Biological and Water Quality Study of the Minor Great Black Swamp Tributaries, 2015-2016

Defiance, Fulton, Hancock, Henry, Paulding, Putnam and Wood Counties

South Turkeyfoot Creek at Township Rd. P, River Mile 3.2.

Ohio EPA Technical Report AMS/2015-MAUMT-2

Division of Surface Water
Assessment and Modeling Section
July 2020

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List of Acronyms

AFO	animal feeding operation
ALU	aquatic life use
AWS	agricultural water supply
BW	bathing water
CAFO	concentrated animal feeding operation
CAP	Conservation Action Project
CBOD	Carbonaceous biochemical oxygen demand
CFR	Code of Federal regulations
cfs	cubic feet per second
cfu	colony forming units
CSO	combined sewer overflow
CWA	Clean Water Act
CWH	coldwater habitat
DC	direct current
DDT	dichlorodiphenyltrichloroethane
DELT	deformities, erosions, lesions, tumors
DIN	dissolved inorganic nitrogen
DMR	Discharge Monitoring Report
D.O.	dissolved oxygen
ECBP	Eastern Corn Belt Plains
EPA	Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, Trichoptera
EQ	equalization
EWH	exceptional warmwater habitat
FPS	feet per second
GIS	geographic information system
GPS	global positioning system
HELP	Huron Erie Lake Plain
HHEI	headwater habitat evaluation index
HUC	hydrologic unit code
IBI	index of biotic integrity
ICI	invertebrate community index
IP	Interior Plateau
IPS	integrated prioritization system
IR	integrated report
IWS	industrial water supply

LCTP	long-term control plan
LLC	limited liability company
LRAU	large river assessment unit
LRW	limited resource water
MCL	maximum contaminant levels
MGD	million gallons per day
MHP	mobile home park
MIwb	Modified Index of well-being
MRBPLG	Maumee River Basin Partnership of Local Governments
MWH-C	Modified Warmwater Habitat - Channelized
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
OAC	Ohio Administrative Code
ODA	Ohio Department of Agriculture
ODNR	Ohio Department of Natural Resources
ORC	Ohio Revised Code
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCR	primary contact recreation
PEC	probable effects concentration
POR	point of record
PWS	public water supply
QHEI	Qualitative Habitat Evaluation Index
RM	river mile
SBR	sequencing batch reactor
SCR	secondary contact recreation
SQG	sediment quality guidelines
SRV	sediment reference value
SRW	state resource water
SSH	seasonal salmonid habitat
SSO	sanitary sewer overflow
STP	sewage treatment plant
s-VOC	semi volatile organic compound
TALU	tiered aquatic life use
TDS	total dissolved solids
TEC	threshold effects concentration
TKN	total Kjeldahl nitrogen

TMDL	total maximum daily load
TOC	total organic carbon
TP	Total Phosphorus
TSS	total suspended solids
TUa	toxicity unit – acute
UAA	use attainability analysis
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VFW	Veterans of Foreign Wars
VOC	volatile organic compound
WAU	watershed assessment unit
WQS	water quality standards
WRF	wastewater reclamation facility
WWH	warmwater habitat
WTP	water treatment plant
WWTP	wastewater treatment plant

Executive Summary

Rivers and streams in Ohio support a variety of beneficial uses such as aquatic life, recreation, human health, and water supply. Ohio EPA evaluates streams throughout the state to determine appropriate beneficial use designations, evaluate temporal trends and to determine if the beneficial use is meeting the goals of the federal Clean Water Act. Fifty tributary streams draining to the upper and middle reaches of the Maumee River were evaluated in 2015 and 2016 for aquatic life, recreation and human health use potential. Most data presented throughout this report were collected in 2015, with additional follow-up data collected during the 2016 sampling season at select locations. Sampling locations and corresponding narrative biological evaluations are displayed in Figure 1 and Table 1.

A total of 40 National Pollutant Discharge Elimination System (NPDES) individual permitted facilities discharge sanitary wastewater, industrial process water and/or industrial storm water into streams within the study area (Table 6). Three major municipal dischargers (city of Wauseon WRF, village of Hicksville, and village of Leipsic) reside in the study area. More substantial discussion pertaining to specific NPDES-permitted dischargers, including facility descriptions, compliance summaries, pollutant loading data, and summaries of effluent quality for various parameters can be found in the ***NPDES Permitted Facilities*** section of this document.

Fish and ***macroinvertebrate*** community samples were collected from 90 locations. 79 of these locations (88 percent) were fully meeting the designated or recommended aquatic life use (ALU), while 11 locations (12 percent) were only in partial attainment (Table 2). Fish community performance has generally improved through time, with declines only noted in the Zuber Cutoff sub-basin, a system that experienced a substantial fish kill and displayed significant enrichment signatures (Table 21). Macroinvertebrate community performance trends, like the fish, were mostly positive. Many locations displayed stable or improving trends, though locations throughout North Turkeyfoot Creek displayed declines in macroinvertebrate community performance, despite still meeting ecoregional criterion (Figure 75); declines (and impairment) were also noted in Brinkman Ditch and throughout the Zuber Cutoff sub-basin.

Negative impacts associated with nutrient enrichment, such as large diel (daily) dissolved oxygen (DO) concentration swings or low DO concentrations, were a likely driver of biological impairment at several locations (Table 21). Deficient instream habitat conditions, including excessive siltation smothering natural substrates and/or low base streamflow were also associated with impairment in some smaller streams. Deficient instream habitat (reduced riparian, simplified stream development) can exacerbate enriched conditions in a stream system. Row crop agriculture, manure application and runoff, and historical channelization activities were the most widespread sources of nonpoint source pollution. Municipal wastewater facilities and unsewered areas were also likely contributing to impairment in more localized areas. A complete list of biological sampling locations, aquatic life beneficial use attainment status, and associated causes and sources of impairment are found in Table 2.

Surface water chemistry grab samples were collected from 98 locations throughout the study area, while ***continuous water quality sonde recorders*** were also placed at 42 locations. Nutrient enrichment signatures were pervasive throughout the study area (Table 21). Surface water chemistry grab samples noted numerous minimum DO exceedances in multiple streams throughout the study area (Table 15). Continuous water quality sonde recorders also noted multiple minimum and average DO exceedances, as well as elevated diel DO ranges at locations throughout the study area (Table 19, Table 20, Table 21). Instream nutrient concentrations were commonly above benchmark concentrations (Table 14). Total dissolved solids (TDS) exceedances were documented in Beaver Creek, Little Yellow Creek, and Sugar Creek (Table 15). Continuous water quality sonde recorders noted a specific conductance exceedance in

Little Yellow Creek (Table 20). Two selenium exceedances were also documented in Little Yellow Creek at RM 0.9 (Table 15). Continuous sonde recorders noted a pH exceedance in North Turkeyfoot Creek at RM 17.85 (Table 19). Surface water grab samples also noted multiple iron and temperature exceedances throughout the study area (Table 15). Though no exceedances occurred, ammonia concentrations were elevated at multiple locations (Figure 23). A complete list of exceedances is displayed in Table 15, Table 19, and Table 20, while nutrient concentrations exceeding benchmark levels are displayed in Table 14.

Stream physical habitat was evaluated at 89 fish sampling locations throughout the area using the Qualitative Habitat Evaluation Index (QHEI). QHEI scores ranged from 16 to 80.5, with corresponding narrative evaluations ranging from very poor to excellent (Figure 51, Table 25). Mean QHEI scores from wading sites ($\bar{x}$=60.1, n=33) indicated generally good habitat quality where evaluated, while habitat quality at headwater sites ($\bar{x}$=47.1, n=59), collectively, was in the fair range. Deficient habitat quality likely limited biological performance in areas (Figure 49).

In support of the ***Recreation beneficial use***, 59 locations in the watershed were tested for *E. coli* levels five times between May 21 and Sept. 8, 2015. Evaluation of *E. coli* results revealed that 50 of the 59 locations sampled failed to meet the applicable geometric mean criterion, indicating non-attainment of the recreation use at these locations (Table 22). The locations that met the recreation beneficial use criterion were all designated secondary contact recreation (SCR), while all locations that failed to meet the criterion maintain a primary contact recreation (PCR) designation.

Sediment chemistry was evaluated at five total locations and was analyzed for percent solids, total organic carbon (TOC), metals, total phosphorus, and s-VOCs (PAHs). Samples were also analyzed for PCBs in School Creek and Little Yellow Creek. A summary of parameters measured above Sediment Quality Guidelines are presented in

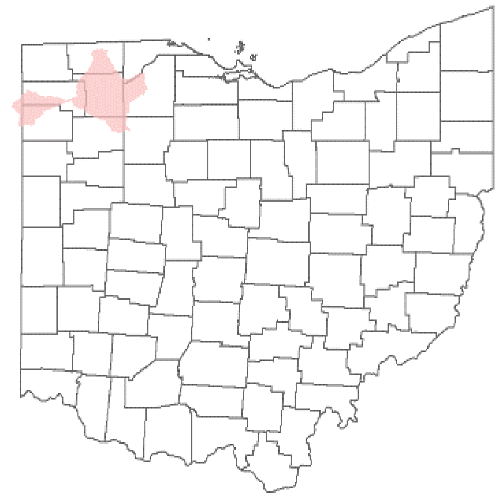
Table 23, while a complete listing of all sediment sampling locations and parameter results can be found in Appendix H. All results were below the probable effect concentration (PEC).

Seven water bodies had ***fish tissue*** sampled as part of the survey. Prior to 2015 sampling, there were no consumption advisories in place for any species at any of these locations. Four fish consumption advisories were issued in 2016 based on the 2015 efforts, all of which were positive, or less restrictive, advisories due to low levels of mercury in fish at these locations. For all other species, the statewide advisories apply. Additionally, fish contaminant data are also used to determine attainment with the human health water quality criteria. Fish tissue data were adequate to determine attainment status for four of the eight watershed assessment units sampled: two units were in attainment and two were impaired because of PCBs in fish tissue (Table 33).

Two public water systems (Delta and Wauseon) are served by surface water sources within the study area. Samples were collected from Bad Creek, Delta Reservoirs #1 and #2, and Wauseon Reservoir #2 to assess the ***Public Water Supply* (PWS)** beneficial use. Nitrate-nitrite concentrations were below drinking water criterion in all reservoir samples, but two PWS criterion exceedances were noted in Bad Creek. Atrazine concentrations ranged from below detect to 1.3 ug/L and was below annual average criterion at all locations. All cyanotoxin results were below method detection limits. Summaries for parameters of concern are contained in Table 34. Lower Bad Creek (HUC 04100007 03 02) was listed as impaired for the PWS beneficial use due to elevated nitrate-nitrate concentrations. Though fully meeting criterion in the reservoir, the North Turkeyfoot Creek assessment unit (04100009 04 02) was put on a watch list due to high instream nitrate-nitrite concentrations near the back-up intakes.

Introduction

Fifty selected tributary streams to the Maumee River were evaluated at 107 sampling locations in Defiance, Fulton, Hancock, Henry, Paulding, Putnam, and Wood counties in 2015 and 2016. In the years preceding this survey, the major tributary streams to the Maumee River residing in Ohio were sampled extensively, including portions of the Auglaize River, the Tiffin River, the St. Joseph River, and the St. Marys River. The 2015-2016 survey focused on the relatively smaller tributary systems in the upper and middle reaches of the Maumee River in Ohio. Streams evaluated in 2015 and 2016 are displayed in Figure 1 and listed in Table 1. Primary sampling occurred in 2015, while additional sampling occurred in 2016 to either gather more information from select streams or elucidate causes or sources of aquatic life use impairment where necessary.



A total of 40 NPDES-permitted facilities discharge sanitary wastewater, industrial process water, and/or industrial storm water into streams within the Minor Great Black Swamp Tributaries study area. A complete list of NPDES-permitted facilities can be found in Table 6.

From 2015-2016, Ohio EPA conducted a water resource assessment of 50 selected tributary streams within the Maumee River watershed residing in Ohio (Figure 1) using standard Ohio EPA protocols as described in Notice to Users, located in the appendices to this document. Included in this study were assessments of the biological, surface water and recreation (bacterial) condition. A total of 90 biological, 98 water chemistry, 42 water quality sonde, and 59 bacteriological stations were sampled in the Minor Great Black Swamp Tributaries study area. Physical habitat was assessed at each biological sampling location. Fish tissue sampling was also conducted within seven waterbodies in the study area to support Ohio's Sport Fish Health and Consumption Advisory program.

Specific objectives of the watershed survey were to:

- systematically sample and assess the principal drainage network of the Minor Great Black Swamp Tributaries in support of both the TMDL process and NPDES permits program;
- ascertain the present biological conditions these tributaries by evaluating fish and macroinvertebrate communities;
- assess physical habitat influences on biotic integrity;
- identify ambient levels of organic, inorganic, and nutrient parameters in the water column and sediments;
- verify the appropriateness of existing Beneficial Use designations (for example, aquatic life, recreational, and water supply);
- assign Beneficial Use designations to undesignated waters;
- determine water quality as it pertains to recreational use potential;
- determine the attainment status and recommend changes to Beneficial Use designations if deemed appropriate; and
- document any changes in the biological, chemical, and physical conditions within the study area where historical information exists.

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

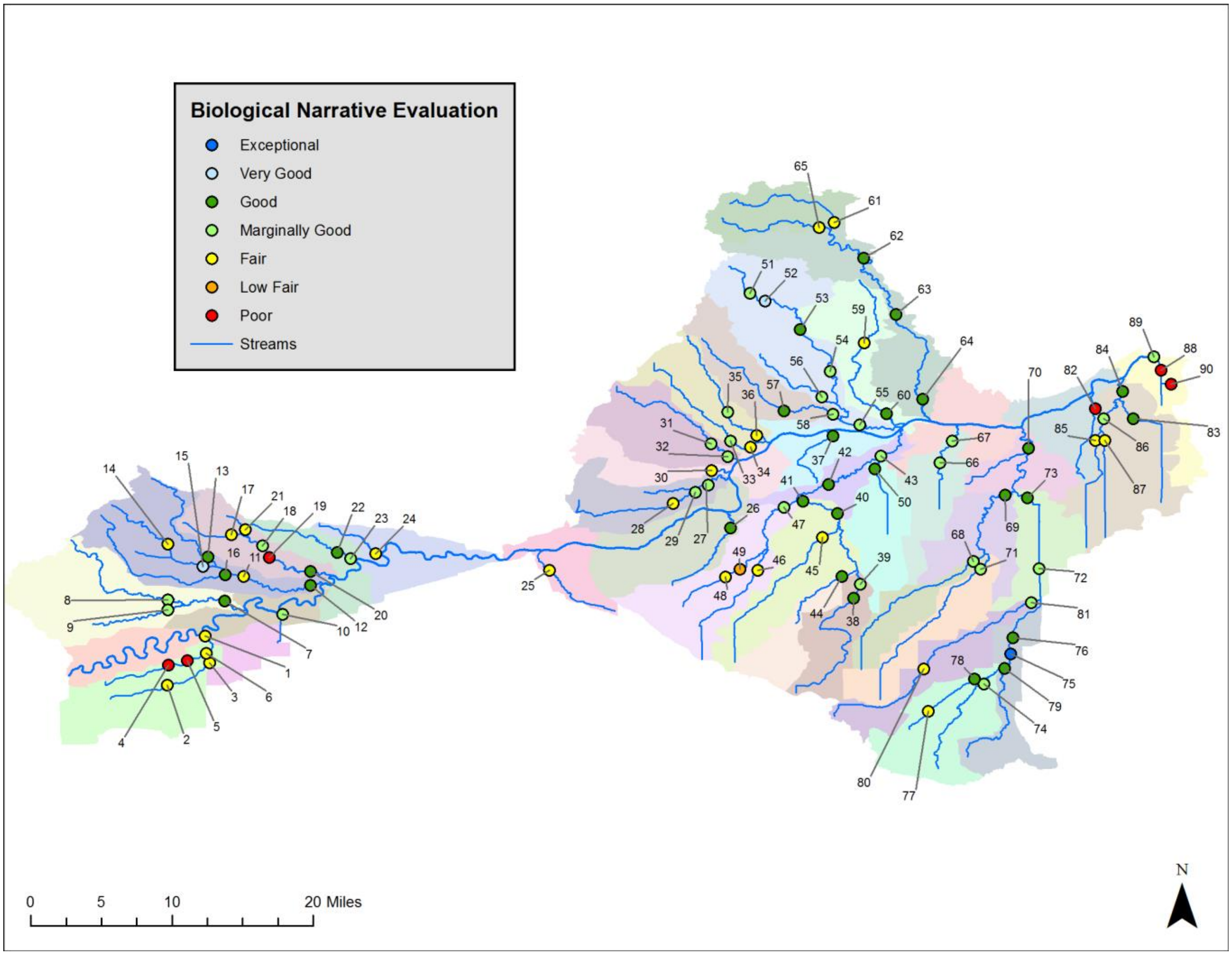


Figure 1 — Biological sampling locations within the Minor Great Black Swamp Tributaries study area, 2015-16. Site numbers correspond to Table 1.

