Creek (05-003-000)														
300674	16.70	17.7	61	-	12	-	6	-	16	-	Mod.	0	Isopods (MT), Hydroptilid caddisflies (F), Midges (F)	G
201332	5.40	35.7	71	87	21	21	15	18	12	12	159	0	*Elimia sp.* snails (MI), *Petrophila sp.* moths (MI), *Neophylax* caddisflies (MI), Heptageniid mayflies (F)	48
Bark Creek (05-002-000)														
300671	3.20	10.0	56	-	8	-	3	-	24	-	Mod. +	0	Corixids (MT), Midges (MT-F), Snails (T-MT)	MG
Muddy Creek (05-219-000)														
201410	21.90	43.5	64	80	18	18	18	20	6	6	317	0	*Elimia sp.* snails (MI), Baetid mayflies (F-MI)	42
U04S01	9.79	72.8	48	61	10	10	6	7	9	12	183	0	Midges (MT-F), *Elimia sp.* snails (MI), Elmid Beetles (F)	38
South Branch Muddy Creek (05-222-000)														
U04S08	5.67	4.6	56	64	14	15	5	6	20	23	613	0	Turbellaria (F), Beetles (MT-F)	36
300679	1.54	21.9	62	74	13	14	6	8	24	25	595	0	Snails (T-MT), Damselflies (F), Beetles (MT-F), Midges (F)	42
Gries Ditch (05-223-000)														
U04Q16	0.93	12.5	68	79	18	18	13	14	19	19	315	0	Heptageniid mayflies (F), Viviparid snails (F), Turbellaria (F)	42

Station	River Mile	Drainage Area (mi^2)	Taxa Count (Qual./Total)		EPT Taxa (Qual./Total)		Sensitive Taxa (Qual./Total)		Tolerant Taxa (Qual./Total)		Density (Organism/ Sq. Ft.)	Coldwater Taxa	Predominant Organisms on the Natural Substrates with Tolerance Category(ies)	ICI/Narrative Evaluation
Little Muddy Creek (05-220-000)														
300677	7.55	12.4	46	-	9	-	4	-	13	-	High	0	Baetid mayflies (MI), Blackfly Larvae (F), Isopods (MT)	MG
Fishing Creek (05-220-001)														
300678	0.20	7.0	31	-	4	-	0	-	19	-	Low	0	Corixids (MT), Midges (MT)	LF

Table 17 – Mussel observations from the 2022 survey. Results for fresh-dead (FD) and live (L) are presented separately.

Station	River Mile	Site Name	Mussels
Sandusky River Mainstem (05-001-000)			
U02G02	93.76	SANDUSKY R. DST. BROKEN SWORD CREEK @ CO. RD. 128	FD: Three Ridge, Plain Pocketbook, Purple Wartyback, Wabash Pigtoe, Fat Mucket, Mapleleaf, Spike, Fluted Shell. L: Purple Wartyback, Elktoe, Maple Leaf, Fat Mucket, Fluted Shell, Plain Pocketbook, Wabash Pigtoe
500860	78.08	SANDUSKY R. DST. UPPER SANDUSKY @ TWP. RD. 121	FD: Fluted Shell
U02P38	72.08	SANDUSKY R. DST UPPER SANDUSKY @ TWP. RD. 40	FD: Plain Pocketbook, Mapleleaf, Purple Wartyback L: Plain Pocketbook
500910	31.15	SANDUSKY R. DST TIFFIN @ ABBOTTS BRIDGE	FD: Mapleleaf L: Maple Leaf, Wabash Pigtoe, Mucket
U04S23	17.70	SANDUSKY R. AT FREMONT @ TIFFIN RD.	FD: Mapleleaf
Grass Run (05-039-000)			
U02G13	3.42	GRASS RUN @ CRAWFORD/WYANDOT COUNTY LINE RD.	FD: Creeper
Broken Sword Creek (05-035-000)			
U02G07	25.48	BROKEN SWORD CREEK @ SCHWEMLEY RD.	FD: Three Ridge, Fat Mucket, Wabash Pigtoe, Cylindrical Papershell
U02S23	12.30	BROKEN SWORD CREEK AT OCEOLA DST. U.S. RT. 30N	FD: Slippershell, Paper Pondshell, Fat Mucket L: Fat Mucket
U02P47	0.60	BROKEN SWORD CREEK NEAR NEVADA @ CO. RD. 62	FD: Fat Mucket, Plain Pocketbook
Indian Run (05-036-000)			
U02G12	0.75	INDIAN RUN NW OF NEVADA @ TWP. RD. 137A	FD: Cylindrical Papershell
Little Sandusky River (05-033-000)			
U02G16	6.52	L. SANDUSKY R. @ WYANDOT/MARION COUNTY LINE RD.	FD: Giant Floater, Cylindrical Papershell L: Giant Floater & Fat Mucket
U02W06	3.71	L. SANDUSKY R. NW OF MORRAL @ TWP. RD. 125	L: Three Ridge, Giant Floater, Fat Mucket
Tributary to Little Sandusky River (05-033-003)			
U02W05	0.78	TRIB. TO L. SANDUSKY R. (8.93) SW OF MORRAL @ FORD	FD: Giant Floater
Tymochtee Creek (05-300-000)			
U01G07	49.44	TYMOCHTEE CREEK AT MEEKER @ MASON RD. (CO. RD. 213A)	FD: Cylindrical Papershell
U01G05	44.95	TYMOCHTEE CREEK @ DRY LANE RD. N.	FD: Cylindrical Papershell, Three Ridge, Giant Floater L: Fat Mucket, Three Ridge, Wabash Pigtoe
U01G04	33.99	TYMOCHTEE CREEK N OF MARSEILLES @ TWP. RD. 97	FD: Fat Mucket, Spike, Giant Floater, Mapleleaf, Wabash Pigtoe, Round Pigtoe, Kidneyshell L: Fluted Shell, Wabash Pigtoe
U01G03	26.28	TYMOCHTEE CREEK W OF UPPER SANDUSKY @ ST. RT. 53	FD: Spike, Fat Mucket, Mapleleaf
U02P44	19.45	TYMOCHTEE CREEK NEAR UPPER SANDUSKY @ TWP. RD. 49	FD: Fat Mucket, Giant Floater L: Giant Floater
500850	7.80	TYMOCHTEE CREEK AT CRAWFORD @ ST. RT. 199	FD: Plain Pocketbook, Fat Mucket, Giant Floater L: Fat Mucket, Giant Floater
Enoch Creek (05-300-006)			
U01W01	1.59	ENOCH CREEK @ DECLIFF RD, SOUTHERN MOST CROSSING	FD: Giant Floater
Carroll Ditch (05-300-004)			
U01G26	0.66	CARROLL DITCH NNW OF MEEKER @ OSBUN RD.	L: Three Ridge

Station	River Mile	Site Name	Mussels
Little Tymochtee Creek (Upper) (05-316-000)			
U01G20	4.00	L. TYMOCHTEE CREEK (UPPER) NW OF MARSEILLES @ CO. RD. 93	FD: Cylindrical Papershell
Warpole Creek (05-314-000)			
U01G18	1.52	WARPOLE CREEK @ TWP. RD. 58	FD: Creek Heelsplitter, Lilliput, Creeper
Little Tymochtee Creek (Lower) (05-304-000)			
U01G13	6.33	L. TYMOCHTEE CREEK (LOWER) SE OF CAREY @ CO. RD. 44	FD: Giant Floater
U02P45	1.95	L. TYMOCHTEE CREEK (LOWER) NEAR CAREY @ CO. RD. 29	FD: Cylindrical Papershell L: Fat Mucket
Tributary to Taylor Run (2.49) (05-023-001)			
304297	0.10	TRIB. TO TAYLOR RUN (2.49) NEAR MOUTH @ CO. RD. 37	FD: Cylindrical Papershell
Honey Creek (05-200-000)			
U03G18	34.14	HONEY CREEK @ BIGHAM RD.	FD: Fat Mucket, Wabash Pigtoe
U03S03	25.03	HONEY CREEK W OF ATTICA @ TWP. RD. 79	FD: Giant Floater L: Giant Floater
Brokenknife Creek (05-209-000)			
201405	1.05	BROKENKNIFE CREEK @ HURON/SENECA COUNTY LINE RD.	FD: Giant Floater
Aicholz Ditch (05-203-000)			
U03G24	2.46	AICHOLZ DITCH E OF BLOOMVILLE @ COOPER RD. (TWP. RD. 77)	L: Giant Floater
Morrison Creek (05-012-000)			
U04G06	9.34	MORRISON CREEK NW OF REPUBLIC @ TWP. RD. 175	FD: Giant Floater
Sugar Creek (05-010-000)			
U04Q10	3.20	SUGAR CREEK NEAR TIFFIN @ TWP. RD. 76	FD: Cylindrical Papershell, Fat Mucket
Wolf Creek (05-005-000)			
201336	13.45	WOLF CREEK 0.2 MI. UPST. CO. RD. 592	FD: Creeper L: Paper Pondshell, Fat Mucket
Harrison Creek (05-005-004)			
U04G11	0.38	HARRISON CREEK E OF FOSTORIA @ CO. RD. 592	FD: Cylindrical Papershell
East Branch Wolf Creek (05-006-000)			
300673	19.13	E. BR. WOLF CREEK @ MEADOWBROOK PARK	FD: Cylindrical Papershell
U04G15	13.63	E. BR. WOLF CREEK @ TWP. RD. 132	FD: Fat Mucket
U04P03	0.86	E. BR. WOLF CREEK NEAR BETTSVILLE @ GILMORE RD.	FD: Mucket L: Giant Floater
Indian Creek (05-004-000)			
500950	0.62	INDIAN CREEK S OF FREMONT @ HURDICK RD.	FD: Cylindrical Papershell
Muskellunge Creek (05-003-000)			
300674	16.70	MUSKELLUNGE CREEK @ ST. RT. 635	FD: Cylindrical Papershell
201332	5.40	MUSKELLUNGE CREEK NEAR FREMONT @ SPIELDENNER RD.	FD: Fat Mucket L: Wabash Pigtoe
Bark Creek (05-002-000)			
300671	3.20	BARK CREEK @ KELLEY RD. (CR 245)	FD & L: White Heelsplitter
Muddy Creek (05-219-000)			
U04S01	9.79	MUDDY CREEK DST. LINDSEY @ CO. RD. 153	FD: Cylindrical Papershell

Macroinvertebrate Community Trends

This survey represented one of many efforts in this watershed since the early 1980s, with the last major survey occurring through the upper watershed in 2001 and the lower watershed in 2009. These will be the primary periods of comparison. There was also another comprehensive effort on the Sandusky River mainstem in 1991, along with other sporadic efforts throughout the basin over the decades. The results for the Sandusky River mainstem and its tributaries are discussed below.

Sandusky River mainstem

Figure 34 displays ICI scores from all major survey efforts on the Sandusky River mainstem – including 2022, 2009, 2001, and 1991. There has been general improvement throughout the mainstem since 1991, most notably around the municipal point sources discharges. The Sandusky River downstream from the Bucyrus WWTP failed to achieve WWH expectations in both 1991 and 2001 but was notably improved in 2022. There were also substantial improvements downstream from the Upper Sandusky WWTP compared to both the 1991 and 2001 surveys. Macroinvertebrate community quality downstream from the former Ballville Dam pool has also improved since its removal, while the remaining sites in the lower mainstem had similar ICI scores as the 2009 survey.

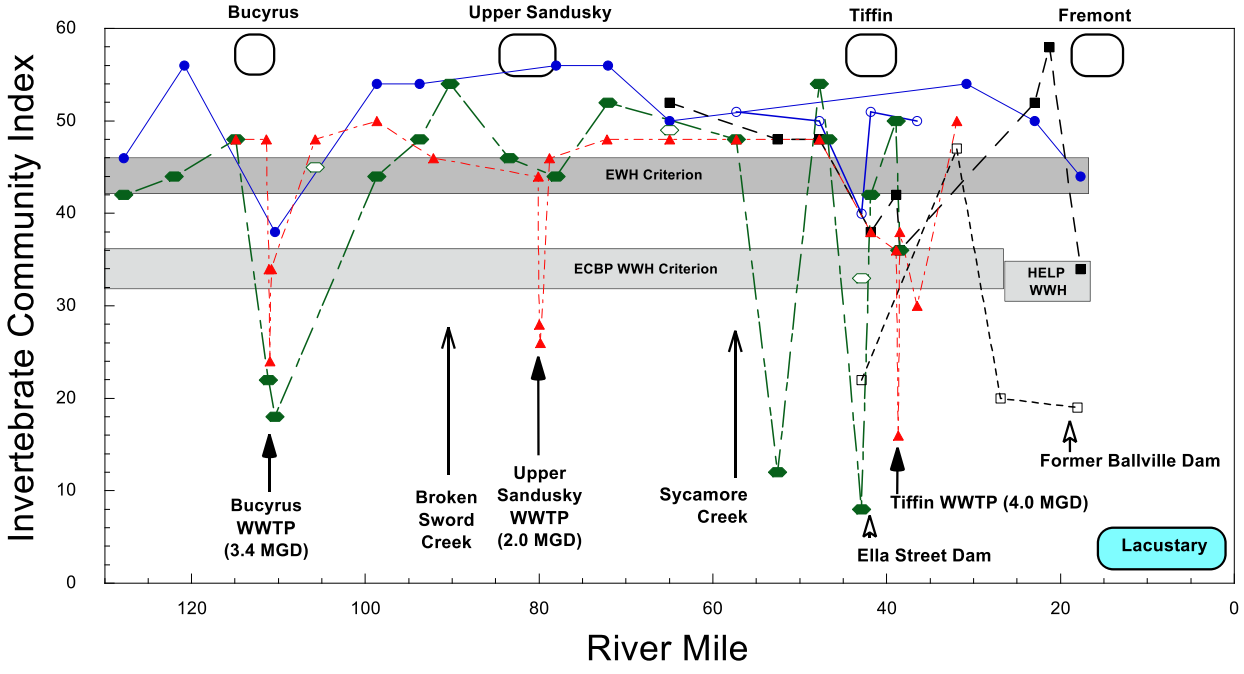


Figure 34 – Longitudinal display of ICI scores from the Sandusky River mainstem from 2022 (blue), 2009 (black), and 2001 (green), and 1991 (red). Predicted ICI scores based on qualitative sampling are used for display when an ICI score isn't available; these are indicated by the open-faced symbols.

Tributaries

Overall, macroinvertebrate community performance was generally higher in 2022 compared to prior basin-wide survey efforts. Figure 35 displays the aggregated number of EPT and sensitive taxa comparing previous basin-wide efforts to 2022 results at paired sampling locations. There were notable increases in the numbers of both EPT and sensitive taxa from 2009 to 2022 at paired locations, with the trend more pronounced in the number of EPT taxa compared to sensitive taxa. The numbers of EPT and sensitive taxa also increased from 2001 to 2022, with both categories increasing in a similar stepwise fashion.

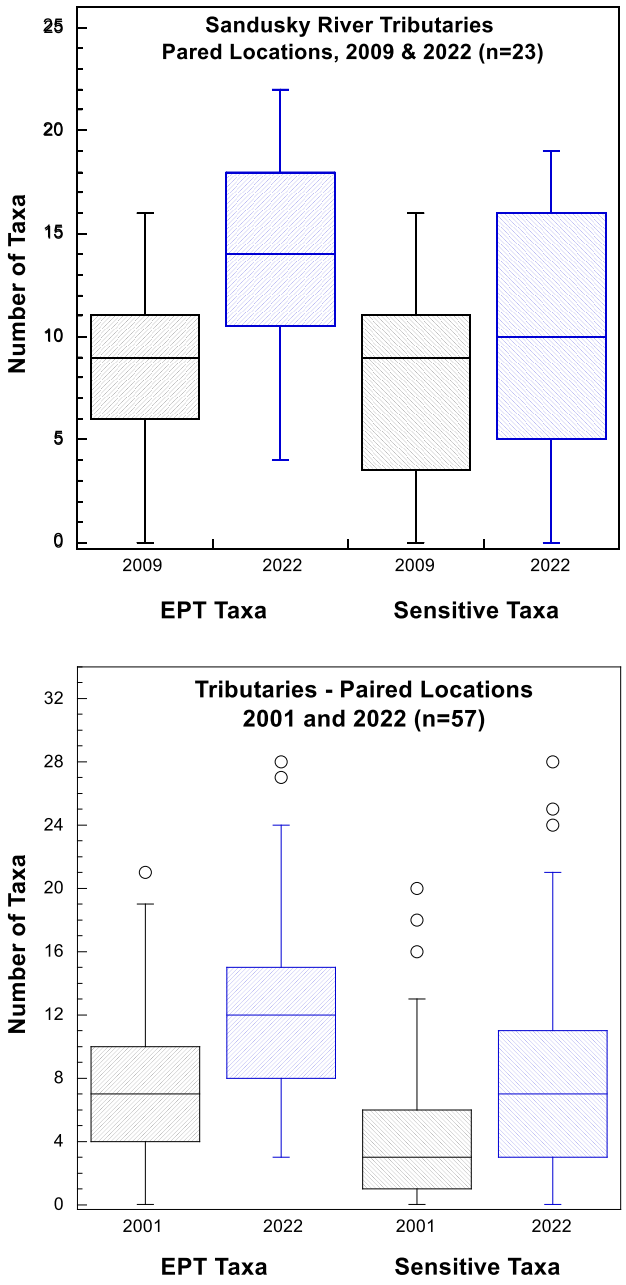


Figure 35 – Box plots displaying the numbers of EPT and sensitive taxa from paired locations in 2022, 2009, and 2001.

Upper Sandusky River Tributaries

Macroinvertebrate community quality throughout most upper tributary sites has improved over time. **Paramour Creek** had similar macroinvertebrate community quality at RM 1.50 (U02P12) compared to 2001 but has greatly improved since 1985, when poor quality communities were documented here. Communities at RM 6.15 (U02P48) have also improved from fair to marginally good since 2001. Similarly, community quality in the **tributary to Paramour Creek (5.13)** has improved from fair to marginally good. **Grass Run** also saw notable improvements from 2001 and 2022, with communities improving from poor and good quality to good and exceptional quality at the two locations assessed during both surveys. Conditions were stable in **South Fork Loss Creek** and good community quality was documented at the one location surveyed in 2001 and 2022.

Macroinvertebrate community quality in **Allen Run** at RM 1.05 (U02G20) has declined over time compared to the earliest samples collected in this stream. Marginally good assemblages that achieved WWH expectations were documented here during the 2001 survey. However, miscellaneous sampling efforts in 2012 and 2016 yielded very poor- and poor-quality macroinvertebrate assemblages, respectively. The most recent survey documented some limited recovery, with macroinvertebrate assemblage quality in the fair range during sampling in both 2022 and 2023 (Table 16). Pollution events documented during the most recent survey just upstream from this site have likely precluded more substantial improvements in Allen Run.

Broken Sword Creek sub-watershed

In addition to the comprehensive efforts in 2001 and 2022, there were smaller efforts through the 2010s focused primarily on the upper reaches of **Broken Sword Creek**. Macroinvertebrate community quality throughout Broken Sword Creek was improved or stable since 2001 at all locations assessed (Figure 36). The upper reaches saw community quality seemingly decline from 2001 to 2013, with consistent signatures across multiple sites. Later sampling in 2017 and 2018 saw scores gradually increase to a range more like those observed in 2022.

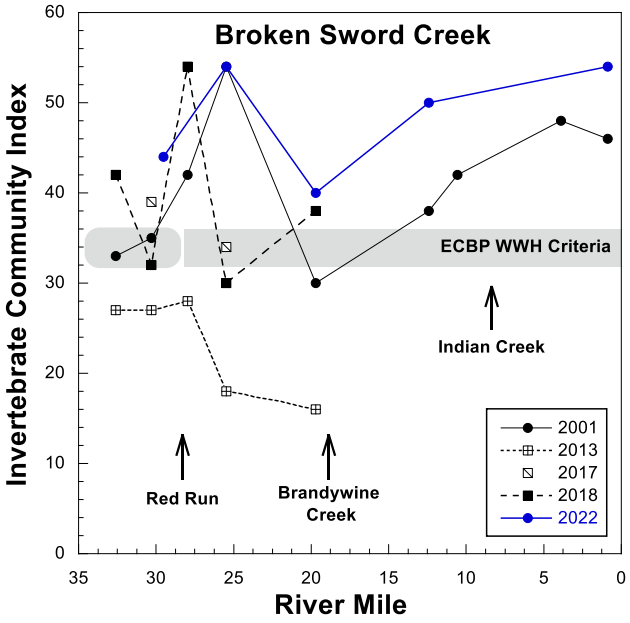


Figure 36 – Longitudinal display of ICI scores from Broken Sword Creek from the indicated years. Predicted ICI scores based on qualitative collections are displayed for the headwaters reaches of Broken Sword Creek where quantitative sampling was not conducted.

Red Run at RM 0.42 (201372) saw macroinvertebrate assemblage quality increase from fair quality in each 2001, 2013, and 2017 to marginally good in 2022. Total taxa, EPT taxa, and sensitive taxa were all higher than what has been observed here historically. **Brandywine Creek** had macroinvertebrate communities improve from poor in 2013 to fair quality in 2022, while community quality in **Indian Run** also improved from marginally good in 2001 to good in 2022.

Little Sandusky River sub-watershed

There was nearly no improvement in macroinvertebrate community quality through the **Little Sandusky River** since the last sampling effort in 2001 and community quality has remained among the worst of all tributary systems in the watershed. The site at RM 10.40 (201361) saw assemblage quality improve incrementally from poor in 2001 to low-fair in 2022, while the remaining two locations at RM 6.52 (U02G16) and RM 3.70 (U02W06) saw minimal change over the same time. Macroinvertebrate assemblage quality in the **tributary to Little Sandusky River (8.93)** improved from the very poor-poor range in 1995 and 2000, to fair in 2022. **Honey Run** was the lone stream in this sub-watershed that has always had comparatively higher scores compared to the rest of the Little Sandusky sub-watershed. Macroinvertebrate community quality at RM 0.50 (U02G18) improved from good in 2001 to exceptional in 2022.

Tymochtee Creek sub-watershed

Macroinvertebrate community quality in **Tymochtee Creek** has generally improved since the earliest samples were collected in 1995 (Figure 37). The reference reach in the lowermost portion of Tymochtee Creek has always supported high-quality macroinvertebrate communities, with most ICI scores here corresponding to exceptional scores. A good ICI score was noted here in 1999. Macroinvertebrate trends from the middle reaches of Tymochtee Creek were more mixed. The two locations at RM 19.60 (U02P44) and RM 33.99 (U01G04) had higher ICIs than in 2001, with scores improving from good and fair to very good and exceptional quality at each site. The site at RM 26.20

(U01G03) had an ICI score of 32 in 2022, a notable decrease compared to a score of 44 observed here in 2001. There were fewer mayfly and caddisfly taxa found here in 2022 compared to 2001, though the total number of EPT taxa was similar. The proportion of mayflies and caddisflies on the artificial substrates was lower in 2022 and the proportion of dipteran & non-insects was also higher here. The site at RM 44.95 (U01G05) was sampled slightly upstream from the reach evaluated in 2001 at RM 43.00. The ICI score recorded in 2022 (34) was lower than that observed in 2001 (44). Like RM 26.20, there were fewer numbers of mayfly taxa collected in 2022, and the proportion of dipteran/non-insects was also higher. However, the total number of EPT taxa and the number of caddisfly taxa collected here were higher than in 2001. Macroinvertebrate community quality in Tymochtee Creek at RM 49.44 (U01G07) improved from very poor to fair and the numbers of EPT taxa collected here were much higher than in 2001 (Figure 37).

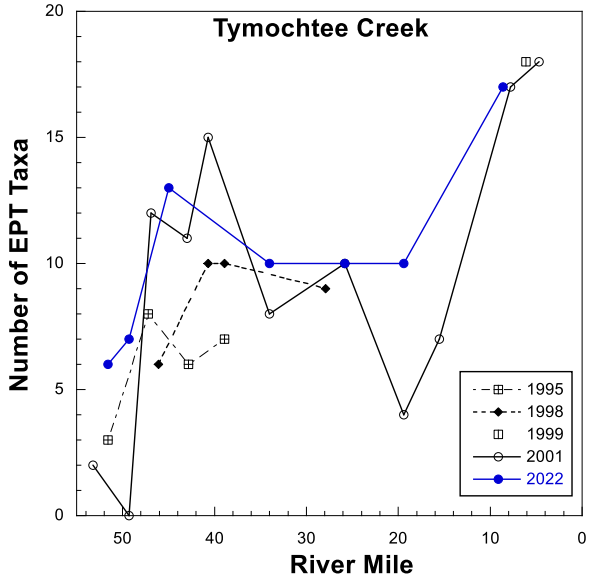


Figure 37 – Longitudinal display of the total number of EPT taxa collected from all qualitative sampling locations in Tymochtee Creek.

Prairie Creek, Enoch Creek, and **Carroll Ditch** all convene to form the uppermost lobe of the Tymochtee Creek watershed. All three streams were evaluated at one site in both 2001 and 2022. Macroinvertebrate assemblage quality in Enoch Creek and Carroll Ditch improved from fair in 2001 to marginally good and good, respectively. Assemblages in Prairie Creek declined from marginally good to fair over this same time-period. **Pawpaw Run and Little Tymochtee Creek (upper)** join the system a short distance downstream, forming the western lobe of Tymochtee Creek before the stream turns northward and cuts through the Fort Wayne end moraine (Figure 6). Macroinvertebrate community quality at the four locations in these tributaries was good, an improvement since 2001 when fair or marginally good assemblages were documented in these streams.

The sites on **Warpole Creek** RM 1.52 (U01G18), **Lick Run** RM 0.83 (U01G15), and **Poverty Run** RM 2.99 (U01G10) all had macroinvertebrate communities improve from marginally good quality in 2001 to good or very good. **Spring Creek** at RM 1.71 (U02P46) saw community quality improve from poor to good over this same period. In 2001, lower Spring Creek was impacted by poorly treated wastewater and stormwater runoff from the town of Carey (Ohio EPA 2003).

Little Tymochtee Creek (lower) is the largest and most downstream tributary stream to Tymochtee Creek before this sub-watershed joins the Sandusky River. Macroinvertebrate community performance in Little Tymochtee Creek (lower) have had mixed over time. Community quality improved at the most upstream site at RM 10.32 (U01G14) from poor in 2001 to fair in 2022. However, macroinvertebrate community quality at RM 6.33 (U01G13) remained fair over the same period, while most downstream locations at RM 1.95 (U02P45) declined from good in 2001 to fair (ICI=28) in 2022. Qualitative sampling at RM 1.95 yielded five fewer EPT in 2022 (5) than in 2001 (10).

Middle Sandusky River tributaries

Macroinvertebrate community quality was improved or stable in most smaller tributaries through the middle portion of the watershed. **Rock Run, Negro Run**, and **Sugar Run** all join the Sandusky River near Upper Sandusky, OH and all were sampled in 2001 and 2022. Macroinvertebrate community quality improved in Rock Run (marginally good to good) and Negro Run (good to very good), while Sugar Run saw quality decline from good to marginally good.

Thorn Run and **Taylor Run** both join the Sandusky River further downstream near the confluence with Tymochtee Creek. Both streams retain many of the common physiographic features as Tymochtee Creek. Macroinvertebrate assemblage quality improved from fair to good at the one location in Thorn Run sampled in both 2001 and 2022. Community quality declined from marginally good to fair at Taylor Run RM 1.88 (U03G04), while communities in the **tributary to Taylor Run (2.49)** remained marginally good over the same period.

Macroinvertebrate assemblages in **Sycamore Creek** were similar or improved between 2001 and 2022. Good to very good communities were observed at the three locations assessed during both periods. The site at RM 9.14 (U03G08) saw community quality improve from good to exceptional, while communities in the upper and lowermost locations evaluated remained good and exceptional quality, respectively.

Mile Run joins the Sandusky downstream from Sycamore Creek and macroinvertebrate assemblage quality at RM 0.30 (U03G14) improved from good to exceptional quality from 2001 to 2022. The number of EPT and sensitive taxa both doubled over this period from 12 of each to 21 and 20, respectively.

Honey Creek sub-watershed

Honey Creek is the last major tributary system before the Sandusky watershed transitions from the ECBP to the HELP ecoregion. The uppermost reaches of this watershed, including most of Celery Creek, drain a large former swamp and streams in this area are heavily modified to facilitate drainage.

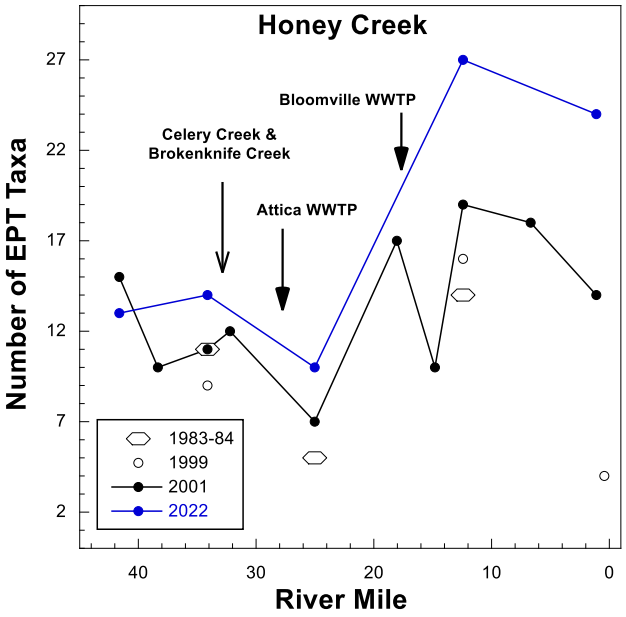


Figure 38 – Longitudinal display of the total number of EPT taxa collected from all qualitative sampling locations in Honey Creek.

Macroinvertebrate community quality was higher throughout much of middle and lower Honey Creek, while its uppermost reaches remained stable. There were more EPT taxa collected in 2022 across all but one location in Honey Creek over the period of record (Figure 38). The four lowermost locations had exceptional or very good community quality in 2022, an improvement over the mostly good quality communities documented in 2001. The site at RM 25.03 (U03S03) saw its ICI score increase from fair (ICI=30) to very good (ICI=44), with improvements most likely related to better wastewater treatment and non-point source control measures in the agricultural areas through this portion of the watershed. In 2001, poorly treated wastewater from the

Attica and Bloomville WWTPs also had negative impacts on macroinvertebrate communities that were not observed during the 2022 survey (Ohio EPA 2003).

Celery Creek drains a large wetland complex that was formerly a portion of pro-glacial Lake Erie. As such, most of its catchment has been heavily modified for drainage and is unlike the other three tributaries to Honey Creek. The one location assessed here in 2022 at RM 0.45 (303862) was located within a heavily modified portion of lower Celery Creek. Macroinvertebrate community performance was low-fair and has remained unchanged since this reach was last sampled in 2017.

The remaining three tributaries to Honey Creek evaluated during the survey were **Brokenknife Creek, Aicholz Ditch,** and **Silver Creek**. There was general improvement in Brokenknife Creek RM 1.05 (201405) and Silver Creek RM 4.08 (U03G22) between 2001 and 2022, with assemblage quality improving from good to very good and marginally good to good in each stream, respectively. Upper Aicholz Ditch at RM 3.72 (U03G25) saw assemblage quality improve from poor to fair, while the site at RM 2.46 (U03G24) declined from good to marginally good.

Lower Sandusky River tributaries

Macroinvertebrate community quality was mostly improved or stable in streams draining this portion of the watershed.

Macroinvertebrate community quality in **Rock Creek** near the mouth at RM 0.75 (U04W06) has remained exceptional since last sampled in 1992. Macroinvertebrate communities in lower **East Branch Rock Creek** have also remained relatively stable, with fair quality communities documented in both 2001 and 2022. Macroinvertebrate community quality was good at both locations assessed in **Morrison Creek**, an improvement over the poor and marginally good condition documented in 2001 (Ohio EPA 2003).

The remaining tributaries in this portion of the watershed were evaluated during a large survey in 2009 of the lower Sandusky River (Ohio EPA 2011). Macroinvertebrate community quality in **Spicer Creek** has remained exceptional over this period, while those in **Sugar Creek** at RM 3.11 (U04Q10) improved from good to exceptional. **Indian Creek**, **Muskellunge Creek**, and **Bark Creek** all join the mainstem in the portions influenced by the Sandusky Bay. Macroinvertebrate community quality improved from marginally good to very good in Indian Creek at RM 0.62 (500950). Similarly, macroinvertebrate community quality in Bark Creek at RM 3.20 (300671) improved from fair to marginally good. Muskellunge Creek is somewhat larger and was evaluated at two locations in 2022, RM 16.70 (300674) and RM 5.40 (201332). Macroinvertebrate community quality remained good at the upper location during both 2009 and 2022 sampling, while communities improved from good to exceptional at RM 5.40.