Table 1 — Biological and water quality sampling locations within the Minor Great Black Swamp Tributaries study area, 2015-16. The color of the site number corresponds to the narrative evaluation of the lowest scoring organism group, either fish or macroinvertebrates. Narrative evaluations can encompass seven tiers: exceptional; very good; good; marginally good; fair; low fair; and poor. Sites shaded blue (exceptional, very good) meet EWH and sites shaded green meet WWH. Sites shaded orange or red do not meet WWH goals. Sites shaded yellow do not meet WWH goals if macroinvertebrates communities are responsible for the fair evaluation, however, a fair narrative with regard to fish communities does meet the WWH criterion in the Huron-Erie Lake Plain (HELP) ecoregion.

Site Number	Stream	River Mile	Drainage Area	Latitude	Longitude
1	Zuber Cutoff	1.1	29.00	41.1922	-84.6819
2	South Creek	3.7	11.35	41.15065	-84.7283
3	South Creek	0.35	23.10	41.1793	-84.6838
4	North Creek	2.95	3.24	41.1711	-84.7272
5	North Creek	1.6	3.89	41.1756	-84.7081
6	North Creek	0.3	4.64	41.18337	-84.6887
7	Marie DeLarme Creek	2.05	26.80	41.23668	-84.6694
8	North Branch Marie DeLarme	1.6	8.40	41.2381	-84.7278
9	South Branch Marie DeLarme	1.3	7.50	41.2275	-84.7278
10	Six Mile Cutoff	0.25	11.20	41.22309	-84.6104
11	Gordon Creek	6.6	37.00	41.2622	-84.65
12	Gordon Creek	1.1	43.40	41.25281	-84.5814
13	North Fork Gordon Creek	1.25	11.10	41.28083	-84.6896
14	Middle Fork Gordon Creek	3.8	5.30	41.295	-84.7281
15	Middle Fork Gordon Creek	0.76	13.00	41.27403	-84.6895
16	South Fork Gordon Creek	0.23	10.91	41.26352	-84.6693
17	Platter Creek	8.0	4.50	41.30343	-84.65
18	Platter Creek	6.4	11.91	41.29321	-84.6309
19	Platter Creek	5.4	12.80	41.28163	-84.6239
20	Platter Creek	1.7	19.96	41.2673	-84.5814
21	Trib. to Platter Creek (7.66)	0.8	5.00	41.31002	-84.65
22	Sulphur Creek	1.2	7.10	41.2811	-84.544
23	Sulphur Creek	0.13	9.90	41.28084	-84.5356
24	Snooks Run	0.5	4.20	41.28547	-84.5149
25	Preston Run	2.45	7.71	41.26802	-84.3366
26	Wade Creek	1.8	9.80	41.3114	-84.1506
27	Benien Creek	2.3	21.60	41.3558	-84.1739
28	Brubaker Creek	2.4	8.45	41.33664	-84.2098
29	Brubaker Creek	0.5	9.90	41.3481	-84.1867
30	Trib. to Maumee River (48.7)	1.34	12.61	41.37057	-84.1702
31	Garrett Creek	2.5	17.24	41.39776	-84.1706
32	Garrett Creek	0.7	27.80	41.3847	-84.1536
33	Oberhaus Creek	2.5	8.30	41.4006	-84.1511
34	Oberhaus Creek	0.4	10.06	41.39919	-84.1237
35	Van Hyning Creek	4.31	9.80	41.43066	-84.1537
36	Van Hyning Creek	0.75	13.76	41.40452	-84.1218
37	Trib. to Maumee River (42.2)	0.4	7.03	41.40617	-84.0458
38	South Turkeyfoot Creek	20.94	18.90	41.2397	-84.0247
39	South Turkeyfoot Creek	19.75	20.20	41.25421	-84.0176
40	South Turkeyfoot Creek	13.18	65.00	41.3267	-84.0411
41	South Turkeyfoot Creek	10.8	73.00	41.3389	-84.0767
42	South Turkeyfoot Creek	7.9	116.00	41.35626	-84.0504
43	South Turkeyfoot Creek	3.2	143.00	41.38556	-83.9965

Site Number	Stream	River Mile	Drainage Area	Latitude	Longitude
44	West Creek (trib. to South Turkeyfoot Ck.)	1.0	15.40	41.2619	-84.0367
45	Lost Creek	1.3	20.70	41.30222	-84.0567
46	School Creek	7.0	9.84	41.26812	-84.1226
47	School Creek	0.9	32.70	41.33299	-84.0958
48	Brinkman Ditch	2.8	8.00	41.2644	-84.1522
49	Brinkman Ditch	2.35	8.30	41.2678	-84.1456
50	Little Turkeyfoot Creek	0.5	22.10	41.37848	-83.9981
51	North Turkeyfoot Creek	19.06	4.50	41.5522	-84.1308
52	North Turkeyfoot Creek	17.85	5.80	41.5444	-84.1153
53	North Turkeyfoot Creek	13.79	19.60	41.5153	-84.0797
54	North Turkeyfoot Creek	9.7	31.00	41.4722	-84.0486
55	North Turkeyfoot Creek	3.4	73.00	41.4175	-84.0183
56	Trib. to North Turkeyfoot Creek (6.68)	1.02	9.94	41.44578	-84.0572
57	Konzen Ditch	4.2	15.56	41.43151	-84.0959
58	Konzen Ditch	0.65	24.70	41.42836	-84.0457
59	Dry Creek	8.8	11.30	41.50122	-84.014
60	Dry Creek	1.6	23.94	41.4286	-83.991
61	Bad Creek	22.5	12.00	41.61794	-84.0473
62	Bad Creek	17.51	36.00	41.5883	-84.0142
63	Bad Creek	10.46	44.00	41.53038	-83.981
64	Bad Creek	2.47	58.00	41.44347	-83.954
65	South Branch Bad Creek	0.44	10.15	41.62016	-84.0538
66	Big Creek	3.51	17.80	41.3786	-83.9361
67	Big Creek	1.3	20.70	41.4008	-83.9233
68	Beaver Creek	16.16	19.39	41.27743	-83.902
69	Beaver Creek	8.3	65.00	41.3456	-83.8692
70	Beaver Creek	2.7	184.00	41.3936	-83.845
71	East Beaver Creek (a.k.a. Hammer Creek)	1.34	24.26	41.2695	-83.8944
72	Jackson Cutoff Ditch	6.6	86.29	41.26976	-83.8342
73	Jackson Cutoff Ditch	1.15	101.00	41.3428	-83.8461
74	Yellow Creek	8.02	18.30	41.1531	-83.8922
75	Yellow Creek	4.5	49.70	41.18251	-83.8636
76	Yellow Creek	3.2	51.00	41.1989	-83.8614
77	Little Yellow Creek	4.6	2.1	41.1239	-83.9479
78	Little Yellow Creek	0.9	7.70	41.1558	-83.9
79	West Creek (trib. to Yellow Ck.)	0.1	13.30	41.16784	-83.8699
80	Brush Creek	8.99	10.02	41.1673	-83.9526
81	Brush Creek	0.58	24.60	41.23514	-83.8425
82	Sugar Creek	1.1	5.40	41.43398	-83.7768
83	Tontogany Creek	4.15	11.21	41.42372	-83.7378
84	Tontogany Creek	1.57	39.40	41.4519	-83.7486
85	West Branch Tontogany Creek	3.42	6.60	41.40859	-83.7725
86	West Branch Tontogany Creek	2.19	20.80	41.42338	-83.7682
87	Trib. to West Branch Tontogany Creek (3.2)	0.72	13.05	41.40141	-83.7671
88	Liberty Hi Rd. Ditch	1.15	11.30	41.47322	-83.7091
89	Liberty Hi Rd. Ditch	0.1	14.40	41.4868	-83.7165
90	Haskins Rd. Ditch	0.3	9.55	41.45918	-83.7036

KEY Exceptional, Very Good, Good, Marginally Good, Fair, Low Fair, Poor

Table 2 — Aquatic life use attainment status for locations sampled within the Minor Great Black Swamp Tributaries study area based on data collected June-October 2015 and 2016; biological scores denoted with [brackets] were collected in 2016. The IBI, MIwb and ICI are scores based on the performance of the biological communities. The QHEI is a measure of the ability of the physical habitat of the stream to support a biotic community. The study area is located entirely within the HELP ecoregion. If biological impairment has occurred, the cause(s) and source(s) of the impairment are noted. Specific sampling locations for fish and macroinvertebrates may differ slightly from what is listed in the below table; any differences are contained within the results tables in their respective sections. NA = not applicable.

Location	STORET (RM)[a]	Drain. (mi^2)	IBI	MIwb[b]	ICI[c]	QHEI	Status[d]	Causes	Sources
Zuber Cutoff (04-001-009)							**Undesignated – WWH Recommended**		
At Co. Rd. 180	P06K13 1.1	29.0[W]	[32]	[6.61*]	[G]	[63.75]	[PARTIAL]	Nutrient enrichment; Fish kills	Manure application and runoff; Row crop agriculture
North Creek (04-061-000)							**WWH Existing – Unverified/MWH-C Recommended**		
Upst. Antwerp WWTP @ Barker Rd.	P06W17 2.95	3.24[H]	24	N/A	LF*	22.00	PARTIAL	Low flow; Siltation; Nutrient enrichment	Channelization; Manure application and runoff; Row crop agriculture
Dst. Antwerp WWTP @ Murphy Rd.	P06W16 1.60	3.89[H]	25	N/A	HF	19.00	FULL		
North Creek (04-061-000)							**WWH Existing – Unverified/Confirmed**		
Near mouth @ Twp. Rd. 61	303746 0.3	4.64[H]	[35]	N/A	[F*]	[47.00]	[PARTIAL]	Nutrient enrichment	Manure application and runoff; Row crop agriculture; Municipal point source
South Creek (04-062-000)							**WWH Existing – Unverified/MWH-C Recommended**		
At Co. Rd. 144 (Gasser Rd.)	302971 3.7	11.35[H]	32 [26]	N/A	P* [HF]	33.50 [30.25]	[FULL]		
South Creek (04-062-000)							**WWH Existing – Unverified/Confirmed**		
At Victory Rd.	302970 0.35	23.10[W]	42 [34]	9.13 [7.25[NS]]	42 [F*]	62.25 [46.75]	[PARTIAL]	Nutrient enrichment; Total ammonia; Fish kills	Manure application and runoff; Row crop agriculture
Marie DeLarme Creek (04-056-000)							**WWH Existing – Unverified/Confirmed**		
At Twp. Rd. 72	303387 2.05	26.80[W]	38	8.41	34	59.10	FULL		
North Branch Marie DeLarme Creek (04-057-000)							**WWH Existing – Unverified/Confirmed**		
North OF Antwerp @ Co. Rd. 45 (Trembley Rd.)	P06K25 1.60	8.40[H]	38	N/A	G	39.00	FULL		

Location	STORET (RM)[a]	Drain. (mi²)	IBI	MIwb[b]	ICI[c]	QHEI	Status[d]	Causes	Sources
South Branch Marie DeLarme Creek (04-060-000)							**WWH Existing – Unverified/Confirmed**		
North of Antwerp @ Co. Rd. 45	P06K26 1.30	7.50 [H]	44	N/A	MG[NS]	42.25	FULL		
Six-mile Cutoff (04-001-011)							**Undesignated/WWH Recommended**		
At Twp. Rd. 206	303386 0.25	11.20 [H]	44	N/A	MG[NS]	67.25	FULL		
Gordon Creek (04-052-000)							**MWH-C Existing/WWH Recommended**		
Southwest of Mark Center at Wonderly Rd.	P06S15 6.67	37.00 [W]	33	8.67	44	41.50	FULL		
Southwest of Sherwood @ Countyline Rd. (lower crossing)	P06S04 1.12	43.40 [W]	38	8.39	42	70.50	FULL		
North Fork Gordon Creek (04-054-000)							**MWH-C Existing/WWH Recommended**		
At Rosedale Rd.	302972 1.25	11.10 [H]	46	N/A	G	48.75	FULL		
Middle Fork Gordon Creek (04-055-000)							**MWH-C Existing/WWH Recommended**		
At Lake Rd.	P06S18 3.8	5.30 [H]	[34]	N/A	[F*]	[31.25]	[PARTIAL]	Direct habitat alterations; Siltation	Channelization; Row crop agriculture
Southeast of Hicksville @ Rosedale Rd.	P06S16 0.76	13.00 [H]	46	N/A	44	44.25	FULL		
South Fork Gordon Creek (04-053-000)							**MWH-C Existing/ WWH Recommended**		
At Breininger Rd.	302973 0.23	10.91 [H]	48	N/A	G	43.25	FULL		
Platter Creek (04-051-000)							**WWH Existing – Unverified/MWH Recommended**		
At Wonderly Rd.	303014 7.95	4.50 [H]	36 [20]	N/A	HF [LF*]	28.5 [16.00]	[PARTIAL]	Low flow	Channelization
Platter Creek (04-051-000)							**WWH Existing – Unverified/Confirmed**		
At Farmer Mark Rd.	302975 6.41	11.91 [H]	46	N/A	MG[NS]	42.75	FULL		
At Fountain Rd.	302974 5.4	12.8 [H]	[26[NS]]	N/A	[F*]	[26.5]	[PARTIAL]	Nutrient enrichment; Low flow alterations; Siltation	Row crop agriculture; Manure application and runoff; Unsewered communities; Channelization

Location	STORET (RM)[a]	Drain. (mi²)	IBI	MIwb[b]	ICI[c]	QHEI	Status[d]	Causes	Sources
At Jericho Rd. (western crossing)	303010 1.70	19.96 [H]	48	N/A	G	61.00	FULL		
Tributary to Platter Creek (7.66) (04-051-001)							**Undesignated/MWH Recommended**		
At Wonderly Rd.	303015 0.78	5.00 [H]	34	N/A	HF	31.50	FULL		
Sulphur Creek (04-050-000)							**WWH Existing – Unverified/Confirmed**		
Upst. Sherwood WWTP @ Coy Rd.	302976 1.20	7.10 [H]	40	N/A	G	64.50	FULL		
Dst. Sherwood @ Roland Rd.	P06W19 0.13	9.90 [H]	40	N/A	MG[NS]	61.25	FULL		
Snooks Run (04-049-000)							**WWH Existing – Unverified/Confirmed**		
At Slough Rd.	P06K17 0.50	4.20 [H]	36	N/A	F*	53.50	PARTIAL	Organic enrichment	Unsewered Areas; Manure application and runoff
Preston Run (04-047-000)							**WWH Existing – Unverified/Confirmed**		
At Standley Rd.	302977 2.45	7.71 [H]	28	N/A	MG[NS]	59.50	FULL		
Wade Creek (04-045-000)							**WWH Existing – Unverified/Confirmed**		
Southeast of Florida @ Co. Rd. K	P09K22 1.80	9.80 [H]	42	N/A	G	74.25	FULL		
Benien Creek (04-042-000)							**WWH Existing – Unverified/Confirmed**		
Southwest of Napoleon @ Twp. Rd. N	P09K18 2.30	21.60 [W]	34	7.72	38	65.75	FULL		
Brubaker Creek (04-043-000)							**WWH Existing – Unverified/Confirmed**		
At Co. Rd. 17-D	302979 2.40	8.45 [H]	32	N/A	G	59.50	FULL		
Northeast of Florida @ Twp. Rd. M-2	P09K19 0.50	9.90 [H]	34	N/A	G	57.25	FULL		
Tributary to Maumee River (48.7) (04-001-012)							**Undesignated/WWH Recommended**		
At Twp. Rd. 16	302980 1.34	12.61 [H]	34	N/A	36	75.25	FULL		
Garrett Creek (04-041-000)							**WWH Existing – Unverified/Confirmed**		
At Twp. Rd. 16	302982 2.49	17.24 [H]	40	N/A	MG[NS]	53.75	FULL		

Location	STORET (RM)[a]	Drain. (mi²)	IBI	MIwb[b]	ICI[c]	QHEI	Status[d]	Causes	Sources
Near Napoleon @ Co. Rd. P	P09K17 0.70	27.80 [W]	38	8.48	MG[NS]	68.50	FULL		
Oberhaus Creek (04-039-000)							**WWH Existing – Unverified/Confirmed**		
Near Napoleon @ Co. Rd. 15	P09K15 2.50	8.30 [H]	40	N/A	MG[NS]	53.5	FULL		
In Napoleon @ Oakwood Ave.	302985 0.40	10.06 [H]	32	N/A	MG[NS]	60.25	FULL		
Van Hyning Creek (04-040-000)							**WWH Existing – Unverified/Confirmed**		
At Twp. Rd. 15	302984 4.31	9.80 [H]	38	N/A	G	54.25	FULL		
In Napoleon @ Oakwood Ave.	302983 0.75	13.76 [H]	32	N/A	G	53.5	FULL		
Tributary to Maumee River (42.2) (04-001-013)							**Undesignated/WWH Recommended**		
At St. Rte. 110	302986 0.40	7.03 [H]	44	N/A	G	56.25	FULL		
South Turkeyfoot Creek (04-029-000)							**WWH Existing – Unverified/Confirmed**		
At Hamler @ Co. Rd. F	P09S27 20.94	18.90 [H]	44	N/A	36	46.25	FULL		
Northwest of Hamler @ Co. Rd. G	P09S26 19.75	20.20 [W]	36	8.25	40	41.50	FULL		
At Malinta @ Co. Rd. L	P09W13 13.18	65.00 [W]	43	9.19	G	66.50	FULL		
Northwest of Malinta @ Co. Rd. 11 (upper crossing)	P09W12 10.80	73.00 [W]	38	8.96	38	67.75	FULL		
Near Shunk @ Co. Rd. N	302836 7.90	116.00 [W]	41	9.26	40	71.75	FULL		
At Twp. Rd. P	303388 3.20	143.00 [W]	37	9.17	VG	63.50	FULL		
West Creek (04-033-000)							**WWH Existing – Unverified/Confirmed**		
At State Rte. 109	P10K07 1.00	15.40 [H]	40	N/A	52	42.25	FULL		
Lost Creek (04-031-000)							**WWH Existing – Unverified/Confirmed**		
Southwest of Malinta @ Co. Rd. 10	P09S09 1.30	20.70 [W]	35	8.50	F*	49.50	PARTIAL	Low flow; Siltation	Channelization

Location	STORET (RM)[a]	Drain. (mi^2)	IBI	MIwb[b]	ICI[c]	QHEI	Status[d]	Causes	Sources
School Creek (04-035-000)							**Undesignated/WWH Recommended**		
Dst. Holgate @ Co. Rd. H	302993 7.00	9.84 [H]	34	N/A	G	37.50	FULL		
At Co. Rd. 12	302994 0.90	32.70 [W]	42	8.79	MG[NS]	65.50	FULL		
Brinkman Ditch (04-036-000)							**WWH Existing – Unverified/Confirmed**		
Upst. Holgate WWTP @ Co. Rd. 15	P09K11 2.80	8.00 [H]	34	N/A	[MG[NS]]	56.75	FULL		
Dst. Holgate WWTP @ Co. Rd. H	P09W17 2.35	8.30 [H]	32	N/A	F*	41.25	PARTIAL	Nutrient enrichment	Row crop agriculture; Municipal point source
Little Turkeyfoot Creek (04-030-000)							**WWH Existing – Unverified/Confirmed**		
At Twp. Rd. 04	302843 0.48	22.10 [W]	44	8.67	46	74.75	FULL		
North Turkeyfoot Creek (04-037-000)							**WWH Existing**		
Upst. Wauseon WRF @ Reighard Park	P09S19 19.06	4.50 [H]	36	N/A	34	44.50	FULL		
Dst. Wauseon WRF @ Co. Rd. 13	P09S04 17.85	5.80 [H]	50	N/A	42	50.00	FULL - THREATENED	Nutrient enrichment	Row crop agriculture; Municipal point source
Southeast of Wauseon @ Co. Rd. C	P09S03 13.79	19.60 [H]	41	N/A	40	66.25	FULL		
Northwest of Liberty Center @ Co. Rd. V	P09K12 9.67	31.00 [W]	34	8.70	46	52.00	FULL		
South of Liberty Center @ Co. Rd. 8	P09S01 3.40	73.00 [W]	37	9.16	42	54.00	FULL		
Tributary to North Turkeyfoot Creek (6.68) (04-037-001)							**Undesignated/WWH Recommended**		
At Co. Rd. 10	302989 1.02	9.94 [H]	40	N/A	MG[NS]	31.00	FULL		
Konzen Ditch (04-038-000)							**MWH-C Existing/WWH Recommended**		
At Co. Rd. 12	302987 4.20	15.56 [H]	40	N/A	34	47.75	FULL		
Near mouth @ Co. Rd. S	P09K14 0.65	24.70 [W]	36	8.81	42	56.50	FULL		
Dry Creek (04-028-000)							**WWH Existing – Unverified/Confirmed**		
At Co. Rd. B	302848 8.80	11.30 [H]	42	N/A	F*	36.50	PARTIAL		

Location	STORET (RM)[a]	Drain. (mi^2)	IBI	MIwb[b]	ICI[c]	QHEI	Status[d]	Causes	Sources
Dst. Liberty Center @ Co. Rd. S	302990 1.60	23.94 W	44	8.41	54	56.50	FULL		
Bad Creek (04-026-000)							**WWH Existing**		
Upst. South branch @ Co. Rd. K	P11K48 22.45	12.00 H	28	N/A	48	42.75	FULL		
Upst. Delta @ Co. Rd. H	P11W22 17.51	36.00 W	41	9.30	VG	71.75	FULL		
Southeast of Delta @ Co. Rd. D	P11S05 10.46	44.00 W	38	8.75	42	55.75	FULL		
South of Colton @ Co. Rd. T	P11S04 2.47	58.00 W	43	8.03	VG	50.00	FULL		
South Branch Bad Creek (04-027-000)							**WWH Existing**		
At Co. Rd. 10	302849 0.44	10.15 H	34	N/A	42	44.50	FULL		
Big Creek (04-024-000)							**WWH Existing – Unverified/Confirmed**		
Near McLure @ Woodlawn Ave.	P09S28 3.51	17.80 H	36	N/A	38	63.5	FULL		
North of McLure @ Twp. Rd. Q	P09K06 1.30	20.70 W	38	7.51	G	67.25	FULL		
Beaver Creek (04-015-000)							**WWH Existing – Unverified/Confirmed**		
West of Custar @ Co. Rd. 2	302998 16.16	19.39 H	40	N/A	30[NS]	40.25	FULL		
Upst. Jackson Cutoff @ Wapakoneta Rd.	P10K03 8.30	65.00 W	43	9.67	38	58.00	FULL		
Southeast of Grand Rapids @ Wintergreen Rd.	P10K02 2.73	184.00 W	40	9.11	46	65.00	FULL		
Hammer Creek (A.K.A. East Beaver Creek) (04-022-000)							**WWH Existing – Unverified/Confirmed**		
At Co. Rd. H	303000 1.34	24.26 W	35	7.94	36	60.00	FULL		
Jackson Cutoff (04-017-000)							**WWH Existing – Unverified/Confirmed**		
Dst. Yellow Creek @ Bays Rd.	303003 6.60	86.29 W	35	8.05	40	67.50	FULL		
Near Weston @ Sand Ridge Rd.	510040 1.15	101.00 W	45	10.40	E	70.75	FULL		

Location	STORET (RM)[a]	Drain. (mi²)	IBI	MIwb[b]	ICI[c]	QHEI	Status[d]	Causes	Sources
Yellow Creek (04-019-000)							**MWH-C Existing – WWH Recommended**		
South of Deshler @ Co. Rd. B	500760 8.02	18.30 H	38	N/A	-	59.25	(FULL)		
At Riegle Rd.	303530 4.5	49.70 W	-	-	46	-	(FULL)		
East of Deshler @ Roundhead Rd.	500780 3.18	51.00 W	40	8.43	46	63.75	FULL		
Little Yellow Creek (04-021-000)							**LRW Existing**		
Northeast of Leipsic @ State Rte. 65 (upper crossing)	P10W08 4.6	2.1 H	[42]	[N/A]	[28]	[27.00]	[FULL]		
Little Yellow Creek (04-021-000)							**LRW Existing/WWH Recommended**		
Northeast of Leipsic @ Co. Rd. 2	500700 0.90	7.70 H	46	N/A	G	45.50	FULL		
West Creek (04-020-000)							**WWH Existing – Unverified/Confirmed**		
At Hancock-Wood Co. Line Rd.	302840 0.10	13.30 H	46	N/A	38	64.50	FULL		
Brush Creek (04-018-000)							**WWH Existing**		
North of Belmore @ Twp. Rd. A	303002 8.99	10.02 H	34	N/A	48	40.50	FULL		
East of Deshler @ Custar Rd.	P10P06 0.58	24.60 W	36	8.20	44	42.50	FULL		
Sugar Creek (04-001-014)							**Undesignated/WWH Recommended**		
At Sugar Creek Rd.	303007 1.06	5.40 H	26[NS]	N/A	G	44.25	FULL		
Tontogany Creek (04-013-000)							**WWH Existing – Unverified/Confirmed**		
Upst. Tontogany @ Tontogany Rd.	303006 4.15	11.21 H	42	N/A	42	56.75	FULL		
North of Tontogany @ Robinson Rd.	P10K01 1.60	39.40 W	40	8.73	G	64.50	FULL		
West Branch Tontogany Creek (04-013-001)							**Undesignated/MWH-C Recommended**		
Southwest of Tontogany @ Tuller Rd.	P10P13 3.42	6.60 H	36	N/A	HF	17.25	FULL		

Location	STORET (RM)[a]	Drain. (mi²)	IBI	MIwb[b]	ICI[c]	QHEI	Status[d]	Causes	Sources
West Branch Tontogany Creek (04-013-001)							**Undesignated/WWH Recommended**		
Near cemetery @ Rangeline Rd.	P10P14 2.19	20.8 [W]	[34]	[7.60]	[42]	[68.25]	[FULL]		
Tributary to West Branch Tontogany Creek (3.2) (04-013-002)							**Undesignated/WWH Recommended**		
At Long-Judson Rd.	303005 0.72	13.05 [H]	32	N/A	MG[NS]	42.00	FULL		
Liberty Hi Road Ditch (04-001-015)							**Undesignated/MWH-C Recommended**		
Upstream from King Rd.	303622 1.15	11.3 [H]	[20]	N/A	[HF]	[47.00]	[FULL]		
Liberty Hi Road Ditch (04-001-015)							**Undesignated/WWH Recommended**		
Dst. Haskins WWTP @ State Rte. 65	303008 0.05	14.40 [H]	38	N/A	G	80.50	FULL		
Haskins Road Ditch (04-001-016)							**Undesignated/MWH-C Recommended**		
Upst. Haskins WWTP @ State Rte. 582	303009 0.30	9.55 [H]	26	N/A	HF	20.00	FULL		

a River Mile (RM) represents the point of record (POR) for the station, not the actual sampling RM.
b MIwb is not applicable to headwater streams with drainage areas ≤ 20 mi².
c A narrative evaluation of the qualitative sample based on attributes such as EPT taxa richness, number of sensitive taxa and community composition was used when quantitative data was not available or considered unreliable. VP=Very Poor; P=Poor; LF=Low Fair; F=Fair; MG=Marginally Good; G=Good; VG=Very Good; E=Exceptional.
d Attainment is given for the proposed status 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.
x-15 Flow over artificial substrate less than 0.3 feet per second required for valid sample; narrative evaluation overrides ICI.

	Biological Criteria - HELP			
Index – Site Type	EWH	WWH	MWH-C	LRW
IBI – Headwaters	50	28	20	18
IBI – Wading	50	32	22	18
MIwb – Wading	9.4	7.3	5.6	4.5
ICI	46	34	22	8

Beneficial Use Recommendations

Streams within the Minor Great Black Swamp Tributaries study area currently listed in the ***Ohio Water Quality Standards*** (WQS) are assigned one or more of the following ALU designations: warmwater habitat (WWH); modified warmwater habitat - channelization (MWH-C); or limited resource water (LRW). Some streams evaluated currently do not have an ALU designation. Aquatic life use designations for most streams evaluated during this survey have not been previously verified using biological data. Many streams in Ohio were originally designated for aquatic life use in the 1978 Ohio WQS, but the techniques used then did not include standardized approaches to the collection of instream biological data or numerical biological criteria. This study used biological data to assess current condition, and then verify the existing ALU or recommend an appropriate ALU for those streams highlighted in Table 3.

Fifty streams in the Minor Great Black Swamp Tributaries study area were evaluated for aquatic life and recreational use potential in 2015-16. Significant findings include the following (Table 3):

Aquatic Life Use

- Four streams with previously verified WWH aquatic life use designations should retain those designations. These streams include: North Turkeyfoot Creek; Bad Creek; South Branch Bad Creek; and Brush Creek.

- The 2015 survey confirmed the WWH use designation is appropriate for 24 streams that were previously unverified. These streams include: Marie DeLarme Creek; North and South Branch Marie DeLarme Creek; Sulphur Creek; Snooks Run; Preston Run; Wade Creek; Benien Creek; Brubaker Creek; Garrett Creek; Oberhaus Creek; Van Hyning Creek; South Turkeyfoot Creek; West Creek (trib. to S. Turkeyfoot Creek); Lost Creek; Brinkman Ditch; Little Turkeyfoot Creek; Dry Creek; Big Creek; Beaver Creek; Jackson Cutoff; West Creek (trib. to Yellow Creek); East Beaver Creek (a.k.a. Hammer Creek); and Tontogany Creek. Despite sub-optimal habitat quality and segments on drainage maintenance within some of these streams, fish and macroinvertebrate communities fully met HELP WWH biocriteria in 20 of these 24 streams. Fish community performance met HELP WWH expectations at all locations in these streams, while macroinvertebrate community performance fell just short of ecoregional expectations in Snooks Run, Lost Creek, and one location in Brinkman Ditch and Dry Creek.

- Seven previously undesignated streams evaluated during the 2015 survey supported biological communities consistent with HELP WWH expectations. These included: Sixmile Cutoff; tributary to Maumee River (48.7); tributary to Maumee River (42.2); tributary to North Turkeyfoot Creek (6.68); School Creek; Sugar Creek; and tributary to West Branch Tontogany Creek (3.2). It is recommended that these seven streams be assigned the WWH aquatic life use.

- Zuber Cutoff is “formed” by the confluence of North and South Creek just east of Antwerp and was evaluated at one location (RM 1.1, P06K13). Fish community performance in Zuber Cutoff fell short of HELP WWH expectations, while macroinvertebrate community performance met HELP WWH expectations. Sampling was conducted in 2016 in this stream in response to a 2015 fish kill upstream in South Creek. Given more time to recover from this kill, fish community performance should continue to recover through time and meet HELP WWH criteria. Both fish and macroinvertebrate communities were previously sampled in 1997 and fully met HELP WWH criteria. It is recommended that Zuber Cutoff, a formerly undesignated waterbody, be assigned the WWH aquatic life use.

- North Creek maintains an unverified WWH aquatic life use and was evaluated at three locations along its length during 2015 and 2016. Fish community performance at RMs 2.95 (P06W17) and 1.6 (P06W16) marginally met HELP WWH expectations, but was among the lowest in the entire basin (Table 2, Figure 52). Overall, fish community performance has remained in the poor range since these two sites were last sampled in 1997. Macroinvertebrate community performance fell short of HELP WWH expectations at both RM 2.95 and 1.6 and has not improved since 1997. North Creek has received significant historical channelization activities and is currently on a drainage maintenance program. QHEI scores at both upstream locations are in the very poor range and have displayed no discernable recovery since 1997. High- and moderate-influence negative habitat attributes were pervasive in these upper reaches.

  Both fish community performance and habitat quality improved substantially downstream at RM 0.3 (303746). However, macroinvertebrate community performance was largely similar to the upstream reaches, despite improved habitat quality. Higher stream gradient throughout these lower reaches also benefitted both macrohabitat quality and overall fish community performance. Several riffle sequences and other WWH attributes were present at this location, while being completely absent from the upper two (Appendix F). Also, continuous flow during a relatively dry year in 2016 was observed throughout this lower reach. Thus, it is recommended that the upper reaches of North Creek from the headwaters to Twp. Rd. 61 (RM 0.3) be assigned the MWH-C aquatic life use designation, while RM 0.3 to the mouth be confirmed WWH.

- South Creek maintains an unverified WWH aquatic life use and was evaluated at two locations along its length during 2015 and 2016. Sampling in 2016 was conducted in response to a documented fish kill in 2015. Fish community performance at all locations in both years (2015 pre-kill and 2016 post-kill) was consistent with HELP WWH expectations, though only marginally met criteria at RM 3.7 (302971) in 2016 and still appeared to be recovering from the fish kill at RM 0.35 (302970) (Figure 52). Macroinvertebrate community performance at RM 3.7 did not meet HELP WWH criteria in either 2015 or 2016, while RM 0.35 exceeded the HELP WWH criterion in 2015 (ICI=42), but still appeared to be recovering from the kill event in 2016. It is recommended that South Creek from its headwaters to Gasser Rd. (RM 3.65) be assigned the MWH-C aquatic life use designation, while RM 3.65 to the confluence with Zuber Cutoff be confirmed WWH.

- Platter Creek and an unnamed tributary to Platter Creek (RM 7.66) were evaluated at five locations overall in 2015 and 2016. Two locations were sampled in Platter Creek in 2016 to evaluate for any lingering effects from a documented manure spill in 2015. Platter Creek maintains an unverified WWH designation, while the unnamed tributary (RM 7.66) is currently undesignated. Fish community performance at all locations in Platter Creek was consistent with HELP WWH expectations in both years, though scores in the upper reaches were among the lowest from the survey (Figure 52). Macroinvertebrate community performance in Platter Creek failed to meet HELP WWH expectations at RM 7.95 (303014) in both 2015-16 and at RM 5.4 (302974) in 2016, but was consistent with WWH expectations at RMs 6.41 (302975) and 1.7 (303010). Performance fell short of WWH expectations in the unnamed tributary (RM 7.66). Habitat quality in the upper reaches of both Platter Creek and the unnamed tributary ranged from fair to very poor overall, while was in the good range (QHEI=61.00) at RM 1.7; moderate- and high-influence negative habitat attributes were pervasive in the upper reaches of both streams (Table 2, Appendix F). Continuous flow was observed at RM 5.4 in 2016, while only highly intermittent conditions, including only very shallow pools were recorded at RM 7.95 during the same year. The majority of Platter Creek and the entirety of the unnamed tributary are on a drainage maintenance program. It is recommended that Platter Creek from its headwaters to the unnamed tributary at RM 7.66 and the unnamed tributary (RM 7.66) be designated MWH-C, while the remainder of Platter Creek from RM 7.66 to the mouth be confirmed WWH.