Wolf Creek sub-watershed

The Wolf Creek sub-watershed is the largest remaining tributary to the Sandusky River, joining just before the lake-influenced portion of the river begins. Like most other streams in the other lower Sandusky watershed, many steams in this sub-watershed had stable or improving macroinvertebrate community performance since last sampled in 2009. **Wolf Creek** and **East Branch Wolf Creek** each drain similar sized areas and join together for only about a short distance before emptying into the lower Sandusky River mainstem (Figure 4). Macroinvertebrate community performance at five

comparable sites in these streams ranged from marginally good to exceptional in 2009, with most scores having good quality communities (Ohio EPA 2011). In 2022, macroinvertebrate community quality improved to very good or exceptional quality at all sites.

Two tributaries to Wolf Creek displayed mixed trend results since the 2009 survey. **Harrison Creek** at RM 0.38 (RM U04G11) saw macroinvertebrate quality improve from poor to good since 2009, while those in **Plum Creek** RM 0.38 (U04G09) remained fair over the same period. The **tributary to Wolf Creek (8.10)** has not been formerly sampled but results from 2022 indicated that very good quality macroinvertebrate communities were present at RM 0.17 (304298).

Two tributaries to East Branch Wolf Creek also had historical data from 2009, including **East Branch of East Branch Wolf Creek** and **Middle Branch of East Branch of East Branch Wolf Creek**. Community quality in the upper East Branch of East Branch Wolf Creek RM 3.52 (U04G13) has remained marginally good since 2009, while the site at RM 1.48 (300682) saw performance improve from good to exceptional. The one sampling site in Middle Branch (RM 0.46, U04G14) had good community quality in both 2009 and 2022.

Muddy Creek sub-watershed

Streams in the Muddy Creek sub-watershed saw general improvement in overall macroinvertebrate community quality. **Muddy Creek** RM 21.95 (201410) had an ICI score that improved from 26 to 42 from 2009 to 2022, though a site further upstream at RM 23.3 had an ICI of 42 in 2009. Local disturbances may have caused the deviation in 2009 between RM 21.95 and RM 23.30. Downstream, Muddy Creek RM 9.79 (U04S01) had an ICI score that improved slightly since 2009, increasing from 36 to 38. Qualitative sampling at RM 9.79 also yielded more EPT and sensitive taxa in 2022 (10, 6) than in 2009 (7, 3).

Macroinvertebrate community quality in tributary streams through this portion of the watershed also showed a general trend of improvement or stability. **South Branch Muddy Creek** saw large improvements in macroinvertebrate community quality in its headwaters at RM 5.67 (U04S08). Two EPT and two sensitive taxa were collected here during qualitative sampling in 2009, while 14 EPT and five sensitive taxa were collected in 2022. The ICI score was similar between 2009 and 2022 at RM 1.54 (300679), though the numbers of EPT and sensitive taxa collected during qualitative sampling increased incrementally. **Little Muddy Creek** RM 7.55 (300677) had macroinvertebrate community quality improve notably from poor to marginally good since 2009. Macroinvertebrate communities in **Fishing Creek** also improved from poor to low-fair quality at RM 0.20 (300678) since 2009. Fishing Creek RM 0.20 was in a Lake Erie backwater and was not free flowing when sampled during either year.

Unlike other Muddy Creek tributaries, **Gries Ditch** at RM 0.93 (U04Q16) had more historical macroinvertebrate samples collected, including information from 1984, 1995, 2009, and 2022. Similar numbers of EPT (10 and eight) and sensitive (five and three) taxa were collected during the earliest sampling efforts in 1984 and 1995. There was some improvement in 2009, with 16 EPT and eight sensitive taxa collected (Ohio EPA 2011). Further improvement has occurred since 2009, with 18 EPT and 13 sensitive taxa being collected at RM 0.93 in 2022.

Water Quality and Aquatic Life Impairment Discussion

Introduction


Sandusky River dst. Broken Sword Creek RM 93.76 (U02G02)

The Sandusky River watershed is one of the principal tributaries to Lake Erie in Ohio, encompassing over 1400 mi^2. The Sandusky River, along with Muddy Creek (112 mi^2) and Green Creek (80 mi^2) are the main tributaries that comprise the Sandusky Bay. The Sandusky River watershed begins near Crestline, OH and flows west through Crawford County, before turning north in Wyandot County, draining much of Seneca and Sandusky Counties, and ultimately emptying into Sandusky Bay and on to Lake Erie (Figure 4). The river's name is derived from three words in the Wyandot language that roughly translate to "cool water gathered in pools of water" (Hord and Michaels 2016). The glacial moraines that define much of the watershed are sources of cool groundwater that help buoy overall stream quality (Figure 6).

Agriculture is the dominant land use through the study area, comprising approximately 77% of the land area (Figure 10, Table 4). Given the predominance of agricultural land and generally poorly draining soils, much of this watershed has a high density of field tiles to help facilitate drainage (Figure 9, Figure 11). There are several population centers situated along the mainstem, including Upper Sandusky, Bucyrus, Tiffin, and Fremont. Portions of Fostoria also drain to the Sandusky River and Muddy Creek. All other population centers in the study area had a population of less than 5,000 people (Table 5, Table 6). All counties that encompass the watershed had declining populations and all population centers aside from Upper Sandusky also had declining populations.

Principal tributaries to the Sandusky River, listed upstream to downstream, include Broken Sword Creek (93 mi^2), the Little Sandusky River (35 mi^2), Tymochtee Creek (304 mi^2), Sycamore Creek (64 mi^2), Honey Creek (179 mi^2), Rock Creek (34 mi^2), and Wolf Creek (156 mi^2) (Figure 7). Paramour Creek is the functional extension of the Sandusky River upstream, draining about 28 mi^2 at its "confluence" with the Sandusky River. The Sandusky River is formed from the confluence of Paramour Creek and Allen Run near river mile 127.90 (Figure 4). Muskellunge Creek and Muddy Creek both drain to Sandusky Bay or lake-influenced portions of the Sandusky River.

The study area crosses two ecoregions – the Eastern Corn Belt Plains to the south and the Huron Erie Lake Plains to the north (Figure 7). The ECBP ecoregion is characterized by rolling hills and mostly coarser, glacially deposited sediments, while the HELP ecoregion is characterized by generally low relief and finer grained, lake-derived sediments comprising most streams. Given their low relief and poor drainage, streams in the HELP ecoregion often were extensively modified in the past and many

smaller waterbodies are still maintained to some extent by landowners and local county engineers under petition ditch maintenance laws.

There are, however, some portions of the study area which have stream segments that are somewhat atypical for their ecoregion. Some stream segments in the HELP portion of study drain exposed limestone bedrock and are higher gradient with more coarse substrates than are expected at more typical HELP stream sites (Figure 5). Exposed limestone bedrock is present on Sandusky mainstem north of Tiffin and through other tributaries in this area, including portions of lower Rock Creek, lower Wolf Creek and East Branch Wolf Creek, and Gries Ditch.


Tymochtee Creek near St. Rt 53 RM 26.28 (U01G03)

In other instances, certain tributaries within the ECBP portion of the watershed drain sediments deposited by proglacial lakes and wetlands that formed between glacial end-moraines (Figure 6). The local physiography of these areas often results in stream habitats that resemble streams more typical of the HELP ecoregion, being lower gradient and having finer grained sediments like clay, silt, and sand. Streams draining these areas often require more extensive hydromodifications than more typical ECBP streams. This is evident in the hierarchical cluster analysis presented in the ensuing section, where biological assemblage composition in lower gradient sites was similar, regardless of ecoregion or spatial considerations (Figure 43). Tymochtee Creek and the Little Sandusky River are two tributaries that drain nearly all inter-morainal lacustrine deposits, while some stream segments in the eastern portion of the watershed (e.g., Paramour Creek, upper Honey Creek, upper Broken Sword Creek) are also influenced to a lesser degree (Figure 6).

The current survey evaluated the entirety of the Sandusky River and Muddy Creek, while Green Creek was sampled in 2023 as part of another survey of Sandusky Bay tributaries (Ohio EPA 2023a). The large river (LRAU) portion of the mainstem was assessed in 2021 as part of the statewide Large Rivers assessment (Ohio EPA 2023b). Most survey samples were collected in 2022, while follow-up sampling in several select areas occurred in 2023.

Previous comprehensive Ohio EPA sampling efforts in the watershed included a 2001 effort focused on the upper portions of the Sandusky River watershed upstream from the confluence of Wolf Creek (Ohio EPA 2003) and a 2009 effort focused on the lower Sandusky watershed and other Sandusky Bay tributaries (Ohio EPA 2011). There were also smaller, targeted efforts throughout the basin, including: a small 1985 effort through the Paramour Creek sub-watershed, a 1990 survey encompassing most of the mainstem and the lower reaches of three tributaries (Ohio EPA 1991), extensive sampling through the Tymochtee basin in 1995 related to an enforcement case, a targeted survey through Sycamore

Creek in 1999 & 2000 related to a large tire fire (Ohio EPA 2000), and sampling through the 2010s in upper Broken Sword Creek and the uppermost Sandusky watershed related to Great Lakes water quality restoration funding (Ohio EPA 2022, 2012). Sporadic biological and chemistry sampling has also occurred beginning in the 1980s at reference sites, monthly ambient chemistry stations, and for other various reasons. This study area also has two existing TMDLs – one for the upper portion of the watershed (Ohio EPA 2004) and another for the lower (Ohio EPA 2014b).

The earliest Ohio EPA surveys in the 1980s and 1990s documented a watershed with most of its waters unable to achieve the baseline goals set forth in the Clean Water Act. Later basin surveys in 2001 and 2009 documented some recovery, but there were still numerous stream reaches throughout the watershed that fell short of Clean Water Act goals (Figure 39). The major causes of impairments identified through these surveys included excessive siltation and nutrients from non-point sources, impairments related to habitat modifications, water quality degradation from poorly treated sewage and sewer discharges, and lack of industrial pre-treatment processes (Ohio EPA 2004, 2014).

Aquatic Life Attainment Status – Overview and Trends

Biological monitoring was conducted at 115 locations, encompassing 113 fish and 115 macroinvertebrate samples. Instream habitat quality and surface water chemistry were also collected at almost all locations. Other types of sampling occurred at select locations through the watershed (Table 2). Table 18 displays the biological and habitat index scores, as well as causes and sources of impairment if biological scores fell below applicable criteria.

Of the 113 sites where aquatic life beneficial use (ALU) attainment was fully assessed during the survey: 88 sites were in full attainment (78%), 17 were in partial attainment (15%), and eight were in non-attainment (7%) of their ALU criteria. All 14 locations on the Sandusky River mainstem met applicable aquatic life criteria, while tributary sites were responsible for partial or non-attainment of aquatic life goals (Table 18).

The current survey documented substantial improvements compared to historical Ohio EPA efforts (Figure 39). Of the 113 sites sampled during the recent survey, 102 sites

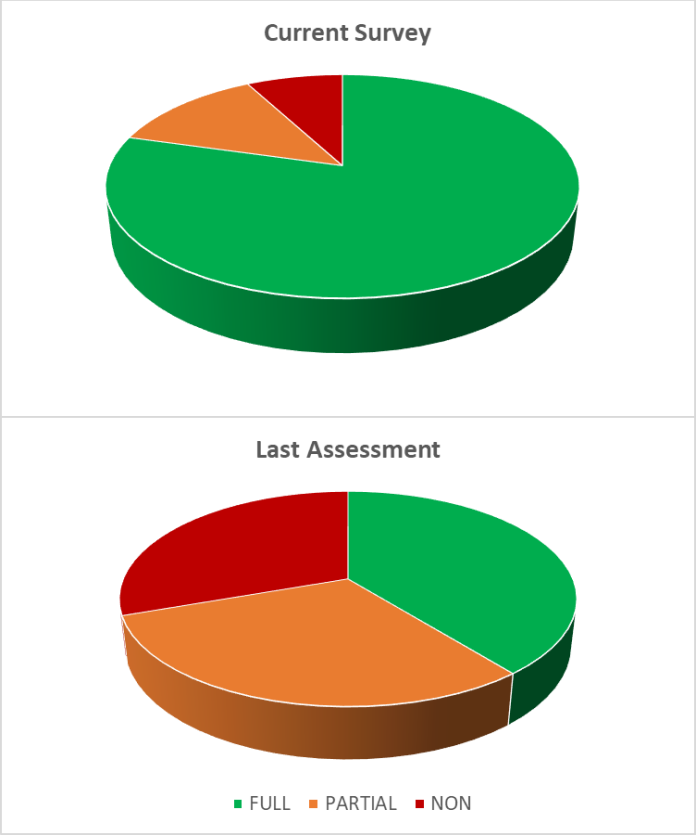


Figure 39 – Pie charts displaying the aquatic life use attainment status for sites from the current survey compared to their last full assessment (n=102). Only sites with historical assessment results are displayed. Results from previous biological collections were compared against the ALU currently being recommended.

had historical biological data with a prior assessment. As water quality conditions have improved over time, the number of sites with respective ALUs in full attainment of the criteria increased from 40 sites (39%) in prior surveys to 81 sites (79%) since their last assessment. All sites were compared against the ALU that is currently being recommended in this document. The numbers of sites in partial and non-attainment both saw corresponding decreases.

Broadly speaking, stream quality has improved dramatically throughout the watershed since the water quality issues documented during the earliest surveys have gradually been addressed. The Industrial and Green Revolution periods in the United States brought about many important technological advances, but also had externalities associated with them. Negative impacts to water quality nationwide were chiefly among those.

Prior to 1850, there were minimal impacts from human development in the Sandusky River watershed. Contiguous, low-lying swamp forests interspersed with wet prairies dominated the landscape and there was little soil erosion (Trautman 1975). These areas flooded during spring and the water slowly retreated from the landscape as summer progressed, providing excellent fish spawning habitat for species like Muskellunge and Lake Sturgeon (Keeler 1904). The water was always clear, with the abundance of decomposing aquatic vegetation helping to precipitate out solids (Keeler 1904). The early Sandusky River was teeming with fish. Records from the early 1800s suggested it was difficult to cross the river by boat during the spawning runs because the river was so dense with fish (Keeler 1904). Lake Sturgeon were so abundant they often fouled fisherman's nets and were removed, stacked along the banks to let dry, and burned for disposal (Keeler 1904).

As the watershed gradually became more developed through the late 1800s and early 1900s, poorly treated sewage and industrial waste began to negatively impact water quality around the major population centers like Bucyrus and Fremont. With the onset of the Green Revolution in the mid-1900s, further habitat degradation occurred as an externality related to advancements in agricultural technologies that ultimately accelerated delivery of excess sediment and non-point source pollutants to agricultural streams.

The earliest formal water quality studies in the Sandusky watershed conducted through the 1960s and 1970s documented water quality that frequently fell below the standards of the time around sewage plants. There were also wide-spread impacts from excessive amounts of non-point source sediment and nutrients that contributed to water quality impairments outside of the developed areas (Baker 1975). More than half of the 88 fish species documented through the system were considered in decline by the mid-1970s (Trautman 1975).

The noteworthy improvements in stream quality documented throughout the watershed since the earliest water quality surveys are directly related to investments in both better wastewater treatment and better non-point source pollution management, specifically excess siltation and nutrients (Figure 28). The first major period of recovery in the Sandusky watershed occurred around the several large municipal wastewater treatment facilities located in the watershed (Figure 29, Figure 34). Investments in wastewater infrastructure and advancements in technology driven by mandates in the Clean Water Act amendments of 1972, 1984, and 1987 were the impetus for the first signs of water quality improvements documented through the Sandusky watershed and statewide through Ohio. Subsequent

actions initiated by regulated entities to comply with the more stringent effluent limits required by these federal and state initiatives included significant equipment upgrades and process improvements to all major publicly owned wastewater treatment works, decommissioning and consolidation of smaller wastewater facilities, implementation of long term control plans for combined and sanitary sewer overflows, improvements to the stormwater collection and storage systems, and implementation of industrial pre-treatment programs. Instream chemical conditions improved relatively quickly around these facilities and better biological community performance soon followed. However, improved conditions around these facilities, alone, do not fully describe the extent of recovery that has been observed through the study area, as most of the wastewater treatment facilities in the watershed are located on the Sandusky River mainstem.

Most of the land area in the study area is comprised of agricultural land, and historically, excess sediments and nutrients in tributary streams caused widespread biological impairments (Ohio EPA 2004, 2014). During the late 19th and early 20th centuries, portions of the mainstem and many tributary streams were systematically modified to facilitate drainage. Channel modifications may have included removal of natural meanders, relocation of the active channel, dredging activities, removal of riparian vegetation, and installation of drainage tiles. These pervasive habitat modifications accelerated the delivery of silts and excess sediment to these streams. Though systematic, basin-wide channel modifications have not been conducted for decades, many of these drainage modifications have been maintained to some degree. Pervasive siltation and embeddedness, along with monotonous channel development have historically plagued the most heavily modified portions of the watershed like the Little Sandusky River, Tymochtee Creek, and Honey Creek.

Advocacy for modern tillage and soil conservation practices designed to reduce sedimentation and non-point source nutrient pollution began in the 1980s and accelerated in the 1990s. As these practices were gradually implemented statewide and throughout the Sandusky watershed, reductions in suspended sediment discharge and total phosphorus have become apparent (Myers et al. 2000, Richards et al. 2009, Meals et al. 2012). As environmental conditions improved from the reductions in non-point source loadings, measurable improvements to biological community performance have been documented in the Sandusky River and other agricultural watersheds throughout Ohio (Miltner 2015). This positive trend is highlighted in the Tymochtee Creek and Honey Creek sub-watersheds, where biological community performance has improved immensely over the period of record in these low-gradient, agricultural watersheds.

The remainder of this section will discuss the water quality and biological sampling results of the current survey, including both a Hierarchical Cluster analysis and individual waterbody discussion summarizing information from impaired stream reaches.

Table 18 – Aquatic life use attainment status for stations sampled in the Sandusky River and Muddy Creek watersheds based on data collected June-October 2021-2023.

Sites and tributary streams are presented upstream to downstream, beginning with the Sandusky River mainstem. The Index of Biotic Integrity (IBI), Modified Index of well-being (MIwb), and Invertebrate Community Index (ICI) are multi-metric index scores based on the performance of the biological communities. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat of the stream to support a biotic community. Portions of the survey area lie within both the Eastern Corn Belt Plains (ECBP) and the Huron Erie Lake Plains (HELP) ecoregion. If biological impairment has occurred, the cause(s) and source(s) of the impairment are noted. Sampling locations listed in the table represent the reaches evaluated with biological monitoring; chemical sampling may have occurred at an alternate sampling point for that station. All absolute sampling locations are reflected in each respective section of this document. Index scores surrounded by [brackets] indicate that samples were not collected in 2022.

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi²)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
Sandusky River (05-001-000)												
U02P08	SANDUSKY R. NEAR LEESVILLE @ LOWER LEESVILLE RD.	ECBP	WWH	127.90	35.0 [W]	44	9.3	46	87.00	**FULL**		
U02G01	SANDUSKY R. @ LOCUST GROVE RD.	ECBP	WWH	120.82	67.2 [W]	38[NS]	9.2	56	78.25	**FULL**		
U02P30	SANDUSKY R. DST. BUCYRUS WWTP @ KERSTETTER RD.	ECBP	WWH	110.43	88.9 [W]	50	9.1	38	83.50	**FULL**		
U02P33	SANDUSKY R. DST. BUCYRUS @ ST. RT. 231	ECBP	WWH	98.69	109.7 [W]	48	9.4	54	84.25	**FULL**		
U02G02	SANDUSKY R. DST. BROKEN SWORD CREEK @ CO. RD. 128	ECBP	WWH	93.76	232.2 [W]	44	9.4	54	72.00	**FULL**		
500860	SANDUSKY R. DST. UPPER SANDUSKY @ TWP. RD. 121	ECBP	WWH	78.09	295.5 [W]	42	9.9	56	75.00	**FULL**		
U02P38	SANDUSKY R. DST UPPER SANDUSKY @ TWP. RD. 40	ECBP	WWH	72.09	337.6 [W]	48	10.2	56	75.00	**FULL**		
U03G01	SANDUSKY R. S OF MCCUTCHENVILLE @ CO. RD. 16	ECBP	EWH(R)	65.01	656.0 [B]	[52]	[9.8]	[50]	[83.00]	**FULL**		
U04S29	SANDUSKY R. NEAR MEXICO @ CO. RD. 9	ECBP	EWH(R)	57.34	760.1 [B]	[52]	[9.9]	[E]	[83.00]	**FULL**		
500830[R]	SANDUSKY R. DST MEXICO @ CO. RD. 90	ECBP	EWH(R)	47.75	774.0 [B]	-	-	[E]	-	-		
500940[R]	SANDUSKY R. UPST. TIFFIN @ U.S. RT. 224	ECBP	MWH-I	42.92	960.4 [B]	44	9.1	MG	50.50	**FULL**		
U04S28	SANDUSKY R. AT TIFFIN @ ELLA ST.	ECBP	EWH(R)	41.84	964.2 [B]	[54]	[10.5]	[E]	[84.25]	**FULL**		
500880	SANDUSKY R. DST. TIFFIN @ CO. RD. 38	ECBP	EWH(R)	36.50	1030.9 [B]	-	-	[E]	-	-		
500910[R]	SANDUSKY R. DST TIFFIN @ ABBOTTS BRIDGE	ECBP	EWH(R)	30.85	1047.5 [B]	[54]	[11.4]	54	[79.00]	**FULL**		
U04Q06[R]	SANDUSKY R. UPST. FREMONT, UPST. WOLF CREEK	HELP	EWH(R)	23.00	1072.0 [B]	[54]	[10.4]	[50]	[64.25]	**FULL**		
U04S23	SANDUSKY R. AT FREMONT @ TIFFIN RD.	HELP	EWH(R)	16.80/ 18.00	1255.3 [B]	[46[NS]]	[10.6]	44[NS]	[84.50]	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi^2)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
Paramour Creek (05-042-000)												
U02P48[R]	PARAMOUR CREEK NE OF CRESTLINE @ FINNEGAN RD.	ECBP	WWH	6.15	5.1 [H]	36[NS]	-	MG[NS]	54.00	**FULL**		
U02P12	PARAMOUR CREEK DST. CRESTLINE @ NAZOR RD.	ECBP	WWH	1.50	26.0 [W]	30*	6.8*	36	58.00	**PARTIAL**	Barrier to fish passage	Dam/impoundment
Tributary to Paramour Creek (5.13) (05-042-003)												
U02S07[R]	TRIB. TO PARAMOUR CREEK (5.13) UPST PPG OUTFALL	ECBP	WWH	3.70	1.0 [H]	[38[NS]]	-	[MG[NS]]	[53.00]	**FULL**		
Allen Run (05-043-000)												
U02G20	ALLEN RUN SE OF LEESVILLE DST. CRESTLINE RD.	ECBP	WWH	1.05	3.6 [H]	[27*]	-	[F*]	[59.50]	**NON**	Fish Kills Total ammonia	Spills/runoff
South Fork Loss Creek (05-041-001)												
201377	S.FK. LOSS CREEK AT MOUTH @ LOSS CREEK RD.	ECBP	WWH	0.10	6.7 [H]	42	-	G	75.25	**FULL**		
Grass Run (05-039-000)												
U02G14	GRASS RUN ADJ. BUCYRUS-NEVADA RD.	ECBP	WWH(R)	8.36	9.1 [H]	38[NS]	-	G	57.00	**FULL**		
U02G13	GRASS RUN @ CRAWFORD/WYANDOT COUNTY LINE RD.	ECBP	WWH	3.42	18.3 [H]	50	-	E	77.25	**FULL**		
Broken Sword Creek (05-035-000)												
U02G09	BROKEN SWORD CREEK @ ST. RT. 98	ECBP	WWH	29.52	10.9 [H]	44	-	G	55.00	**FULL**		
U02G07	BROKEN SWORD CREEK @ SCHWEMLEY RD.	ECBP	WWH	25.48	32.6 [W]	38[NS]	8.9	54	55.75	**FULL**		
201366	BROKEN SWORD CREEK NE OF BENTON @ ST. RT. 19/100	ECBP	WWH	19.70	42.0 [W]	34*	7.9[NS]	40	61.75	**PARTIAL**	Siltation/sedimentation	Agriculture
U02S23	BROKEN SWORD CREEK AT OCEOLA DST. U.S. RT. 30N	ECBP	WWH	12.30	69.1 [W]	46	9.8	50	75.00	**FULL**		
U02P47	BROKEN SWORD CREEK NEAR NEVADA @ CO. RD. 62	ECBP	WWH	0.87	93.3 [W]	49	9.8	54	72.75	**FULL**		
Red Run (05-038-000)												
201372	RED RUN NEAR MOUTH @ HENRY COOPER RD.	ECBP	WWH(R)	0.42	8.0 [H]	39[NS]	-	MG[NS]	45.50	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi²)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
Brandywine Creek (05-037-000)												
302323	BRANDYWINE CREEK S OF BROKEN SWORD @ HOLMES CENTER RD.	ECBP	WWH(C)	0.45	11.1 [H]	30*	-	F*	65.00	**NON**	Siltation/sedimentation	Inappropriate waste disposal
												Agriculture
											Direct habitat alterations, Flow regime alteration	Channelization
											Organic enrichment	Uknown source
Indian Run (05-036-000)												
U02G12	INDIAN RUN NW OF NEVADA DST. TWP. RD. 137A	ECBP	WWH	0.75	8.5 [H]	36[NS]	-	G	53.75	**FULL**		
Little Sandusky River (05-033-000)												
201361	L. SANDUSKY R. AT MORRAL @ GOODNOW RD.	ECBP	MWH-C (R)	10.40	6.9 [H]	22*	-	LF*	29.25	**NON**	Siltation/sedimentation	Agriculture
											Direct habitat alterations	Channelization
											Flow regime alterations	
U02G16	L. SANDUSKY R. @ WYANDOT/MARION COUNTY LINE RD.	ECBP	WWH	6.40/ 6.52	16.8 [H]	20*	-	F*	46.75	**NON**	Siltation/sedimentation	Agriculture
											Direct habitat alterations	Channelization
											Flow regime alterations	
U02W06	L. SANDUSKY R. NW OF MORRAL @ TWP. RD. 125	ECBP	WWH	3.71	21.5 [W]	26*	6.1*	34[NS]	42.5	**NON**	Siltation/sedimentation	Agriculture
											Flow regime alterations	Channelization
											Organic enrichment	Unsewered areas, Impacts from land application of wastes, Failing HSTS, Agriculture
Tributary to Little Sandusky River (8.93) (05-033-003)												
U02W05	TRIB. TO L. SANDUSKY R. (8.93) SW OF MORRAL @ FORD	ECBP	MWH-C	0.78	5.9 [H]	32	-	F	30.75	**FULL**		
Honey Run (05-034-000)												
U02G18	HONEY RUN SE OF LITTLE SANDUSKY @ CO. RD. 126	ECBP	WWH	0.52	9.0 [H]	40	-	E	65.25	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi²)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
Rock Run (05-032-000)												
U02S20	ROCK RUN NE OF UPPER SANDUSKY @ TWP. RD. 122	ECBP	WWH	1.40	9.4 [H]	36[NS]	-	G	64.75	**FULL**		
Negro Run (05-027-000)												
U02S19	NEGRO RUN NE OF UPPER SANDUSKY @ CO. RD. 124	ECBP	WWH	0.52	13.1 [H]	50	-	VG	67.25	**FULL**		
Sugar Run (05-026-000)												
201354	SUGAR RUN NEAR SMITHVILLE, UPST. ST. RT. 67, UPST. TRIB.	ECBP	WWH	0.60	4.6 [H]	40	-	MG[NS]	70.25	**FULL**		
Tymochtee Creek (05-300-000)												
U01W05	TYMOCHTEE CREEK SE OF MEEKER @ CRAMER RD.	ECBP	MWH-C (R)	51.43	6.4 [H]	26	-	F	42.50	**FULL**		
U01G07	TYMOCHTEE CREEK AT MEEKER @ MASON RD. (CO. RD. 213A)	ECBP	WWH	49.44	16.1 [H]	34*	-	F*	49.75	**NON**	Siltation/sedimentation	Agriculture
											Direct habitat alterations	Channelization
											Flow regime alterations	
											Organic enrichment	Unsewered areas, Impacts from land application of wastes, Failing HSTS, Agriculture
U01G05	TYMOCHTEE CREEK S OF MARSEILLES @ DRY LANE RD. N.	ECBP	WWH	44.95	64.5 [W]	33*	7.3*	34[NS]	56.00	**PARTIAL**	Siltation/sedimentation	Agriculture
											Flow regime modification	Channelization
U01G04	TYMOCHTEE CREEK N OF MARSEILLES @ TWP. RD. 97	ECBP	WWH	33.99	146.2 [W]	36[NS]	8.2[NS]	48	65.00	**FULL**		
U01G03	TYMOCHTEE CREEK W OF UPPER SANDUSKY @ ST. RT. 53	ECBP	WWH	26.28	175.0 [W]	38[NS]	8.8	32[NS]	67.25	**FULL**		
U02P44	TYMOCHTEE CREEK NEAR UPPER SANDUSKY @ TWP. RD. 49	ECBP	WWH	19.45	204.3 [W]	38[NS]	8.1[NS]	42	74.00	**FULL**		
500850[R]	TYMOCHTEE CREEK AT CRAWFORD @ ST. RT. 199	ECBP	WWH	7.80	232.0 [W]	45	9.5	50	70.38	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi^2)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
Prairie Run (05-300-007)												
U01W04	PRAIRIE RUN @ AGOSTA-MEEKER RD.	ECBP	MWH-C (R)	1.02	8.6 [H]	19*	-	F	29.50	**NON**	Siltation/sedimentation	Agriculture
											Low flows	Channelization
											Flow regime alterations	
											Direct habitat alterations	
											Uknown cause	Unknown source
Enoch Ditch (05-300-006)												
U01W01	ENOCH CREEK @ DECLIFF RD, SOUTHERN MOST CROSSING	ECBP	MWH-C (R)	1.59	6.5 [H]	28	-	MG	54.50	**FULL**		
Carroll Ditch (05-300-004)												
U01G26	CARROLL DITCH NNW OF MEEKER @ OSBUN RD.	ECBP	MWH-C	0.66	10.3 [H]	32	-	G	37.75	**FULL**		
Pawpaw Run (05-319-000)												
U01G25	PAWPAW RUN @HARDIN/MARION COUNTY LINE RD.	ECBP	WWH	6.13	8.2 [H]	38[NS]	-	G	59.50	**FULL**		
U01G24	PAWPAW RUN S OF MARSEILLES @ RUBINS RD.	ECBP	WWH	0.80	16.3 [H]	[37[NS]]	-	G	[70.90]	**FULL**		
Little Tymochtee Creek (Upper) (05-316-000)												
304302	L. TYMOCHTEE CREEK (UPPER) @ CO RD 205	ECBP	MWH-C	8.63	11.9 [H]	30	-	G	47.25	**FULL**		
U01G20	L. TYMOCHTEE CREEK (UPPER) NW OF MARSEILLES @ CO. RD. 93	ECBP	WWH	4.00	35.5 [W]	36[NS]	8.4	38	72.75	**FULL**		
Reevhorn Run (05-317-000)												
U01G23	REEVHORN RUN 4.8 MI. W OF MARSEILLES @ CO. RD. 76	ECBP	WWH(C)	2.26	12.5 [H]	36[NS]	-	MG[NS]	61.50	**FULL**		
Pawpaw Run (05-318-000)												
201432	PAWPAW RUN AT HOPEWELL CHURCH @ ST. RT. 67	ECBP	WWH(C)	1.10	5.6 [H]	32*	-	VG	36.75	**PARTIAL**	Direct habitat alterations	Channelization
											Flow regime alterations	
Warpole Creek (05-314-000)												
U01G18	WARPOLE CREEK @ TWP. RD. 58	ECBP	WWH(R)	1.52	18.8 [H]	36[NS]	-	G	56.00	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi^2)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
St. James Run (05-315-000)												
304296	ST. JAMES RUN NEAR MOUTH @ TWP. RD. 108	ECBP	WWH(C)	0.15	10.7 [H]	42	-	VG	58.50	**FULL**		
Oak Run (05-312-000)												
U01G16	OAK RUN @ TWP. RD. 54	ECBP	WWH(C)	0.29	15.2 [H]	34*	-	G	64.50	**PARTIAL**	Siltation/sedimentation	Agriculture
											Flow regime alterations	Channelization
Lick Run (05-308-000)												
U01G15	LICK RUN S OF CAREY @ CO. RD. 97	ECBP	WWH	0.83	7.9 [H]	40	-	G	53.25	**FULL**		
Little Tymochtee Creek (lower) (05-304-000)												
U01G14	L. TYMOCHTEE CREEK (LOWER) NW OF UPPER SANDUSKY @ TWP RD 49	ECBP	MWH-C (R)	10.32	11.1 [H]	[24]	-	[F]	[39.25]	**FULL**		
U01G13	L. TYMOCHTEE CREEK (LOWER) SE OF CAREY @ ST. RT. 199	ECBP	WWH	6.33	18.5 [H]	34*	-	F*	35.75	**NON**	Siltation/sedimentation	Agriculture
											Direct habitat alterations	Channelization
											Flow regime alterations	
											Organic enrichment	Agriculture, Failing HSTS
U02P45	L. TYMOCHTEE CREEK (LOWER) NEAR CAREY @ TWP. HWY 106	ECBP	WWH	1.95	28.4 [W]	32*	6.8*	28*	58.00	**NON**	Siltation/sedimentation	Agriculture
											Direct habitat alterations	Channelization
											Flow regime alterations	
Spring Run (05-301-000)												
U02P46	SPRING RUN DST. CAREY @ MOTT RD.	ECBP	WWH	1.71	16.9 [H]	38[NS]	-	G	73.00	**FULL**		
Poverty Run (05-302-000)												
U01G10	POVERTY RUN NE OF CAREY @ POVERTY RUN RD. (TWP. RD. 11).	ECBP	WWH	2.99	9.3 [H]	40	-	VG	57.50	**FULL**		
Thorn Run (05-024-000)												
U03G03	THORN RUN AT MCCUTCHENVILLE @ ST. RT. 53	ECBP	WWH	0.70	9.1 [H]	34*	-	G	70.25	**PARTIAL**	Siltation/sedimentation	Agriculture
											Flow regime alterations	Channelization