- Gordon Creek mainstem and the North, Middle, and South Forks were evaluated at six locations. Five of six sampling locations were evaluated in 2015, while one location in upper Middle Fork was evaluated in 2016. These streams all maintain an existing, verified MWH-C aquatic life use designation. Fish community performance exceeded HELP WWH expectations at all six locations evaluated, while macroinvertebrate community performance exceeded WWH expectations at all but the uppermost location on Middle Fork (Table 2). Habitat quality in these streams ranged from fair to poor in the middle and upper reaches to excellent near the mouth of Gordon Creek. Both Middle and South forks are on an active maintenance program in their middle reaches downstream from their origination in the Ft. Wayne moraine (Figure 5, Figure 7). North Fork is not on an active maintenance program. Gordon Creek mainstem, less the lowermost mile, is also in an active maintenance program. Despite some obvious habitat limitations and periodic stream maintenance activities, biological performance generally exceeded HELP WWH expectations, and overall has improved substantially compared to historical performance throughout the Gordon Creek sub-basin (Figure 56). It is recommended that the aquatic life use for the entirety of Gordon Creek and the North, Middle, and South Forks all be upgraded from MWH-C to WWH.

- Konzen Ditch was evaluated at two locations and currently maintains an existing MWH-C aquatic life use designation. Konzen Ditch is also a modified reference site (Ohio EPA 1987). Habitat quality ranged from fair to good at both locations assessed. Though moderate-influence negative habitat attributes were present at both locations, high-influence negative habitat attributes were nearly absent and several WWH attribute features were present at each location (Appendix E). Biological community performance exceeded HELP WWH expectations at both locations assessed, despite some habitat limitations and stretches of Konzen Ditch on a drainage maintenance program. It is recommended that the entirety of Konzen Ditch be upgraded from MWH-C to the WWH aquatic life use.

- The West Branch of Tontogany Creek was evaluated at two locations and is currently not assigned an aquatic life use. Habitat quality displayed a marked difference up and downstream from the unnamed tributary at RM 3.2. Upstream from RM 3.2, habitat quality at the one location assessed was in the very poor range and among the lowest quality of the entire study area (QHEI=17.25, Table 25). Downstream from RM 3.2, habitat quality improved substantially into the good range (QHEI=68.25). Moderate- and high-influence negative habitat attributes are pervasive upstream from RM 3.2, with WWH attributes completely absent. The opposite is the case downstream from RM 3.2 where WWH attributes were numerous (Appendix F). Additionally, stream size more than tripled between the up (6.6 mi^2) and downstream (20.8 mi^2) sampling locations. West Branch Tontogany Creek is on a drainage maintenance program from its headwaters to RM 3.2. Fish community performance met HELP WWH expectations at both sampling locations, though the community at RM 3.42 (P10P13) was anomalous and indicative of habitat and water quality stressors (channel modification, nutrient enrichment stressors) documented throughout this reach. Macroinvertebrate community performance fell short of HELP WWH expectations at RM 3.42. It is recommended that West Branch Tontogany Creek from its headwaters to RM 3.2 be designated MWH-C and RM 3.2 to its confluence with Tontogany Creek be designated WWH.

- Liberty Hi Rd. and Haskins Rd. Ditches were evaluated at three locations in 2015 and 2016. Both streams are not currently listed in the WQS and are undesignated. Biological performance in Liberty Hi Rd. Ditch downstream from King Ave. exceeded HELP WWH expectations. The stretch of Liberty Hi Rd. Ditch immediately downstream from King Ave. (RMs 1.1-0.6) maintains a functional riparian corridor and naturally directed recovery of habitat quality has occurred within the incised channel, while the lowermost reaches (RM 0.6 to mouth) are natural and have not been channelized. Habitat quality in this lowermost reach evaluated at RM 0.2 (303008) was in the excellent range and was among the highest habitat scores in the survey area.

  Fish community performance in Liberty Hi Rd. Ditch upstream from King Ave. did not meet HELP WWH expectations, while performance in Haskins Rd. Ditch only marginally met. The fish community in these reaches was generally depauperate and reflective of the modified habitat conditions. Macroinvertebrate community performance in both segments evaluated did not meet HELP WWH expectations. Instream habitat throughout both reaches is highly modified and a stable channel form is maintained to ensure minimal erosion and interference with the adjacent infrastructure. There is also a substantial barrier to fish passage present when Liberty Hi Rd. Ditch passes under King Rd. where the bridge culvert drops several feet.

  It is recommended that the lower stretch of Liberty Hi Rd. Ditch from King Road (RM 1.1) to the mouth receive the WWH aquatic life use designation, while the remainder of Liberty Hi Rd. Ditch and the entirety of Haskins Rd. Ditch receive the MWH-C designation.

- Yellow Creek was evaluated at three locations and currently maintains an existing MWH-C aquatic life use. Biological performance throughout Yellow Creek exceeded HELP WWH expectations and has improved drastically since last sampled in 1981. Habitat quality at both locations assessed is in the good range ($\bar{x}$=61.5) and has also improved drastically since 1981. Warmwater habitat attributes were numerous at both locations, while negative habitat attributes were not predominant. It is recommended that the entirety of Yellow Creek be upgraded from the MHW-C to the WWH aquatic life use.
- Little Yellow Creek was evaluated at two locations in 2015 and 2016 currently maintains a LRW designation from its source to the confluence with Yellow Creek at RM 7.45. Little Yellow Creek is approximately 6.38 river miles long and, on paper, drains approximately 8 mi^2 at its mouth. However, the volume of water passing through this small stream is substantially greater than would typically be present in other streams of similar drainage area in the HELP ecoregion. The Leipsic WWTP (2PB00040), with an average daily design flow of 1.5 million gallons per day (MGD), functionally "starts" the stream; Little Yellow Creek does not exist upstream from this outfall.

  Biological performance at RM 0.9 (500700) exceeded HELP WWH expectations and has improved drastically since last sampled in 1981, while habitat quality throughout this reach has also improved from very poor to fair. The current survey noted several WWH attributes were present and the pervasiveness of high-influence negative habitat attributes was substantially diminished since 1981 (Appendix E). Biological performance at RM 4.6 (P10W08) was mixed. Fish community performance nominally met HELP WWH expectations (IBI=42), however, the community here was anomalous compared to other streams in the study area. An overwhelming abundance of a singular fish species that can predominate in degraded conditions (Figure 64), coupled with extremely low overall abundance of all other fish species, reduced diversity, and complete absence of other important fish species groups (darters, sensitive species) reflects both the very poor habitat quality and other stressors present at this location. Macroinvertebrate community performance (ICI=28) failed to meet HELP WWH expectations at RM 4.6. Habitat quality at RM 4.6 (QHEI=27) has shown little recovery since sampling in 1981; moderate- and high-influence negative habitat attributes were still pervasive throughout these upper reaches. Little Yellow Creek at RM 4.6 has an extremely small drainage area (2.1 mi^2) and is actively maintained to some degree.

The potential for more substantial recovery of biological communities in upper Little Yellow Creek is functionally precluded by very poor habitat quality coupled with substantial flow influences from the major municipal discharger outfall that “starts” Little Yellow Creek just a short distance upstream. Little Yellow Creek is a functional effluent channel in its most upstream reaches. The effects of augmented stream baseflow and improved habitat quality were reflected in biological community performance in the downstream reaches. The continuous discharge from the Leipsic WWTP undoubtedly augments flow and biological performance to some degree throughout Little Yellow Creek. The upper reaches of Little Yellow Creek would likely be dry or intermittent if this constant source of flow were not present. It is therefore recommended that Little Yellow Creek retain the LRW use designation from its source to RM 4.6 and be assigned the WWH aquatic life use from RM 4.6 to its confluence with Yellow Creek.

Public, Agricultural, Industrial Water Supply Use

The only stream within the study area with an existing PWS beneficial use (Bad Creek at RM 17.0) should retain this use; no other streams within the project area have public water supply intakes. All streams or stream segments with existing AWS and IWS use designations should retain those uses. Those streams listed in Table 3 with existing, unverified AWS and IWS use designations should have those uses confirmed. It is recommended that streams evaluated during the current survey that are not listed in the WQS should be assigned the AWS and IWS beneficial use designations.

Recreation Use

- Those streams listed in Table 3 with an existing, verified PCR recreation use should retain this use. Those streams that were not previously listed in the WQS or those that have an unverified PCR use designation should have the PCR use designation confirmed.

- Streams or stream segments previously designated SCR, including Middle Fork Gordon Creek, North Turkeyfoot Creek, Konzen Ditch, Bad Creek from the headwaters to RM 6.2, Bad Creek at RM 17.0, South Branch Bad Creek, Brush Creek, Yellow Creek and Little Yellow Creek from RM 4.6 to the mouth are recommended re-designated as PCR.

General Watershed Recommendations

Land use within the study area consists primarily of row crop agriculture. Additionally, many streams in the region (especially small streams) were systematically modified and channelized to facilitate drainage for crop production and other socio-economic needs. Streams that receive excess nutrient inputs and have generally deficient instream habitat (reduced riparian vegetation, simplified development) are naturally more prone to nutrient over-enrichment. Enrichment signatures were well documented and pervasive in streams throughout the study area (Table 21). The presence of animal feeding operations, especially high densities contained within a particular sub-watershed, can be an additional, indirect source of excess nutrients (through manure application and runoff) within a system.

Following prescribed courses of actions outlined in *Ohio's Nutrient Reduction Strategy* (Ohio EPA 2013c) and recommendations from the Ohio Phosphorus Reduction Task Force should help to reduce the negative impacts that excess nutrients can have on a stream system. Targeting areas with elevated nutrient enrichment signatures would be beneficial (Table 21). Even if these sites/stream reaches aren't biologically impaired, they are ultimately still a source of nutrients to Lake Erie. Practices can include, but are certainly not limited to, increasing the area of forested riparian buffers, improving manure and livestock management practices, best fertilizer application practices, and further advocacy for modern tillage and other conservation practices.

Many streams and ditches throughout the study area receive some form of recurring drainage maintenance (sediment dipping, vegetative controls, etc.). Though impacts from these activities, individually, are somewhat localized and relatively acute in terms of temporal influences, the cumulative influences from various stream maintenance activities within a given stream and throughout a watershed (study area) have the potential for larger scale negative impacts. It would be beneficial to have a "lighter touch" when conducting maintenance activities on streams and ditches throughout the study area and to follow the recommendations and guidelines of the Rural Drainage Committee (ODNR 2008, 2009).

Advocacy for the full suite of modern tillage practices should continue. The cumulative effects of the full suite of modern tillage and related soil and water conservation practices has resulted in significant reduction in gross erosion documented at national and regional scales since the late 1970s (USDA 2013). Studies within the Maumee River basin (and other watersheds throughout Ohio) have demonstrated an association between agricultural best management practices (BMPs), reduced soil loss, instream sedimentation and suspended sediment, and finally, a concurrent positive response from the ambient biology (Barton and Farmer 1997, Meyer et al. 2000, Yoder et al. 2004, Richards et al. 2009, Miltner 2015). The re-establishment of formerly imperiled, substrate-sensitive fish species, such as the eastern sand darter throughout the Maumee River watershed, is just one biological endpoint that highlights the apparent successes these programs have had on keeping soil on farm fields and out of adjacent stream networks (Tessler et al. 2012). It is important to highlight successes that modern tillage practices and other agricultural BMPs have had in reducing soil erosion and sediment loading to streams and rivers, not only because of improved environmental conditions, but because of the significant amounts of money invested in these programs. The following quote from Myers et al. (2000) characterizes the situation well: "*Without direct evidence of improving water quality, farmers and others may become indifferent to the voluntary use of these practices and programs. This, in turn, could negate the apparent success of these programs and the investments made by federal, state, and local natural-resource managers.*"

Additionally, a small, obsolete impoundment was discovered through the course of sampling in Jackson Cutoff just downstream from Sand Ridge Rd. This low-head impoundment was constructed in the late 1960s and was historically used as a drinking water intake structure for the village of Weston. However, by the early 1970s, the city of Weston abandoned this intake and began to source drinking water from other areas (A. Phillips, pers. communication). Removal of this small, obsolete impoundment would free a substantial portion of stream network for fish passage and should help further improve biological performance throughout this relative high-quality stream network.

Table 3 — Existing and recommended beneficial use designations for water bodies within the Minor Great Black Swamp Tributaries study area. Streams highlighted in yellow were those evaluated during the current survey.

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	
Liberty Hi Rd. Ditch – headwaters to King Rd. (RM 1.1)				Δ					Δ	Δ		*/+		HELP ecoregion - channel modification
- King Rd. to mouth		Δ							Δ	Δ		*/+		
Haskins Rd. Ditch				Δ					Δ	Δ		*/+		HELP ecoregion - channel modification
Tontogany Creek		*/+							*/+	*/+		*/+		
West Branch Tontogany Creek – headwaters to unnamed tributary (RM 3.2)				Δ					Δ	Δ		*/+		HELP ecoregion - channel modification
- RM 3.2 to mouth		Δ							Δ	Δ		*/+		
Unnamed tributary to West Branch Tontogany Creek (3.2)		Δ							Δ	Δ		*/+		
Sugar Creek		Δ							Δ	Δ		*/+		
Kettle Run		*							*	*		*		
Beaver Creek		*/+							*/+	*/+		*/+		
Little Beaver creek		*							*	*		*		
Jackson Cutoff		*/+							*/+	*/+		*/+		
Brush Creek		+							+	+		Δ	~~+~~	
Hickey ditch							+		+	+			+	Small drainageway maintenance
Selhorst ditch							+		+	+			+	Small drainageway maintenance
Yellow Creek		Δ		~~+~~					+	+		Δ	~~+~~	~~HELP ecoregion - channel modification~~
West Creek		*/+							*/+	*/+		*/+		
Little Yellow Creek – headwaters to St. Rt. 65 (RM 4.6)							+		+	+			+	Small drainageway maintenance
- RM 4.6 to mouth		Δ					~~+~~		+	+		Δ	~~+~~	~~Small drainageway maintenance~~
East Beaver Creek (a.k.a. Hammer Creek)		*/+							*/+	*/+		*/+		
West Beaver Creek		*							*	*		*		
Big Creek		*/+							*/+	*/+		*/+		
Lick Creek		*							*	*		*		
Bad Creek~~– headwaters to Fulton county line (RM 6.2)~~		+							+	+		Δ	~~+~~	
~~- Fulton county line to the mouth~~		~~+~~							~~+~~	~~+~~		~~+~~		
- at RM 17		+						+	+	+		Δ	~~+~~	PWS intake - Delta
South Branch Bad Creek		+							+	+		Δ	~~+~~	
Dry Creek		*/+							*/+	*/+		*/+		
South Turkeyfoot Creek		*/+							*/+	*/+		*/+		
Little Turkeyfoot Creek		*/+							*/+	*/+		*/+		
School Creek		Δ							Δ	Δ		*/+		
Brinkman Ditch		*/+							*/+	*/+		*/+		
Lost Creek		*/+							*/+	*/+		*/+		

Water Body Segment	Use Designations	Aquatic Life Habitat						Water Supply			Recreation			Comments
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Brush Creek		*							*	*		*		
West Creek		*/+							*/+	*/+		*/+		
Mess Ditch		*							*	*		*		
Gustwiller Ditch		*							*	*		*		
North Turkeyfoot Creek		+							+	+		Δ	~~+~~	
Konzen Ditch (North Turkeyfoot Creek RM 4.65)		Δ		~~+~~					+	+		Δ	~~+~~	~~HELP ecoregion - channel modification~~
Unnamed tributary (North Turkeyfoot Creek 6.68)		Δ							Δ	Δ		*/+		
Unnamed tributary segments immediately adjacent to Wauseon reservoir		*						+	*	*		*		PWS intake - Wauseon
Unnamed tributary (North Turkeyfoot Creek RM 17.3)		+							+	+			+	
Unnamed tributary (North Turkeyfoot Creek RM 18.4)							+		+	+			+	Small drainageway maintenance
Unnamed tributary (Maumee River RM 42.2)		Δ							Δ	Δ		*/+		
Oberhaus Creek		*/+							*/+	*/+		*/+		
Van Hyning Creek		*/+							*/+	*/+		*/+		
Garrett Creek		*/+							*/+	*/+		*/+		
Unnamed tributary (Maumee River 48.7)		Δ							Δ	Δ		*/+		
Benien Creek		*/+							*/+	*/+		*/+		
Brubaker Creek		*/+							*/+	*/+		*/+		
Barnes Creek		*							*	*		*		
Wade Creek		*/+							*/+	*/+		*/+		
Huston Creek		*							*	*		*		
Miami and Erie canal (Maumee river RM 53.6) - Independence (RM 6.1) to the mouth				+					*	*		+		HELP ecoregion - channel modification
Preston run		*/+							*/+	*/+		*/+		
Auglaize River - headwaters to Blanchard River (RM 26.2)		+							+	+		+		
Stevens Ditch		*							*	*		*		
Snooks Run		*/+							*/+	*/+		*/+		
Sulphur Creek		*/+							*/+	*/+		*/+		
Platter Creek – headwaters to unnamed tributary (RM 7.66)		~~*~~		Δ					*/+	*/+		*/+		HELP ecoregion - channel modification
- RM 7.66 to mouth		*/+							*/+	*/+		*/+		
Unnamed tributary (Platter Creek RM 7.66)				Δ					Δ	Δ		*/+		
Gordon Creek		Δ		~~+~~					+	+		+		~~HELP ecoregion - channel modification~~
South Fork		Δ		~~+~~					+	+		+		~~HELP ecoregion - channel modification~~
North Fork		Δ		~~+~~					+	+		+		~~HELP ecoregion - channel modification~~
Middle Fork		Δ		~~+~~					+	+		Δ	~~+~~	~~HELP ecoregion - channel modification~~
Mill Creek				+					+	+			+	HELP ecoregion - channel modification
Sixmile Cutoff		Δ							Δ	Δ		Δ		
Marie DeLarme 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	
North Branch		*/+							*/+	*/+		*/+		
Hook Ditch		*							*	*		*		
Tustison Creek		*							*	*		*		
South Branch		*/+							*/+	*/+		*/+		
Zuber Cutoff		Δ							Δ	Δ		Δ		
North Creek – headwaters to Twp. Rd. 61 (RM 0.3)		~~*~~		Δ					*/+	*/+		*/+		HELP ecoregion - channel modification
- RM 0.3 to mouth		*/+							*/+	*/+		*/+		
South Creek – headwaters to Gasser Rd. (RM 3.65)		~~*~~		Δ					*/+	*/+		*/+		HELP ecoregion - channel modification
- Gasser Rd. to mouth		*/+							*/+	*/+		*/+		
Worm Ditch		*							*	*		*		

* Designated use based on the 1978 water quality standards.
+ Designated use based on the results of a biological field assessment performed by Ohio EPA.
*/+ Designated use confirmed based on the results of a biological field assessment performed by Ohio EPA.
Δ New beneficial use recommended based on the results of a biological field assessment performed by Ohio EPA.

Items in the above table that have a ~~double strikethrough~~ indicate suggestion for removal from WQS coinciding with a recommended beneficial use change.

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

Study Area Description

Location, Scope, and Demographics

This survey evaluated 50 streams encompassing 40 Hydrologic Unit Code (HUC) 12-digit watershed assessment units (WAUs) (Figure 2 and *Figure 4*). The study area drains approximately 1,040 mi^2 from eight counties in northwest Ohio. These WAUs account for approximately 15.7 percent of the total Maumee River watershed area. The study area originates at Ohio's western border with Indiana in Defiance and Paulding counties and stretches eastward to Bowling Green. Stream systems that outlet directly to the Maumee River from the state line to Waterville that are not a part of the Auglaize or Tiffin River watersheds were evaluated during the summers of 2015 and 2016.

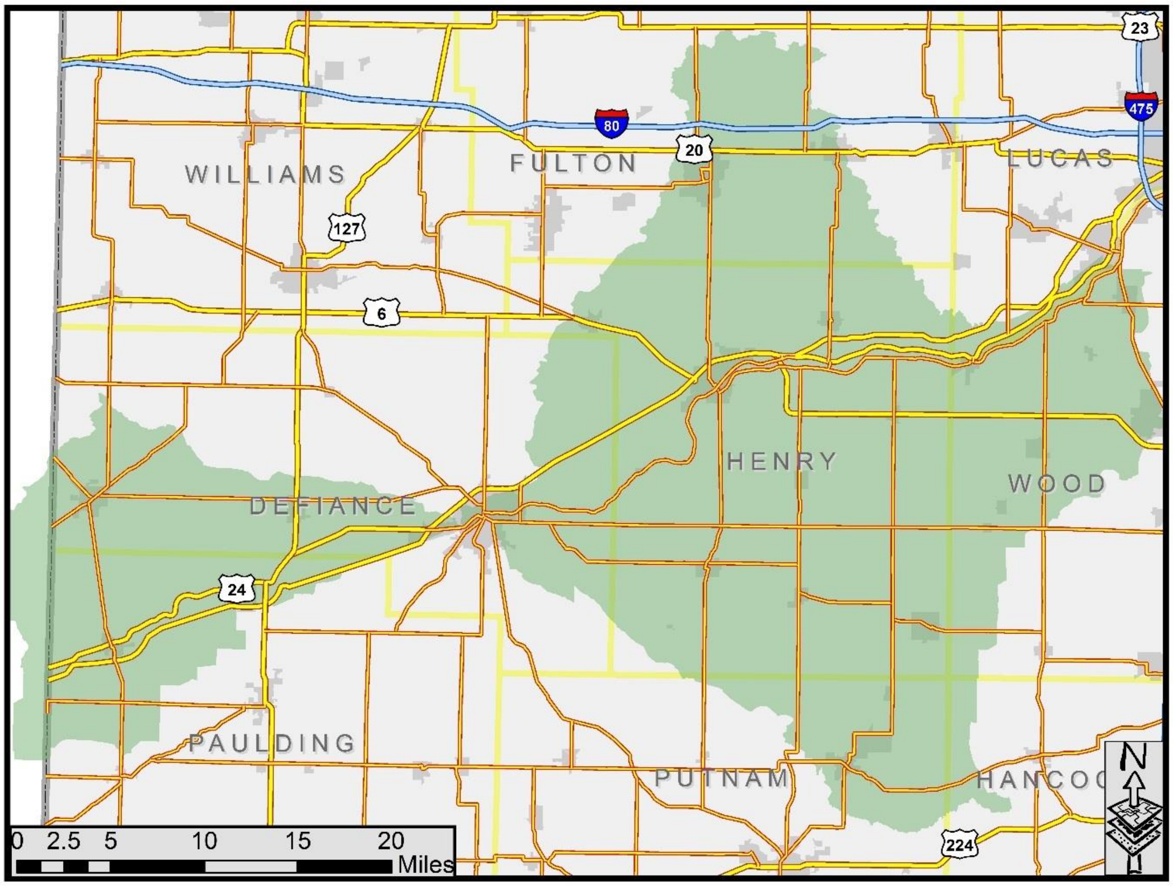


Figure 2 — Minor Great Black Swamp Tributaries project study area boundaries, 2015-16.

The Sixmile Cutoff sub-watershed was included in the current survey as shown by the darker gray shading to the left in Figure 3. The eastern portion of this sub-watershed, shown in light purple, was included in the 2014 survey of the Lower and Little Auglaize River watershed. The upstream portion (in gray) no longer drains to the Auglaize but has been rerouted to the Maumee River directly (Figure 3).

The project study area drains part or all of the communities of Bowling Green (30,028), Defiance (16,494), Napoleon (8,749), Wauseon (7,332), Waterville (5,523), Hicksville (3,581), Delta (3,103), and nearly two dozen smaller villages. Eighty-five percent of Henry County, 42 percent of Defiance County, 28 percent of Fulton County and 24 percent of Paulding County reside within in the study area.

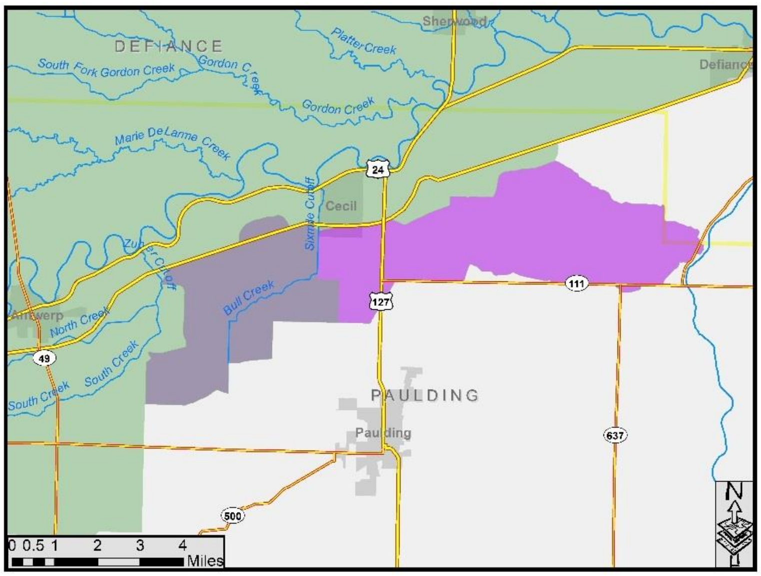


Figure 3 — Sixmile Cutoff was sampled as a part of the Minor Great Black Swamp Tributaries survey in 2015. Sixmile Creek was sampled below Sixmile Cutoff in 2014 as a part of the Lower and Little Auglaize project.

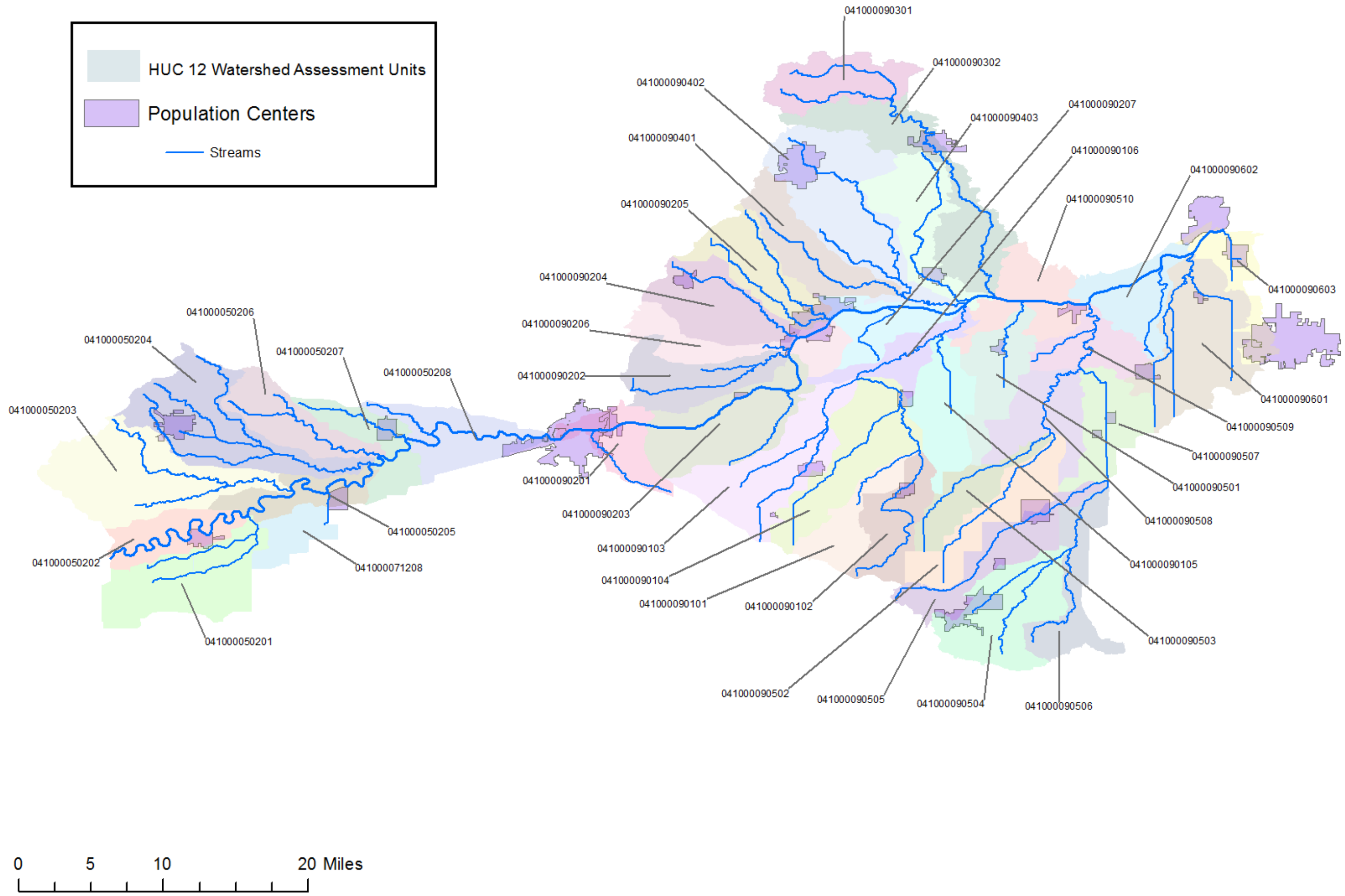


Figure 4 — Twelve-digit hydrologic unit code (HUC) watershed assessment units (WAUs) within the Minor Great Black Swamp Tributaries study area.

Ecoregions, Geology and Soils

The watershed is located almost exclusively in the Huron-Erie Lake Plains (HELP) ecoregion (Omernick 1987). The upper-most reaches of the Platter, Gordon and Marie DeLarme watersheds in Defiance County and the State of Indiana reach into the Eastern Corn Belt Plains (ECBP) ecoregion. A map detailing various ecoregion boundaries can be viewed in Figure 2-1 of ***Ohio EPA (1987)***. All sampling locations within the study area were in the HELP ecoregion.

The HELP is dominated by poorly drained soils, namely hydrologic groups C, C/D, and D (Figure 6). Most of the region was channelized and drained for cropland by the turn of the 20th century. "The ecoregion consists of broad, nearly level lake plain crossed by beach ridges and low moraines. Most of the area was once covered by forested wetlands… but much of the region has been drained and cleared for cropland," (Omernick and Galland 1988). This area is largely a remnant of the Great Black Swamp, a historical wetland that was deforested and extensively drained. Historically, the HELP has had the most widespread and severe agricultural impacts of any of the five Ohio ecoregions. This is primarily related to channelization, excessive export of silts and flocculent clays to receiving streams, a lack of woody riparian vegetation and low stream gradients, all of which can often delay or preclude full recovery of natural stream habitat features. Local relief is generally only a few feet and soils are typically poorly to very poorly drained.

All watersheds' drainage patterns, topography, soils and water chemistry are influenced by their underlying geology. The geology within the survey area has been profoundly influenced by glacial advances and retreats. Of these, the later Wisconsin glacial epoch arguably has had the most profound influences on streams within this study area (Trautman 1981). As much of the inland ice retreated northward, only areas along the eastern portions of Lake Erie remained. This, along with the Ft. Wayne and Defiance end moraines, roughly defined the boundary of glacial Lake Maumee, the first and largest of the several glacial lakes that formed during this time period (Figure 5, Trautman 1981). Much of the study area is situated within the confines of the historical lakebed. Local relief (stream gradient) is generally very low, which can reduce stream power and ability to recover from historical channelization activities and flush excess silts and sediments. Also, finer grained sediments (sand, lacustrine deposited clays and silts), which are generally less desirable than more course gravels and cobbles, are pervasive throughout the study area. Streams that drain the various moraines and beach ridges may receive cool ground water inputs. Cool ground water inputs to a stream system can help ameliorate negative effects that poor water chemistry or physical habitat may be having on biological communities.

The study area is dominated by level clay soils, with occasional ribbons of sandy beach ridges and stream channels interspersed (Flesher, Jr. 1974). Bad Creek, in the northeast portion of the watershed, includes fringes of the Oak Openings area, where the soils are sandier, and thus much better drained. Hoytville, Paulding and Latty clays constitute more than 50 percent of the soils. Low-gradient loams and clays make up a total of more than 85 percent of the soils (USDA SSURGO Soils). The Hoytville, Paulding and Latty association soils are nearly level and poorly draining.