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi²)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
Taylor Run (05-023-000)												
U03G04	TAYLOR RUN NW OF SYCAMORE @ TWP. RD. 16	ECBP	WWH	1.88	17.4 [H]	38[NS]	-	F*	75.00	**PARTIAL**	Siltation/sedimentation	Agriculture
											Flow regime alterations	Channelization
Tributary to Taylor Run (05-023-001)												
304297	TRIB. TO TAYLOR RUN (2.49) NEAR MOUTH @ CO. RD. 37	ECBP	MWH-C	0.10	6.7 [H]	30	-	MG	61.00	**FULL**		
Sycamore Creek (05-021-000)												
U03G10	SYCAMORE CREEK E OF LYKENS @ KENNEDY RD.	ECBP	WWH(R)	18.92	18.2 [H]	40	-	G	63.25	**FULL**		
U03G08	SYCAMORE CREEK @ WYANDOT/CRAWFORD COUNTY LINE	ECBP	WWH	9.14	47.2 [W]	40	9.0	46	72.00	**FULL**		
U03P05	SYCAMORE CREEK NEAR MEXICO @ CO. RD. 37	ECBP	WWH	0.41	64.2 [W]	45	9.6	48	77.75	**FULL**		
Spring Creek (05-021-002)												
U03G13	SPRING CREEK (TRIB TO SYCAMORE CK. 12.92) @ ST. RT. 100	ECBP	WWH	1.88	8.8 [H]	40	-	MG[NS]	52.50	**FULL**		
Mile Run (05-020-000)												
U03G14	MILE RUN N OF MEXICO @ CO. RD. 37	ECBP	WWH	0.30	6.4 [H]	40	-	E	72.25	**FULL**		
Honey Creek (05-200-000)												
U03G20	HONEY CREEK NW OF TIRO @ TIRO RD.	ECBP	WWH	41.66	10.4 [H]	38[NS]	-	G	75.50	**FULL**		
U03G18[R]	HONEY CREEK @ BIGHAM RD.	ECBP	WWH(R)	34.14	26.5 [W]	37[NS]	8.4	48	47.50	**FULL**		
U03S03	HONEY CREEK W OF ATTICA @ TWP. RD. 79	ECBP	WWH	25.03	84.4 [W]	36[NS]	7.4*	44	61.25	**PARTIAL**	Siltation/sedimentation	Agriculture
U03S02[R]	HONEY CREEK AT MELMORE @ ST. RT. 67/100	ECBP	WWH	12.30	149.3 [W]	44	9.9	48	91.50	**FULL**		
500970[R]	HONEY CREEK NEAR TIFFIN @ CO. RD. 19	ECBP	WWH(R)	0.20/ 1.10	179.3 [W]	46	9.2	58	46.75	**FULL**		
Celery Creek (05-200-003)											**MWH-C Existing**	
303862	CELERY CREEK @ WEIS RD. (RD. 84)	ECBP	MWH-C	0.45	13.4 [H]	36	-	LF*	33.00	**PARTIAL**	Siltation/sedimentation	Agriculture
											Direct habitat alterations	Channelization
											Flow regime alterations	

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi^2)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
Brokenknife Creek (05-209-000)												
201405	BROKENKNIFE CREEK @ HURON/SENECA COUNTY LINE RD.	ECBP	WWH	1.05	18.6 [H]	38[NS]	-	VG	65.50	**FULL**		
Aicholz Ditch (05-203-000)												
U03G25	AICHOLZ DITCH E OF BLOOMVILLE @ CO. RD. 23	ECBP	MWH-C	3.72	9.4 [H]	32	-	F	42.25	**FULL**		
U03G24	AICHOLZ DITCH E OF BLOOMVILLE @ COOPER RD. (TWP. RD. 77)	ECBP	WWH	2.46	15.0 [H]	36[NS]	-	MG[NS]	60.00	**FULL**		
Silver Creek (05-202-000)												
U03G22	SILVER CREEK S OF BLOOMVILLE @ ST. RT. 19	ECBP	WWH	4.08	16.3 [H]	34*	-	G	45.50	**PARTIAL**	Siltation/sedimentation Direct habitat alterations Flow regime alterations	Agriculture Channelization
Rock Creek (05-014-000)												
U04G18	ROCK CREEK @ CO. RD. 43	ECBP	WWH	11.69	14.7 [H]	29*	-	MG[NS]	51.50	**PARTIAL**	Siltation/sedimentation Low streamflow Flow regime alterations	Agriculture Channelization
U04W06	ROCK CREEK AT TIFFIN @ REBECCA ST. NEAR USGS GAUGE	ECBP	WWH	0.75	34.5 [W]	44	8.4	54	73.25	**FULL**		
East Branch Rock Creek (05-015-000)												
U04G03	EAST BRANCH ROCK CREEK @ CO. RD. 16	ECBP	WWH	0.47	6.4 [H]	36[NS]	-	F*	73.00	**PARTIAL**	Siltation/sedimentation Low streamflow Flow regime alterations	Agriculture Channelization
Willow Creek (05-013-000)												
U04W09	WILLOW CREEK AT TIFFIN @ MARKET ST.	ECBP	MWH-C	0.82	5.7 [H]	22*	-	F	50.00	**NON**	Siltation/sedimentation Flow regime alterations	Agriculture Stormwater runoff Channelization Stormwater runoff
Morrison Creek (05-012-000)												
U04G06	MORRISON CREEK NW OF REPUBLIC @ TWP. RD. 175	ECBP	MWH-C	9.34	9.3 [H]	30	-	G	54.75	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi²)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
U04G05	MORRISON CREEK @ TWP. RD. 15	ECBP	WWH	2.05/ 2.36	16.4 [H]	32*	-	G	68.50	**PARTIAL**	Siltation/sedimentation	Agriculture
											Loss of riparian habitat	Channelization
											Flow regime alterations	
Spicer Creek (05-011-000)												
U04Q11	SPICER CREEK N OF TIFFIN DST. CO. RD. 33	ECBP	WWH(C)	0.65	12.5 [H]	48	-	E	70.50	**FULL**		
Sugar Creek (05-010-000)												
U04Q10[R]	SUGAR CREEK NEAR TIFFIN @ TWP. RD. 76	ECBP	WWH(C)	3.20	8.6 [H]	44	-	50	75.00	**FULL**		
Wolf Creek (05-005-000)												
201336	WOLF CREEK 0.2 MI. UPST. CO. RD. 592	HELP	WWH(C)	13.45	28.1 [W]	34	7.5	44	65.75	**FULL**		
U04S40	WOLF CREEK AT BETTSVILLE @ CEMETERY	HELP	WWH(C)	5.60	66.5 [W]	38	8.9	50	74.25	**FULL**		
U04G07	WOLF CREEK UPST. EAST BRANCH @ TOWNSHIP LINE RD.	HELP	WWH(C)	1.58	71.7 [W]	42	9.0	52	71.25	**FULL**		
Harrison Creek (05-005-004)												
U04G11	HARRISON CREEK E OF FOSTORIA @ CO. RD. 592	HELP	WWH(R)	0.38	9.1 [H]	46	-	G	44.00	**FULL**		
Plum Run (05-005-003)												
U04G09	PLUM RUN E OF FOSTORIA @ ST. RT. 635	HELP	WWH(R)	0.79	9.8 [H]	44	-	F*	49.25	**PARTIAL**	Siltation/sedimentation	Agriculture
											Direct habitat alterations	Channelization
											Flow regime alterations	
Tributary to Wolf Creek (8.10) (05-005-002)												
304298	TRIB. TO WOLF CREEK (8.10) @ ST. RT. 12	HELP	WWH(R)	0.17	6.7 [H]	42	-	VG	56.50	**FULL**		
East Branch Wolf Creek (05-006-000)												
300673	E. BR. WOLF CREEK @ N. TWP RD. 109	HELP	WWH(C)	19.13	20.3 [W]	34	7.8	G	56.25	**FULL**		
U04G15	E. BR. WOLF CREEK @ TWP. RD. 132	HELP	WWH(C)	13.63	33.2 [W]	42	8.6	42	73.00	**FULL**		
201338	E. BR. WOLF CREEK SW OF FORT SENECA @ TWP. RD. 150	HELP	WWH(C)	9.00	67.8 [W]	41	8.9	52	65.50	**FULL**		
U04P03	E. BR. WOLF CREEK NEAR BETTSVILLE @ GILMORE RD.	HELP	WWH(C)	0.86	82.0 [W]	43	10.3	E	77.75	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi^2)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
Eicher Ditch (05-006-004)												
304299	EICHER DITCH NEAR MOUTH UPST. W. BEECH ST.	HELP	WWH(R)	0.01	9.3 [H]	34	-	MG[NS]	60.75	**FULL**		
East Branch of East Branch Wolf Creek (05-008-000)												
U04G13	E. BR. OF EAST BRANCH WOLF CREEK @ CO. RD. 26	ECBP	WWH(C)	3.52	7.2 [H]	32*	-	MG[NS]	68.25	**PARTIAL**	Flow regime alterations Direct habitat alterations	Channelization
300682	E. BR. OF EAST BRANCH WOLF CREEK @ CO. RD. 48 (TWP. RD. 118)	ECBP	WWH(C)	1.48	19.7 [H]	44	-	52	71.50	**FULL**		
Middle Branch of East Branch Wolf Creek (05-009-000)												
U04G14	M. BR. OF E. BR. OF EAST BRANCH WOLF CREEK @ CO. RD. 26	HELP	WWH(C)	0.46	10.9 [H]	38	-	G	78.25	**FULL**		
Indian Creek (05-004-000)												
500950	INDIAN CREEK S OF FREMONT @ HURDICK RD.	HELP	WWH(C)	0.62	12.0 [H]	36	-	VG	72.25	**FULL**		
Muskellunge Creek (05-003-000)												
300674	MUSKELLUNGE CREEK @ ST. RT. 635	HELP	WWH	16.70	17.7 [H]	46	-	G	45.25	**FULL**		
201332	MUSKELLUNGE CREEK NEAR FREMONT @ SPIELDENNER RD.	HELP	WWH	5.40	35.7 [W]	42	7.9	48	63.50	**FULL**		
Bark Creek (05-002-000)												
300671	BARK CREEK @ KELLEY RD. (CR 245)	HELP	WWH	3.20	10.0 [H]	34	-	MG[NS]	47.00	**FULL**		
Muddy Creek (05-219-000)												
201410[R]	MUDDY CREEK W OF FREMONT @ TWP. RD. 55	HELP	WWH	21.90	43.5 [W]	44	9.0	42	69.00	**FULL**		
U04S01	MUDDY CREEK DST. LINDSEY @ CO. RD. 153	HELP	WWH	9.79	72.8 [W]	40	9.2	38	53.60	**FULL**		
South Branch Muddy Creek (05-222-000)												
U04S08[R]	S. BR. MUDDY CREEK @ SENECA CO. RD. 28	HELP	WWH	5.67	4.6 [H]	30	-	36	50.50	**FULL**		
300679	S. BR. MUDDY CREEK @ ANDERSON RD.	HELP	WWH	1.54	21.9 [W]	28	7.4	42	38.00	**FULL**		
Gries Ditch (05-223-000)												
U04Q16[R]	GRIES DITCH W OF FREMONT @ STAFF RD.	HELP	WWH	0.93	12.5 [H]	27[NS]	-	42	63.60	**FULL**		
Little Muddy Creek (05-220-000)												
300677	L. MUDDY CREEK @ BOOKTOWN RD. (W. CO. RD. 89)	HELP	WWH	7.55	12.4 [H]	28	-	MG[NS]	57.00	**FULL**		

STORET	Location	Eco-region	Aquatic Life Use	River Mile [a]	Drain (mi^2)	IBI	MIwb [b]	ICI [c]	QHEI	Attainment Status [d]	Cause	Source
Fishing Creek (05-220-001)												
300678	FISHING CREEK @ WEICKERT RD.	HELP	WWH	0.20	7.0 [H]	34	-	LF*	25.75	**PARTIAL**	Natural conditions	Natural sources – Lake Erie backwaters

a River Mile (RM) represents the sampling location of biological communities; other sampling types may be collected at an alternative location
b MIwb is not applicable to headwater streams with drainage areas ≤ 20 mi^2.
c A narrative evaluation of the qualitative sample was used when quantitative data was not available or was unable to be collected. F=Fair; MG=Marginally Good; G=Good; VG=Very Good; E=Exceptional.
d Attainment status is given for the proposed ALU designation when a change is recommended.
ns Nonsignificant departure from biocriteria (≤4 IBI or ICI units, or ≤0.5 MIwb units)
* Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range and would automatically place a site into non-attainment.
B Boat site.
H Headwater site.
W Wading site.
L Lacustary Site
R Reference Site

Biological Assemblage Multi-Dimensional Stressor Analysis

Statistical methods described in Appendix L were used to group the survey sites based on similarities between the biological assemblages collected and then evaluate these groups of sites based on the environmental conditions driving these associations. Fish and macroinvertebrate assemblages are evaluated separately and independent from each other. This analysis is useful for providing general information about the relationships among the stream biota and between the environmental conditions documented during the survey. This analysis also provides additional evidence to help identify chemical or habitat stressors impacting sets of similar sampling locations. It can help determine causative factors that drive biological community structure and can also help determine why a site or a group of sites failed to achieve aquatic life goals.

The attainment status and accompanying causes/sources of impairment for non-attaining sites, for stream survey locations are summarized in Table 18. The hierarchical clustering analysis described in Appendix L for fish and macroinvertebrate assemblages are displayed in Figure 40 and Figure 43. These figures display dendrograms representing the similarity/dissimilarity between biological assemblages collected at each sampling location. Sites closer together on the dendrogram have more similar fish or macroinvertebrate assemblages compared to sites further apart on the dendrogram. The LRAU portions of the Sandusky River mainstem (RMs 65.01 – 17.70) were excluded from this analysis. South Fork Loss Creek RM 0.10 (201377) was also excluded from this analysis due to lack of inorganic chemistry data.

Organism groupings (fish and macroinvertebrate) and the subsequent summaries of environmental parameters specific to those organism groupings are regarded separately and independently from each other (e.g., Fish Group #8 is regarded differently and has no bearing on Macro Group #8).

Fish Grouping Results

Fish assemblages from survey sites were separated into 7 distinct groupings based on indicator species and similarity of the assemblages (Figure 40, Table 19). Two broad clades separated out, with fish groups #1, #4, and #6 having distinctly different fish assemblages from those in groups #2, #3, #5, and #7.

Fish groups #1, #4, and #6 were comprised of sites that drained larger streams segments and were also associated with comparatively higher overall IBI scores (Figure 40, Figure 42). All these groups had relatively good QHEI scores, though habitat quality was somewhat lower overall in group #4 sites. Pool quality and instream cover were similar among groups, while bank/riparian metric scores were decidedly lower in group #1 sites and channel metric scores were somewhat lower in group #4 sites. Of these three groups, stream gradient values were highest in group #6, followed by groups #1 and #4.

Of these, fish group #4 sites had assemblages that were distinctly different than those in groups #1 and #6. IBI scores in group #4 were similar to group #1 and both were decidedly lower than sites in group #6. Group #4 sites had the highest median drainage area of all fish groupings and also had generally good habitat quality. However, the stream gradients here were the lowest of all survey sites and many of these streams were sluggish and drain wetland-influenced areas. Group #4 sites had consistently low pH and dissolved oxygen levels, reflecting the reduced conditions at sites. Sites in this group had the highest overall TP and TSS values, and total organic nitrogen (TKN) and carbon (TOC) were also

higher than most other groups of sites. Sites in this group included larger, lower gradient stream sites throughout the study area that had generally sufficient biological, habitat, and water quality. Streams in this group included: two sites in lower gradient portions of Honey Creek and nearby Celery Creek, most of Tymochtee Creek, Muddy Creek, and Fishing Creek. Two sites in this group had biological impairment, with fish assemblages failing to achieve expectation at Honey Creek RM 25.03 (U03S03), while macroinvertebrate assemblages fell short at Celery Creek RM 0.45 (303862).

Sites in groups #1 and #6 were sister clades that had fish assemblages most closely related to each other. Both these groups had sites that were generally well oxygenated. These sites had similar TP and organic nitrogen concentrations, while TKN concentrations were decidedly higher in group #6. On larger streams, lower TKN and total ammonia, coupled with higher inorganic nitrogen concentrations is often a signature of the discharges from municipal wastewater systems effectively converting nitrogen from organic to an inorganic form.

Sites in fish group #6 had the highest habitat quality and IBI scores, by far, compared to all other site groupings. Group #6 sites encompassed the next largest set of drainages in the survey, though stream gradients were higher here compared to those in group #4. Most of the Sandusky River mainstem sites were included in this group along with the lower reaches of higher-quality, higher-gradient tributary streams (Grass Run, Broken Sword Creek, Spring Run, Sycamore Creek, Rock Creek, Honey Creek, Wolf Creek, and East Branch Wolf Creek). All sites in this group had biological assemblages that met WWH criteria.

Group #1 was comprised of many smaller wading and larger headwater stream sites in rural agricultural areas. While overall habitat quality was still generally good, the bank/riparian condition was lowest among the three groups of larger stream sites (Figure 42). IBI scores were also slightly lower overall compared to groups #4 and #6. Of the 18 sites in group #1, only two had biological impairments. Broken Sword Creek RM 19.70 (201366) and Brandywine Creek RM 0.45 (302323) were in partial and non-attainment of their ALU, respectively. The fish assemblage was impaired in Broken Sword Creek, while both organism groups failed to achieve expectations in Brandywine Creek. These two sites are located very close together spatially; Brandywine Creek joins Broken Sword Creek at RM 18.90, less than a mile downstream from the impaired reach of Broken Sword Creek (Figure 4).

Fish assemblages in groups #2, #3, #5, and #7 were all associated with the smallest drainages of the survey. Collectively, these groups comprised many headwater stream sites throughout the study area (Figure 42).

Fish assemblages in group #2 were most distinct from those in groups #3, #5, and #7. Sites in this group were strongly associated with higher local stream gradient values – the highest of the survey (Figure 42). Unsurprisingly, these sites were also among the smallest sites of the study. Overall QHEI scores and all individual components were among the higher values compared to other groupings and were highest among all smaller streams, though some sites in this group did still have limiting habitat factors present. Collectively, these sites had the lowest water temperatures of the survey and had the highest alkalinity and calcium concentrations of the survey, a signature of groundwater inputs from adjacent glacial features. Some sites in this group had outlier ammonia concentrations that were some of the highest observed during the survey (Figure 42). IBI scores across group #2 sites varied widely,

ranging from exceptional to poor quality assemblages. The median value indicates marginally good quality, while fish assemblages at most sites fell in the fair range. Of the 23 sites comprising fish group #2, eleven sites had biological assemblages that did not achieve WWH expectations and five also had at least one organism group in non-significant departure from the WWH criteria (Table 18, Table 19). There may be some room to improve conditions in these streams given the relative underperformance of biological communities in this group compared to the generally good habitat present at these sites.

Of the remaining clades, fish assemblages in group #3 were distinctly different from groups #5 and 7, while the latter two were sister clades (Figure 40). Group #3 sites were associated with higher TKN, ammonia, and nitrite (Figure 42). The presence of higher nitrite and ammonia reflected the reduced conditions present at many of these sites. Group #3 sites were also associated with higher TOC concentrations. Habitat quality was a limiting factor at many of these sites and all components of the QHEI were slightly lower than group #2 sites (Appendix L). Though sites in fish group #3 are spread throughout the study area, they all mostly drain finer grained, lake-deposited sediments (Figure 6). Sites in this group encompass streams that were historically channelized in the past and drain areas formerly influenced heavily by wetlands. Though all sites in this group had discernable streamflow, these stream segments were sluggish and lower gradient. Rock Creek RM 11.69 (U04G18) was interstitial during late season sampling. Only 11 of 21 sites in this group achieved WWH expectations, while nine additional sites had at least one organism group that only marginally achieved WWH expectations (Table 18, Table 19).

Fish groups #5 and #7 had the most closely related assemblages of sites in this sub-clade (Figure 40). Fish group #5 consisted of mostly smaller stream sites located in rural areas throughout the watershed. Most stream sites in this group were formerly channelized and QHEI scores were in the range where habitat may be limiting biological performance (Appendix L). Sites in this group were also strongly associated with TSS, TOC, and TKN, reflecting somewhat of a more enriched condition (Figure 42). Most sites in this group fully or marginally achieved WWH expectations (7 of 12), while three sites achieved MWH-C expectations (Table 18, Table 19). Two sites in this group are ecoregional reference sites – South Branch Muddy Creek RM 5.67 (U04S08) and Gries Ditch RM 0.93 (U04Q16). Silver Creek RM 4.08 (U03G22) and Plum Run RM 0.79 (U04G09) each had one organism group fall short of WWH criteria.

Fish group #7 was a small group of sites, with five locations spread between the Tymochtee Creek watershed and the Little Sandusky River RM 6.52 (U02G16) (Table 19). No sites in this group achieved WWH expectations (Table 18, Table 19). These sites had the lowest IBI scores, by far, of the survey (Figure 42). Substrate quality at these sites was decidedly lower than any other group and many other QHEI components were also the lowest of the survey (Appendix L). These sites also had the highest TOC, TKN, TP, and nitrite concentrations of all other groups. Though nutrient values were generally high, they generally did not manifest as nutrient over enrichment at these sites – most DO values were lower at these sites and no large diel swings were observed (Figure 19, Table 8). There were, however, both minimum and average dissolved oxygen exceedances documented at these sites. Chronically low dissolved oxygen values coupled with high total phosphorus, organic nitrogen, and organic carbon indicate that organic enrichment may be a limiting stressor at some of these sites. Higher nitrites coupled with similar levels of nitrates compared to other groups reflect the nutrient rich conditions

and low gradient, reducing environments at these sites. All these sites encompass poorly drained, lake-deposited sediments and lie in portions of their respective sub watersheds that have been extensively channelized.

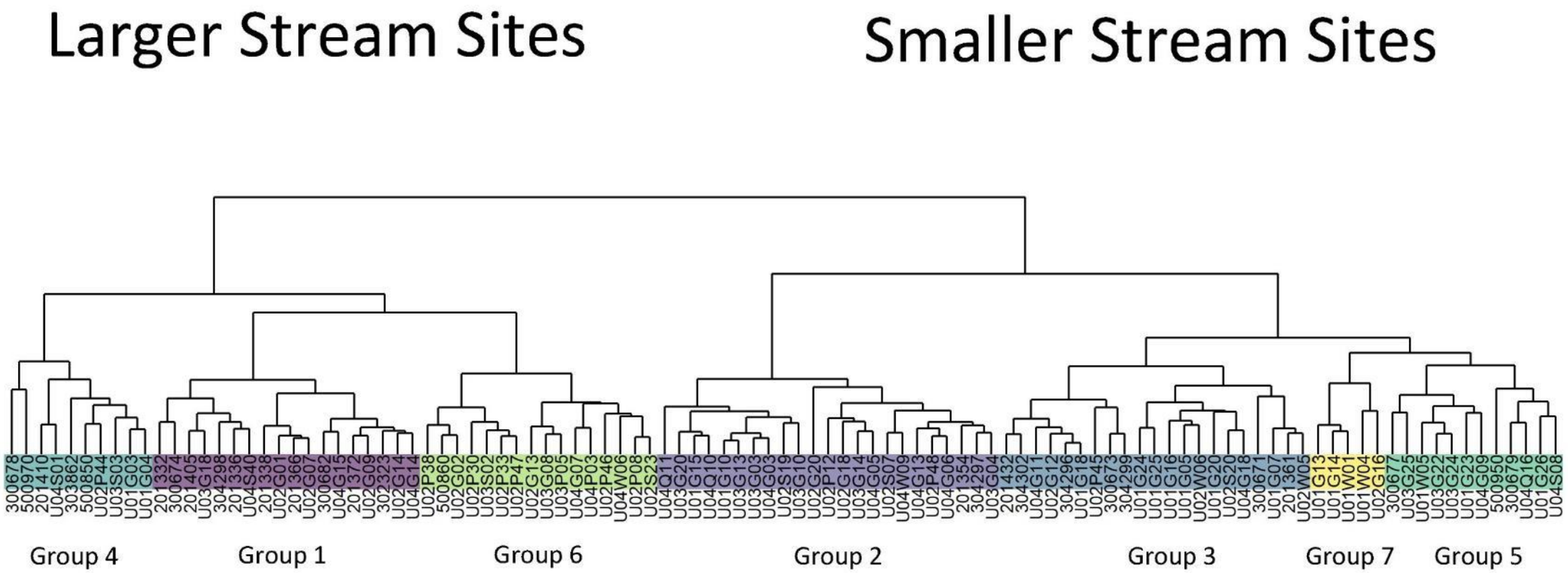


Figure 40 – A dendrogram resulting from hierarchical clustering of fish assemblages sampled from the Sandusky River watershed. Labels hanging from the terminal branches are station codes. Numbers displayed correspond to the clustering groups for survey locations.

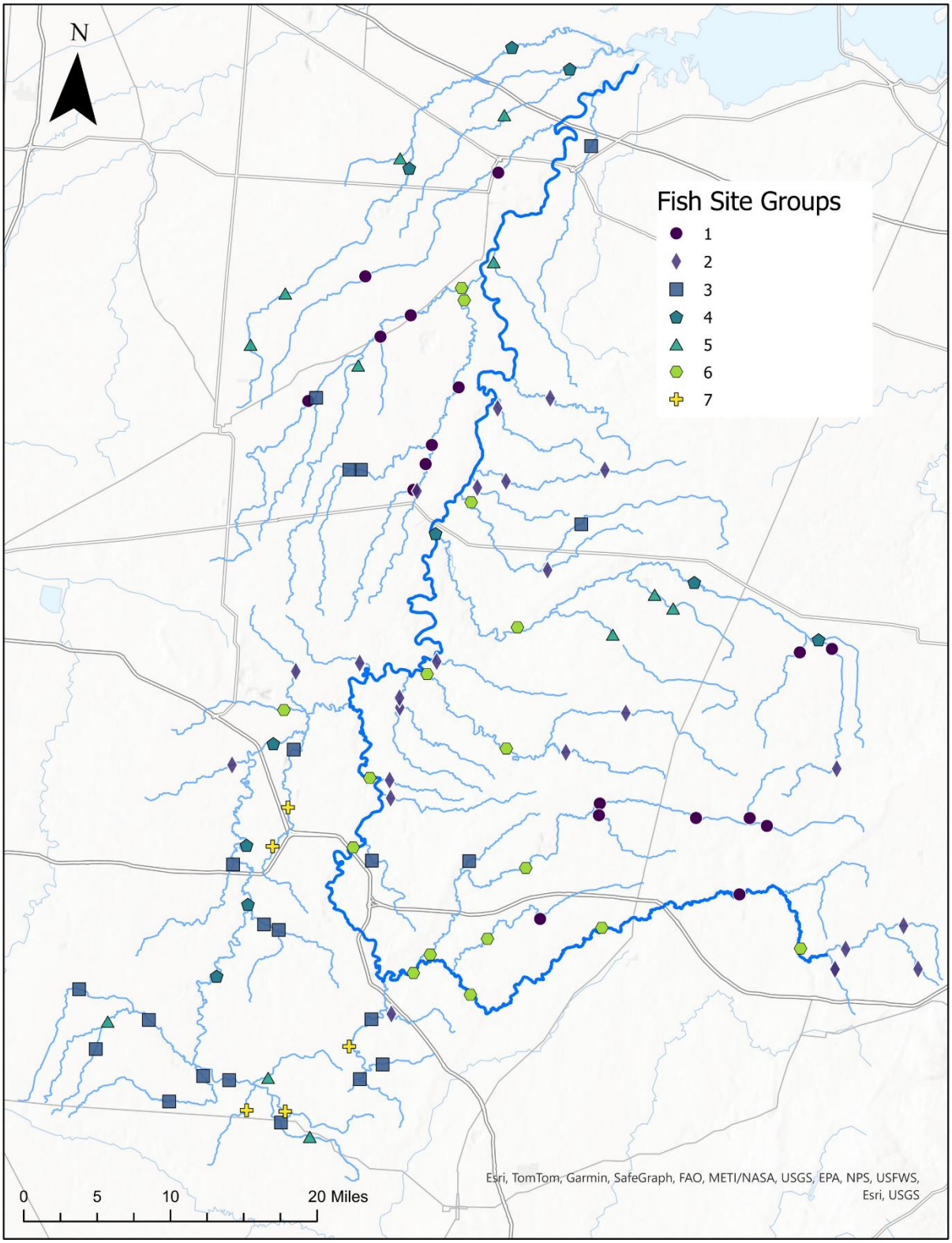


Figure 41 – Map displaying the fish site groupings from the current survey. Fish site groupings correspond to the values shown in Figure 40 and Table 19.

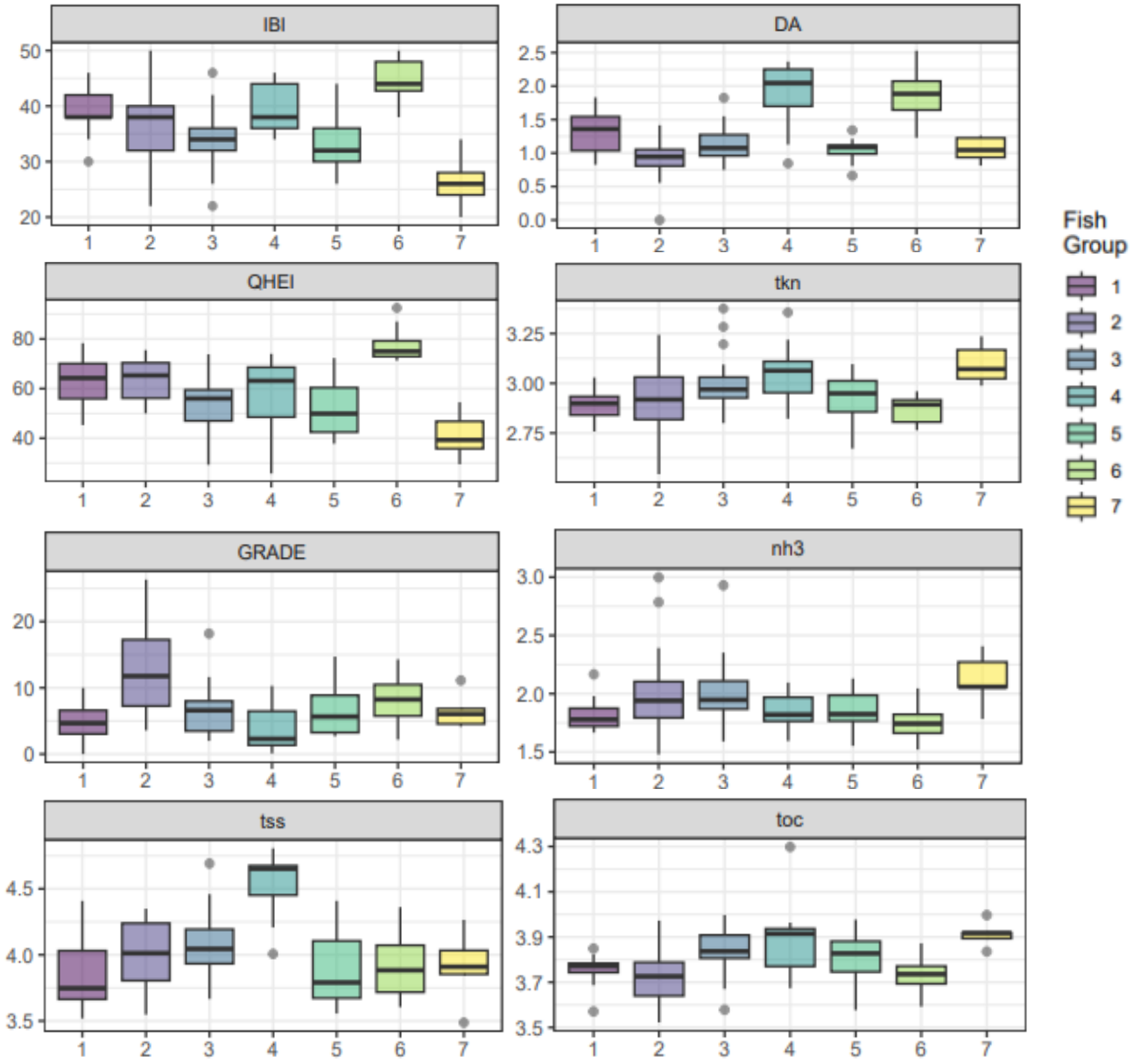


Figure 42 – Selected boxplots showing environmental parameters by fish assemblage groups. A complete list of boxplots for all parameters are found in Appendix L.