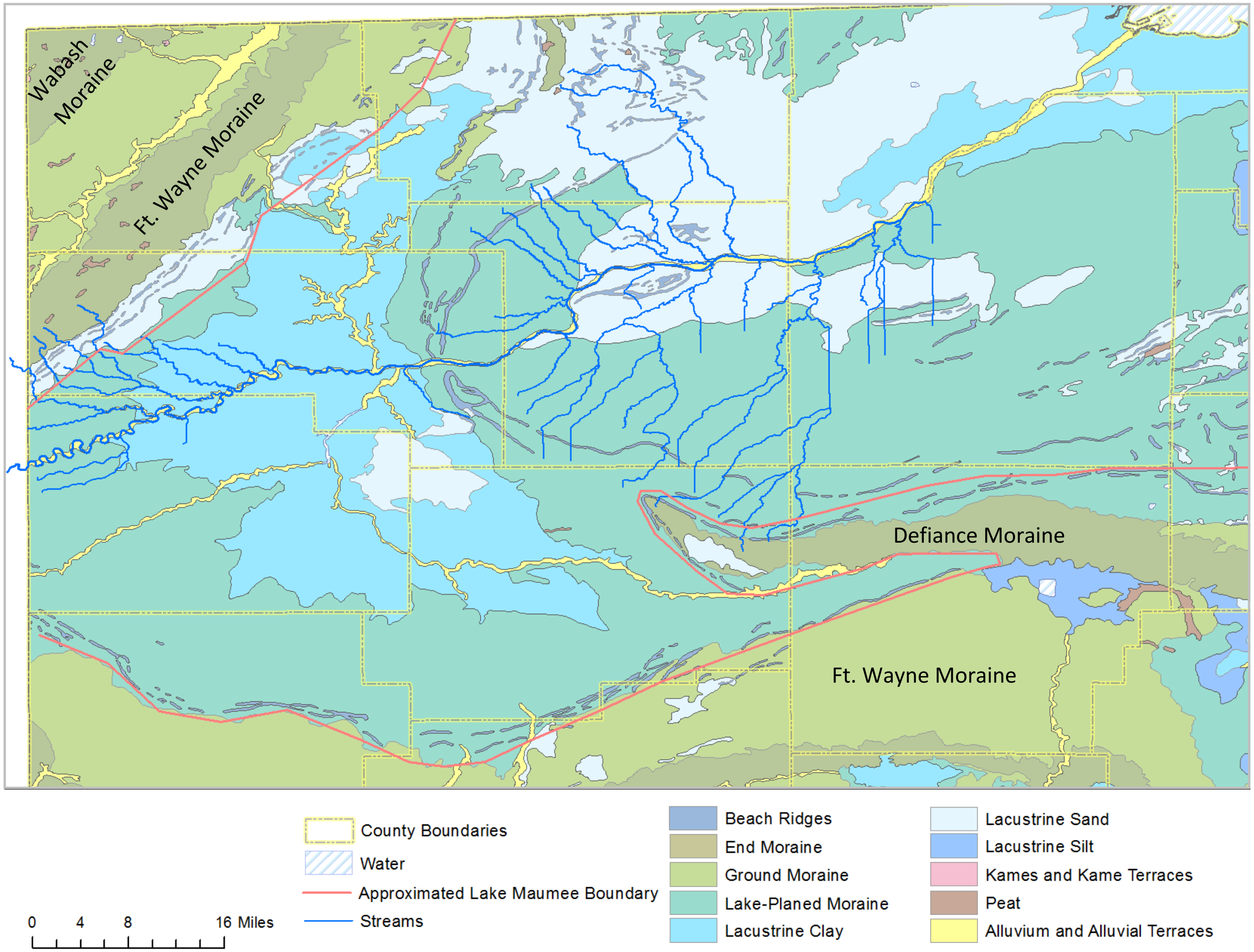


Figure 5 — Quaternary geology within the Minor Great Black Swamp Tributaries study area. Quaternary geology layer derived from Ohio Division of Natural Resources Quaternary Geology GIS layer. Approximated Lake Maumee boundary derived from Trautman 1981. Created 12/15/16.

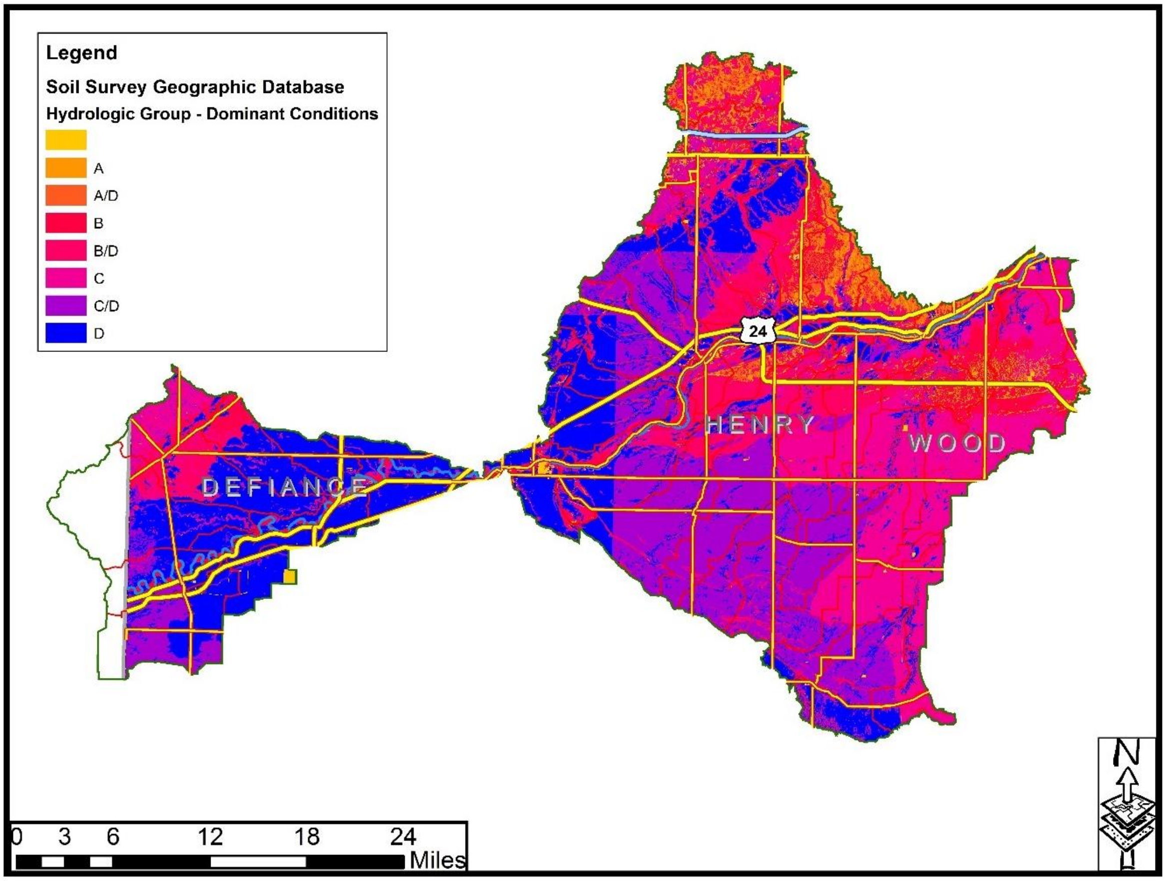


Figure 6 — STATSGO hydrologic soil groups within the Minor Great Black Swamp Tributaries study area, 2015.

Beneficial Uses

Beneficial use designations within the watershed include those for aquatic life, recreation, water supply, and human health (fish tissue). Existing and recommended beneficial use designations for streams in the study area include WWH, MWH and LRW for aquatic life uses, PCR and SCR for the recreational use, and PWS, AWS and IWS for the water supply use. The study area does not include the large river assessment unit (LRAU) for the mainstem of the Maumee River.

Beneficial use designations for many streams within this study area have not been previously verified by the collection of instream biological data or numerical biological criteria. A major emphasis of the current survey was to verify the appropriateness existing beneficial uses and, where warranted, recommend appropriate beneficial use designations.

Hydrology

The study area is a collection of relatively small tributaries that drain to the Maumee River and reaches from Ohio's western border with Indiana to Waterville, Ohio. The Auglaize and Tiffin rivers, which drain into the Maumee River near Defiance, Ohio, and the main stem of the Maumee River, were evaluated separately from this project in years preceding this survey. The major tributary systems evaluated during the survey include Beaver Creek (187 mi^2) and Jackson Cutoff Ditch (101 mi^2), South Turkeyfoot Creek (145.6 mi^2), North Turkeyfoot Creek (74.9 mi^2), Bad Creek (64.6 mi^2), Gordon Creek (44.1 mi^2), Tontogany Creek (42.1 mi^2), and Zuber Cutoff (29.5 mi^2). Jackson Cutoff Ditch is an entirely man-made stream that joins Beaver Creek west of Bowling Green. Jackson Cutoff accounts for nearly 55 percent of the overall drainage area of Beaver Creek. Prior to the digging of Jackson Cutoff Ditch, many of its receiving streams flowed east to the Portage River watershed south of Bowling Green. The remaining stream systems evaluated during the survey were around 20 mi² or less.

Active maintenance programs and historical efforts to drain the region have resulted in many altered stream sections. Figure 7 depicts waterways within the study area currently under some form of maintenance by county programs (in red). Streams within Paulding and Putnam counties are not displayed in this map.

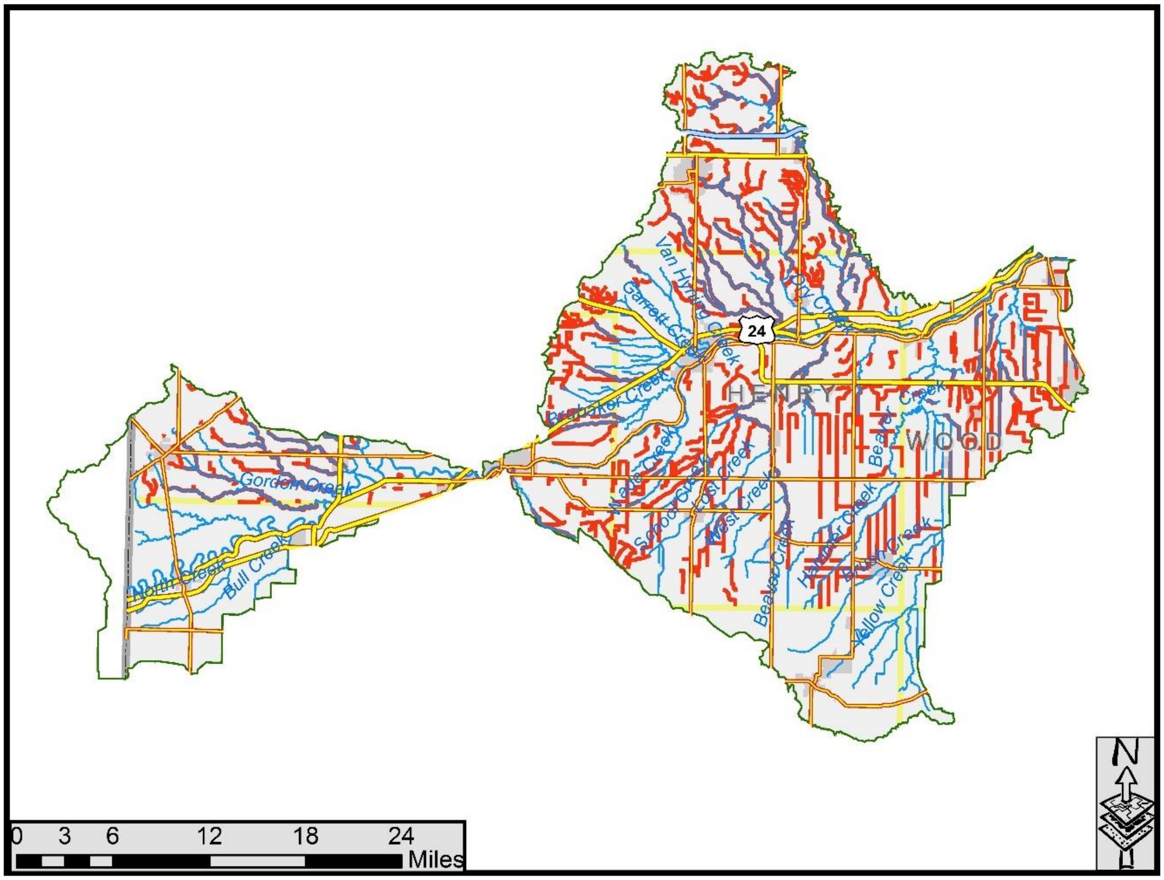


Figure 7 — Streams segments maintained under Ohio's petition ditch improvement law (ORC 6131.04). Waterways under some form of maintenance are denoted in red. Defiance Co., 2013; Fulton Co., 2014; Henry Co., 2014; Wood Co., 2014.

Land Use

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

Table 4 — Land use types within the Minor Great Black Swamp Tributaries study area (NLCD 2011).

Land Use Type	Percent of Watershed
Cropland	83.20%
Herbaceous	5.43%
Hay/Pasture	4.57%
Evergreen Forest	1.88%
Shrub/Scrub	1.38%
Development (Low Intensity)	1.08%
Other Land Uses	2.46%

Protected Lands

The Mary Jane Thurston State Park complex is the most significant protected area in the study area. Mary Jane Thurston and the accompanying North Turkeyfoot Area exceeds 580 acres. Providence, Bend View and Farnsworth Metroparks are a series of linear parks connected by a towpath trail along the Maumee River. Each of these facilities is located along the mainstem of the Maumee River and has little impact on the tributaries included in this project.

The largest protected lands upstream are Baldwin Woods Preserve in the Tontogany Creek watershed, just east of Weston. Other protected lands in the study area are listed below in Table 5. Areas directly adjacent to the Maumee River are listed in italics.

Table 5 — Protected lands, including natural areas and parks, within the Minor Great Black Swamp Tributaries study area. From the USFWS Conservation and Recreation Lands (CARL) GIS layer (2007).

Site Name	Owner	Description	HUC 12	Acres
North Turkeyfoot State Park	*Ohio DNR*	*Park*	*North Turkeyfoot Creek (04100009 04 02)*	*478.8*
Providence, Bend View, Farnsworth Metroparks	*Toledo Metropolitan Park District*	*Park*	*Sugar Creek-Maumee (04100009 06 02)*	*451.66*
Camp Libbey	*Girl Scouts of America*	*Campgrounds*	*Wade Creek-Maumee (04100009 02 03)*	*321.4*
Independence Dam State Park	*Ohio DNR*	*Park*	*Wade Creek-Maumee (04100009 02 03)*	*188.01*
Baldwin Woods Preserve	Wood County Park District	Nature Preserve	Tontogany Creek (04100009 06 01)	131.28
Van Tassel WA	*Ohio DNR*	*Wildlife Area*	*Sugar Creek-Maumee (04100009 06 02)*	*104.41*
Mary Jane Thurston State Park	*Ohio DNR*	*Park*	*Lick Creek-Maumee (04100009 05 10)*	*102.5*
Wintergarden/St. John's Nature Preserve	Bowling Green Parks and Recreation	Nature Preserve	Haskins Road Ditch-Maumee (04100009 06 03)	58.1
Wildlife Habitat Restoration Program Jones	Ohio DNR	Natural Area	Middle Beaver Creek (04100009 05 08)	57.77
Wildlife Habitat Restoration Program Adler	Ohio DNR	Natural Area	Middle Beaver Creek (04100009 05 08)	42.55
Wildlife Habitat Restoration Program (Knipp 29)	Ohio DNR	Natural Area	Middle South Turkeyfoot Creek (04100009 01 04)	41.96
Wildlife Habitat Restoration Program (Ferrell)	Ohio DNR	Natural Area	Sugar Creek-Maumee (04100009 06 02)	39
Wildlife Habitat Restoration Program (Knipp 28)	Ohio DNR	Natural Area	Wade Creek-Maumee (04100009 02 03)	38.04
UAW Park	*Local*	*Park*	*Snooks Run-Maumee (04100005 02 08)*	*36.9*

Site Name	Owner	Description	HUC 12	Acres
Meyerholtz Wildlife Area	*Ohio DNR*	*Wildlife Area*	*Village of Napoleon-Maumee (04100009 02 06)*	*32.12*
Lanker Wildlife Area	Ohio DNR	Wildlife Area	Sugar Creek-Maumee (04100009 06 02)	25.75
Village Park (Sherwood)	Local	Park	Sulphur Creek-Maumee (04100005 02 07)	25.56
Otsego Park	Wood County Park District	Park	Sugar Creek-Maumee (04100009 06 02)	20.14
Riverside Park (Antwerp)	*Local*	*Park*	*North Chaney Ditch-Maumee (04100005 02 02)*	*20.01*
Wildlife Habitat Restoration Program Euller	Ohio DNR	Natural Area	Tontogany Creek (04100009 06 01)	16.35
Maumee (Flatrock) Scenic River Access	*Ohio DNR*	*Access Point*	*Wade Creek-Maumee (04100009 02 03)*	*9.43*
North Wintergarden Arboretum	Bowling Green Parks and Recreation	Botanical/Arboretum Garden	Haskins Road Ditch-Maumee (04100009 06 03)	7.8
Maumee (The Bend) Scenic River Access	*Ohio DNR*	*Access Point*	*Snooks Run-Maumee (04100005 02 08)*	*7.39*
Maumee River Weir Rapids Wildlife Access	*Ohio DNR*	*Access Point*	*Sugar Creek-Maumee (04100009 06 02)*	*6.18*
Turkeyfoot Creek Wildlife Access	*Ohio DNR*	*Access Point*	*North Turkeyfoot Creek (04100009 04 02)*	*3.63*
Florida Wildlife Area	*Ohio DNR*	*Wildlife Area*	*Wade Creek-Maumee (04100009 02 03)*	*1.28*
Dry Creek Wildlife Area	*Ohio DNR*	*Wildlife Area*	*Dry Creek-Maumee (04100009 04 03)*	*1.15*

Drinking Water Supply

There are 44 public water systems in the project area. Two of these are surface water systems that utilize streams for part or all of their water supply, while there are 42 ground water systems. Surface water systems using the Maumee River exclusively were not included in these totals.

Table 6 — Public water systems within the Minor Great Black Swamp Tributaries study area, 2015.