Macroinvertebrate Grouping Results

Macroinvertebrate assemblages from sites in the current survey were separated into 6 distinct groupings based on dissimilarity (Figure 43, Table 19).

Sites in macroinvertebrate group #1 were distinctly different from those in all other groups (Figure 43). Sites in this group were most strongly associated with high quality habitat and were also associated with the highest IBI scores of the survey (Figure 45). These sites had lower total phosphorus values than other groups and were generally well-oxygenated. They also had the highest inorganic nitrogen values coupled with the lowest total ammonia values - a common signature of municipal wastewater systems operating effectively. Sites in group #1 also had among the lowest TKN and TOC values of the survey. Total dissolved solids concentrations here were low compared to all other groups. All 25 locations in this group had biological assemblages achieve biocriteria and these sites were generally higher quality (Table 19). Sites in this group included all the Sandusky River mainstem, the lower portions of most major tributaries throughout the watershed, and some portions of streams in the HELP ecoregion with coarser substrates (Muddy Creek RM 21.90 and Gries Ditch RM 0.93) (Table 19).

Macroinvertebrate group #3 was distinct from the other four remaining groups (Figure 43). This was the largest of all macroinvertebrate site groups (n=34), encompassing many of the smallest drainages of sites in the survey. Like group #1, sites in group #3 were also associated with relatively high IBI and QHEI scores (Figure 45). Sites in group #3 had the highest overall stream gradient values, suggesting many are well drained. High QHEI scores, high channel quality scores, and higher overall gradients suggest that many sites in this group have likely recovered from any previous channelization and habitat modifications that may have historically caused impairments. Sites in this group had the lowest TP and TOC values of the survey, while inorganic nitrogen was relatively high, and some sites had higher nitrite concentrations. TKN concentrations, though, were among the lowest of all survey sites. This is likely a reflection of runoff from excess nitrogen fertilizer applications on fields draining to these stream sites. Some sites in this group had some lower DO values, but most sites in group #3 were well-oxygenated. Sites in group #3 had some of the lowest water temperatures of the survey, indicating inputs of cool groundwater to these sites. All 34 sites in this group had macroinvertebrate assemblages that met expected criteria, while only three sites had fish assemblages that fell just short of expectations (Thorn Run RM 0.70 – U03G03, Silver Creek RM 4.08 - U03G22, Morrison Creek RM 2.05 – U04G05) (Table 18). Most sites in this group were smaller tributary streams scattered throughout the watershed (Table 19).

Macroinvertebrate group #2 sites were distinct from the three other remaining groups (Figure 43). Group #2 encompassed the third largest grouping – 17 sites total. Collectively, these sites encompassed slightly smaller drainages than those in group #1 but had distinctly larger drainages than sites in groups #3, #4, #5, and #6. Sites in group #2 were associated with the highest overall water temperatures of the survey. Total suspended solids were significantly correlated with group #2 and total organic carbon was also higher here compared to other site groups. Group #2 sites had the lowest gradient values and lower channel scores compared to other sites with higher IBI scores (groups 1 & 3) (Figure 45). Dissolved oxygen values were lower here compared to other groups and total ammonia

was also somewhat higher, suggesting sluggish and wetland-influenced stream habitats present in this group. These sites were spread throughout the study area and comprised the lower gradient portions of many medium to large tributary streams from the survey, including: Paramour Creek, the middle reaches of the three largest ECBP tributaries – Broken Sword Creek, Tymochtee Creek , and Honey Creek, several tributaries to Tymochtee Creek, much of the Little Sandusky River, upper Wolf Creek, Eicher Ditch, and lower Muddy Creek (Table 19). Most sites in this group (14 of 17) were in the ECBP ecoregion.

Sites in macroinvertebrate group #2 had lower associated fish IBI scores than groups #1 and #3, but most were still decidedly higher than those associated with groups #4, #5, and #6 (Figure 45). The median fish IBI score associated with macroinvertebrate group #3 was only marginally good and there were also some outlier values in the poor range. Of the 17 sites in this group – 8 sites displayed biological impairment (5 fish, 2 macro, 1 both) and 7 sites marginally met respective criteria (5 fish, 1 macro, 1 both), while only 2 sites had both organism groups fully attaining respective criteria (i.e., indexes or narrative scores above the non-significant departure range) (Table 18, Table 19).

Of the remaining three groupings, macroinvertebrate groups #5 and #6 were sister clades and had the most closely related assemblages, while the four sites comprising group #4 were distinctly different (Figure 43). Macroinvertebrate group #4 was comprised of only four sites spread widely throughout the watershed (Table 19). Group #4 sites were characterized by very low QHEI scores, the lowest of all groupings. All QHEI sub-metrics were decidedly lower than other groupings, though substrate quality was the lowest of all (Figure 45, Appendix L). All sites had thick blankets of silt through the zone.

Two of the sites in group #4 were in the Little Sandusky River basin in the southern portion of the study area (Table 19). Much of the Little Sandusky River watershed drains lacustrine derived deposits from former glacial lakes. These areas typically consist of finer grained sediments, more silt, and are generally lower gradient (Figure 6). These areas often require heavier local drainage than others to facilitate agriculture and other development. Another site in this group (Celery Creek RM 0.45 – 303862) is very heavily modified and maintained, draining the rich muck soils and wetlands around Celeryville, OH. The last site in this group (Fishing Creek RM 0.20 - 300678) was near Sandusky Bay and was influenced by Lake Erie backwater conditions.

Macroinvertebrate assemblages in groups #5 and #6 were sister groups and were most closely related but still well partitioned in ordination space (Figure 43, Appendix L). Groups #5 and #6 consisted of a similar number of sites – 11 and 14, respectively. Both groups had generally lower QHEI scores than the other macroinvertebrate groups associated with higher IBI scores – groups #1, #2, and #3 (Figure 45).

Sites in group #5 had slightly higher QHEI scores, gradients, and overall substrate quality compared to group #6 (Figure 45). Groups #5 and #6 also had a disparity between fish and macroinvertebrate community quality. Though sites in both groups had a similar median IBI score, group #5 sites were associated with higher end IBI scores than those in group #6, indicating generally better but somewhat variable fish community quality among group #5 sites. In contrast to fish scores, macroinvertebrate community performance was generally higher at group #6 sites than group #5 sites. Six sites in group #5 had fair macroinvertebrate assemblage quality, while three were marginally good and only two

were good quality. In comparison, group #6 had good quality macroinvertebrate assemblages at four sites, very good at one site, marginally good at six sites, and fair at only three sites.

Macroinvertebrate group #6 sites were strongly associated with total organic carbon and TKN (Figure 45, Appendix L). These sites also had higher ammonia, nitrates and nitrites, and total phosphorus compared to other groups. Macroinvertebrate group #5 sites were also strongly associated with alkalinity, whereas group #6 sites had comparatively more acidic.

Eight of 14 sites in macroinvertebrate group #6 were located in the ECBP ecoregion and five of these eight had the MWH-C aquatic life designation (Table 18). The remaining four sites were in the HELP ecoregion. Despite being associated with lower IBI scores than other groups, no macroinvertebrate assemblages fell below requisite criteria and only four sites had fish assemblages fall short of aquatic life goals (Table 19).

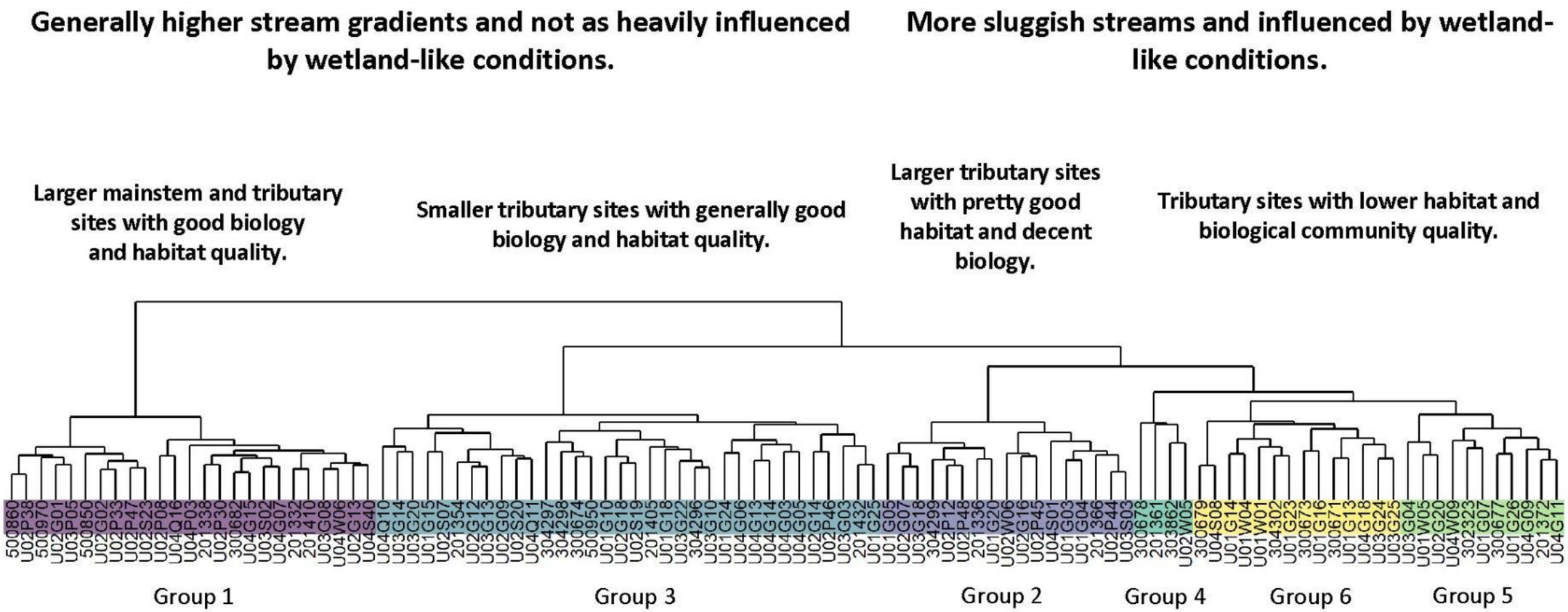


Figure 43 – A dendrogram resulting from hierarchical clustering of results from macroinvertebrate qualitative sampling results from the Sandusky River watershed. Labels hanging from the terminal branches are station codes. Numbers displayed correspond to the clustering groups for survey locations.

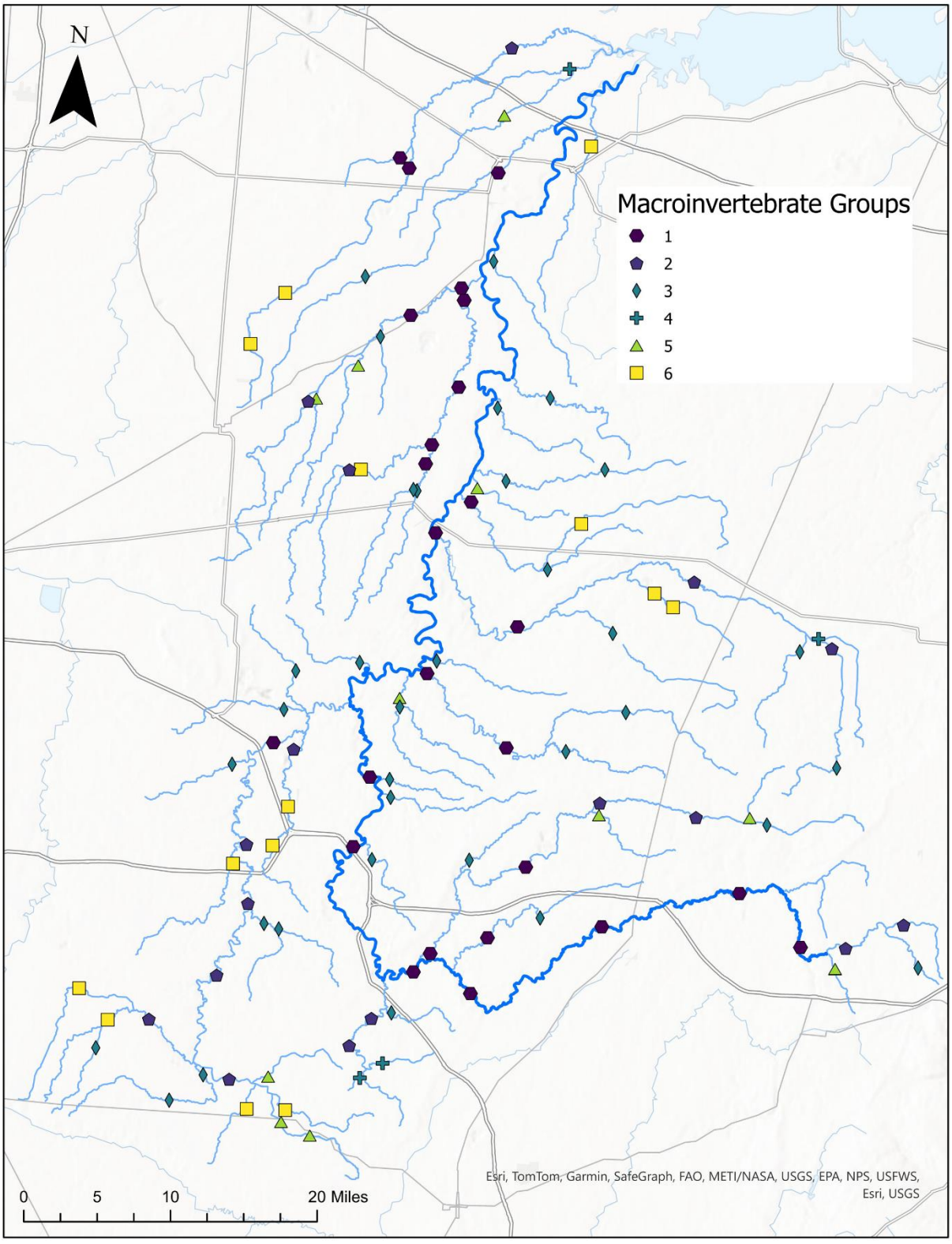


Figure 44 – Map displaying the macroinvertebrate site groupings from the current survey. Macroinvertebrate site groupings correspond to the values shown in Figure 43 and Table 19.

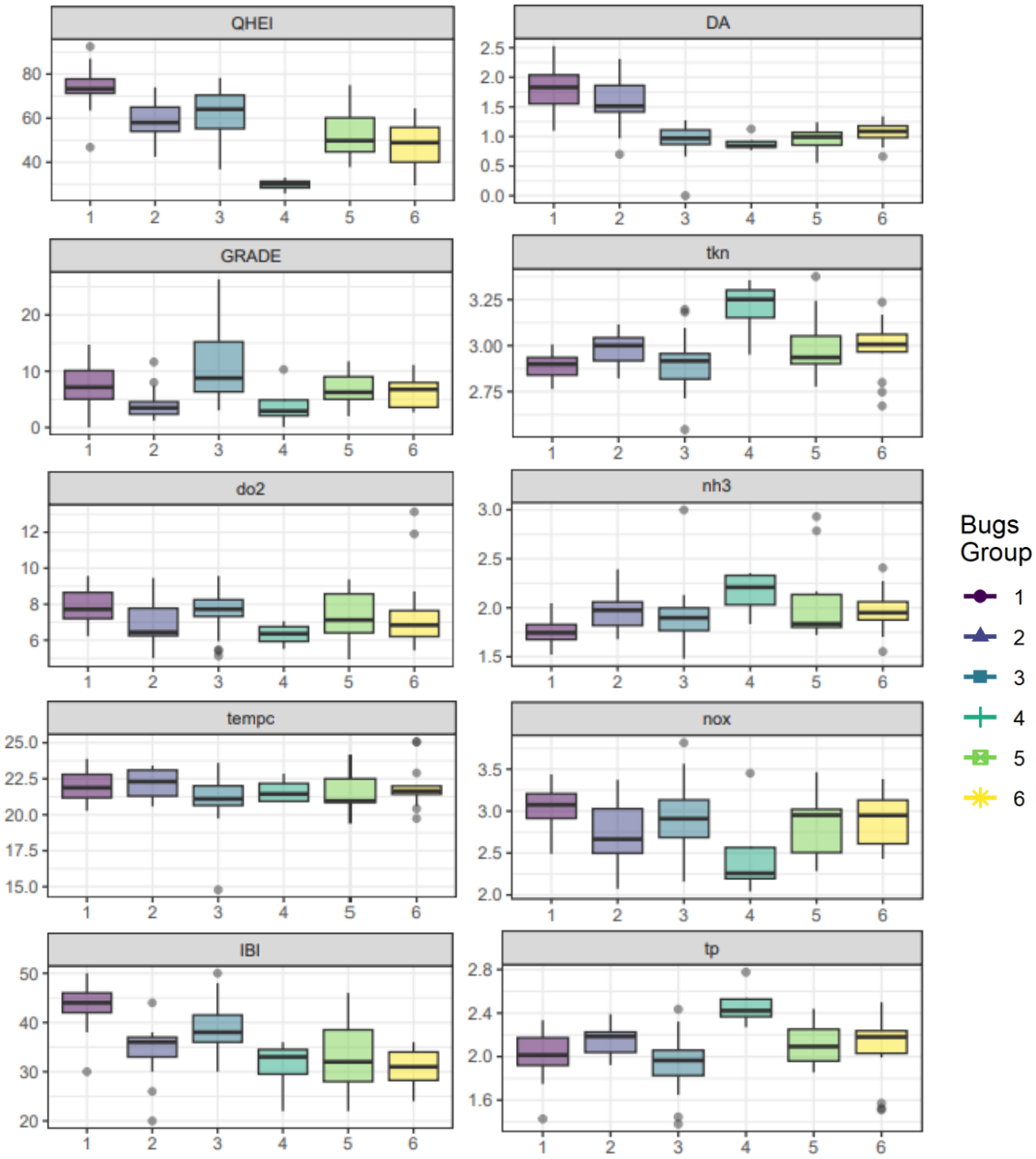


Figure 45 – Selected boxplots showing environmental parameters by macroinvertebrate assemblage groups. A complete list of boxplots for all parameters are found in Appendix L.

Table 19 – Site groupings of the hierarchical clustering results for fish and macroinvertebrate assemblages from the current survey.

*Sites and tributary systems are presented from upstream to downstream as they join the Sandusky River or their respective receiving tributary. An *asterisk* after the organism group number indicates an organism group that did not achieve requisite criterion. An underlined organism group number indicates a site with an existing or recommended sub-use ALU, either MWH or LRW.*

Stream Name	STORET	River Mile	Drainage Area	Fish Group	Macro Group
Sandusky River	U02P08	127.80	35.5	6	1
Sandusky River	U02G01	120.82	67.1	1	1
Sandusky River	U02P30	110.43	88.9	6	1
Sandusky River	U02P33	98.69	109.7	6	1
Sandusky River	U02G02	93.76	232.2	6	1
Sandusky River	500860	78.09	295.5	6	1
Sandusky River	U02P38	72.09	337.6	6	1
Paramour Creek	U02P48	6.15[R]	5.1	2	2*
Paramour Creek	U02P12	1.50	26.0	2*	2
Trib. to Paramour Ck. (5.13)	U02S07	3.70	1.0	2	3
Allen Run	U02G20	1.05	3.6	2*	5
Grass Run	U02G14	8.36	9.1	1	3
Grass Run	U02G13	3.42	18.3	6	1
Broken Sword Creek	U02G09	29.52	10.9	1	3
Broken Sword Creek	U02G07	25.48	32.6	1	2
Broken Sword Creek	201366	19.70	42.0	1*	2
Broken Sword Creek	U02S23	12.30	69.1	6	1
Broken Sword Creek	U02P47	0.87	93.3	6	1
Red Run	201372	0.42	8.0	1	5
Brandywine Creek	302323	0.45	11.1	1*	5*
Indian Run	U02G12	0.75	8.5	3	3
Little Sandusky River	201361	10.40	6.9	3*	4*
Little Sandusky River	U02G16	6.52/6.40	16.8	7*	2*
Little Sandusky River	U02W06	3.71	21.5	3*	2
Trib. to the L. Sandusky. R. (8.93)	U02W05	0.78	5.9	3	4
Honey Run	U02G18	0.52	9.0	2	3
Rock Run	U02S20	1.40	9.4	3	3
Negro Run	U02S19	0.52	13.1	2	3
Sugar Run	201354	0.60	4.6	2	3
Tymochtee Creek	U01W05	51.43	6.4	5	5
Tymochtee Creek	U01G07	49.44	16.1	3*	5*
Tymochtee Creek	U01G05	44.95	64.5	3*	2
Tymochtee Creek	U01G04	33.99	146.2	4	2
Tymochtee Creek	U01G03	26.28	175.0	4	2
Tymochtee Creek	U02P44	19.45	204.3	4	2
Tymochtee Creek	500850	7.80[R]	232.0	4	1
Prairie Run	U01W04	1.02	8.6	7*	6
Enoch Creek	U01W01	1.59	6.5	7	6
Carroll Ditch	U01G26	0.66	10.3	5	5
Pawpaw Run	U01G25	6.13	8.2	3	3

Stream Name	STORET	River Mile	Drainage Area	Fish Group	Macro Group
Pawpaw Run	U01G24	0.80	16.3	3	3
Little Tymochtee Creek (upper)	304302	8.63	11.9	3	6
Little Tymochtee Creek (upper)	U01G20	4.00	35.5	3	2
Reevhorn Run	U01G23	2.26	12.5	5	6
Pawpaw Run (Trib. to Reevhorn)	201432	1.10	5.6	3	3
Warpole Creek	U01G18	1.52	18.8	3	3
St. James Run	304296	0.15	10.7	3	3
Oak Run	U01G16	0.29	15.2	3*	6
Lick Run	U01G15	0.83	7.9	2	3
Lower Little Tymochtee Creek	U01G14	10.32	11.1	7	6
Lower Little Tymochtee Creek	U01G13	6.33	18.5	7*	6
Lower Little Tymochtee Creek	U02P45	1.95	28.4	3*	2*
Spring Run	U02P46	1.71	16.9	6	3
Poverty Run	U01G10	2.99	9.3	2	3
Thorn Run	U03G03	0.70	9.1	2*	3
Taylor Run	U03G04	1.88	17.4	2	5*
Trib. to Taylor Run (2.49)	304297	0.10	6.7	2	3
Sycamore Creek	U03G10	18.92	18.2	2	3
Sycamore Creek	U03G08	9.14	47.2	6	1
Sycamore Creek	U03P05	0.41	64.2	6	1
Spring Creek	U03G13	1.88	8.8	2	3
Mile Run	U03G14	0.30	6.4	2	3
Honey Creek	U03G20	41.66	10.4	2	3
Honey Creek	U03G18	34.14[R]	26.5	1	2
Honey Creek	U03S03	25.03	84.4	4*	2
Honey Creek	U03S02	12.30[R]	149.3	6	1
Honey Creek	500970	1.10/0.2[R]	179.3	4	1
Celery Creek	303862	0.45	13.4	4	4*
Brokenknife Creek	201405	1.05	18.6	1	3
Aicholz Ditch	U03G25	3.72	9.4	5	6
Aicholz Ditch	U03G24	2.46	15.0	5	6
Silver Creek	U03G22	4.08	16.3	5*	3
Rock Creek	U04G18	11.69	14.7	3*	6
Rock Creek	U04W06	0.75	34.5	6	1
East Branch Rock Creek	U04G03	0.47	6.4	2	3
Willow Creek	U04W09	0.82	5.7	2*	5
Morrison Creek	U04G06	9.34	9.3	2	3
Morrison Creek	U04G05	2.36/2.05	16.6	2*	3
Spicer Creek	U04Q11	0.65	12.5	2	3
Sugar Creek	U04Q10	3.20[R]	8.6	2	3
Wolf Creek	201336	13.45	28.1	1	2
Wolf Creek	U04S40	5.60	65.3	1	1
Wolf Creek	U04G07	1.58	71.7	6	1
Harrison Creek	U04G11	0.38	9.1	3	5
Plum Run	U04G09	0.79	9.8	5	5*
Trib. to Wolf Creek (8.10)	304298	0.17	6.7	1	3

Stream Name	STORET	River Mile	Drainage Area	Fish Group	Macro Group
East Branch Wolf Creek	300673	19.13	20.3	3	6
East Branch Wolf Creek	U04G15	13.63	33.2	1	1
East Branch Wolf Creek	201338	9.00	67.8	1	1
East Branch Wolf Creek	U04P03	0.86	82.0	6	1
Eicher Ditch	304299	0.01	9.3	3	2
E. Br. of East Branch Wolf Creek	U04G13	3.40	7.3	2*	3
E. Br. of East Branch Wolf Creek	300682	1.48	19.7	1	1
M. Br. of E. Br. of East Branch Wolf Creek	U04G14	0.10	10.9	1	3
Indian Creek	500950	0.62	12.0	5	3
Muskellunge Creek	300674	16.70	17.7	1	3
Muskellunge Creek	201332	5.40	35.7	1	1
Bark Creek	300671	3.20	10.0	3	6
Muddy Creek	201410	21.90[R]	43.5	4	1
Muddy Creek	U04S01	9.90/9.79	72.8	4	2
South Branch Muddy Creek	U04S08	5.67[R]	4.6	5	6
South Branch Muddy Creek	300679	1.54	21.9	5	6
Gries Ditch	U04Q16	0.93[R]	12.5	5	1
Little Muddy Creek	300677	7.55	12.4	5	5
Fishing Creek	300678	0.20	7.0	4	4*

Individual Waterbody Discussion

Sandusky River mainstem

Biological assemblage quality in the Sandusky River mainstem ranged from marginally good to exceptional (Table 13, Table 16). Most biological index scores were exceptional through the large river portions of the Sandusky River mainstem, while scores trended more toward the good to very good range through the upper mainstem. Most all fish and macroinvertebrate assemblages at sites on the Sandusky River mainstem – groups #6 and #1, respectively – were most closely associated with one another and were associated with the highest IBI and QHEI scores of the survey (Table 19, Figure 42, Figure 45). All sites on the mainstem met the existing or recommended aquatic life use (ALU) criteria – either EWH, WWH, or MWH-I in the Ella Street Dam pool.

Biological community quality has improved throughout the Sandusky River compared to previous surveys. Both IBI and MIwb scores have gradually improved through time, indicating both the improved structural (diversity, numbers, and biomass) and functional components (types of species and proportions) of fish assemblages throughout the Sandusky River (Figure 29). Both indices improved dramatically through much of the Sandusky mainstem from the earliest surveys in 1979/81 to 2001. Only the most upstream reaches did not see higher IBI scores over this period. From 2001 to present, IBI scores improved through the headwater reaches upstream from Bucyrus and remained relatively stable through the rest of the mainstem. The MIwb has increased throughout the mainstem in a generally stepwise fashion during all major watershed surveys. The MIwb is an index that evaluates overall fish numbers, biomass, and overall diversity, while compensating for the highly tolerant fish species that thrive in degraded conditions. In comparison, the IBI is skewed more toward fish community function. Higher MIwb scores equate to higher numbers of desirable fish present and better community diversity, while higher IBI scores reflect a more favorable mix of the types, proportions, and overall physical condition of the fish present. Macroinvertebrate community performance followed a similar pattern to fish over the same periods (Figure 34).

Improvements were evident downstream from Bucyrus, with both fish and macroinvertebrate assemblages now in full attainment of the WWH use at RM 110.43 (U02P30) (Table 18). Both fish and macroinvertebrate assemblages were impaired during the 2001 survey, with sources of impairment attributable to both the Bucyrus WWTPs and CSOs (Ohio EPA 2003). Macroinvertebrate assemblages still did not achieve the WWH criterion during a small 2013 survey, while fish assemblage quality improved somewhat and achieved WWH expectations. Fish index scores now indicated very good to exceptional community quality through this reach in 2022, while the ICI score indicated good community quality. The MIwb score has also increased downstream from the Upper Sandusky WWTP (Figure 29).

The removal of the Ballville Dam in 2018 marked a major milestone for the Sandusky River. There are now over 44 contiguous free-flowing river miles, beginning at the Ella Street Dam in Tiffin, OH downstream to its confluence with Lake Erie. This effort both improved water quality in the immediate vicinity of the old structure and has opened over 20 new river miles of spawning habitat formerly inaccessible to some fish species. Recent studies have shown that native fish species, including Walleye and White Bass, now use the reaches upstream from the dam for spawning (Sasek

2021) and Ohio EPA has also documented its first records other native species like Emerald Shiners, Bigmouth Buffalo, and Smallmouth Buffalo upstream from the former structure. Confirmed angler records have even documented Lake Sturgeon in a tributary to the Sandusky River during spawning (Profitt 2022). Early investigations of the Sandusky River had found that these species formerly thrived through the lower Sandusky River before the installation of dams and systematic drainage through the watershed (Trautman 1975).

Upper Mainstem Tributaries

Tributary streams in the upper Sandusky watershed evaluated during the survey included Paramour Creek, an unnamed tributary to Paramour Creek (5.13), Allen Run, South Fork Loss Creek, and Grass Run (Table 1). Functionally, Paramour Creek is an upstream extension of the Sandusky River mainstem (Figure 4). Nominally, the Sandusky River "starts" at the confluence of Paramour Creek and Allen Run. This portion of the watershed is in the ECBP ecoregion and most streams are higher gradient, draining ground and end moraines (Figure 7). Paramour Creek is lower gradient and drains old lacustrine deposits derived from proglacial lakes and wetlands (Figure 6).

The **Paramour Creek** sub-watershed drains just over 27 mi^2 and encompasses the small village of Crestline, OH. A major wastewater facility, the Crestline WWTP, is situated on an unnamed tributary just upstream from the sampling location on Paramour Creek RM 1.50 (U02P12) (Appendix B). Historically, this facility and associated CSOs had contributed to water quality impairments through lower Paramour Creek (Ohio EPA 2003).

The current survey evaluated the Paramour Creek sub-watershed with three locations – two on Paramour Creek and one on the unnamed tributary to Paramour Creek (5.13) (Table 18). Both Paramour Creek RM 6.15 (U02P48) and the tributary to Paramour Creek (5.13) RM 3.70 (U02S07) are reference locations. These two sites both attained WWH criteria and biological assemblage quality improved compared to results in 2001, when both sites were impaired (Ohio EPA 2003).

Paramour Creek RM 1.50 (U02P12) remains impaired, as both fish indices fell below respective WWH criteria. Macroinvertebrate assemblage quality has remained stable from 2001 to 2022, with good quality communities that met WWH criteria documented during both surveys. Paramour Creek RM 1.50 and the Sandusky River at RM 127.90 (U02P08) are very similar in drainage area. However, the fish assemblages display very distinct differences between these two locations. Only 12 total fish species were collected from Paramour Creek RM 1.50, while 20 species were collected just a few miles downstream on the Sandusky River RM 127.90. Many common species including two native sucker species, three darters, two minnow species, Rock Bass, and Smallmouth Bass were excluded from the entirety of Paramour Creek. Fish assemblages at the three sites in the Paramour Creek sub-basin all grouped together (fish group #2), and along with Allen Run, were the only set of fish group #2 sites in this portion of the study area (Figure 41).