Water System Name	PWS ID	County
Village of Delta (surface water system)	OH2600311	Fulton
City of Wauseon (surface water system)	OH2600111	Fulton
American Legion Post 454	OH3530712	Henry
Antwerp Village	OH6300012	Paulding
Bavarian Club Inc.	OH3531112	Henry
Bethlehem Lutheran Church	OH2030812	Defiance
Brentwood Community MHP	OH6300212	Paulding
Campfire Grille	OH4836612	Lucas
Campfire RV Park	OH4846313	Lucas
Deshler Village	OH3500112	Henry
Emanuel's Christian Church	OH3532012	Henry
G, H, & A-Brick Reclamation Yard	OH2637913	Fulton
Hamler Village	OH3500312	Henry
Harvest Fellowship	OH3538712	Henry
Hickory Hills Golf Club	OH2032012	Defiance
Hicksville Village	OH2000212	Defiance
Hillandale Farms-Hicksville	OH2036412	Defiance
Holgate Village	OH3500512	Henry
Hosanna Lutheran Ch-Grand Rapids	OH8749112	Wood
Independence Education Center	OH2032612	Defiance
Jehovah Witnesses Kingdom - Antwerp	OH6332112	Paulding
Jewell Cafe	OH2031412	Defiance
Lafarge North America-Paulding	OH6332212	Paulding
Leatherman AMLC	OH3538812	Henry
Leipsic Village	OH6900612	Putnam
Liberty Chapel U M Church	OH3533412	Henry
Log Cabin Tavern	OH3538112	Henry
Lucy's 22 Campground	OH3539012	Henry
Old Pines Golf Club	OH2633312	Fulton
Peace Evangelical Luth - Deshler	OH3534712	Henry
Pioneer Hi Bred International	OH8745412	Wood
Shepherd Pasture Campground PWS	OH2036112	Defiance
Sherwood Village Water	OH2000712	Defiance
Shiloh Christian Union Church	OH2636912	Fulton
St. Isadore Catholic Parish	OH2032412	Defiance
St. John Lutheran Church	OH3536012	Henry
St. John Lutheran Church-Sherwood	OH2033112	Defiance
St. John Lutheran School-Napoleon	OH3536112	Henry
St. Luke Lutheran Church	OH2635612	Fulton
St. Michael Catholic Church	OH2034312	Defiance
St. Paul Lutheran Church-Napoleon	OH3536212	Henry
The Ridge Project McClure	OH3533012	Henry
Vagabond Village Restaurant	OH6331212	Paulding
VFW Post 8847	OH3537112	Henry

Watershed Groups

There are four watershed-based organizations with an active interest in and around the project study area. They include CAP of Ohio, Maumee Watershed Conservancy District, Maumee River Basin Partnership of Local Governments, and the Upper Maumee Watershed Partnership.

"The Upper Maumee Watershed Partnership is a locally-led group of concerned citizens and organizations whose primary goal is the improvement of water quality throughout the Upper Maumee River Watershed and ultimately throughout the Western Lake Erie Basin" (UMWP 2016). The Upper Maumee Partnership has implemented volunteer monitoring projects in the study area with support from the Ohio Lake Erie Commission's Lake Erie Protection Fund. Partnership staff have been kept informed of the study's progress and data collected has been shared with them.

CAP was organized to be a positive influence and voice in promoting Ohio's agriculture through innovative programs that will improve the quality of soil and water resources in Defiance, Fulton, Henry, Lucas, Paulding, Williams and Wood counties. Recent projects have included cover crop planting, controlled drainage practices and farm equipment rental.

Maumee Watershed Conservancy District is a legal subdivision of the State of Ohio created under Section 6101 of the Ohio Revised Code. They serve 15 counties, including: Allen; Auglaize; Defiance; Fulton; Hancock; Hardin; Henry; Lucas; Mercer; Paulding; Putnam; Shelby; Van Wert; Williams; and Wood county. The District focuses primarily on flood risk reduction and drainage improvement projects. They implement practices such as single-side ditch maintenance in an effort to reduce impacts to stream quality.

The Maumee River Basin Partnership of Local Governments (MRBPLG) is a consortium of local government entities, which was founded in March 2001 by the city of Fort Wayne, Indiana and the city of Toledo, Ohio. The Partnership stretches focuses on a watershed-based approach to water quality management in the Maumee River Basin in three states: Ohio; Indiana; and Michigan. MRBPLG's activities include: lobbying; regional watershed coordination; technical resources; NPDES permit compliance resources; education and outreach; and water quality data consolidation.

NPDES-Permitted Facilities

A total of 40 NPDES-permitted facilities discharge sanitary wastewater, industrial process water and/or industrial storm water into streams within the study area. All tributaries in the study are located within 04100005 and 04100009 HUCs and within portions of Defiance, Fulton, Hancock, Henry, Paulding, Putnam, and Wood counties. 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). Individual NPDES permits in the Maumee River basin select tributaries watersheds are listed in Table 6. NPDES-permitted facilities within the study plan area that discharge directly to the Maumee River are not included in the list. The city of Wauseon, village of Hicksville and village of Leipsic are considered major dischargers based on the volume (>1 MGD) and type of waste they discharge. All other individual NPDES-permitted facilities in the watershed are considered minor dischargers. Minor dischargers include three activated sludge sewage treatment plants, 11 sewage lagoon systems, two sequencing batch reactor treatment plants, one oxidation ditch, eight package plants, and 12 industrial discharges (three concentrated animal feeding operations).

General NPDES permits are a potential alternative for facilities that have a minimal effect on the environment, have similar operations and meet certain eligibility criteria. There are several different types of general permits, including, but not limited to: small sanitary sewer discharges; petroleum bulk storage; and non-contact cooling water. A list of facilities covered under each type may be found at ***epa.ohio.gov/dsw/permits/NonStormgplist.aspx*** . There are also several types of general permits specific to storm water, including, but not limited to: small MS4s; construction sites; industries; and marinas. A list of facilities covered under each type may be found at ***epa.ohio.gov/dsw/permits/gplist.aspx*** . All major dischargers and relevant minor dischargers located in the study area are discussed in detail below.

Table 7 — Facilities regulated by an individual NPDES permit for the portions of 04100005 and 04100009 included in the Maumee basin select tributaries.

Ohio EPA Permit	Facility Name	Design Discharge (MGD)	Permit Type	Plant Description	Discharge Stream and River Mile	County
041000050201 - Zuber Cutoff						
2IK00013	Zylstra Dairy Ltd.		Ind.	Storm water; Manure discharge to fields	Upst. South Creek	Paulding
2PA00037	Antwerp WWTP	0.33	Mun.	Lagoon system – continuous discharge	North Creek (2.7)	Paulding
041000050204 - Gordon Creek						
2PB00042	Hicksville WWTP	2.25	Mun.	Activated sludge treatment	Mill Creek (2.0)	Defiance
2PG00049	Middle Gordon Creek Subdiv. WWTP	0.008	Mun.	Activated sludge treatment	Middle Fork Gordon Creek (5.57)	Defiance
041000050205 - Sixmile Cutoff-Maumee River (Lafarge was in HUC 041000071208. Construction of US. 24 moved it to 041000050205)						
2PA00033	Cecil WWTP	0.025	Mun.	Activated sludge treatment	Upst. to Maumee River	Paulding

Ohio EPA Permit	Facility Name	Design Discharge (MGD)	Permit Type	Plant Description	Discharge Stream and River Mile	County
2IJ00015	Lafarge North America	0.715	Ind.	Sedimentation pond discharge	Bowie Ditch and Bull Creek	Paulding
041000050207 - Sulphur Creek-Maumee River						
2PA00017	Sherwood WWTP	0.16	Mun.	Lagoon system – continuous discharge	Sulphur Creek (0.7)	Defiance
041000090102 - Upper South Turkeyfoot Creek						
2PB00043	Hamler WWTP	0.113	Mun.	Lagoon system – continuous discharge	S. Turkeyfoot Creek (20.62)	Henry
041000090103 - School Creek						
2PB00041	Holgate WWTP	0.247	Mun.	Lagoon system – controlled discharge	Brinkman Ditch (2.55)	Henry
041000090104 - Middle South Turkeyfoot Creek						
2PA00098	Malinta WWTP	0.052	Mun.	Lagoon system – controlled discharge	S. Turkeyfoot Creek (11.24)	Henry
041000090202 - Benien Creek						
2PA00091	Florida WWTP	0.48	Mun.	Lagoon system – controlled discharge	Brubaker Creek	Henry
041000090205 - Oberhaus Creek						
2PG00111	Country View Haven	0.01	Mun.	Package plant	Upst. to Van Hyning Creek	Henry
041000090207 - Creager Cemetery-Maumee River						
2IF00019	Universal Cooperatives Inc.	0.4	Ind.	Carbon filter; Stabilization pond	Ditch 1518 to Maumee River	Henry
041000090301 - Upper Bad Creek						
2PG00110	Airport Industrial Park	0.005	Mun.	Package plant	S. Branch Bad Creek (5.58)	Fulton
041000090302 - Lower Bad Creek						
2PG00109	Pleasant View Subdivision	0.02	Mun.	Package plant	Bad Creek (9.5)	Fulton
2PB00003	Delta WWTP	0.725	Mun.	Sequencing batch reactor	Bad Creek (13.87)	Fulton
2IW00070	Delta WTP		Ind.	Backwash water to controlled discharge lagoon	Bad Creek (17.55)	Fulton
041000090401 - Konzen Ditch						
2IK00022	Peters Dairy LLC (Napoleon Dairy LLC)		Ind.	Storm water; Manure discharge to fields	Upst. to Konzen Ditch	Henry
041000090402 - North Turkeyfoot Creek						
2PD00016	Wauseon WRF	1.5	Mun.	Trickling filter; Extended aeration	N. Turkeyfoot Creek (18.61)	Fulton
041000090403 - Dry Creek-Maumee River						
2PY00038	Camelot South Estates MHP	0.0125	Mun.	Package plant	Dry Creek (10.5)	Fulton

Ohio EPA Permit	Facility Name	Design Discharge (MGD)	Permit Type	Plant Description	Discharge Stream and River Mile	County
041000090501 - Big Creek						
2PT00019	Hope School (a.k.a. The Ridge Project)	0.0033	Mun.	Package plant	Upst. Big Creek	Henry
2PA00056	McClure WWTP	0.1	Mun.	Lagoon system – controlled discharge	Big Creek (3.4)	Henry
041000090502 - Hammer Creek						
2PR00163	Bavarian Club Inc.	0.007	Mun	Package plant	Hammer Creek	Henry
041000090504 - Upper Yellow Creek						
2PB00040	Leipsic WWTP	1.5	Mun.	Sequencing batch reactor	Little Yellow Creek (6.38)	Putnam
2PC00002	Deshler WWTP	0.57	Mun.	Lagoon system – controlled discharge	Brush Creek (9.8)	Henry
2IN00171	BP Amoco Oil Corp Bulk Plant West Leipsic		Ind.	Oil water separator to pond	Upst. Little Yellow Creek	Putnam
2IF00023	Summit Ethanol LLC	0.305	Ind.	Non-contact cooling water	Hickey Ditch (0.52)	Putnam
041000090507 - Cutoff Ditch						
2PA00090	Custar WWTP	0.05	Mun.	Lagoon system – controlled discharge	Jackson Cutoff (5.9)	Wood
041000090508 - Middle Beaver Creek						
2IJ00034	Custar Stone Co. Inc. Custar Plant	2.016	Ind.	Sedimentation pond discharge	Beaver Creek (10.5)	Wood
041000090509 - Lower Beaver Creek						
2PA00029	Grand Rapids WWTP	0.18	Mun.	Oxidation Ditch	Beaver Creek (0.38)	Wood
2PR00067	UMC Widewater Retreat and Ministry Center		Mun.	Lagoon system – controlled discharge	Upst. to Maumee River (0.45)	Henry
041000090601 - Tontogany Creek						
2IK00023	Drost Land Co. LLC (Manders Dairy LLC)		Ind.	Storm water; Manure discharge to fields	Upst. W. Branch Tontogany Creek	Wood
2PY00071	Country Side MHP	0.008	Mun.	Package plant	Wingston Rd. Ditch (2.4)	Wood
2PB00011	Weston WWTP	0.28	Mun.	Activated Sludge	W. Branch Tontogany Creek (8.1)	Wood
2IN00120	Wood County Landfill		Ind.	Storm water sedimentation pond	Norris Euler Ditch	Wood

Ohio EPA Permit	Facility Name	Design Discharge (MGD)	Permit Type	Plant Description	Discharge Stream and River Mile	County
2PB00024	Tontogany Area WWTP	0.1	Mun.	Lagoon system – continuous discharge	Tontogany Creek (3.6)	Wood
041000090602 – Sugar Creek						
2PY00061	Riverview MHP	0.0035	Mun.	Package plant	Upst. Maumee River	Wood
041000090603 - Haskins Road Ditch-Maumee River						
2IJ00047	Hanson Aggregate MW-Waterville Quarry		Ind.	Storm water sedimentation pond	Upst. to Maumee River	Lucas
2PA00026	Haskins WWTP	0.3	Mun.	Sequencing batch reactor	Liberty High Rd. Ditch (0.86)	Wood

City of Wauseon WRF (Ohio EPA Permit # 2PD00016)

The city of Wauseon WRF serves approximately 7,100 residents in the city of Wauseon and surrounding area. Sewer services for the city are provided by a municipal sanitary sewage treatment plant with an average daily design flow of 1.5 MGD. Sanitary waste from the city receives treatment through fine screening, grit removal, primary settling, trickling filters, activated sludge aeration, chemical phosphorus removal, final clarification, and chlorination/de-chlorination. In 2011 the city constructed a 5.7-million-gallon equalization (EQ) basin to collect excessive flow beyond the plant's capacity. The final treated effluent is discharged to North Turkeyfoot Creek at RM 18.61.

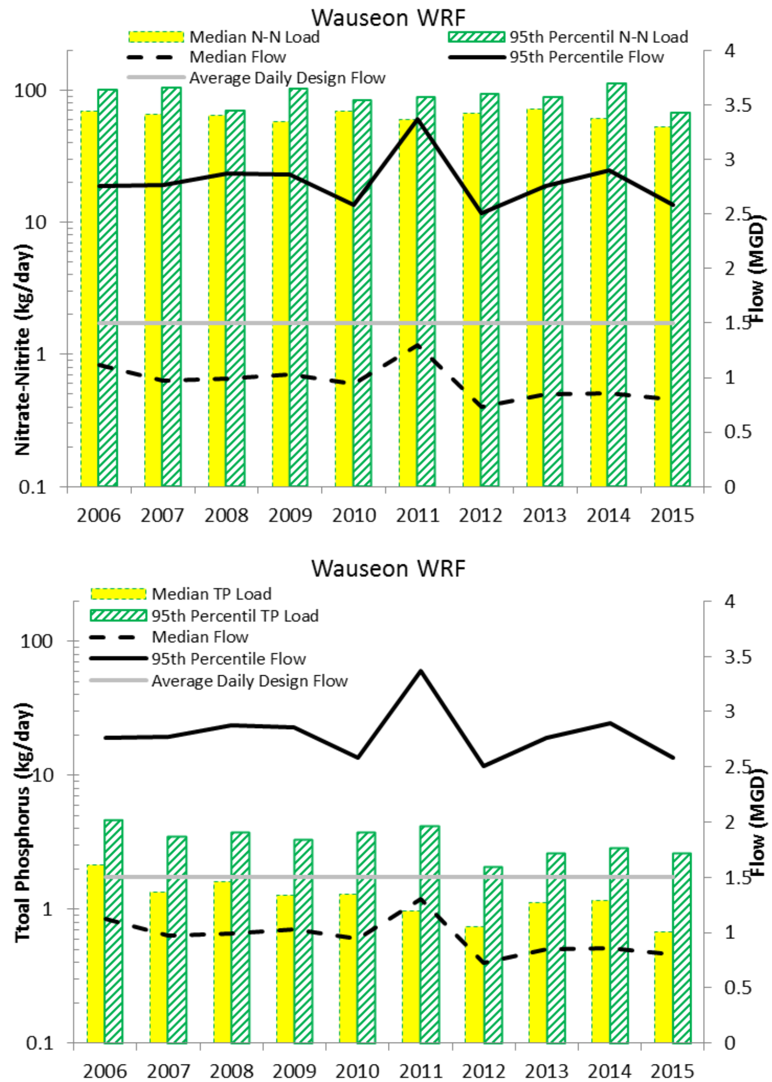


Figure 8 — Annual nitrate-nitrite (top) and total phosphorus (bottom) loadings for the Wauseon WRF from 2006-2015.

The collection system consists of 90 percent separate and 10 percent combined sewers. Combined sewer overflows (CSO) directly to North Turkeyfoot Creek (RM 18.61) occur during excessive flows in the system above the capacity of the EQ basin. The city has completed the activities as required by the long-term control plan (LTCP) and continues to monitor he CSO outfalls. All three CSO outfalls discharged less than four times in 2015. One CSO exists at the plant (outfall 602) while two other overflows exist within the sanitary sewer collection system (outfall 004 and 008). Outfall 004 discharged 1,000 gallons on June 27, 2015, Outfall 008 discharged 1,000 gallons on Feb. 27, 2015, and Outfall 602 discharged 220,000 gallons on June 1, 2015, 13.44 million gallons on June 27-30, 2015, and 3.3 million gallons on July 9-10, 2015. Five sanitary sewer overflow (SSO) discharges were also documented on June 27, 2015. Estimated inflow and infiltration rate to the system is 0.012 MGD.