There is a low head dam located near the mouth of Paramour Creek at RM 0.05 (pictured below) that seemingly presents a barrier to fish passage. Given the similarities in drainage area and sufficient habitat, the fish assemblage in Paramour Creek RM 1.50 grouped with other very small tributary sites instead of those comprising the Sandusky mainstem (fish groups #6 or #1). Taken together, this

suggests that this dam is likely influencing the fish assemblage composition through the Paramour Creek sub-basin.


Impoundment on Paramour Creek near mouth

Historically, the Crestline WWTP and CSOs had affected water quality through lower Paramour Creek and contributed to impairments at RM 1.50. This facility had numerous permit limit violations during 2022, and construction of a new facility is currently underway (Appendix B). Despite the permit limit violations from this facility, there was only one minimum dissolved oxygen exceedance documented at RM 1.50 and sondes did not exhibit indicators of over-enrichment, such as large DO swings or prolonged sags, during both deployments in 2022 (Figure 19, Table 7, Table 8).

With fish assemblages being grouped together and the disparity in community composition, the impacts from this dam as an impediment to fish passage are the most direct cause of fish community impairment at Paramour Creek RM 1.50. Given that macroinvertebrate assemblages met WWH criteria, sub-par water quality or habitat quality was likely not causing biological impairments like the degraded conditions observed during 1985 sampling. Removal of this dam would likely result in full attainment of the WWH use through lower Paramour Creek.

Biological assemblages in **Allen Run** RM 1.05 (U02G20) failed to achieve WWH criteria during the current survey and the site was in non-attainment (Table 18), despite having generally good habitat quality (Table 12). This site was fully assessed both in 2022 and 2023. The sampling efforts in 2023 followed up on a documented fish kill that occurred around August 18, 2022. Initial fish sampling occurred in Allen Run RM 1.05 on 7/19/2022 before the kill event that occurred, while macroinvertebrates were also sampled in June before the kill event. A later fish sample occurred after the fish kill on 9/15/2022. Fish index scores fell short of WWH criterion during both sampling events in 2022, with no fish being collected after the fish kill on 9/15/2022. Follow-up sampling in 2023 yielded fish communities that marginally met the WWH criterion (IBI=36) but were still recovering. Low fish numbers and many juveniles were observed, including numerous small White Suckers, while adult fish were nearly absent. There was still a very high proportion of highly tolerant and omnivorous fish, driven mostly by the presence of juvenile White Suckers. Macroinvertebrate assemblages also fell short of WWH expectations in both 2022 and 2023, with only fair community quality being documented in both years. Though biological index scores met WWH criteria at RM 1.05 during the 2001 survey, this site has been in continued non- or partial attainment over the past 4 series of data collections, including efforts in 2011, 2012, 2016, and 2022.

A separate investigation of the fish kill incident outside of this survey by Ohio EPA Emergency Response on 8/18/2022 found elevated ammonia levels in Allen Run, with the source being traced to a

stormwater pond at the Sunrise Cooperative. The company had conducted hydrostatic testing of approximately 40 to 45 anhydrous ammonia tanks over the two days prior to the kill event. At the conclusion of the testing, up to 4,000 gallons of the hydrostatic test water was discharged onto the company parking lot. The ammonia-laden water entered the company's stormwater detention pond and subsequently discharged into Allen Run. A notice of violation (NOV) was issued to the facility on 8/22/2022. Continued monitoring related to the incident indicated periodically high ammonia levels discharging from the stormwater ponds through the fall of 2022 as the company worked to resolve the issues.

Poor water quality was the primary stressor leading to biological impairment in Allen Run. Habitat quality in Allen Run was generally good (Table 18). The current survey documented total ammonia concentrations that exceeded the maximum water quality standard on 7/13/2022, with an instream value of 33.0 mg/l. observed. This value far exceeds all acute toxicity values for aquatic life, as was confirmed during sampling in September 2022 when this site was fishless. Though no other exceedances occurred here, total ammonia concentrations in the remaining grab samples were all elevated in 2022 and 2023, with all grab samples greater than 75th percentile of statewide values and half greater than the 90th percentile of statewide values. A water quality sample collected on July 18, 2012, that was associated with the biological collections at the time also documented an ammonia value of 35.9 mg/L, a level acutely toxic to most aquatic life. The ammonia toxicity issues here appear to be chronic. There has been continued impairment over four reporting cycles since 2011 and a fish kill was also previously documented in 2012 which coincided with the construction of this cooperative in 2010 (Ohio EPA 2003, 2012).

Biological communities from sites in both **South Fork Loss Creek** and **Grass Run** met WWH criteria. Macroinvertebrate community quality through upper Grass Run were decidedly improved (Table 16, Ohio EPA 2003).

Broken Sword Creek sub-basin

Broken Sword Creek joins the upper portion of the Sandusky River downstream from Bucyrus (Figure 4). This system drains just over 94 square miles at its confluence. It originates from the Fort Wayne glacial end moraine and flows through mostly ground moraine confined between end moraines before joining the Sandusky River (Figure 6). Given its proximity to these features, this system receives strong groundwater inputs that help ameliorate habitat and water quality deficiencies, especially in its most upper reaches.

Habitat quality in Broken Sword Creek is generally good or excellent downstream from RM 19.70, but channelization is more pervasive in the upper portions of this sub-watershed and stream modifications here detract from overall habitat quality. Channelization and reduced riparian buffers are evident through Broken Sword Creek upstream from RM 19.70. Like other portions of the watershed that originate from the eastern portion of the watershed, the Broken Sword sub-watershed is higher gradient compared to other systems like Tymochtee Creek (Figure 5). A higher gradient stream system has more energy and can recover more quickly from habitat disturbances like channelization or siltation.

Biological assemblages met WWH criteria at four of five locations on Broken Sword Creek and two of three locations on its principal tributaries (Table 18). Results from the 2022 survey indicated improvements in the Broken Sword Creek sub-basin compared to previous sampling results. Both IBI and MIwb scores have increased through much of the Broken Sword Creek sub-basin, while macroinvertebrate community quality has also generally improved (Figure 31, Figure 36, Table 14, Table 15).

Broken Sword Creek RM 19.70 (201366) and Brandywine Creek RM 0.45 (302323) were two sites that did not meet WWH criteria in this sub-basin. These two sites are in the middle reaches of Broken Sword Creek and are located very close to one another (Figure 4). These middle reaches of Broken Sword Creek around river miles 25-19 are lower gradient than its headwaters or lower reaches (Table 12). This can result in more fines settling through this reach compared to higher gradient reaches.

The average IBI score fell just short of WWH criterion at Broken Sword Creek RM 19.70 (201366) in 2022, while ICI scores attained WWH criteria but were decidedly lower than surrounding reaches. Omnivorous fish species comprised an outsized component of the fish assemblage here compared to other survey sites and the number of qualitative EPT (9) and sensitive (5) macroinvertebrate taxa were among the lower values of similarly sized survey sites (Figure 33). The 2022 survey documented a temperature exceedance at Broken Sword Creek RM 19.70 (Table 7). Sondes also documented a lower dissolved oxygen profile here (5.4-7.9 mg/L) in 2023, though no wide swings or minimum exceedances were observed. This portion of Broken Sword Creek maintains a substantial amount of riparian forest; however, the stream was wide and there was an open canopy near the bridge where sampling occurred. There were wide diel DO swings indicative of nutrient over-enrichment (6.1-14.2 mg/L) documented upstream at RM 25.48 (U02G07) during the same deployment in September 2023, but biological assemblages here met WWH criteria (Figure 19). Moderate to heavy siltation was also noted at RM 19.70 in 2022 and was likely a primary stressor given the low proportions of simple lithophilic fish species found here (Appendix G). While conditions have generally improved through upper Broken Sword Creek and biological assemblages met WWH criteria, nutrient over-enrichment signatures were still present here. Groundwater from the adjacent glacial moraines helped ameliorate habitat deficiencies and other issues here.

Brandywine Creek RM 0.45 (302323) had both fish and macroinvertebrate assemblages fall short of WWH criteria (Table 18). This site was first monitored in 2013, and biological assemblages have largely failed to achieve WWH criteria since. Fish communities marginally met WWH criteria in 2018 (IBI=36) but again fell short in 2022. Macroinvertebrate assemblage quality was poor in 2013 and improved to fair in 2022 but still failed to achieve WWH expectations. Habitat quality was generally good here, though the stream was sluggish and excessive silt and sedimentation was present throughout the reach evaluated (Appendix H). Sondes documented a prolonged period of low DO from 9/12/2023 through 9/14-2023 (Figure 19). Both minimum DO exceedances and a 24-hour DO average criterion exceedance for the entire duration of the sonde deployment, lasting 47 consecutives reading hours, were documented here (Table 8). Values as low as 1.7 mg/L were recorded during this deployment. These prolonged periods of very low DO in a large headwater stream are likely indicative of excessive organic loadings. A possible source of excess loading was runoff from a large pile of construction debris and other materials dumped immediately upstream from Holmes Center Road.

This pile lacked any runoff mitigation and had increased in size substantially since around 2015. There may also be contributions from local agricultural sources or poorly performing septic systems upstream. General habitat limitations and flow regime alterations through Brandywine Creek exacerbate impacts from excess loadings to this system by reducing stream assimilative capacity.

Little Sandusky River sub-basin

The Little Sandusky River and its two primary tributaries were evaluated at five locations total (Table 18). This system abuts upper Tymochtee Creek. Like Tymochtee Creek, this sub-watershed is lower gradient and drains almost entirely fine-grained lacustrine deposits (Figure 6). Many waterways in this small sub-watershed have been heavily modified to facilitate drainage.

All three locations on the Little Sandusky River were in non-attainment of WWH criteria, while the site at RM 10.40 (201361) failed to even achieve MWH-C criteria (Table 18). Biological community quality in this sub-watershed has changed little here since the earliest Ohio EPA sampling efforts in the mid-1990s. Fish community quality remains generally poor and communities are characterized by low abundances of highly tolerant individuals (Table 14, Appendix C). Macroinvertebrate assemblages also failed to achieve expectations at the two upper locations on the Little Sandusky River and only marginally achieved WWH criterion at RM 3.71 (U02W06). All sites on the Little Sandusky River had fewer numbers of EPT and sensitive taxa than other similarly sized streams in the study area (Figure 33), and assemblages were comprised mostly of tolerant organisms or ecological generalists (Table 16).

Habitat quality is an obvious factor affecting biological community at all sites in the Little Sandusky River, with thick blankets of siltation, channelization, and other negative influence habitat features pervasive throughout (Appendix H). All sites had scores in the range where habitat is likely causing or contributing to biological impairment (Figure 21). Additionally, minimum and average DO exceedances were documented during a sonde deployment from 8/30-9/1/2022 (Figure 19). Values as low as 3.0 mg/l were documented and minimum DO average exceedances lasted for as long as 29 hours (Table 8). It is likely that impacts from organic over enrichment are negatively impacting this sub-watershed as a whole and are also directly related to impairment at the lowermost site at RM 3.71 (U02W06). No continuous sonde data was collected from upstream sites in this watershed. Sources of excessive organic inputs to this portion of the watershed include agricultural sources, the unsewered village of Morral, and failing home septic treatment systems. The small village of Morral is working to find funding and is in the design stages to become sewered.

The unnamed **tributary to the Little Sandusky (8.93)** and **Honey Run** were evaluated at one location each (Table 18). Biological assemblages attained the MWH criterion in the unnamed tributary and communities reflected the heavily modified habitats and pervasive siltation present here. Habitat quality was much better in Honey Run compared to the rest of the Little Sandusky sub-basin and biological assemblages reflected this, with fish and macroinvertebrate communities being good and exceptional, respectively. Honey Run drains a comparatively higher proportion of glacial end moraines than the rest of the Little Sandusky River basin and has a higher gradient than all other sites sampled here (Appendix H).

Tymochtee Creek sub-basin

Tymochtee Creek is the largest tributary system to the Sandusky River, draining over 304 mi^2 at its confluence with the Sandusky River north of Upper Sandusky, OH. Tymochtee Creek and the upper segment of the Sandusky River converge to form the large river segment of the Sandusky River. The watershed almost doubles in size downstream from this confluence.

Tymochtee Creek is a sluggish, low-gradient stream system splayed between adjacent glacial end moraines. It drains areas comprised predominantly of finer, lacustrine deposited sediments like pea gravels, sand, and silt (Figure 6). Instream habitats through much of this sub-basin tend to resemble those common in the HELP ecoregion, despite it being located well within the ECBP ecoregion. Historically, Tymochtee Creek was a major source of non-point source sediment and phosphorus to the Sandusky River (Baker 1975). Many streams in this watershed retain good riparian buffers and profuse amounts of large woody debris that create habitat for the instream biota. Logjams several tenths of a river mile long aren't uncommon in portions of Tymochtee Creek, like the one encountered at RM 33.99 (U01G04). However, these logjams also can create areas of constricted flow, and coupled with the fine-grained sediments, can help provide good habitat for freshwater mussels. Eight different freshwater mussel species were collected from Tymochtee Creek RM 33.99.

Tymochtee Creek was evaluated at seven locations in 2022 and met applicable biological criteria at 5 of 7 locations (Table 18). This has been a substantial improvement since the 2001 survey, when all but one of these same locations, the reference site at RM 7.8 (500850), fell short of these same criteria (Ohio EPA 2001). Fish assemblages through most of the Tymochtee Creek were closely related with other sluggish, wetland-influenced sites (fish group #6) and index scores generally decreased from good-excellent to poor quality in an upstream progression. Macroinvertebrate community performance, however, was marginally good to excellent through the lower reaches and fair in the uppermost headwaters.

The headwaters of the Tymochtee Creek sub-basin have been very heavily modified in the past, including the complete straightening of larger mainstem segments around Marseilles, OH. This results in long stretches of upper Tymochtee Creek that consists of deeper glide habitats with pervasive siltation and sub-par instream development. Despite this, the adjacent forested riparian areas remain generally intact. Given the generally good riparian corridors through much of Tymochtee Creek and low stream gradient, inputs of leaf matter accumulate in early fall and can result a very dark, tannic stain in the waters through upper Tymochtee Creek. This was observed during several instances of late season sampling.

Tymochtee Creek RM 49.44 (U01G07) had both fish and macroinvertebrate assemblages fail to achieve WWH criteria. Despite the site being in non-attainment, both fish and macroinvertebrate assemblages have improved and attainment of the WWH criteria may be feasible if further improvements occur here. However, the predominance of moderate-influence negative features suggest habitat is likely limiting biological performance here still (Appendix H). Additionally, both minimum and average DO exceedances documented on a sonde deployment from 9/12/2023 through 9/14/2023 were indicative of excessive organic inputs (Figure 19, Table 8). Tymochtee Creek RM 44.95 (U01G05) was also in partial attainment of its ALU, however macroinvertebrate community quality marginally met WWH criteria

and there were no DO exceedances documented during the sonde deployment or in surface grab samples here. Pervasive siltation and flow regime modifications related to channelization are most directly related to the fish community impairments here.

Prairie Run, **Enoch Ditch**, and **Carroll Ditch** all convene to form the uppermost lobe of the Tymochtee Creek watershed and all three have been heavily modified throughout. These streams were evaluated at one location each. All these streams have an existing or recommended MWH-C ALU, and all had negative influence habitat ratios that would suggest habitat features limit biological performance (Appendix H). Fish assemblages in Prairie Run fell short of MWH-C criterion during one of two sampling events in 2022. Only five individual fish, encompassing three species, were collected on 7/26/2022, whereas 143 individuals and seven species were collected on 9/22/2022. Poor habitat quality here was related to pervasive siltation, lack of channel development, and general lack of water in the stream related to pervasive hydromodifications through this portion of the watershed. Given the very low number of fish species collected on 7/26/2022, an unreported fish kill event may have impacted biological communities early in the summer. Pervasive hydromodifications and general de-watering through this portion of the watershed will also continue to impact biological assemblages in these tributaries, especially regarding fish community performance.

Little Tymochtee Creek (upper) and Pawpaw Run from another lobe and join Tymochtee Creek from the west before the stream system turns northward and cuts through the Fort Wayne end moraine (Figure 6). Biological assemblages at both sites in **Pawpaw Run (05-319-000)** have improved substantially over time and met WWH criteria in 2022 (Ohio EPA 2003, Table 18). **Little Tymochtee Creek (upper)** was assessed at two locations on its mainstem and two locations on its principal tributaries. Though biological assemblage quality has generally improved through this stream system, wide DO swings indicative of nutrient over-enrichment were present and were likely a stressor through this system (Figure 19). **Reevhorn Run** and **Pawpaw Run (05-318-000)** combine to form the largest tributary system to the Little Tymochtee Creek (upper). Pawpaw Run is a small tributary to Reevhorn Run and fish communities fell short of the WWH criteria at RM 1.10 (201432), though macroinvertebrate community quality was good. Overall habitat quality was poor and elevated modified-influence habitat ratios suggest habitat here is limiting biological performance (Appendix H). No elevated DO ranges were documented here that would be indicative of nutrient over-enrichment. No prior biological samples have been collected from Reevhorn Run.

Warpole Creek, **St. James Run**, **Oak Run**, and **Lick Run** all drain to the middle portions of Tymochtee Creek and were all evaluated with one site each. Three of four streams had biological assemblages that met WWH criteria, while the IBI in Oak Run fell just short of meeting the WWH criterion. Three different IBI metrics were near cutoff values that could have all potentially resulted in positive two-point swings. Habitat here was sluggish and heavy siltation throughout the zone likely limited fish community performance enough to result in the minor impairment observed here. No prior biological sampling has occurred in St. James Run or Warpole Creek. Fish assemblages were similar in Warpole Creek RM 1.55 (U01G18), while the numbers of overall and sensitive macroinvertebrate taxa have notably increased. Both fish and macroinvertebrate community performance has improved in lower Lick Run.

Little Tymochtee Creek (lower) was evaluated at three locations along its length and biological community performance was fair to poor. Biological communities have improved somewhat through the upper reaches of this tributary. The most upstream site at RM 10.32 (U01G14) met the MWH-C criterion in 2022, having failed to attain this 2001 (Ohio EPA 2003). Biological community quality also improved somewhat through the remainder of Little Tymochtee Creek (lower) since 2001, though both fish and macroinvertebrate assemblages still did not attain WWH criteria (Table 18).

Habitat quality through the remaining portions of Little Tymochtee Creek (lower) was fair to poor. Conditions were characterized by a modified channel with sluggish flows and a streambed blanketed with heavy siltation. Additionally, continuous water quality sondes at RM 6.87 (U01G13) noted minimum DO exceedances as low as 3.7 mg/L and 24-hour average DO concentrations values below their respective criteria for five hours. Modified habitat and excessive siltation remain the primary stressors in this system, while signatures of organic enrichment suggest this as an additional cause of impairment at RM 6.87. Agriculture and failing HSTS are possible sources of excess organic inputs. Channelization and habitat modifications exacerbated issues with excess organic inputs here.

Spring Run and **Poverty Run** are the two lowermost tributaries that join Tymochtee Creek just before its confluence with the Sandusky River. These streams were sampled at one location each and met WWH criteria at both locations. Both fish and macroinvertebrate assemblages have improved markedly through lower Spring Run at RM 1.71 (U02P46) since 2001 (Table 18). The Carey WWTP formerly impacted lower Spring Run causing biological impairments, but no chemical exceedances or declines in biological performance were noted in 2022 (Ohio EPA 2003).

Middle Sandusky River tributaries

Several other smaller tributaries join the Sandusky River mainstem as it turns northward before transitioning into the HELP ecoregion. Those sampled included (upstream to downstream) Rock Run, Negro Run, Sugar Run, Taylor Run, Sycamore Creek, Thorn Run, and Mile Run. Like the Little Sandusky River and Tymochtee Creek sub-watershed, many of these tributaries drain pockets of fine-grained, lake deposited sediments (Figure 6). Portions of these tributary streams also cut through glacially deposited ground and end moraines that provide sufficient gradient and groundwater inputs.

Both **Thorn Run** and **Taylor Run** join the Sandusky River just downstream from Tymochtee Creek. Like Tymochtee Creek, Thorn Run and Taylor Run also drain predominantly fine-grained, lacustrine deposited sediments. Lacustrine derived sediments comprise approximately 82% and 54% of the drainages Thorn Run and Taylor Run, respectively, while values for all other middle Sandusky tributaries ranged from only 7-30% (Figure 6). The downstream reaches of these two streams are lower gradient systems and are more likely to accumulate excessive sediments than other area headwater streams.

As such, Thorn Run and Taylor Run had comparatively lower biological community quality than the other sites that join the Sandusky River in this area. Biological assemblages ranged from fair to good and the two sites sampled in these streams were only in partial attainment of their ALU (Table 18). Though both sites still fell short of attaining WWH, biological community quality has generally improved since the 2001 survey. Fish assemblages at Thorn Run RM 0.70 (U03G03) improved from poor quality in 2001 to fair in 2022 and nearly met WWH expectations. Macroinvertebrate

performance here improved from fair to good over the same period (Ohio EPA 2003). Fish assemblages also improved at Taylor Run RM 1.88 (U03G04), while macroinvertebrate assemblage quality fell to the fair range.

Despite good quality habitat present in Thorn Run, sampling noted heavy siltation and extensive embeddedness at RM 0.70. Only moderate amounts of siltation were noted in Taylor Run. The upper reaches of both streams have been heavily modified & channelized to facilitate drainage. No chemical water quality exceedances were documented in either stream in 2022 (Table 7). Habitat modifications and excessive siltation/sedimentation were the two most prominent stressors to biological assemblages in these two streams. Thorn Run RM 0.70 is also downstream from the unsewered village of McCutchenville, Ohio. Though there has been progress and biological community impairments aren't directly caused by nutrient or organic enrichment, underperforming septic systems and associated untreated sewage may provide a source of pathogens.

Sycamore Creek is a larger tributary system to the Sandusky River, draining just over 60 mi^2 at its confluence. Sycamore Creek joins the Sandusky River from the east and is situated between two other major tributary streams in the watershed, Broken Sword Creek and Honey Creek. The lowermost and uppermost reaches of the Sycamore Creek sub-watershed drain lacustrine deposited sediments, though most of the system cuts through glacial end and ground moraines. Most stream segments in this sub-watershed are higher gradient and their instream substrates are generally comprised of coarse till materials.

Sycamore Creek and its main tributary, Spring Creek, were evaluated at four total locations (Table 18). Biological communities met WWH criteria at all four locations in 2022. Both fish and macroinvertebrate performance has notably improved through Sycamore Creek since 2001, when two of three locations did not meet WWH criteria. A large fire at a tire recycling facility and the subsequent stormwater runoff significantly impacted water quality in 1999, including acutely toxic levels of some contaminants (Ohio EPA 2000). The impacts from this event were a continued source of non-attainment during the 2001 survey (Ohio EPA 2003). The 2022 survey documented full recovery of biological index scores from this event. Sycamore Creek is now among the highest-quality tributaries in the Sandusky River watershed. A lack of any freshwater mussels documented in Sycamore Creek despite ideal habitat may reflect the legacy impacts from this event (Table 17).

Biological assemblages met WWH criteria at all four sampling locations in **Rock Run**, **Negro Run**, **Sugar Run**, and **Mile Run**. The quality of the biological community has improved in all these systems since 2001. Three sites sampled in Rock Run, Sugar Run, and Mile Run all formerly failed to meet WWH criteria in 2001 (Ohio EPA 2003).

Honey Creek sub-basin

Honey Creek is the last major tributary stream that joins the Sandusky River before the watershed transitions into the HELP Ecoregion (Figure 7). Most of this system is lower relief, though higher gradient areas with exposed bedrock and large glacial till materials are present around river mile 12. Otherwise, most sediments through Honey Creek and its tributaries consist of finer grained sand and gravels. The uppermost portion of Honey Creek and Celery Creek drain portions of a large swamp, Willard Marsh, that was historically much larger. Aside from being generally productive agricultural

lands, peat deposits in the area make soils feasible for vegetable farming (celery, lettuce, radishes, etc.). The streams in this area are heavily modified and maintained to facilitate drainage in these productive agricultural areas.

Both fish and macroinvertebrate index scores have improved markedly through Honey Creek and its tributaries. Four of five locations on Honey Creek met WWH criteria in 2022, while only one of these same five sites met WWH criteria during the 2001 survey (Ohio EPA 2003). Across all five locations, the average IBI and MIwb scores increased from 36.2/7.3 in 2001 to 40.6/8.7 in 2022. Macroinvertebrate assemblages also improved and were generally high quality throughout Honey Creek, including exceptional quality communities documented through the lowermost reaches (Table 18).

Only the fish MIwb score fell just below WWH criterion at Honey Creek RM 25.03 (U03S03), resulting in partial attainment through this reach. This site had heavy blankets of silt and was a generally sluggish zone with profuse amounts of large woody debris. The only semblances of a riffle here were woody constrictions near the beginning of the zone. Aside from elevated iron, there were no other chemical exceedances at this site (Table 7, Table 8). This was an improvement since 2001, when both DO and temperature exceedances were observed here (Ohio EPA 2003). Similarly, continuous water quality sonde data from 2022 did not exhibit large DO swings and instream nutrient concentrations here were only in a moderate risk category for over-enrichment (Table 9).

Fish assemblages at Honey Creek RM 25.03 were not grouped with the other free-flowing sites in Honey Creek but were in fish group #4 along with other silty, low-gradient sites scattered throughout the watershed like Muddy Creek and Tymochtee Creek (Figure 42, Table 19). Fish abundance here was low and sensitive species were nearly absent (Appendix E). The predominance of highly tolerant fish species and low abundances of simple lithophilic species suggest that the negative impacts from excessive siltation are the primary factor limiting fish assemblage quality here. The low proportions of omnivorous fish and high proportions of insectivorous species suggest that nutrient over-enrichment is not a primary source of impairment at this site. This site is downstream from Celery Creek (discussed below), a major source of sediment to this portion of Honey Creek.

Celery Creek is the most upstream tributary to Honey Creek and the location sampled may be wholly artificial. This portion of the watershed encompassed the heart of the former Williard Marsh and is currently heavily maintained and extensively drained. The habitat quality observed in Celery Creek was among the worst encountered during the survey and negative habitat attributes far outweigh natural stream habitat characteristics (Table 12, Appendix H). Conditions were characterized by a simplified, straight stream channel with no riparian shading and vast swaths of shin-deep silt and muck. Some depth heterogeneity was present around large drainage tile outlets, but the evaluation reach was otherwise shallow. Macroinvertebrate assemblages here (group #4) were most similar to several other sites that had the heaviest siltation of the survey, including a site in the backwaters of a small, direct Lake Erie tributary (Fishing Creek RM 0.20 – 300678). Many streams in this area are heavily dipped and maintained to facilitate drainage. Excessive siltation, direct habitat alterations, and flow regime alterations from subsurface drainage were the most direct and obvious factors limiting biological performance here.

Celery Creek RM 0.45 (303862) also had wide DO swings (8.2 mg/L) documented, while nutrient concentrations were in the medium risk category (Figure 20, Table 9). The wide DO swings documented here did not extend downstream into Honey Creek at RM 25.03. Nutrient over-enrichment signatures at RM 0.45 were unsurprising given the poor habitat quality and a general lack of assimilative capacity through this reach. Despite the presence of nutrient over-enrichment signatures in Celery Creek, poor habitat quality and fish assemblages that met MWH-C criteria suggest that sub-par habitat quality is likely the primary cause of biological impairment here. Any impacts to biological assemblages from nutrient over-enrichment here are secondary and reflect the highly modified nature of the habitat in a portion of the watershed that is intensively farmed.

Brokenknife Creek, Aicholz Ditch, and **Celery Creek** were the three other principal tributaries to Honey Creek evaluated in 2022. The three sites located in Brokenknife Creek and Aicholz Ditch achieved their respective ALU criteria in 2022 (Table 18). This has been an improvement since 2001, when two of these three sites were impaired (Ohio EPA 2003). Fish assemblage quality in Silver Creek at RM 4.08 (U03G22) was only fair and fell just short of achieving WWH criteria. Instream habitat quality was only fair, excessive amounts of silt, and generally homogenous habitat were limiting factors here. There were no chemical water quality exceedances documented. Fish abundance was low and the IBI score here had values for several metrics near scoring cut-off lines, including: the number of darters species, headwater species, minnow species, and total species. Macroinvertebrate assemblage quality, however, was good. Good quality macroinvertebrate assemblages, coupled with fish assemblages that nearly met WWH criteria suggest that habitat related stressors are likely the primary cause of biological impairment here.

Lower Sandusky River Tributaries

Tributaries in the lowermost portion of the watershed were all generally located around the divide between the lake-plane sediments of the HELP ecoregion and the newest, Wisconsin-aged glacial formations that roughly form the ECBP/HELP eco-region divide (Figure 6). Streams in this portion of the watershed generally displayed a mix of features between the ECBP and HELP ecoregions.

Rock Creek is the first of several tributary streams that join the Sandusky River through this area. It drains just over 34 mi.^{2} at its confluence in downtown Tiffin, OH. Two sites were located on Rock Creek and one on East Branch Rock Creek (Table 18). Only the lowermost site in Rock Creek at RM 0.75 (U04W06) met WWH criteria. The habitat conditions here were unlike upper Rock Creek. This segment of Rock Creek flows over limestone bedrock and is higher gradient than the sluggish flows and fine-grained sediments present upstream.

Rock Creek at RM 11.69 (U04G18) was lower gradient and interstitial flows were observed during a second fish sampling event on 9/15/2022. Macroinvertebrate assemblages here marginally met WWH expectations, while fish scores were only fair. Habitat sampling also noted heavy siltation and excessive sedimentation here. Iron concentrations were the only chemical water quality exceedances observed here (Table 7, Table 8). Continuous water quality sondes demonstrated a somewhat elevated DO range (6.2 mg/L), though it was still below the over-enrichment threshold of 6.5 mg/L. Excessive siltation, flow alterations, and generally low flows at the time of sampling were most directly responsible for the aquatic life impairments observed here. The upper reaches of Rock Creek have

already demonstrated two cycles of non-attainment (2001 and 2022). If biological impairments persist during future assessments, this reach should be considered for the MWH-C use.

Macroinvertebrate assemblage quality was only fair quality in **East Branch Rock Creek** RM 0.47 (U04G03) and did not meet WWH expectations, while fish assemblage quality only marginally met (Table 18). Habitat quality here was better compared to upper Rock Creek, but this reach was much shallower overall and there were low flows present when sampled. The pervasiveness of siltation was still moderate to heavy, and while this reach wasn't channelized, much of the upper Rock Creek watershed is impacted by hydromodifications from channelization. No water quality exceedances were observed here (Table 7). Siltation and widespread hydromodifications are the most direct stressors to biological assemblages here and through the upper portions of the Rock Creek sub-watershed.

Willow Creek and **Morrison Creek** are two other small tributaries to the Sandusky River on the outskirts of Tiffin, OH. Though these two streams drain portions of Tiffin, most of the upper reaches of their drainages encompass row crop agriculture. Both streams have been heavily modified along their entire length to facilitate drainage. All of Willow Creek and the upper reaches of Morrison Creek maintain MWH-C designations verified by previous surveys. Fish assemblages in Willow Creek fell just short of attaining the MWH-C criterion (Table 18). Excessive siltation smothering natural substrates, and flow regime alterations from channelization and stormwater runoff were the primary causes of biological impairment in Willow Creek. There were no chemical water quality exceedances here (Table 7).

Figure 46 – Aerial imagery from before and after riparian removal and channelization activities in upper Morrison Creek, 2018 and 2021.

Biological assemblages at Morrison Creek RM 9.34 (U04G06) met its MWH-C use, while the lower location at RM 2.36 (U04G05) fell short of achieving WWH goals (Table 18). Despite the good overall habitat quality and macroinvertebrate community quality at RM 2.36, fish community quality was only fair. There were no water quality exceedances from either surface water grab samples or continuous water quality sondes (Table 7, Table 8). This site did have some highwall bank erosion and was scoured from flashy stormwater flows due to hydromodifications. Several large stream segments in the Morrison Creek watershed were freshly channelized in the years immediately preceding the 2022 survey. Figure 46 displays a before and after aerial of one such segment. Flow regime alterations

associated with upstream channelization, coupled with excessive siltation are likely the primary contributors to the fish community impairment observed here.

Spicer Run, **Sugar Creek** and **Indian Creek** are the three remaining tributaries evaluated that join the Sandusky River mainstem through its free-flowing sections. All other tributaries evaluated during the survey discharge to the Sandusky River lacustuary or directly to Sandusky Bay. The three sites located in these tributaries all met or exceeded WWH criteria. Spicer Creek at RM 0.70 (U04Q11) was formerly impaired here in 2009, with only fair quality fish assemblages being observed (Ohio EPA 2011). Fish IBI scores improved from 34 to 44 since the previous survey (Table 14). Macroinvertebrate assemblage quality was also much higher in Sugar Creek and Indian Creek in 2022 compared to 2009, while fish assemblage quality was also slightly improved.

Bark Creek and **Muskellunge Creek** were evaluated at three total locations in the free-flowing segments of these tributaries. The lowermost reaches of both Muskellunge Creek and Bark Creek are backwaters to Sandusky Bay. Biological assemblages met WWH criteria at all three locations and community quality was stable or improved in both streams since 2009 (Table 18, Ohio EPA 2011).

Wolf Creek sub-basin

The Wolf Creek sub-basin is the principal tributary system to the lowermost section of the Sandusky River, joining just before the river becomes lake affected. The entire subbasin drains just over 156 mi.^{2} and consists of two, nearly equal sized lobes - Wolf Creek (about 72 mi.^{2}) and East Branch Wolf Creek (about 84 mi.^{2}). These two lobes converge about a mile upstream from where they join the Sandusky River (Figure 4). Both streams originate from the Defiance Moraine that roughly comprises the HELP/ECBP ecoregion divide before coursing through a mix of lake deposited sediments and former beach ridges (Figure 6).

Biological assemblages were evaluated at 14 total sites in this basin – three in **Wolf Creek**, four **in East Brach Wolf Creek**, and seven sites in six different tributary streams. All seven sites in Wolf Creek and East Branch Wolf Creek met or exceeded WWH criteria. Habitat quality was good to excellent across all sites and there were no chemical water quality exceedances (Table 7, Table 8). Exposed bedrock and a natural escarpment are present in East Branch Wolf Creek at RM 0.8 (U04P03). Macroinvertebrate community quality was among the highest across all survey tributary sites, especially in the lower reaches (Table 16). Fish scores have remained relatively stable or were somewhat improved across these sites, while macroinvertebrate community performance has improved more decidedly across all locations since 2009 (Ohio EPA 2011).

Of the three tributaries to Wolf Creek assessed, only macroinvertebrate assemblages in **Plum Run** RM 0.79 (U04G09) fell short of WWH expectations (Table 18). This site was a recovering agricultural ditch with excessive amounts of siltation and fair overall habitat quality (Table 12). There were no chemical water quality exceedances here. Siltation, and habitat/flow alterations from channelization were the most direct causes of biological impairment here. The two sites in **Harrison Creek** and **tributary to Wolf Creek (8.10)** both met WWH criteria. Macroinvertebrate assemblage quality in Harrison Creek RM 0.38 (U04G07) has improved substantially, from poor quality communities observed in 2009 to good quality in 2022. The tributary to Wolf Creek (8.10) had not previously been sampled.

Tributaries to East Branch Wolf Creek evaluated during the 2022 survey include **Eicher Ditch**, **East Branch of East Branch Wolf Creek**, and **Middle Branch of East Branch of East Branch Wolf Creek** (Table 18). Biological assemblages met WWH criteria at three of four locations, with only fish assemblages in East Branch of the East Branch of Wolf Creek at RM 3.52 (U04G13) falling below the WWH criterion. This site had generally good habitat quality (Table 12) and there were no chemical water quality exceedances documented here (Table 7), but this reach has been formerly channelized. The most upstream portions of this stream are agricultural and have also been channelized to facilitate drainage. Additionally, there are several other newer, large commercial complexes located upstream from this site and a new sports facility was constructed adjacent the stream around 2005-2006. The stream at RM 3.52 was deeply entrenched within leveed banks, limiting access to its floodplain here. The combination of direct habitat alterations here from legacy channelization and changes to the hydrology from channelization and developed areas are likely the primary sources of biological impairment here.

Muddy Creek and tributaries

Streams in this portion of the study area are entirely within the HELP ecoregion and drain mostly lower gradient areas with fine grained sediments. Streams evaluated here included Muddy Creek, South Branch Muddy Creek, Gries Ditch, Little Muddy Creek, and Fishing Creek. Little Muddy Creek and Fishing Creek are separated from each other and the Muddy Creek sub-watershed by Lake Erie backwaters.

The two sites in **Muddy Creek** met WWH criteria. Biological community performance in Muddy Creek was stable at RM 9.79 and much improved at RM 21.10 (Table 18, Ohio EPA 2011). The three sites in **South Branch Muddy Creek** and **Gries Ditch** also met WWH criteria, despite habitat limitations and low flows being present in each stream (Appendix H). Biological assemblages in **Little Muddy Creek** at RM 7.55 (300677) also met WWH criteria, an improvement since 2009 when only poor-quality assemblages were documented here.

Fishing Creek at RM 0.20 (300678) is within Lake Erie backwaters. Biological community quality here has improved only slightly since 2009 and still fell short of WWH criteria for flowing streams (Table 18, Ohio EPA 2011). Habitat quality here was very poor (Table 12). The zone was wide with no visible flow, somewhat shallow with knee high silt, and flanked with cattails and other aquatic macrophytes all along its banks. There were wide DO swings recorded here due to the shallow conditions, open canopy, and general lack of flow (Table 9). There was also one minimum DO exceedance observed in a chemistry grab sample and average minimum exceedances documented with continuous water quality sondes (Table 7, Table 8). The fish and macroinvertebrate communities collected here reflected the natural lack of flow and silty conditions present in the backwater area of this small tributary stream draining to the Sandusky Bay.

Fish Tissue Sampling, Consumption Advisories, and Human Health Beneficial Use Attainment

Background

Ohio releases the *Sport Fish Consumption Advisory* on an annual basis with fish consumption advice frequency based on fish tissue contaminant data obtained during Ohio EPA biological and water quality studies. Fish contaminant data are used to establish safe meal frequencies for human consumption, such as "*two meals per week", "one meal per month*," or *"do not eat"*. Based on these determinations, fish advisories are issued for specific species and locations.

A minimum of three samples of a single species collected within the past 10 years is required to issue a species-specific fish advisory. Since 2001, Ohio has also implemented a statewide fish consumption advisory to address potential mercury contamination from global atmospheric deposition in areas where insufficient data are available.

The statewide advisories include:

- Sunfish (e.g., Bluegill (*Lepomis macrochirus*), Pumpkinseed (*Lepomis gibbosus*) and Yellow Perch (*Perca flavescens*): Two meals per week
- Northern Pike, Flathead Catfish (longer than 23 inches), and Steelhead Trout (*Oncorhynchus mykiss*) (in Lake Erie and its tributaries): One meal per month
- All other species: One meal per week

In addition to setting safe meal frequencies, fish contaminant data are used to assess attainment with human health water quality criteria, as outlined in Ohio Administrative Code Rules 3745-1-33 and 3745-1-34. These criteria, expressed as water column concentrations (µg/L), are translated into tissue concentrations (mg/kg) for comparison with fish tissue data. Contaminants such as PCBs, mercury, DDT, chlordane, mirex, and hexachlorobenzene are evaluated against these criteria to determine attainment status. Further details can be found in *Section E of Ohio's 2024 Integrated Water Quality Monitoring and Assessment Report*, which reports the attainment status of Ohio's watershed assessment units (HUC12).

To achieve attainment with water quality standards, fish collected within a watershed assessment unit in the Lake Erie Basin must have weighted average concentrations (based on geometric means for all species) below:

- 0.350 mg/kg for mercury
- 0.023 mg/kg for PCBs
- 0.140 mg/kg for DDT
- 0.130 mg/kg for chlordane
- 0.029 mg/kg for hexachlorobenzene
- 0.088 mg/kg for mirex

At least two samples from trophic level three species and two samples from trophic level four species collected within the last 10 years are required for analysis of each assessment unit. An exception is made for assessment units with 10 or more samples from one trophic level and only one sample from

the other trophic level. Assessment units that do not meet the sample requirements are classified as having "Insufficient or No Data".

Mercury and Total PCBs

Mercury and total PCBs are the most common contaminants prompting fish consumption advisories and non-attainment of the Human Health Beneficial Use in Ohio. Mercury was the most widely detected contaminant in fish tissue throughout the 2022 survey area, while PCBs were detected in several samples. Less common contaminants (DDT, chlordane, hexachlorobenzene, Mirex, etc.) were either below detection limits or were detected at concentrations too low to trigger fish consumption advisories or an impaired Human Health Use attainment status. Consequently, the focus of this section is on mercury and total PCBs

Broken Sword Creek

Mercury and total PCBs concentrations from fish tissue collected in 2022 from Broken Sword Creek can be found in Table 20. Sufficient data were available to assess the need for fish consumption advisories for Channel Catfish and Common Carp (*Cyprinus carpio*). Mercury concentrations in Channel Catfish and Common Carp were consistent with the statewide advisory of *one fish meal per week* for both species. Although fish tissue contaminants were also sampled in Broken Sword Creek in 1996, the available data did not meet the requirements to determine the need for consumption advisories for any species during that year.

Table 20 – Mercury and total PCB concentrations for fish tissue samples collected in 2022 from Broken Sword Creek.

River Mile	Station	Fish Species	Trophic Level	HUC12	Mercury (mg/kg)	Total PCBs (mg/kg)
0.87	U02P47	Channel Catfish	3	041000110302	0.223	< Detection Limit
0.87	U02P47	Common Carp	3	041000110302	0.309	< Detection Limit
12.41	U02S23	Channel Catfish	3	041000110302	0.235	< Detection Limit
12.41	U02S23	Channel Catfish	3	041000110302	0.093	< Detection Limit
12.41	U02S23	Common Carp	3	041000110302	0.276	< Detection Limit
12.41	U02S23	Common Carp	3	041000110302	0.170	< Detection Limit
12.41	U02S23	Common Carp	3	041000110302	0.114	< Detection Limit
12.41	U02S23	Common Carp	3	041000110302	0.084	< Detection Limit
12.41	U02S23	Smallmouth Bass	4	041000110302	0.221	< Detection Limit
12.41	U02S23	Smallmouth Bass	4	041000110302	0.489	< Detection Limit

When evaluating mercury concentrations in fish tissue, it is often helpful to group sample data by trophic level. Since mercury concentrations increase with an organism's position in the food web (i.e., predatory fish have higher levels than herbivorous or insectivorous fish), results can be averaged annually within each trophic level and compared across years to provide a more informative analysis. Figure 47 presents a comparison of mercury levels in trophic level 3 and trophic level 4 fish from Broken Sword Creek in 1996 versus 2022.

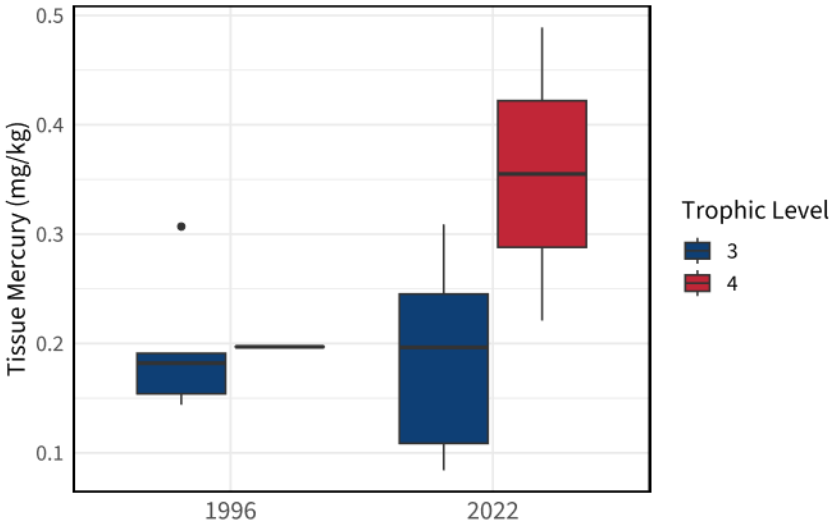


Figure 47 – Fish tissue mercury levels in trophic level 3 and trophic level 4 species collected from Broken Sword Creek in 1996 and 2022.

Trophic level 3 fish tissue mercury did not increase significantly from 1996 to 2022 (one-way ANOVA, $P = 0.619$). No statistical comparison could be made for trophic level 4 species as only one sample was collected in 1996. However, all samples collected in 2022 had greater tissue mercury than the sample collected in 1996. These findings indicate that from 1996 to 2022 there was no increase in fish tissue mercury in trophic level 3 species and there was possibly a slight increase in tissue mercury in trophic level 4 species.

Total PCB levels in fish tissue from Broken Sword Creek were below the detection limit in all samples collected (Table 20). This was consistent with results from 1996 where all samples were also below the limit of detection. This suggests that risks from PCB contamination in Broken Sword Creek are minimal.

The sites sampled in Broken Sword Creek during the survey are all contained within the Indian Run-Broken Sword Creek watershed assessment unit (HUC12: 041000110302). Levels of contaminants in the tissue of fish collected from the Indian Run-Broken Sword Creek Assessment Unit were sufficiently low that this assessment unit was listed as unimpaired in Ohio's 2024 Integrated Report. The attainment status of this assessment unit has not been determined in the Integrated Report prior to 2024.

Tymochtee Creek

Fish tissue mercury and total PCB data collected from Tymochtee Creek in 2021 and 2022 are presented in Table 21. Several samples were collected in 2021 at one location in Tymochtee Creek as part of a dedicated fish tissue effort. The 2022 effort was used to collect any additional materials needed from the remainder of Tymochtee Creek. Sufficient samples were available to evaluate the need for fish consumption advisories for Channel Catfish, Common Carp, and Largemouth Bass in this

waterbody. Total PCB levels were below the detection limit in all samples, while mercury levels for each species fell within the range recommending a statewide advisory of one-meal-per-week.

Based on data collected in 2001, a mercury advisory limiting consumption to one meal per month was established in 2004 for Channel Catfish in Tymochtee Creek from State Route 37 (Marseilles) to the Sandusky River. The data collected from 2021 and 2022 indicated a decrease in mercury levels in Channel Catfish tissue within this reach of Tymochtee Creek. As a result, the one meal per month mercury advisory was rescinded in Ohio's 2023 Sport Fish Consumption Advisory, reverting to the statewide recommendation of one meal per week.

Table 21 – Mercury and total PCB concentrations for fish tissue samples collected in 2021 and 2022 from Tymochtee Creek.

Site Name	RM	Year	Species	Trophic Level	HUC12	Mercury (mg/kg)	Total PCBs (mg/kg)
TYMOCHTEE CREEK AT CRAWFORD @ ST. RT. 199	8.060	2022	Channel Catfish	3	041000110605	0.305	< Detection Limit
TYMOCHTEE CREEK AT CRAWFORD @ ST. RT. 199	8.060	2022	Channel Catfish	3	041000110605	0.255	< Detection Limit
TYMOCHTEE CREEK AT CRAWFORD @ ST. RT. 199	8.060	2022	Channel Catfish	3	041000110605	0.229	< Detection Limit
TYMOCHTEE CREEK NEAR UPPER SANDUSKY @ TWP. RD. 49	19.45	2022	Channel Catfish	3	041000110602	0.301	< Detection Limit
TYMOCHTEE CREEK NEAR UPPER SANDUSKY @ TWP. RD. 49	19.45	2022	Channel Catfish	3	041000110602	0.208	< Detection Limit
TYMOCHTEE CREEK NEAR UPPER SANDUSKY @ TWP. RD. 49	19.45	2022	Channel Catfish	3	041000110602	0.133	< Detection Limit
TYMOCHTEE CREEK W OF UPPER SANDUSKY @ ST. RT. 53	26.28	2022	Channel Catfish	3	041000110602	0.188	< Detection Limit
TYMOCHTEE CREEK W OF UPPER SANDUSKY @ ST. RT. 53	26.28	2022	Channel Catfish	3	041000110602	0.118	< Detection Limit
TYMOCHTEE CREEK N OF MARSEILLES @ TWP. RD. 97	33.99	2022	Channel Catfish	3	041000110509	0.284	< Detection Limit
TYMOCHTEE CREEK AT ST. RT. 37 ADJ. CEMETERY	41.40	2021	Common Carp	3	041000110509	0.179	< Detection Limit
TYMOCHTEE CREEK AT ST. RT. 37 ADJ. CEMETERY	41.40	2021	Common Carp	3	041000110509	0.156	< Detection Limit
TYMOCHTEE CREEK AT ST. RT. 37 ADJ. CEMETERY	41.40	2021	Common Carp	3	041000110509	0.181	< Detection Limit
TYMOCHTEE CREEK AT ST. RT. 37 ADJ. CEMETERY	41.40	2021	Channel Catfish	3	041000110509	0.199	< Detection Limit
TYMOCHTEE CREEK AT ST. RT. 37 ADJ. CEMETERY	41.40	2021	Channel Catfish	3	041000110509	0.228	< Detection Limit

Site Name	RM	Year	Species	Trophic Level	HUC12	Mercury (mg/kg)	Total PCBs (mg/kg)
TYMOCHTEE CREEK AT ST. RT. 37 ADJ. CEMETERY	41.40	2021	Channel Catfish	3	041000110509	0.114	< Detection Limit
TYMOCHTEE CREEK AT ST. RT. 37 ADJ. CEMETERY	41.40	2021	Largemouth Bass	4	041000110509	0.237	< Detection Limit
TYMOCHTEE CREEK AT ST. RT. 37 ADJ. CEMETERY	41.40	2021	Largemouth Bass	4	041000110509	0.210	< Detection Limit
TYMOCHTEE CREEK AT ST. RT. 37 ADJ. CEMETERY	41.40	2021	Largemouth Bass	4	041000110509	0.191	< Detection Limit
TYMOCHTEE CREEK AT ST. RT. 37 ADJ. CEMETERY	41.40	2021	White Crappie	3	041000110509	0.122	< Detection Limit

Figure 48 compares mercury levels in trophic level 3 and trophic level 4 fish from Tymochtee Creek in 1996, 2001, 2021, and 2022. Because tissue mercury data were not normally distributed, a Kruskal-Wallis test with a Dunn post-hoc test was used for statistical comparisons across years. Significant differences were found among years for trophic level 3 species ($P = 0.030$) but not for trophic level 4 species ($P = 0.119$).

The Dunn post-hoc test identified a significant difference between 1996 and 2022 (adjusted $P = 0.018$), but no other comparisons among years were statistically significant (all $P < 0.05$). These findings indicate that mercury levels in trophic level 3 species were significantly higher in 2022 than in 1996. However, most fish tissue samples analyzed in 2022 were either below or only slightly above the *one meal per week* consumption advisory threshold for mercury (0.220 mg/kg); therefore, no consumption advisories beyond the statewide guidance were warranted.

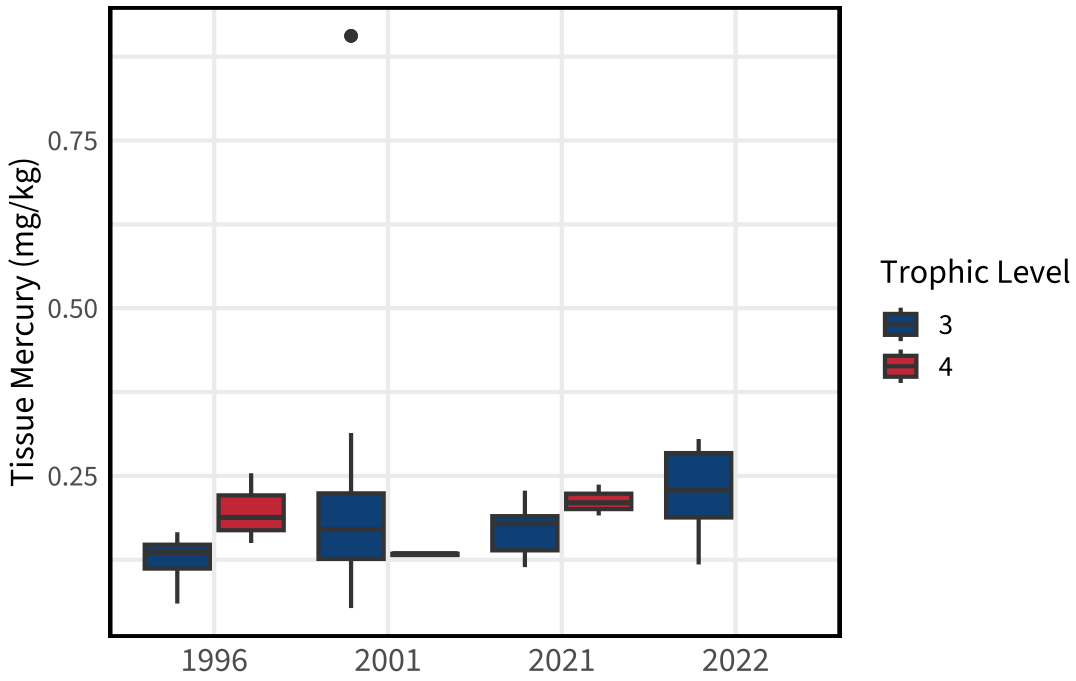


Figure 48 – Fish tissue mercury levels in trophic level 3 and trophic level 4 species collected from Muddy Creek in 1996, 2001, 2021, and 2022.

Total PCB levels in fish tissue from Tymochtee Creek were below the detection limit in all samples collected (Table 21). This aligns with results from 1996 and 2001, where all samples were also below the detection limit, indicating that PCB contamination in Tymochtee Creek has historically been minimal and remains low.

The sampling sites in Tymochtee Creek during the Sandusky River Watershed and Muddy Creek Survey were located in three Integrated Report watershed assessment units: Mouth Tymochtee Creek (HUC12: 041000110605), Baughman Run-Tymochtee Creek (HUC12: 041000110602), and Enoch Creek-Tymochtee Creek (HUC12: 041000110509).

In the 2024 Integrated Report, the Mouth Tymochtee Creek and Enoch Creek-Tymochtee Creek assessment units were classified as Unimpaired. The Mouth Tymochtee Creek unit had previously received the same classification based on 2001 data, while the status of Enoch Creek-Tymochtee Creek had not been determined before. The Baughman Run-Tymochtee Creek assessment unit was classified as having insufficient data in the 2024 Integrated Report due to the absence of trophic level 4 species in the samples. Prior to 2024, its attainment status had not been determined in the Integrated Report.

Sycamore Creek

Mercury and total PCB concentration found in fish tissue from Sycamore Creek in 2022 can be found in Table 22. Sufficient data were available to assess a fish consumption advisory for Channel Catfish. Mercury was detected at a level where the statewide advisory of one fish meal per week was recommended. Fish tissue contaminants were also analyzed from Sycamore Creek in 2000. Even though sufficient data was collected during this historical survey to determine if consumption advisories for Central Stoneroller, Common Carp, Creek Chub, and Rock Bass were necessary, the contaminant levels detected at the time suggested the statewide one meal per week advisory was appropriate. Sampling of non-sport fish species in 2000 occurred in response to a large pollution event (Ohio EPA 2000).

Figure 49 presents a comparison of mercury levels in trophic level 3 species from Sycamore Creek in 2000 versus 2022. Mercury levels were not significantly higher in 2022 compared to 2000 (one-way ANOVA, $P = 0.193$). Trophic level 2 and 4 species were collected in 2000; however, no yearly comparisons of contaminants at these trophic levels could be made because these species were not collected from Sycamore Creek in 2022.

Table 22 – Mercury and total PCB concentrations for fish tissue samples collected in 2022 from Sycamore Creek.

River Mile	Station	Species	Trophic Level	HUC12	Mercury (mg/kg)	Total PCBs (mg/kg)
0.41	U03P05	Channel Catfish	3	041000110903	0.204	< Detection Limit
0.41	U03P05	Channel Catfish	3	041000110903	0.180	0.027
0.41	U03P05	Channel Catfish	3	041000110903	0.205	< Detection Limit
0.41	U03P05	Rock Bass	3	041000110903	0.225	< Detection Limit

River Mile	Station	Species	Trophic Level	HUC12	Mercury (mg/kg)	Total PCBs (mg/kg)
9.14	U03G08	Channel Catfish	3	041000110903	0.297	0.034
9.14	U03G08	Channel Catfish	3	041000110903	0.158	< Detection Limit

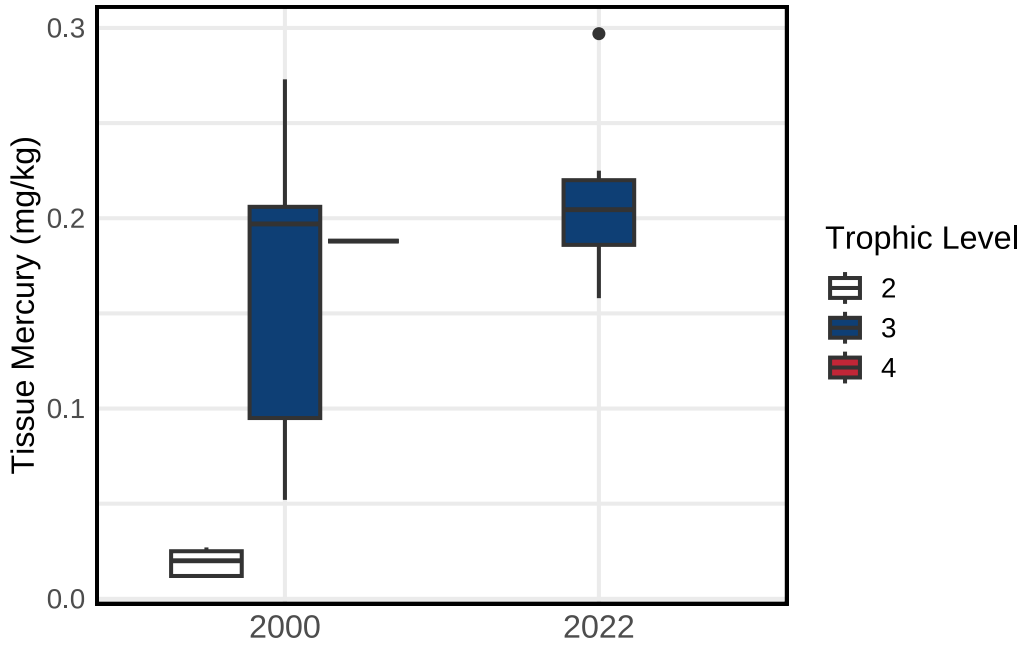


Figure 49 – Fish tissue mercury levels in trophic level 2, trophic level 3, and trophic level 4 species collected from Sycamore Creek in 2000 and 2022.

Total PCB concentrations in fish tissue from Sycamore Creek were generally low, though two samples of Channel Catfish were above the detection limit (Table 22). Despite being above the detection limit, total PCBs in these samples were still in the range (< 0.050 mg/kg) that would be recommended for unrestricted fish consumption. These total PCB levels were consistent with those from 2000, where all samples were below the method detection limits. These results suggest that PCB contamination in Sycamore Creek is present, but the impacts to water quality have been minimal over the period of record.

The sites sampled in Sycamore Creek during the Survey are contained in the Greasy Run-Sycamore Creek watershed assessment unit (HUC12: 041000110903). Because no trophic level 4 species were collected within this assessment unit it was classified as having insufficient data in the 2024 Integrated Report. The attainment status of this assessment unit was not determined in the Integrated Report prior to 2024.

Honey Creek

Fish tissue mercury and total PCBs data collected in 2022 from Honey Creek can be found in Table 23. Sufficient data were available to assess fish consumption advisories of Common Carp and Channel Catfish. Mercury concentrations in Common Carp were consistent with the general statewide

consumption advisory of one meal per week, while a one-meal per month mercury advisory was issued for Channel Catfish. Although fish tissue contaminants were also sampled in Honey Creek in 1996 and 2000, the available data did not meet the requirements to determine the need for consumption advisories during those years.

Figure 50 presents a comparison of mercury levels in trophic level 3 and trophic level 4 fish from Honey Creek in 1996, 2000, and 2022. Because tissue mercury data were not normally distributed, a Kruskal-Wallis test with a Dunn post-hoc test were used for statistical comparisons among years. Slight significant differences were identified among years for both trophic level 3 ($P = 0.048$) and trophic level 4 ($P = 0.048$) species, however, no significant differences among years were identified with the Dunn test (all comparisons $P < 0.05$). These findings suggest that any change in fish tissue mercury from 1996 to 2022 in Honey Creek was generally small.

Total PCB levels in fish tissue from Honey Creek were below the detection limit for all samples collected (Table 23). These results were consistent with results from 1996 and 2000, where all samples also had total PCBs below the detection limit. These results suggest that there are likely no impacts from PCB contamination in Honey Creek.

Table 23 – Mercury and total PCB concentrations for fish tissue samples collected in 2022 from Honey Creek.

River Mile	Station	Species	Trophic Level	HUC12	Mercury (mg/kg)	Total PCBs (mg/kg)
0.20	500970	Channel Catfish	3	041000110806	0.219	< Detection Limit
0.20	500970	Channel Catfish	3	041000110806	0.178	< Detection Limit
0.20	500970	Common Carp	3	041000110806	0.135	< Detection Limit
0.20	500970	Common Carp	3	041000110806	0.281	< Detection Limit
0.20	500970	Largemouth Bass	4	041000110806	0.396	< Detection Limit
0.20	500970	Largemouth Bass	4	041000110806	0.252	< Detection Limit
12.30	U03S02	Channel Catfish	3	041000110806	0.252	< Detection Limit
12.30	U03S02	Channel Catfish	3	041000110806	0.456	< Detection Limit
12.30	U03S02	Channel Catfish	3	041000110806	0.150	< Detection Limit
12.30	U03S02	Common Carp	3	041000110806	0.189	< Detection Limit
12.30	U03S02	Common Carp	3	041000110806	0.159	< Detection Limit
12.30	U03S02	Rock Bass	3	041000110806	0.173	< Detection Limit
12.30	U03S02	Rock Bass	3	041000110806	0.263	< Detection Limit

River Mile	Station	Species	Trophic Level	HUC12	Mercury (mg/kg)	Total PCBs (mg/kg)
12.30	U03S02	Smallmouth Bass	4	041000110806	0.263	< Detection Limit
12.30	U03S02	Smallmouth Bass	4	041000110806	0.566	< Detection Limit
12.30	U03S02	Yellow Bullhead	3	041000110806	0.170	< Detection Limit
25.03	U03S03	Channel Catfish	3	041000110805	0.202	< Detection Limit
25.03	U03S03	Common Carp	3	041000110805	0.118	< Detection Limit
25.03	U03S03	Common Carp	3	041000110805	0.146	< Detection Limit
25.03	U03S03	Yellow Bullhead	3	041000110805	0.284	< Detection Limit

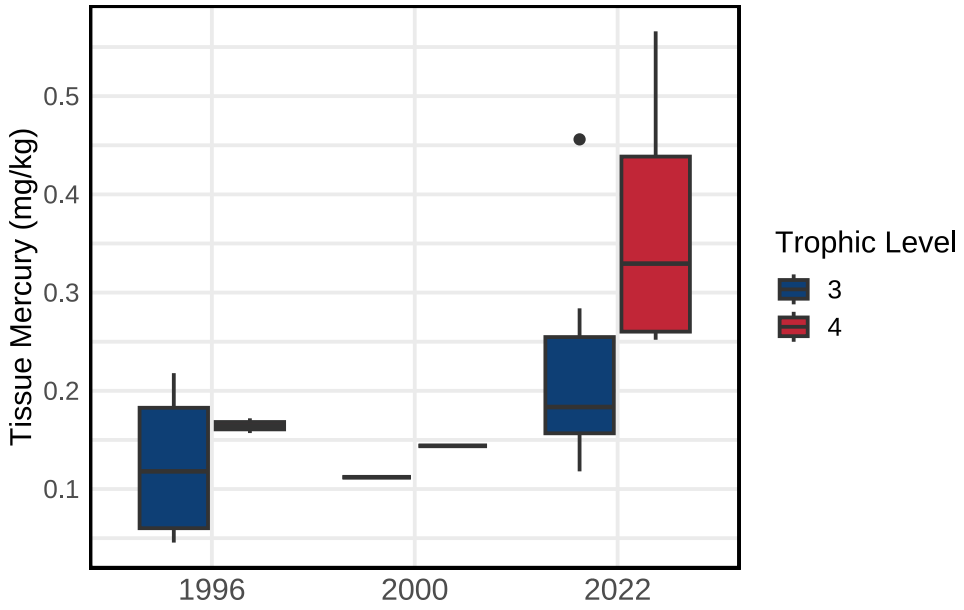


Figure 50 – Fish tissue mercury levels in trophic level 3 and trophic level 4 species collected from Honey Creek in 1996, 2000, and 2022.

The sites sampled in Honey Creek during the Survey were contained in the Middle Honey Creek (HUC12: 041000110805) and Lower Honey Creek (HUC12: 041000110806) watershed assessment units. Despite the slightly higher fish tissue mercury concentrations identified in Honey Creek in 2022, levels of contaminants were still low enough that the Lower Honey Creek assessment unit was classified as in attainment with the Human Health beneficial use in Ohio's 2024 Integrated Report. No trophic level 4 species were collected from the Middle Honey Creek assessment unit, and it was classified as having insufficient data. The attainment statuses of these assessment units were not determined prior to the 2024 Integrated Report.

East Branch Wolf Creek

Fish tissue mercury and total PCBs data collected in 2022 from East Branch Wolf Creek can be found in Table 24. Insufficient samples were available to assess the need for fish consumption advisories for any species in this waterbody. Of the fish tissue samples that were collected, none exceeded the "1 meal per week" consumption advisory threshold for PCBs (0.220 mg/kg) and only one sample (Largemouth Bass) exceeded the "1 meal per week" consumption advisory threshold for mercury (0.220 mg/kg).

The sites sampled in East Branch Wolf Creek during the Survey were contained in the Snuff Creek-East Branch Wolf Creek watershed assessment unit (HUC12: 041000111003). Data was insufficient to determine attainment status for this assessment unit; however, levels of mercury in individual samples were all below the impairment threshold for mercury, and both Channel Catfish samples slightly exceeded the threshold for total PCBs (0.023 mg/kg).

Although data from East Branch Wolf Creek were limited, the results suggest minimal fish tissue contamination. Since fish tissue contaminants in the East Branch of Wolf Creek have not been previously analyzed, no historical comparisons could be made. The attainment status of this assessment unit was also not determined in the Integrated Report prior to 2024.

Table 24 – Mercury and total PCB concentrations for fish tissue samples collected in 2022 from East Branch Wolf Creek.

River Mile	Station	Species	Trophic Level	HUC12	Mercury (mg/kg)	Total PCBs (mg/kg)
0.86	U04P03	Channel Catfish	3	041000111003	0.158	0.029
0.86	U04P03	Channel Catfish	3	041000111003	0.208	0.064
0.86	U04P03	Rock Bass	3	041000111003	0.154	< Detection Limit
0.86	U04P03	Largemouth Bass	4	041000111003	0.264	< Detection Limit

Muddy Creek

Fish tissue mercury and total PCB data collected from Muddy Creek in 2022 are displayed in Table 25. Insufficient data was available to assess the need for fish consumption advisories for any species.

Table 25 – Mercury and total PCB concentrations for fish tissue samples collected in 2022 from Muddy Creek.

River Mile	Station	Species	Trophic Level	HUC12	Mercury (mg/kg)	Total PCBs (mg/kg)
9.79	U04S01	Hybrid X Sunfish	3	041000111404	6.279	< Detection Limit
9.79	U04S01	Yellow Bullhead	3	041000111404	0.102	< Detection Limit
9.79	U04S01	Yellow Bullhead	3	041000111404	0.090	< Detection Limit
21.90	201410	Bluegill	3	041000111402	0.059	< Detection Limit
21.90	201410	Common Carp	3	041000111402	0.134	0.083

21.90	201410	Rock Bass	3	041000111402	9.070	< Detection Limit

Figure 51 presents a comparison of mercury concentrations in trophic level 3 and trophic level 4 species in Muddy Creek from 1994-2022. Because tissue mercury data were not normally distributed, a Kruskal-Wallis test was used for statistical comparisons among years. No significant differences were identified among years for both trophic level 3 ($P = 0.666$) and trophic level 4 ($P = 0.492$) species. These results indicate that levels of fish tissue mercury have not significantly changed from 1994 to 2022 in Muddy Creek.

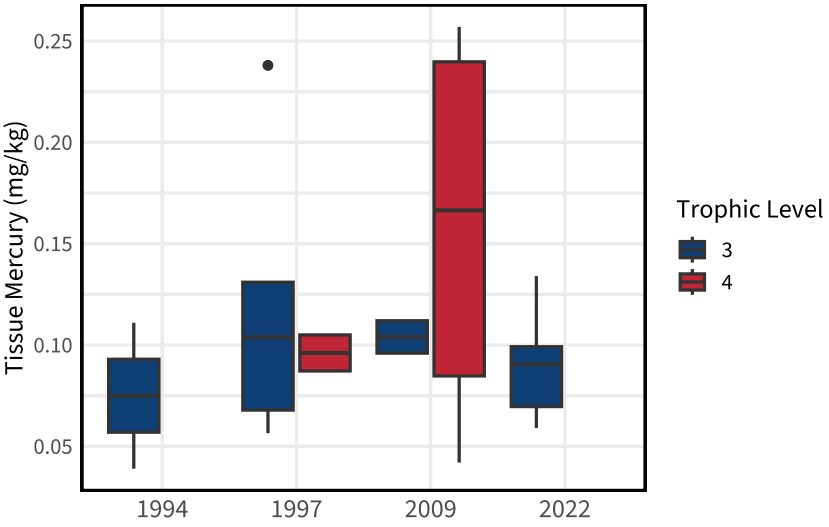


Figure 51 – Fish tissue mercury concentrations in trophic level 3 and trophic level 4 species collected from Muddy Creek in 1994, 1997, 2009, and 2022.

Total PCBs were below the detection limit for all fish tissue samples collected from Muddy Creek except for one Common Carp sample (Table 25). Total PCB concentrations were still relatively low in this sample and they fell within the range of the one meal per week consumption advisory recommendation. However, this sample did exceed the total PCB threshold for the Human Health beneficial use impairment (0.023 mg/kg) in the 2024 Integrated Report.

Figure 52 compares total PCB levels in trophic level 3 and trophic level 4 species from Muddy Creek between 1994 and 2022. Non-detect values are plotted as half the detection limit for display purposes. Unlike mercury, total PCB concentrations should generally not be averaged annually within each trophic level or compared across years, as PCB levels are more influenced by the fat content of fish species than by their trophic level. Additionally, because few species have been consistently sampled in Muddy Creek over time, a comprehensive analysis of historical trends in total PCBs is challenging. One species that may provide insight into PCB trends in Muddy Creek is Common Carp, shown in Figure 52 by red dots. While insufficient Common Carp samples have been collected historically to perform statistical analysis, the sample analyzed in 1994 contained higher total PCB concentrations than those from 1997, 2009, and 2022. This suggests there is a potential decrease in total fish tissue PCB concentrations since Muddy Creek was first sampled in the early 1990s.

The sites sampled in Muddy Creek during the survey were within two watershed assessment units: Town of Helena-Muddy Creek (HUC12: 041000111402) and Town of Lindsey-Muddy Creek (HUC12: 041000111404).

The Town of Helena-Muddy Creek assessment unit was classified as having insufficient data because no trophic level 4 species were collected. Prior to 2024, the attainment status of this assessment unit was not determined in the Integrated Report. Similarly, insufficient trophic level 4 samples were collected to determine the attainment status for the Town of Lindsey-Muddy Creek assessment unit. However, since this unit had been classified as impaired in previous Integrated Reports based on 2009 data, the impaired status for this assessment unit was retained in the 2024 Integrated Report.

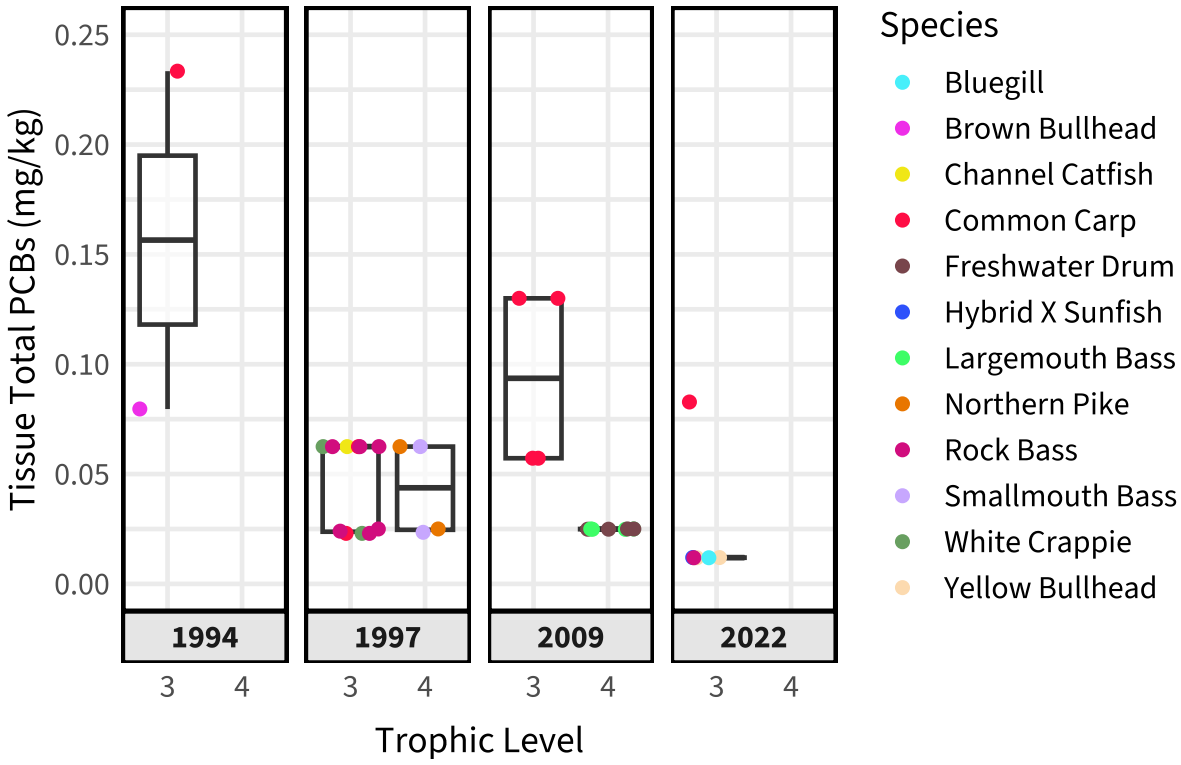


Figure 52 – Fish tissue mercury levels in trophic level 3 and trophic level 4 species collected from Muddy Creek in 1994, 1997, 2009, and 2022.

Recreation Beneficial Use – Results and Discussion

Water quality criteria for determining attainment of recreation use are established in the Ohio Water Quality Standards (Table 37-2 in OAC 3745-1-37) based upon the presence or absence of bacteria indicators (*Escherichia coli*) in the water column.

Escherichia coli (*E. coli*) bacteria are microscopic organisms that are present in large numbers in the feces and intestinal tracts of humans and other warm-blooded animals. *E. coli* typically comprises approximately 97% of the organisms found in the fecal coliform bacteria of human feces[1], but 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 practicable. 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 them directly. 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 source or another. Swimming or other recreational-based contact with water having a high fecal coliform or *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.

Streams evaluated during this survey are designated as either Primary Contact Recreation (PCR) or Secondary Contact Recreation (SCR) in OAC Rule 3745-1-12. Water bodies with a designated recreational use of PCR "…are waters that, during the recreation season, 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. All surface waters of the state are designated as primary contact recreation unless otherwise designated as bathing waters or secondary contact recreation (SCR)" [OAC 3745-1-07 (B)(3)(b)]. Water bodies with a designated recreational use of SCR "…are waters that result in minimal exposure potential to water-borne pathogens because the waters are rarely used for water-based recreation such as, but not limited to, wading; situated in remote, sparsely populated areas; have restricted access points; and have insufficient depth to provide full body immersion, thereby greatly limiting the potential for water-based recreation activities" [OAC 3745-1-07 (B)(3)(c)]. The *E. coli* criteria that apply to PCR streams include a geometric mean 126 cfu/100 ml, and a statistical threshold value (STV) of 410 cfu/100 ml. The *E. coli* criteria that apply to SCR streams include a geometric mean of 1,030 cfu/100 ml, and statistical threshold values of 1,030 cfu/100 ml. The geometric mean is based on two or more samples and is used as the basis for determining attainment status

[1] Dufour, A.P. (1977). Escherichia coli: The fecal coliform. Am. Soc. Test. Mater. Spec. Publ. 635: 45-58.

when more than one sample is collected (Table 26). The statistical threshold value shall not be exceeded in more than 10% of samples taken in a 90-day period.

Summarized bacteria results are listed in Table 26, and the complete dataset is reported in Appendix N. Sixty-two locations in the Sandusky River watershed study area were sampled for *E. coli* five times, during 90-day windows in either the 2021 or 2022 field seasons. Evaluation of *E. coli* results revealed that none of the sixty-two stations met the criteria to be considered in attainment of recreational use.

Table 26 — A summary of *E. coli* data for the locations in the Sandusky River Tributaries sampled May through August 2022.

Recreation Use Attainment Status is determined by comparing samples collected within a 90-day period during the recreation season to the geometric mean criterion of 126 cfu/100 ml and to the statistical threshold value (STV) of 410 cfu/100 ml (for PCR), or geometric mean of 1,030 cfu/100 ml, and statistical threshold values of 1,030 cfu/100 ml (for SCR). The STV must not be exceeded by more than 10% of individual samples.

Station ID	Location	River Mile	No. Samples	Geometric Mean	% > STV	Maximum Value	Attainment Status	Possible Source(s)[1] of Bacteria
04100011 03 01 - Brandywine Creek-Broken Sword Creek								
201366	BROKEN SWORD CREEK NE OF BENTON @ ST. RT. 19/100	19.70	5	**252.53**	**20%**	644	**NON**	AG, HSTS
04100011 03 02 - Indian Run-Broken Sword Creek								
U02P47	BROKEN SWORD CREEK NEAR NEVADA @ CO. RD. 62	0.87	5	**688.89**	**40%**	8,164	**NON**	AG, HSTS
04100011 04 01 - Headwaters Paramour Creek-Sandusky River								
U02P12	PARAMOUR CREEK DST. CRESTLINE @ NAZOR RD.	1.50	5	**700.90**	**100%**	1,050	**NON**	AG, HSTS, Urban
04100011 04 02 - Loss Creek-Sandusky River								
U02G20	ALLEN RUN SE OF LEESVILLE @ CRESTLINE RD.	1.18	5	**986.18**	**100%**	2,382	**NON**	AG, HSTS
U02P08	SANDUSKY R. NEAR LEESVILLE @ LOWER LEESVILLE RD.	127.80	5	**291.08**	**20%**	520	**NON**	AG, HSTS
04100011 04 03 - Headwaters Middle Sandusky River								
U02G01	SANDUSKY R. @ LOCUST GROVE RD.	120.82	5	**606.05**	**80%**	2,359	**NON**	AG, HSTS
04100011 04 04 - Grass Run								
U02G13	GRASS RUN @ CRAWFORD/WYANDOT COUNTY LINE RD.	3.42	5	**931.67**	**40%**	24,196	**NON**	AG, HSTS
04100011 04 05 - Headwaters Lower Sandusky River								
U02P33	SANDUSKY R. DST. BUCYRUS @ ST. RT. 231	98.69	5	**788.59**	**60%**	10,462	**NON**	AG, CAFO, HSTS
04100011 05 01 - Reevhorn Run								
U01W04	PRAIRIE RUN @ AGOSTA-MEEKER RD.	1.02	5	**1,004.24**	**80%**	6,488	**NON**	AG, HSTS
04100011 05 02 - Upper Little Tymochtee Creek								
U01G07	TYMOCHTEE CREEK AT MEEKER @ MASON RD. (CO. RD. 213A)	49.44	5	**1,746.02**	**80%**	12,997	**NON**	AG, HSTS
04100011 05 03 - Lower Little Tymochtee Creek								
U01G26	CARROLL DITCH NNW OF MEEKER @ OSBUN RD.	0.66	5	**1,440.08**	**60%**	9,208	**NON (SCR)**	AG, HSTS
04100011 05 04 - Pawpaw Run								
U01G24	PAWPAW RUN S OF MARSEILLES @ FAIL RD. (LOWER CROSSING)	0.57	5	**888.49**	**60%**	14,136	**NON**	AG, HSTS

Station ID	Location	River Mile	No. Samples	Geometric Mean	% > STV	Maximum Value	Attainment Status	Possible Source(s)[1] of Bacteria
04100011 05 05 - Prairie Run								
U01G23	REEVHORN RUN 4.8 MI. W OF MARSEILLES @ CO. RD. 76	2.26	5	**835.31**	**60%**	24,196	**NON**	AG, HSTS
04100011 05 06 - Headwaters Tymochtee Creek								
304302	L. TYMOCHTEE CREEK (UPPER) @ RAGER RD.	8.63	5	**1,069.27**	**60%**	12,997	**NON**	AG, HSTS
04100011 05 07 - Carroll Ditch								
U01G20	L. TYMOCHTEE CREEK (UPPER) NW OF MARSEILLES @ CO. RD. 93	4.00	5	**1,052.26**	**40%**	14,136	**NON**	AG, HSTS
04100011 05 08 - Warpole Creek								
U01G18	WARPOLE CREEK @ TWP. RD. 58	1.52	5	**1,220.56**	**100%**	9,804	**NON**	AG, HSTS
04100011 05 09 - Enoch Creek-Tymochtee Creek								
U01G05	TYMOCHTEE CREEK S OF MARSEILLES @ FAIL RD.	42.83	5	**843.98**	**40%**	24,196	**NON**	AG, CAFO, HSTS
U01G04	TYMOCHTEE CREEK N OF MARSEILLES @ TWP. RD. 97	33.99	5	**1,124.09**	**80%**	19,863	**NON**	AG, CAFO, HSTS
04100011 06 01 - Oak Run								
U01G16	OAK RUN @ TWP. RD. 54	0.29	5	**938.29**	**80%**	19,863	**NON**	AG, HSTS
04100011 06 02 - Baughman Run-Tymochtee Creek								
U02P44	TYMOCHTEE CREEK NEAR UPPER SANDUSKY @ TWP. RD. 49	19.45	5	**1,229.60**	**100%**	11,199	**NON**	AG, HSTS
04100011 06 03 - Hart Ditch-Little Tymochtee Creek								
U02P45	L. TYMOCHTEE CREEK (LOWER) NEAR CAREY @ CO. RD. 29	0.90	5	**534.71**	**80%**	794	**NON**	AG, HSTS
04100011 06 04 - Spring Run								
U02P46	SPRING RUN DST. CAREY @ MOTT RD.	1.71	5	**279.94**	**40%**	512	**NON**	AG, HSTS, Urban
04100011 06 05 - Mouth Tymochtee Creek								
500850	TYMOCHTEE CREEK AT CRAWFORD @ ST. RT. 199	8.06	5	**336.35**	**40%**	767	**NON**	AG, HSTS
04100011 07 01 - Little Sandusky River								
U02W06	L. SANDUSKY R. NW OF MORRAL @ TWP. RD. 125	3.71	5	**893.94**	**60%**	19,863	**NON**	AG, HSTS
U02G18	HONEY RUN SE OF LITTLE SANDUSKY @ CO. RD. 126	0.52	5	**1,442.96**	**80%**	8,664	**NON**	AG, HSTS
04100011 07 02 - Town of Upper Sandusky-Sandusky River								
500860	SANDUSKY R. DST. UPPER SANDUSKY @ TWP. RD. 121	78.09	5	**310.44**	**40%**	1,989	**NON**	AG, CSOs, HSTS, Urban

Station ID	Location	River Mile	No. Samples	Geometric Mean	% > STV	Maximum Value	Attainment Status	Possible Source(s)[1] of Bacteria
04100011 07 03 - Negro Run								
U02S19	NEGRO RUN NE OF UPPER SANDUSKY @ CO. RD. 124	0.52	5	**331.16**	**20%**	512	**NON**	AG, HSTS
04100011 07 04 - Cranberry Run-Sandusky River								
U02S20	ROCK RUN NE OF UPPER SANDUSKY @ TWP. RD. 122	0.80	5	**532.96**	**20%**	24,196	**NON**	AG, HSTS
04100011 07 05 - Sugar Run-Sandusky River								
U02P38	SANDUSKY R. DST UPPER SANDUSKY @ TWP. RD. 40	72.09	5	**503.18**	**60%**	7,701	**NON**	AG, CSOs, HSTS, Urban
04100011 08 01 - Brokenknife Creek								
201405	BROKENKNIFE CREEK @ HURON/SENECA COUNTY LINE RD.	1.05	5	**654.11**	**100%**	1,439	**NON**	AG, HSTS
04100011 08 02 - Upper Honey Creek								
U03G18	HONEY CREEK @ BIGHAM RD.	34.14	5	**704.87**	**80%**	1,515	**NON**	AG, HSTS
04100011 08 03 - Aicholz Ditch								
U03G24	AICHOLZ DITCH E OF BLOOMVILLE @ COOPER RD. (TWP. RD. 77)	2.46	5	**418.88**	**60%**	690	**NON**	AG, HSTS
04100011 08 04 - Silver Creek								
U03G22	SILVER CREEK S OF BLOOMVILLE @ ST. RT. 19	4.08	5	**671.79**	**60%**	2,000	**NON**	AG, CAFO, HSTS
04100011 08 05 - Middle Honey Creek								
U03S03	HONEY CREEK W OF ATTICA @ TWP. RD. 79	25.03	5	**600.88**	**80%**	1,100	**NON**	AG, HSTS
04100011 08 06 - Lower Honey Creek								
500970	HONEY CREEK NEAR TIFFIN @ CO. RD. 19	1.1	5	**754.83**	**60%**	9,600	**NON**	AG, HSTS
04100011 09 01 - Taylor Run								
U03G04	TAYLOR RUN NW OF SYCAMORE @ TWP. RD. 16	1.88	5	**650.74**	**80%**	960	**NON**	AG, HSTS
04100011 09 02 - Headwaters Sycamore Creek								
U03G10	SYCAMORE CREEK E OF LYKENS @ KENNEDY RD.	18.92	5	**417.42**	**40%**	749	**NON**	AG, HSTS
04100011 09 03 - Greasy Run-Sycamore Creek								
U03P05	SYCAMORE CREEK NEAR MEXICO @ CO. RD. 37	0.41	5	**498.87**	**80%**	712	**NON**	AG, HSTS
04100011 09 04 - Thorn Run-Sandusky River								
U03G03	THORN RUN AT MCCUTCHENVILLE @ ST. RT. 53	0.7	5	**778.21**	**80%**	2,247	**NON**	AG, HSTS
U03G01*	SANDUSKY R. S OF MCCUTCHENVILLE @ CO. RD. 16	65.01	5	**341.14**	**20%**	770	**NON**	AG, HSTS

Station ID	Location	River Mile	No. Samples	Geometric Mean	% > STV	Maximum Value	Attainment Status	Possible Source(s)[1] of Bacteria
04100011 09 05 - Mile Run-Sandusky River								
U04S29*	SANDUSKY R. NEAR MEXICO @ CO. RD. 9	57.34	5	**209.96**	**20%**	440	**NON**	AG, HSTS
500830	SANDUSKY R. DST MEXICO @ CO. RD. 90	47.75	5	**181.23**	0%	390	**NON**	AG, HSTS
04100011 10 01 - East Branch East Branch Wolf Creek								
300682	E. BR. OF EAST BRANCH WOLF CREEK @ CO. RD. 48 (TWP. RD. 118)	1.48	5	**396.70**	**20%**	17,000	**NON**	AG, HSTS, Urban
04100011 10 02 - Town of New Riegel-East Branch Wolf Creek								
U04G15	E. BR. WOLF CREEK @ TWP. RD. 132	13.63	5	**781.55**	**60%**	20,000	**NON**	AG, HSTS, Urban
04100011 10 03 - Snuff Creek-East Branch Wolf Creek								
U04P03	E. BR. WOLF CREEK NEAR BETTSVILLE @ GILMORE RD.	0.86	5	**486.11**	**20%**	8,700	**NON**	AG, HSTS
04100011 10 04 - Wolf Creek								
U04S40	WOLF CREEK AT BETTSVILLE @ ST. RT. 12	5.15	5	**294.74**	**20%**	14,000	**NON**	AG, HSTS, Urban
04100011 11 01 - Rock Creek								
U04W06	ROCK CREEK AT TIFFIN @ MAIN ST.	1.05	5	**1,678.66**	**100%**	24000+	**NON**	AG, HSTS, Urban
04100011 11 02 - Morrison Creek								
U04G05	MORRISON CREEK @ TWP. RD. 15	2.36	5	**1,640.64**	**100%**	24000+	**NON**	AG, HSTS
04100011 11 03 - Willow Creek-Sandusky River								
U04S28*	SANDUSKY R. AT TIFFIN @ ELLA ST.	41.84	5	**169.17**	**20%**	770	**NON**	AG, HSTS, Urban
04100011 11 04 - Sugar Creek								
U04Q10	SUGAR CREEK NEAR TIFFIN @ TWP. RD. 76	3.11	5	**958.42**	**60%**	24,000	**NON**	AG, HSTS
04100011 11 05 - Spicer Creek-Sandusky River								
U04Q11	SPICER CREEK N OF TIFFIN @ CO. RD. 33	0.8	5	**922.51**	**60%**	24,000	**NON**	AG, HSTS
500910*	SANDUSKY R. DST TIFFIN @ ABBOTT's BRIDGE	30.85	5	**292.19**	**40%**	1,700	**NON**	AG, HSTS
U04Q06*	SANDUSKY R. UPST. FREMONT, UPST. WOLF CREEK	23	5	**131.41**	**20%**	690	**NON**	AG, HSTS
04100011 13 01 - Muskellunge Creek								
201332	MUSKELLUNGE CREEK NEAR FREMONT @ SPIELDENNER RD.	5.4	5	**483.61**	**40%**	10,000	**NON**	AG, HSTS, Urban
04100011 13 02 - Indian Creek-Sandusky River								
500950	INDIAN CREEK S OF FREMONT @ HURDICK RD.	0.62	5	**795.34**	**60%**	12,000	**NON**	AG, HSTS
304130*	SANDUSKY R. JUST UPST HISTORIC BALLVILLE DAM (FREE FLOWING)	18.1	5	77.72	**20%**	790	**NON**	AG, HSTS

Station ID	Location	River Mile	No. Samples	Geometric Mean	% > STV	Maximum Value	Attainment Status	Possible Source(s)[1] of Bacteria
04100011 13 03 - Mouth Sandusky River								
300671	BARK CREEK @ KELLEY RD. (CR 245)	3.2	5	**387.92**	**20%**	6,100	**NON**	AG, HSTS, Urban
04100011 14 01 - Gries Ditch								
U04Q16	GRIES DITCH W OF FREMONT @ STAFF RD. (SCR)	0.9	5	451.62	**20%**	7,700	**NON**	AG, HSTS
04100011 14 02 - Town of Helena-Muddy Creek								
201410	MUDDY CREEK W OF FREMONT, DST. TWP. RD. 55	21.1	5	**836.15**	**80%**	7,300	**NON**	AG, HSTS
04100011 14 03 - Little Muddy Creek								
300677	L. MUDDY CREEK @ BOOKTOWN RD. (W. CO. RD. 89)	7.55	5	**815.09**	**40%**	7,700	**NON**	AG, HSTS
300678	FISHING CREEK @ WEICKERT RD.	0.2	5	**558.24**	**60%**	6,900	**NON**	AG, HSTS
04100011 14 04 - Town of Lindsey-Muddy Creek								
U04S01	MUDDY CREEK DST. LINDSEY @ CO. RD. 153	9.79	5	**882.99**	**60%**	9,200	**NON**	AG, HSTS
04100011 14 05 - North Side Sandusky Bay Frontal								
No sites could be located in this HUC.								

[1] Possible Sources:
AG – Agriculture
CAFO – Concentrated Animal Feeding Operation
HSTS – Home Sewage Treatment Systems
WWTP – Wastewater Treatment Plants
CSOs – Combined Sewer Overflows
SSOs – Sanitary Sewer Overflows
Urban – Urban runoff

* Sites sampled for e. coli during 2021 field season.

Public Drinking Water Supply Beneficial Use – Sampling Results

Impaired surface water sources that are used as a public drinking water supply may contribute to increased human health risk and/or increased treatment costs. Ohio EPA has developed an assessment methodology for the public drinking water supply (PWS) beneficial use which focuses on source water contaminants that are not effectively removed through conventional treatment methods. The PWS beneficial use in the Water Quality Standards (OAC 3745-1-33) currently applies within 500 yards of drinking water intakes and for all publicly owned lakes used as a drinking water source. Source water quality is assessed though comparison of water quality data to numeric chemical water quality criteria for three core indicators: nitrate; pesticides (atrazine); and cyanotoxins. The ***Ohio Integrated Water Quality Monitoring and Assessment Report*** describes this methodology. The Ohio Integrated Report is updated on a two-year cycle.

When surface water is pumped to an upground reservoir, the surface water source is evaluated separately from the upground reservoir. These assessments are designed to determine if the quality of source water meets the standards and criteria of the Clean Water Act. Monitoring the safety and quality of treated, finished drinking water is regulated under the Safe Drinking Water Act and evaluated separately from this assessment. However, for purposes of this assessment, if treatment plant processes do not remove a source water contaminant, the finished water quality may be considered representative of the raw source water.

Within the study area, the following community public water systems are served by surface water sources: Attica, Tiffin, Upper Sandusky, Bucyrus, Fremont, and Clyde. Attica has an intake on Honey Creek at RM 28.35. Four public water systems have intakes on Sandusky River: Tiffin at RM 41.08, Upper Sandusky at RM 82.90 and RM 83.15, Bucyrus at RM 115.40, and Fremont at RM 18.02. Clyde also has an intake on Beaver Creek at RM 2.88 that was included in this sampling effort.

To assess the PWS beneficial use for each indictor, samples were collected at representative sites and analyzed for nitrate, atrazine, and cyanotoxins (e.g., microcystins, saxitoxins and cylindrospermopsin). Additionally, all surface water public drinking water supply sources must conduct routine microcystins monitoring and cyanobacteria screening as specified in OAC 3745-90-03.

City of Attica

The City of Attica operates a community public water supply that serves a population of approximately 1,148 people through approximately 530 service connections. The system's treatment capacity is approximately 0.120 million gallons per day, but the current average production is 0.500 million gallons per day. The facility obtains its water from an intake on Honey Creek at RM 28.35 which is then directed to two upground reservoirs. The treatment process is conventional treatment with the ability to increase the dosage of powder activated carbon. This public water supply has developed both a Harmful Algal Bloom (HAB) Treatment Optimization Protocol and a Cyanotoxin General Plan in place if cyanotoxin treatment becomes necessary.

Ohio EPA collected water quality samples from Honey Creek during 2022 and 2023. The PWS assessment unit is HUC 04100011 08 05 Middle Honey Creek. The results for each impairment indicator are summarized as follows:

- Nitrate Indicator: All results were below the water quality criterion for nitrate (10.00 mg/L). Nitrate-nitrite data was used in place of nitrates based on the data available for calculations.
    - Honey Creek: Nitrate-Nitrite results ranged from below detection limit to 5.40 mg/L.
- Pesticides Indicator: There were no exceedances of the maximum instantaneous value >12.00 µg/L. All annual averages for atrazine were below the water quality criteria.
    - Honey Creek: Atrazine results ranged from below detection limits to 1.56 µg/L.
- Algae, Cyanotoxins Indicator: There were no exceedances of the water quality criterion for microcystins (1.60 µg/L), saxitoxins (1.60 µg/L), cylindrospermopsin (3.00 µg/L), or anatoxin-a (1.60 µg/L).
    - Honey Creek: All results for cyanotoxins (microcystins, saxitoxins, cylindrospermopsin, anatoxin-a) were below detection limits.
    - PWS routine monitoring at raw water sampling point occurred January 2022 through December 2023. Microcystins and saxitoxins were below detection limits.

City of Tiffin

The City of Tiffin's community public water supply is operated by Aqua Ohio and serves a population of approximately 20,035 people through approximately 8211 service connections. The system's treatment capacity is approximately 3.430 million gallons per day, but current average production is 1.854 million gallons per day. The facility obtains its source water from a combination of ground water from wells and surface water from the Sandusky River. The facility utilizes conventional treatment with the ability to use advanced treatment. Additionally, this public water supply has a HAB Treatment Optimization Protocol in place if cyanotoxin treatment becomes necessary.

Ohio EPA collected water quality samples from the Sandusky River near Tiffin's intake during 2021, 2022, and 2023. The PWS assessment unit is HUC 04100011 90 01 Sandusky River Mainstream. The results for each impairment indicator are summarized as follows:

- Nitrate Indicator: All results were below the water quality criterion for nitrate (10.00 mg/L). Nitrate-nitrite data was used in place of nitrates based on the data available for calculations.
    - Sandusky River: Nitrate-Nitrite results ranged from 0.24 to 7.92 mg/L.
- Pesticides Indicator: There was one exceedance of the maximum instantaneous value >12.00 µg/L. One annual average for atrazine was above the water quality criteria.
    - Sandusky River: Atrazine results ranged from 0.50 to 20.70 µg/L.
- Algae, Cyanotoxins Indicator: There were no exceedances of the water quality criterion for microcystins (1.60 µg/L), saxitoxins (1.60 µg/L), cylindrospermopsin (3.00 µg/L), or anatoxin-a (1.6 µg/L).
    - Sandusky River: All results for saxitoxins, cylindrospermopsin, anatoxin-a were below detection limits. Microcystins ranged from below detection limits to 0.28 µg/L.
    - PWS routine monitoring at the raw water sampling point occurred January 2022 through December 2023.

- Microcystins were below detection limits. There were two raw water saxitoxin detections, and the saxitoxin data ranged from below detection limits to 0.05 µg/L.

City of Upper Sandusky

The City of Upper Sandusky operates a community public water supply that serves a population of approximately 6,698 people through approximately 2,935 service connections. The system's treatment capacity is approximately 2.160 million gallons per day, but current average production is 0.730 million gallons per day. The facility obtains its water from the Sandusky River and has two upground reservoirs. Water can be pumped directly from the Sandusky River to the facility or to the reservoirs prior to final treatment. The facility's treatment processes include a combination of conventional treatment with the ability to use advanced filtration when needed. Additionally, the facility has both a HAB Treatment Optimization Protocol and a Cyanotoxin General Plan in place if cyanotoxin treatment becomes necessary.

Ohio EPA collected water quality samples from the Sandusky River near Upper Sandusky's intake during 2022 and 2023. The PWS assessment unit is HUC 04100011 07 02 Sandusky River. The results for each impairment indicator are summarized as follows:

- Nitrate Indicator: All results were below the water quality criterion for nitrate (10.00 mg/L). Nitrate-nitrite data was used in place of nitrates based on the data available for calculations.
  - Sandusky River: Nitrate-Nitrite results ranged from 0.59 to 8.72 mg/L.
- Pesticides Indicator: There were no exceedances of the maximum instantaneous value >12.00 µg/L. The 2022 annual average concentration for atrazine was above the water quality criteria.
  - Sandusky River: Atrazine results ranged from 0.23 to 11.6 µg/L.
- Algae Cyanotoxins Indicator: There was one exceedance of the water quality criterion for microcystins (1.60 µg/L). There were no exceedances for saxitoxins (1.60 µg/L), cylindrospermopsin (3.00 µg/L), or anatoxin-a (1.60 µg/L).
  - Sandusky River: All results for cyanotoxins were below detection limits.
  - PWS routine monitoring at the raw water sampling point occurred January 2022 through December 2023.
    - There were six raw water microcystins detections and the sample data ranged from below detection limits to 1.91 µg/L.
    - There were two raw water saxitoxins detections and the sample data ranged from 0.05 to 0.07 µg/L.

City of Bucyrus

The City of Bucyrus operates a community public water supply that serves a population of approximately 12,570 people through approximately 5,937 service connections. The system's treatment capacity is approximately 3.000 million gallons per day, but the current average production is 1.225 million gallons per day. The water treatment system obtains its water from the Sandusky River and has a total of two upground reservoirs and two in-stream, backup reservoirs. Water is pumped from the Sandusky River to the upground reservoirs for storage prior to treatment. The facility

employs a combination of conventional treatment and advanced treatment. The facility has a HAB Treatment Optimization Protocol if cyanotoxin treatment becomes necessary.

Ohio EPA collected water quality samples from the Sandusky River near Bucyrus's intake during 2022 and 2023. The PWS assessment unit is HUC 04100011 04 03 Sandusky River. The results for each impairment indicator are summarized as follows:

- Nitrate Indicator: All results were below the water quality criterion for nitrate (10.00 mg/L). Nitrate-nitrite data was used in place of nitrates based on the data available for calculations.
    - Sandusky River: Nitrate-nitrite results ranged from 0.31 to 9.77 mg/L.
- Pesticides Indicator: There were no exceedances of the maximum instantaneous value >12.00 µg/L. All annual averages for atrazine were below the water quality criteria.
    - Sandusky River: Atrazine results ranged from 0.29 to 3.96 µg/L.
- Algae, Cyanotoxins Indicator: There were no exceedances of the water quality criterion for microcystins (1.60 µg/L), saxitoxins (1.60 µg/L), cylindrospermopsin (3.00 µg/L), or anatoxin-a (1.60 µg/L).
    - Sandusky River: All results for saxitoxins, cylindrospermopsin, anatoxin-a were below detection limits. Microcystins ranged from below detection limits to 0.26 µg/L.
    - PWS routine monitoring at the raw water sampling point occurred January 2022 through December 2023. Microcystins were below detection limits.

City of Fremont

The City of Fremont operates a community public water supply facility that serves a population of approximately 18,319 people through approximately 7800 service connections. The system's treatment capacity is approximately 14.000 million gallons per day, but the current average production is 6.016 million gallons per day. The facility obtains its water from the Sandusky River and has one upground reservoir. Water is pumped from the Sandusky River to the reservoir for storage prior to treatment. The public water supply process at this facility is a combination of conventional treatment and advanced treatment when needed. Additionally, this public water supply has both a HAB Treatment Optimization Protocol and a Cyanotoxin General Plan in place if they need to address cyanotoxin treatment.

Ohio EPA collected water quality samples from the Sandusky River near Freemont's intake during 2022 and 2023. The PWS assessment unit is HUC 04100011 13 02 Sandusky River. The results for each impairment indicator are summarized as follows:

- Nitrate Indicator: All results were below the water quality criterion for nitrate (10.00 mg/L). Nitrate-nitrite data was used in place of nitrates based on the data available for calculations.
    - Sandusky River: Nitrate-nitrite results ranged from 0.13 to 8.41 mg/L.
- Pesticides Indicator: There were no exceedances of the maximum instantaneous value >12.00 µg/L. All annual averages for atrazine were below the water quality criteria.
    - Sandusky River: Atrazine results ranged from 0.24 to 3.36 µg/L.

- Algae, Cyanotoxins Indicator: There were no exceedances of the water quality criterion for microcystins (1.60 µg/L), saxitoxins (1.60 µg/L), cylindrospermopsin (3.00 µg/L), or anatoxin-a (1.6 µg/L).
    - Sandusky River: All results for saxitoxins, cylindrospermopsin, anatoxin-a were below detection limits. Microcystins ranged from below detection limits to 0.36 µg/L.
    - PWS routine monitoring at the raw water sampling point occurred January 2022 through December 2023. Microcystins and saxitoxins were below detection limits.

City of Clyde

The City of Clyde operates a community public drinking water facility that serves a population of approximately 6,325 people through approximately 2,890 service connections. The system's treatment capacity is approximately 2.400 million gallons per day, but the current average production is 1.079 million gallons per day. The facility obtains its water from Beaver Creek and fills two reservoirs which supply water to the treatment plant. Clyde's treatment process is a combination of conventional treatment with the ability to use advanced treatment when needed. This public water supply has a HAB Treatment Optimization Protocol if they need to address cyanotoxin treatment.

Ohio EPA collected water quality samples from the Sandusky River near Clyde's intake during 2022 and 2023. The PWS assessment unit is HUC 04100011 12 02 Beaver Creek. The results for each impairment indicator are summarized as follows:

- Nitrate Indicator: One detection was detection was above the water quality criterion for nitrate (10.0 mg/L). Nitrate-nitrite data was used in place of nitrates based on the data available for calculations.
    - Beaver Creek: Nitrate-nitrite results ranged from 0.17 to 11.70 mg/L.
- Pesticides Indicator: There were no exceedances of the maximum instantaneous value >12.00 µg/L. All annual averages for atrazine were below the water quality criteria.
    - Beaver Creek: Atrazine results ranged from below detection limits to 2.71 µg/L.
- Algae, Cyanotoxins Indicator: There were no exceedances of the water quality criterion for microcystins (1.60 µg/L), saxitoxins (1.60 µg/L), cylindrospermopsin (3.00 µg/L), or anatoxin-a (1.60 µg/L).
    - Sandusky River: All results for saxitoxins, cylindrospermopsin, anatoxin-a were below detection limits. Microcystins ranged from below detection limits to 0.25 µg/L.
    - PWS routine monitoring at raw water sampling point occurred January 2022 through December 2023. Microcystins were below detection limits to 0.65 µg/L.

Beneficial Use Designations and Recommendations

Aquatic Life Use

All streams evaluated during the current survey listed in the WQS are either assigned to the WWH, MWH-C, or LRW aquatic life use (ALU) or were undesignated (i.e. not listed in WQS). Ohio EPA has conducted monitoring within the watershed beginning in 1979 and has evaluated every major and many minor tributaries. Early efforts were focused on larger waters and around NPDES-permitted dischargers, while later efforts also included small streams spread through the watershed. The previous larger-scale surveys occurred in 2009 through the lower watershed and in 2001 through the upper watershed (Ohio EPA 2003 and 2011). Pursuant to these efforts, many streams have existing ALU designations that were previously verified using standardized biological field collections.

However, waterbodies remain where the ALU and other beneficial use designations are still based on the original 1978 and 1985 state water quality standards. The techniques used at that time did not include standardized approaches to the collection of in-stream biological data or numeric biocriteria. Also, multiple streams evaluated during the current survey were undesignated and not listed in the WQS. Ohio EPA has an obligation to assign beneficial uses to all waters of the state (ORC 3745-1-07) and a primary objective of this survey was to gather data to help determine an appropriate ALU for unverified and undesignated streams. Data from the current survey was used to either verify or recommend an appropriate ALU for these streams.

Significant findings from this survey are summarized below.

- Most of the Sandusky River mainstem maintains an existing WWH designation, while the impounded segment through Tiffin, OH is designated MWH-I (Table 27). The Sandusky River from Freemont through Upper Sandusky is also recognized as a State Scenic River by ODNR. Results from the current survey yielded exceptional quality macroinvertebrate assemblages through much of the mainstem and exceptional quality fish assemblages through the free-flowing LRAU portion of the mainstem (RMs 65-17). Though still high-quality, fish community performance was somewhat lower overall upstream from the LRAU segment (Figure 26). It is recommended that the free-flowing portions of the Sandusky River from the confluence of Tymochtee Creek (RM 65.73) downstream to Roger Young Memorial Park (RM 16.6) receive the EWH aquatic life use. The downstream extent of this designation would coincide with the State Scenic Rivers designation. The impounded portion of the Sandusky River through Tiffin, OH (RMs 45-42.1) is recommended to maintain the MWH-I use, while the remaining portions of mainstem are recommended to retain their WWH use.

- Many tributary streams in the lower watershed sampled in 2022 still have an unverified WWH use despite being previously sampled in 2009. These include Indian Creek, Wolf Creek, East Branch Wolf Creek, East Branch of East Branch Wolf Creek, Middle Branch of East Branch of East Branch Wolf Creek, Sugar Creek, and Spicer Creek. All these streams should have their WWH use confirmed. Snuff Creek was sampled in 2009, but not in 2022 and should have the WWH use confirmed. Additionally, Harrison Creek, Plum Run, the tributary to Wolf Creek (8.10), and Eicher Ditch are all undesignated and should receive the WWH designation.

- Michael Gruss Ditch is not a formally recognized stream within the Wolf Creek basin and the site location in the Ohio EPA EA3 database is an upstream extension of Eicher Ditch. John Smith Ditch joins Eicher Ditch north of New Riegel, Ohio. This rule should be updated to reflect the proper tributary network as is shown in Table 27.

- Two portions of Honey Creek maintain MWH designations – an upper segment is designated MWH-C through a heavily modified portion of the watershed that drains a former swamp, and the lowermost reaches are MWH-I due to the impounded conditions from the Ella Street dam (Table 27). Biological community quality has improved throughout Honey Creek and sites in both these areas met WWH criteria in 2022. The MWH-C portion of Honey Creek still has habitat limitations from pervasive channel modifications, but despite this, can still support assemblages consistent with WWH criteria. Through its lowermost reaches, enough deposition has occurred over time and there were now riffles with constricted flow at RM 1.1 (500970) near the bridge crossing. Fish were sampled by boat at RM 0.20 and the assemblage quality here was very good. Macroinvertebrate community quality at this location was also exceptional. It is recommended that both these reaches of Honey Creek receive the WWH designation, while the remainder of this stream retain the WWH use.

- Conditions have also improved throughout Sycamore Creek, Grass Creek, and Red Run. Biological assemblages attained WWH criteria at all sites in these streams in 2022. Upper Sycamore Creek and Grass Creek are currently designated MWH-C, while Red Run is designated LRW. These streams all drain higher relief areas emanating from the eastern portion of the watershed, affording them more stream power and a greater ability to recover from prior habitat modifications (Figure 5). While sub-optimal habitat may still be present, these streams have demonstrated the ability to support WWH biological communities and all are recommended to receive the WWH designation.

- Most of Tymochtee Creek is naturally very poorly drained (Figure 9) and functions much like low-gradient streams in the HELP ecoregion. The whole system has required a much heavier degree of modification to facilitate drainage compared to other typical ECBP streams, with the uppermost reaches of the Tymochtee sub-basin south of Fort Wayne end moraine even more so. Biological community quality was somewhat lower overall in the uppermost portion of Tymochtee Creek compared to the more downstream portions of this sub-watershed. Tymochtee Creek maintains a LRW use in its most upstream reaches, while several other smaller tributary streams in the upper Tymochtee basin are designated MWH-C.

  Tymochtee Creek at Cramer Road (RM 51.43, U01W05) only drains 6.1mi^2 and had fair habitat quality in 2022. This reach was formerly channelized and heavy blankets of silt were pervasive through the zone. Moderate- and high-influence habitat ratios were both elevated here (Appendix H). Habitat quality was similar to the conditions observed in 1995. Biological communities have improved incrementally from poor or very poor quality to fair quality

communities in 2022. Given the extensive channel modifications and irretrievable changes to hydrology through this portion of the watershed, attainment of WWH is likely precluded for most stream segments in this area. Tymochtee Creek from its headwaters to its confluence with the unnamed tributary at RM 49.69 is recommended to receive the MWH-C designation. The remainder of Tymochtee Creek should retain the WWH designation. Biological assemblages have improved through much of this system and most mainstem sites now support biological assemblages that met WWH expectations.

- Carroll Ditch, Prairie Run, and Enoch Creek are all located in the uppermost portions of the Tymochtee Creek watershed. As previously discussed, many streams in this portion of the watershed have been heavily modified to facilitate drainage. Carroll Ditch maintains a verified MWH-C use and 2022 sampling indicated that this use remains appropriate (Table 27). Prairie Run and Enoch Creek are located near Carroll Ditch, and both have verified WWH uses based on the 2001 survey results. Much like upper Tymochtee Creek, biological assemblages in all three streams were comparable to other survey sites located in areas with the heaviest degrees of degradation (Table 18). Prairie Run at RM 1.02 (U01W04) had very poor habitat quality (QHEI=29.50) in 2022, and conditions were comparable to 2001. This stream had very little flow when sampled in 2022 and may go dry periodically during the summer months. Despite being formerly confirmed WWH, irretrievable changes to the hydrology in this portion of the watershed preclude Prairie Run from establishing assemblages that consistently meet even MWH-C criteria (Table 14). Enoch Creek had somewhat better instream habitat than Prairie Run but still had fish assemblages that were far from achieving WWH goals and have changed little since 2001. Like other sites in this area, extensive hydromodifications here will also preclude biological assemblages from fully attaining WWH criteria through Enoch Creek. Both Prairie Run and Enoch Creek are recommended to receive the MWH-C designation. Similarly, the upper segment of Little Tymochtee Creek (upper) should also maintain its MWH-C designation.

- Reevhorn Run and Pawpaw Run are both recommended to be confirmed WWH. Habitat limitations were still present in both systems and hydromodifications were pervasive in this portion of the watershed. Despite having fish assemblages that fell short of WWH expectations at Pawpaw Run RM 1.10 (201432), macroinvertebrate community quality was very good. Both fish and macroinvertebrate communities only marginally met WWH expectations in Reevhorn Creek.

- Oak Run and Saint James Run are both recommended to have their WWH uses confirmed. Biological assemblages in Warpole Creek have improved through time and this stream is recommended to receive the WWH designation.

- Little Tymochtee Creek (lower) currently has a LRW use designation in its headwaters. Biological communities have improved here and met MWH-C criteria at RM 10.32 (U01G14).

This upper reach is recommended to be re-designated MWH-C. The remainder of Little Tymochtee Creek (lower) is recommended to retain the WWH designation.

- Though located in an adjacent watershed, the Little Sandusky River drains the same physiographic features as uppermost Tymochtee Creek and has similar habitat characteristics (Figure 6, Table 12). However, habitat quality and biological community performance have changed little here compared to the earliest samples collected in 1995. Instream habitat quality at RM 10.40 (201361) remains very poor and is unable to support assemblages that can consistently meet even MWH-C criteria. The upper reaches of the Little Sandusky River from its headwaters to its confluence with the tributary at RM 8.93 (Morral Run) is recommended to receive the MWH-C use designation. Despite general habitat limitations, the rest of the Little Sandusky River should retain its WWH use. Morral Run should also retain its MWH-C designation.

- All other streams sampled during the current survey and not explicitly discussed above should retain their existing ALU designation.

Recreation Use

Most streams evaluated during the survey maintain the Primary Contact Recreation (PCR) beneficial use and should retain this use. Four streams evaluated during the current survey had a Secondary Contact Recreation (SCR) designation, including Gries Ditch, Carol Ditch, tributary to Little Sandusky River (8.93), tributary to Paramour Creek (5.15). Carol Ditch and the tributary to Little Sandusky River (8.93) should retain the SCR use, while the remaining streams are recommended to receive the PCR use.

Prairie Run, Enoch Creek, and the uppermost segments of the Little Sandusky River are currently designated PCR. However, current survey results noted generally shallow conditions with limited potential for full body emersion. All are recommended to receive the SCR designation.

Numerous streams had an unverified PCR use designation, including Red Run, Reevhorn Run, Pawpaw Run, Oak Run, St. James Run, Spicer Creek, Sugar Creek, Indian Creek, Wolf Creek, East Branch Wolf Creek, East Branch of East Branch Wolf Creek, and Middle Branch of East Branch of East Branch Wolf Creek. These streams all should all have their PCR use designation confirmed. All formerly undesignated streams sampled during the survey should receive the PCR designation.

Water Supply Use

The Sandusky River maintains five locations along the mainstem that have public water supply intake and maintain the PWS use. Honey Creek at RM 28.35 and the unnamed tributary to Brokenknife Creek also maintain the PWS beneficial use.

All streams or stream segments with existing Agricultural Water Supply (AWS) and Industrial Water Supply (IWS) use designations should retain those uses. Those streams sampled during the survey that maintain unverified AWS and IWS use designations should have those uses confirmed. It is recommended that streams evaluated during this survey that did not have AWS and IWS beneficial use designations receive these designations.

Anti-degradation

The Sandusky River maintains an Outstanding State Waters (OSW) classification based on exceptional ecological values from U.S. Route 30 (RM 82.1) to Roger Young Memorial Park in Freemont, OH (RM 16.6). All other streams maintain a general high-quality waters (GHQW) classification. These uses should be retained.

Table 27 – Use designations for water bodies in the Sandusky River and Sandusky Bay tributaries effective 4/21/2021 (ORC 3745-1-12). Stream segments sampled during the survey are highlighted in grey.

Suggested revisions to beneficial uses are displayed below in red. A delta symbol (Δ) indicates recommended changes for that stream segment, while a ~~double strikethrough~~ indicates suggested removal of language from the WQS.

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	
| | | | | | | |														
Muddy Creek		+							+	+		+		
Little Muddy Creek		+							+	+		+		
Fishing Creek		+							+	+		+		
Gries Ditch		+							+	+		Δ	~~+~~	
North Branch		+							*	*		*		
South Branch		+							*/+	*/+		*/+		
Sandusky River - at RMs 18.02, 41.08, 82.9, 83.15 and 115.45		+						o	+	+		+		PWS intakes - Fremont (RM 18.02), Tiffin (RM 41.08), Upper Sandusky (RMs 82.9 and 83.15), and Bucyrus (RM 115.45)
- confluence of Tymochtee Creek (RM 65.73) to Roger Young Memorial Park (RM 16.6) (excludes MWH-I river segment)			Δ						Δ	Δ		Δ		
- RM 45.0 to Ella St. dam (RM 42.1)				+					+	+		+		ECBP ecoregion - impounded
- all other segments		+							+	+		+		
Bark Creek		+							+	+		+		
Muskellunge Creek		+							+	+		+		

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	
| | | | | | | |														
Indian Creek		*/+							*/+	*/+		*/+		
Wolf Creek		*/+							*/+	*/+		*/+		
Harrison Creek		Δ							Δ	Δ		Δ		
Plum Run		Δ							Δ	Δ		Δ		
Unnamed tributary (Wolf Creek at RM 8.10)		Δ							Δ	Δ		Δ		
East Branch		*/+							*/+	*/+		*/+		
Snuff Creek		*/+							*/+	*/+		*/+		*Note - sampled in 2009 but uses were not confirmed.*
East Branch		*/+							*/+	*/+		*/+		
Middle Branch		*/+							*/+	*/+		*/+		
Eicher Ditch (East Branch Wolf Ck. RM 20.37)		Δ							Δ	Δ		Δ		
John Smith Ditch (Eicher Ditch RM 4.00)							+		*	*			+	Small drainageway maintenance
~~Michael Gruss ditch (John Smith Ditch RM 3.97)~~							~~+~~		~~*~~	~~*~~			~~+~~	*Note - this stream is the continuation of Eicher Ditch upstream – no existing data.*
Sugar Creek		*/+							*/+	*/+		*/+		
Spicer Creek		*/+							*/+	*/+		*/+		
Morrison Creek – headwaters to Co. Rd. 43 (RM 7.9)				+					+	+		*/+		ECBP ecoregion – channel modification

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	
| | | | | | | |														
- Co. Rd. 43 (RM 7.9) to the mouth		+							+	+		*/+		
Willow Creek				+					+	+		+		ECBP ecoregion – channel modification
Unnamed tributary (Willow Creek RM 0.88)							o						o	Small drainageway maintenance
Rock Creek		+							+	+		+		
East Branch		+							+	+		+		
Armstrong & Beighly Ditch		*							*	*		*		
Carpenter Ditch		*							*	*		*		
Gibson Creek		+							+	+		+		
Bells Run		+							+	+		+		
Honey Creek ~~- headwaters to Scott Road (RM 37.3)~~		+							+	+		+		*Note: confirm all Honey Creek WWH*
~~- Scott road (RM 37.3) to State Route 4 (RM 28.35)~~				~~+~~					~~+~~	~~+~~		~~+~~		~~ECBP ecoregion – channel modification~~
- at RM 28.35		+						o	+	+		+		PWS intake - Attica
~~- State Route 4 (RM 28.35) to co. rte. 19 (RM 1.1)~~		~~+~~							~~+~~	~~+~~		~~+~~		
~~- co. rte. 19 (RM 1.1) to the mouth~~				~~+~~					~~+~~	~~+~~		~~+~~		~~ECBP ecoregion – impounded~~
Van Meter Creek (Honey Creek RM 3.69) - headwaters to Infirmary Road (RM 1.7)				+					+	+		+		ECBP ecoregion – channel modification
- Infirmary Road (RM 1.7) to the mouth		*							*	*		*		
Buckeye Creek		+							+	+		+		

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	
| | | | | | | |														
Silver Creek – headwaters to Brillhart Road (RM 8.7)							+		+	+		+		Small drainageway maintenance
- Brillhart Road (RM 8.7) to the mouth		+							+	+		*/+		
Slee Ditch (Silver Creek RM 0.72)		+							+	+		+		
Aicholz Ditch – headwaters to Co. Rd. 12 (RM 2.8)				+					+	+		+		ECBP ecoregion – channel modification
- Co. Rd. 12 (RM 2.8) to the mouth		+							+	+		+		
Kagy Ditch		*							*	*		*		
Bolinger Ditch		*							*	*		*		
Hedden Ditch		*							*	*		*		
Hooper Ditch		*							*	*		*		
Schaaf Ditch		*							*	*		*		
Brokenknife Creek - headwaters to Seneca/Crawford county line (RM 3.2)				+					+	+		+		ECBP ecoregion – channel modification
- Seneca/Crawford Co. Line (RM 3.2) to mouth		+							+	+		+		
Kibler Ditch (Brokenknife creek RM 5.27)							+		*	*			+	Small drainageway maintenance
Unnamed tributary (Brokenknife creek RM 5.50) - at RM 2.15								o						PWS intake - New Washington
Celery Creek (Honey Ck. RM 32.84) – Base Line Rd. (RM 4.54) to Section Line Rd. 30S (RM 2.2)		+							+	+		+		
- all other segments				+					+	+		+		ECBP ecoregion – channel modification
Tiro Creek (Honey Creek RM 41.75)		+							+	+		+		

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	
| | | | | | | |														
Mile Run		+							+	+		+		
~~Sycamore Creek – headwaters to State Route 19 (RM 17.8)~~				~~+~~					~~+~~	~~+~~		~~+~~		~~ECBP ecoregion – channel modification~~
Sycamore Creek ~~– State Route 19 (RM 17.8) to the mouth~~		+							+	+		+		*Note - confirm all Sycamore Creek WWH.*
Greasy Run		+							+	+		+		
Spring Creek (Sycamore Creek RM 12.92)		+							+	+		+		
Taylor Run		+							+	+		+		
West Branch (Taylor Run RM 2.49)				+					+	+		+		ECBP ecoregion – channel modification
Thorn Run		+							+	+		+		
Tymochtee creek – headwaters to ~~Cramer road (RM 51.8)~~ tributary at RM 49.69				Δ			~~+~~		+	+		+		~~Small drainageway maintenance~~ ECBP ecoregion – channel modification
~~– Cramer road (RM 51.8) to the mouth~~ -tributary at RM 49.69 to mouth		+							+	+		+		
Spring Run		+							+	+		+		
Poverty Run		+							+	+		+		
No. 32 Ditch		+							+	+		+		
Little Tymochtee Creek – headwaters to Co. Rd. 108 (RM 9.1)				Δ			~~+~~		+	+		*/+		~~Small drainageway maintenance~~ ECBP ecoregion – channel modification
- Co. Rd. 108 (RM 9.1) to the mouth		+							+	+		*/+		

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	
| | | | | | | |														
Hart Ditch		*							*	*		*		
Browns Run		*							*	*		*		
Veith Ditch		*							*	*		*		
Lick Run		+							+	+		+		
Baughman Run		*							*	*		*		
Blake Ditch		*							*	*		*		
Perkins Run		*							*	*		*		
Oak Run		*							*	*		*		
Sugar Run		+							+	+		+		
Warpole Creek		Δ		-					+	+		+		~~ECBP ecoregion – channel modification~~
St. James Run		*/+							*/+	*/+		*/+		
Unnamed tributary (Tymochtee Creek RM 40.30)				+					+	+			+	ECBP ecoregion - channel modification.
Little Tymochtee Creek – headwaters to Co. Rd. 205 (RM 8.63)				+					+	+		+		ECBP ecoregion – channel modification
- Co. Rd. 205 (RM 8.63) to the mouth		+							+	+		+		
Reevhorn Run		*/+							*/+	*/+		*/+		
Pawpaw Run		*/+							*/+	*/+		*/+		
Pawpaw Run		+							+	+		+		

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	
| | | | | | | |														
Unnamed tributary (Pawpaw Run RM 4.17)				+					+	+			+	ECBP ecoregion - channel modification.
Carroll Ditch				+					+	+			+	ECBP ecoregion - channel modification.
Enoch Creek		≠		Δ					+	+		≠	Δ	ECBP ecoregion - channel modification.
Blood Run		+							+	+		+		
Prairie Run		≠		Δ					+	+		≠	Δ	ECBP ecoregion - channel modification.
Thompson Ditch				+					+	+			+	ECBP ecoregion - channel modification.
Layton Ditch		+							+	+		+		
Sugar Run		+							+	+		+		
Negro Run		+							+	+		+		
Spring Branch		+							+	+		+		
Kiser Run		*							*	*		*		
Porcupine Creek		*							*	*		*		
Cranberry Run		*							*	*		*		
Rock Run		+							+	+		+		
Little Sandusky River – headwaters to unnamed tributary (RM 8.93)				Δ					Δ	Δ			Δ	ECBP ecoregion - channel modification.
- unnamed tributary (8.93) to mouth		+							+	+		+		
Honey Run		+							+	+		+		
Unnamed tributary (Little Sandusky River RM 8.93)				+					+	+			+	ECBP ecoregion - channel modification.

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	
| | | | | | | |														
Broken Sword Creek		+							+	+		+		
Indian Run – headwaters to State Route 231 (RM 1.7)				+					+	+		+		ECBP ecoregion – channel modification
- State Route 231 (RM 1.7) to the mouth		+							+	+		+		
Brandywine Creek – headwaters to Temple Road (RM 1.6)							+		+	+		*		Small drainageway maintenance
- Temple Road (RM 1.6) to the mouth		*/+							+	+		+		
Unnamed tributary (Broken Sword Creek RM 28.04)		+							+	+		+		
Red Run		Δ					~~+~~		+	+		*/+		~~Small drainageway maintenance~~
~~Grass run – headwaters to Marion Melmore road (RM 6.0)~~				~~+~~					~~+~~	~~+~~		~~+~~		~~ECBP ecoregion – channel modification~~
Grass Run ~~– Marion Melmore road (RM 6.0) to the mouth~~		+							+	+		+		*Note - confirm all Grass Run WWH.*
Gray Eye Run		+							+	+		+		
West North Robinson Run (Sandusky River RM 121.19)		+							+	+		+		
East North Robinson Run (Sandusky River RM 122.09)		+							+	+		+		
Loss Creek		+							+	+		+		
South Fork		+							+	+		+		
Paramour Creek		+							+	+		+		
Westerly Creek (Paramour Creek RM 1.92)		+							+	+		+		
East Crestline tributary (Paramour Creek RM 2.88)		+							+	+		+		
~~PPG Tributary~~ Unnamed tributary (Paramour Creek RM 5.13)		+							+	+		Δ	~~+~~	

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	
| | | | | | | |														
Allen Run		+							+	+		+		
Yellow Slough		*							*	*		*		
Green Creek - confluence with Beaver Creek (RM 20.4) to St. Rt. 20 (RM 10.1)						+			+	+		+		Native fauna
- all other segments		+							+	+		+		
Flag Run		*							*	*		*		
Beaver Creek - at RM 2.88		+						o	+	+		+		PWS intake - Clyde
- all other segments		+							+	+		+		
Owl Creek		*							*	*		*		
Emerson Creek		+							+	+		+		
Royer Ditch		+							+	+		+		
Westerhouse Ditch		+							+	+		+		
Albright Ditch		*							*	*		*		
Noel Ditch		*							*	*		*		
South Creek		+							+	+		+		
Raccoon Creek - at RM 13.1		+						+	+	+		+		PWS intake - Clyde (formerly)
- all other segments		+							+	+		+		
Little Raccoon Creek		+							+	+			+	
Buck Creek		+							+	+		+		

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	
| | | | | | | |														
Pickerel Creek		+							+	+		+		
Strong Creek		*							*	*		*		
Fuller Creek		*							*	*		*		
Little Pickerel Creek						+			+	+		+		Inland trout stream
Cold Creek - Blue Hole (RM 4.28) to confluence with Lake Erie						+			+	+		+		Inland trout stream
- all other segments		*							*	*		*		
Cold Creek tributaries downstream of Blue Hole						*			*	*		*		
Mills Creek		+							+	+		+		
Caswell Ditch (Mills Creek RM 3.95)		+							+	+		+		
Snyders Ditch - at RMs 5.0 and 5.5				+				o	+	+			+	HELP ecoregion - channel modification; PWS intakes - Bellevue.
- all other segments				+					+	+			+	HELP ecoregion - channel modification.
Pipe Creek		+							+	+		+		
Plum Brook		*							*	*		*		
Sawmill Creek		+							+	+		*		

Acknowledgements

Ohio EPA's Division of Surface Water (DSW) appreciates the cooperation of all property owners who assisted agency personnel access to the stream sites throughout the project area.

The following Ohio EPA staff provided technical expertise for this project:

Report preparation and analysis:

Andrew Phillips – report coordinator, Chris Riddle, Ben Smith, Josh Clifton, Kylie Smith, Rich Budnik, Ben Foster

Reviewers:

Ben Rich, Ruth Briland, Mariah Hood, Melinda Harris, Will Kiourtsis, and Chloe Welch

Field Sampling:

Fish Community Collections

Andrew Phillips with seasonal technicians Ryan Peetz, Chase Hall, and Troy Keller; Murphy Coan; Brian Alsdorf

Macroinvertebrate Community Collections

Ben Foster with seasonal technician Sara Miller; Edward Moore

Surface Water Chemistry

Chris Riddle, Ben Smith, Josh Clifton with season technician Brendon Herbert

Water Quality Modeling

Mohammed Asasi, Paul Gledhill, Will Kiourtsis, Matthew Lane, Spencer Lydon, and Christopher Selbe

Numerous other seasonal technicians not specifically listed assisted with the completion of this survey. Though unnamed, know that your contributions were critical in helping complete this project.

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