There are 21 industrial users responsible for 0.086 MGD of daily flow into the plant. One of these facilities is categorical, accounting for 0.005 MGD of flow and two are non-categorical accounting for 0.006 MGD of flow. A pretreatment program was approved for the city on Jan. 9, 1985.

Ohio EPA most recently conducted a compliance sampling inspection and bioassay at the Wauseon WRF on May 14-15, 2012. The effluent from outfall 001 was not acutely toxic to *Pimephales promelas* or *Ceriodaphnia dubia*. Compliance history for the plant during the sampling period showed the facility obtained a 7-day concentration total phosphorus violation on April 8, 2015.

Pollutant loadings from the city of Wauseon WRF from 2006 through 2015 were evaluated and annual statistics for nitrate-nitrate and total phosphorus are depicted in Figure 8. The plant discharged at a relatively consistent flow during the evaluation period. The annual nitrate-nitrite loadings have remained relatively steady; however, annual discharge concentrations are high and contribute to the highly elevated (>95th percentile reference concentrations) nitrate-nitrite concentrations observed in North Turkeyfoot Creek. The observed phosphorus loads demonstrate a slightly decreasing trend over the past 10 years.

Village of Leipsic WWTP (Ohio EPA Permit # 2PB00040)

The village of Leipsic WWTP serves approximately 2,300 residents. Sewer services for the village are provided by a municipal sanitary sewage treatment plant with an average daily design flow of 1.5 MGD. The WWTP consists of screening, grit removal, primary sedimentation, trickling filter, sequencing batch reactor (SBR), secondary clarification, and ultraviolet disinfection. The treatment plant was most recently upgraded in the spring of 2013 by upgrading the existing three SBRs and adding a fourth SBR. Effluent discharges to Little Yellow Creek at RM 6.38. This discharge functionally starts Little Yellow Creek.

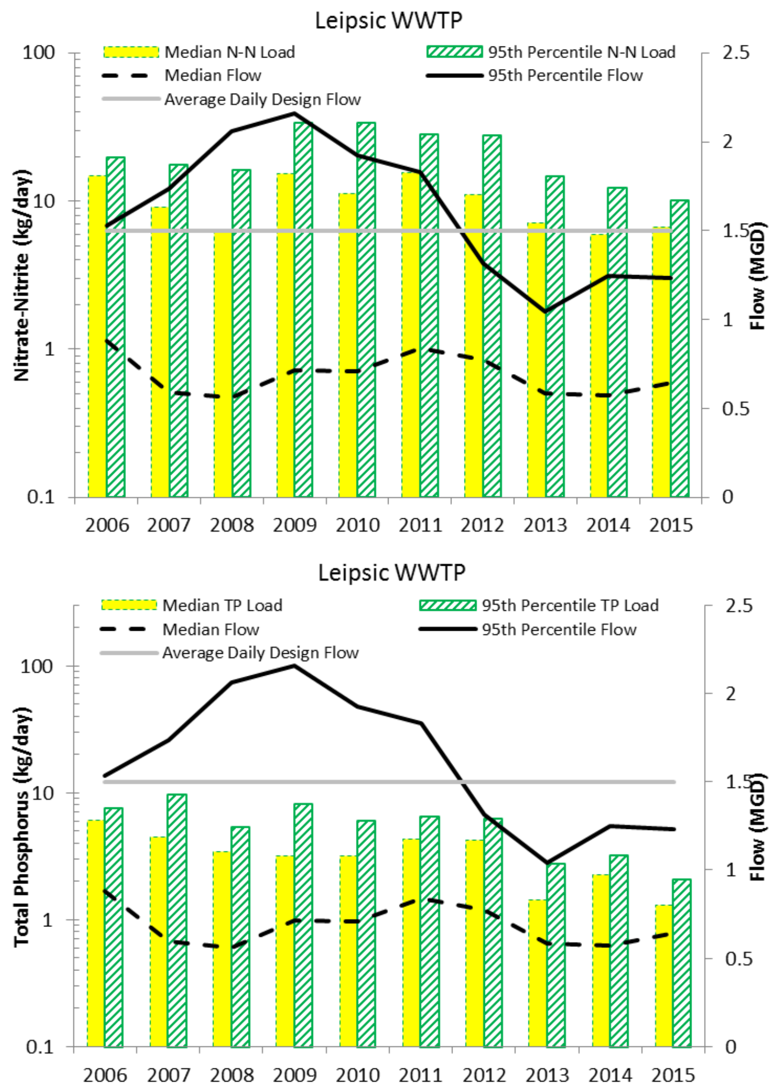


Figure 9 — Annual nitrate-nitrite (top) and total phosphorus (bottom) loadings for the Leipsic WWTP from 2006 - 2015.

The sanitary sewer collection system for the village is made up of 100 percent separate sanitary sewers. Complete separation was achieved in June 2010. The facility did not have any permit limit violations during the survey year. Leipsic has five industrial users, two of which are categorical industrial users. There is no approved pretreatment program for the village.

Pollutant loadings from the WWTP from 2006 through 2015 were evaluated and annual statistics for nitrate-nitrate and total phosphorus loadings are displayed in Figure 9. The plant has discharged at a relatively consistent flow with a noticeable decrease in the 95th percentile flow after the plant upgrades in 2013. The annual nitrate-nitrite and total phosphorus loadings show an overall decreasing trend during the 10-year period observed.

Facility DMRs dating back to 2014 indicate that the Leipsic WWTP was a source of elevated total filterable residue (total dissolved solids). Despite not having total filterable residue limits in the current permit effective 1/1/2014, monitoring requirements were added to the current permit because "… (TDS) is an emerging water quality issue for municipal wastewater treatment plants. The purpose of the monitoring is to obtain data on the level and variability of total dissolved solids in the Leipsic WWTP effluent." Elevated TDS and conductivity were noted in Little Yellow Creek and extended downstream into Yellow Creek. Instream TDS concentrations collected from grab samples from Little Yellow Creek in August and September 2015 at RM 0.9 (500700) were consistently above the 95th percentile compared to streams of similar size in the HELP ecoregion. Relatively lower instream TDS concentrations were noted earlier in the summer, but it is likely substantially higher than average flows for this time of the year provided dilution, resulting in the comparatively low instream concentrations early in the summer (Figure 20). ***Diel sonde monitoring results*** from 2016 at RM 4.6 (P10W08) and 2015 at RM 0.9 showed elevated specific conductance.

Annual acute toxicity monitoring requirements were also added to the current permit. Since monitoring began in 2014, an acute toxicity hit on *Ceriodaphnia dubia* of 1.8 TUa (toxicity unit – acute) was noted and was very likely caused by or related to elevated TDS concentrations. Despite elevated TDS concentrations, no biological impairment was documented downstream from the Leipsic WWTP in either Little Yellow or Yellow Creek. Little Yellow Creek fully supports WWH assemblages at RM 0.9 and biological performance in Yellow Creek generally exceeded HELP WWH expectations.

Village of Hicksville WWTP (Ohio EPA Permit # 2PB00042)

The village of Hicksville WWTP serves approximately 3,600 residents. Sewer services for the village are provided by a municipal sanitary sewage treatment plant with an average daily design flow of 0.95 MGD and a peak hydraulic capacity of 4 MGD. The village of Hicksville has nine significant non-categorical industrial users responsible for 0.15 MGD flow into the plant.

The municipal wastewater treatment plant consists of screening, grit removal, activated sludge with extended aeration, secondary clarification, alum addition, post aeration and ultraviolet disinfection. Effluent discharges to Mill Creek at RM 2.0.

The sanitary sewer collection system for the village is made up of 15 percent separate sanitary sewers and 85 percent combined sewers. Five CSO outfalls exist in the collection system. CSO outfall occurrence and volume data for 2015 are documented in Table 8. A revised long-term control plan for the village specifies that portions of the system will be separated, and inflow and infiltration will be removed, existing lift stations will be replaced and reconstructed, and a high rate treatment facility will be installed to substantially reduce the number of CSO discharges to Mill Creek. The inflow/infiltration rate for the collection system is estimated to be 0.5 MGD.

Table 8 — Hicksville CSO outfall occurrence and volume data, 2015.

CSO Outfall	Date	Occurrences	Volume (MG)
002	3/26/2015	1	0.1
002	6/1/2015	1	0.5
002	7/1/2015	3	0.25
002	10/28/2015	1	0.004
003	3/26/2015	1	2.5
003	5/1/2015	3	2.5
003	6/1/2015	4	10
003	7/1/2015	3	4.25
003	10/28/2015	1	0.5
003	12/24/2015	1	5
004	6/1/2015	1	0.5
004	7/1/2015	1	0.35
005	-	-	-
006	6/3/2015	1	0.01
006	7/1/2015	3	2.5

The Hicksville WWTP had permit limit violations for low-level mercury and ammonia in 2015. These permit limit exceedances are documented in Table 9. There were no apparent impacts to stream biota downstream from Mill Creek in Middle Fork Gordon Creek RM 0.76.

Pollutant loadings from the Hicksville WWTP between 2006 and 2015 were evaluated and annual statistics for nitrate-nitrate, total phosphorus, and ammonia loadings are displayed in Figure 10. The annual, median nitrate-nitrite loadings show a slightly decreasing trend. Phosphorus loads show a decreasing trend. Median ammonia loading from the plant displayed a substantial increase in 2014 and 2015. The facility had CBOD5 and ammonia violations in 2016, 2017, and 2018. The facility staff attributed these to a single die-off event at the plant that has taken some time to recover from. That event also resulted in *E. coli* violations. They are working with the manufacturer of their UV system to address performance issues.

Table 9 — Hicksville WWTP permit limit compliance, 2015.

Permit No.	Station	Parameter	Limit Type	Limit	Reported Value	Violation Date
2PB00042*OD	001	Mercury, Total (Low Level)	30D Conc.	14.72	19.7	5/1/2015
2PB00042*OD	001	Ammonia	30D Conc.	1.7	4.055	10/1/2015
2PB00042*OD	001	Ammonia	7D Conc.	2.55	6.41	10/1/2015
2PB00042*OD	001	Ammonia	7D Conc.	2.55	6.135	10/8/2015
2PB00042*OD	001	Ammonia	7D Conc.	2.55	2.885	10/15/2015

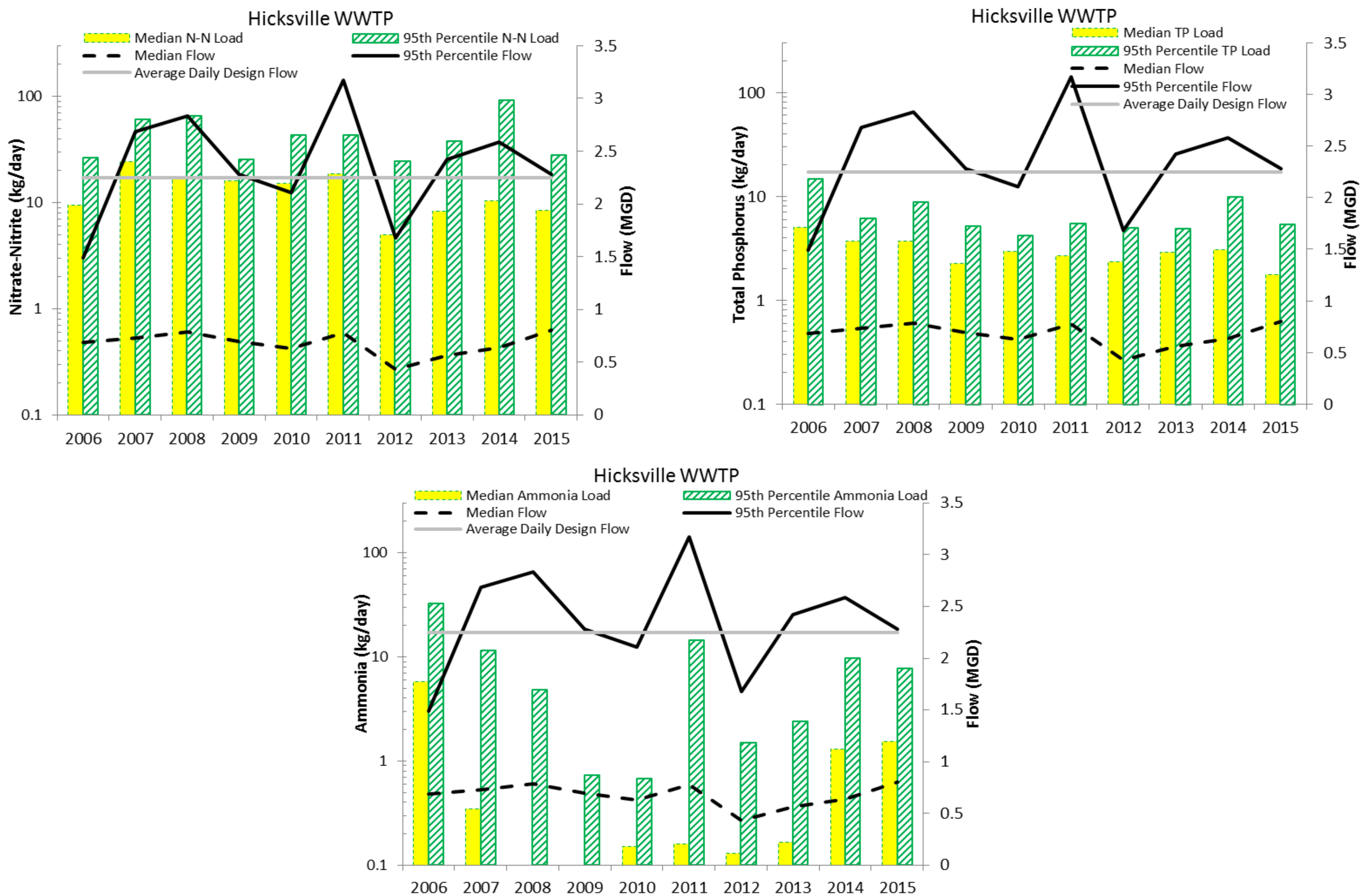


Figure 10 — Annual nitrate-nitrite (top-left), total phosphorus (top-right), and ammonia (bottom) loadings from the Hicksville WWTP. 2006-2015.

Village of Delta WWTP (Ohio EPA Permit # 2PB00003)

The village of Delta wastewater treatment plant provides sanitary wastewater treatment to approximately 3,100 people. The plant consists of a comminutor, grit removal, SBR, and chlorination/de-chlorination with an average daily design flow of 0.725 MGD.

The village's sanitary waste consists of 25 percent separate and 75 percent combined sewers. The plant discharges into Bad Creek at RM 13.87. Nine CSO outfalls exist in the collection system. CSO outfall occurrence and volume of discharge data for 2015 are documented in Table 10. Plant upgrades were completed and a revised long-term control plan (LTCP) was submitted by the village of Delta that resulted from Directors Final Findings and Orders in 2011 and 2013. The community had scheduled for completion the construction of an EQ basin in accordance with the LTCP in spring 2017. This scheduled completion date was ultimately met.

In addition to CSOs, the village has a SSO. The SSO discharged on Feb. 23-24, March 12, and March 23-27, 2015, for a total estimated discharge of 2.15 million gallons. The Delta WWTP had a permit limit violation for copper in 2015.

Pollutant loadings from the village of Delta WWTP between 2006 and 2015 were evaluated and annual statistics for nitrate-nitrate, total phosphorus and ammonia loadings are displayed in Figure 11. Flow data suggests that plant upgrades completed in accordance with the 2011 Director's Final Findings and Orders reduced the 95th percentile wet-weather flows being discharged from the plant. The annual nitrate-nitrite loadings were high and demonstrate an increasing trend, while phosphorus and ammonia loads have decreased over the past 10 years.

Table 10 — Delta CSO outfall occurrence and volume data, 2015.

CSO Outfall	Date	Occurrences	Volume (MG)
004	6/28/2015	1	flooded
006	6/28-29/15	1	0.25
006	12/29/2015	1	0.01
007		0	0
008		0	0
009	3/26/2015	1	0.05
009	6/28-30/15	1	0.6
010	3/26/2015	1	0.05
010	4/10/2015	1	0.05
010	5/31/2015	1	0.25
010	6/16-17/15	1	0.5
010	6/28-30/15	1	flooded
010	7/1/2015	1	flooded
010	7/10/2015	1	flooded
010	12/29/2015	1	0.006
012	3/12/2015	1	0.01
012	3/26/2015	1	0.75
012	3/27/2015	1	0.5
012	3/28/2015	1	0.25
012	5/31/2015	1	1
012	6/16/2015	1	0.5
012	6/28-30/15	1	0.75 and flooded
012	7/1/2015	1	flooded
012	12/29/2015	1	flooded
013	3/26/2015	1	0.3
013	3/27/2015	1	0.15
013	5/31/2015	1	0.75
013	6/16/2015	1	0.5
013	6/28-30/15	1	1.0 and flooded
014	6/28/2015	1	flooded
014	12/29/2015	1	flooded

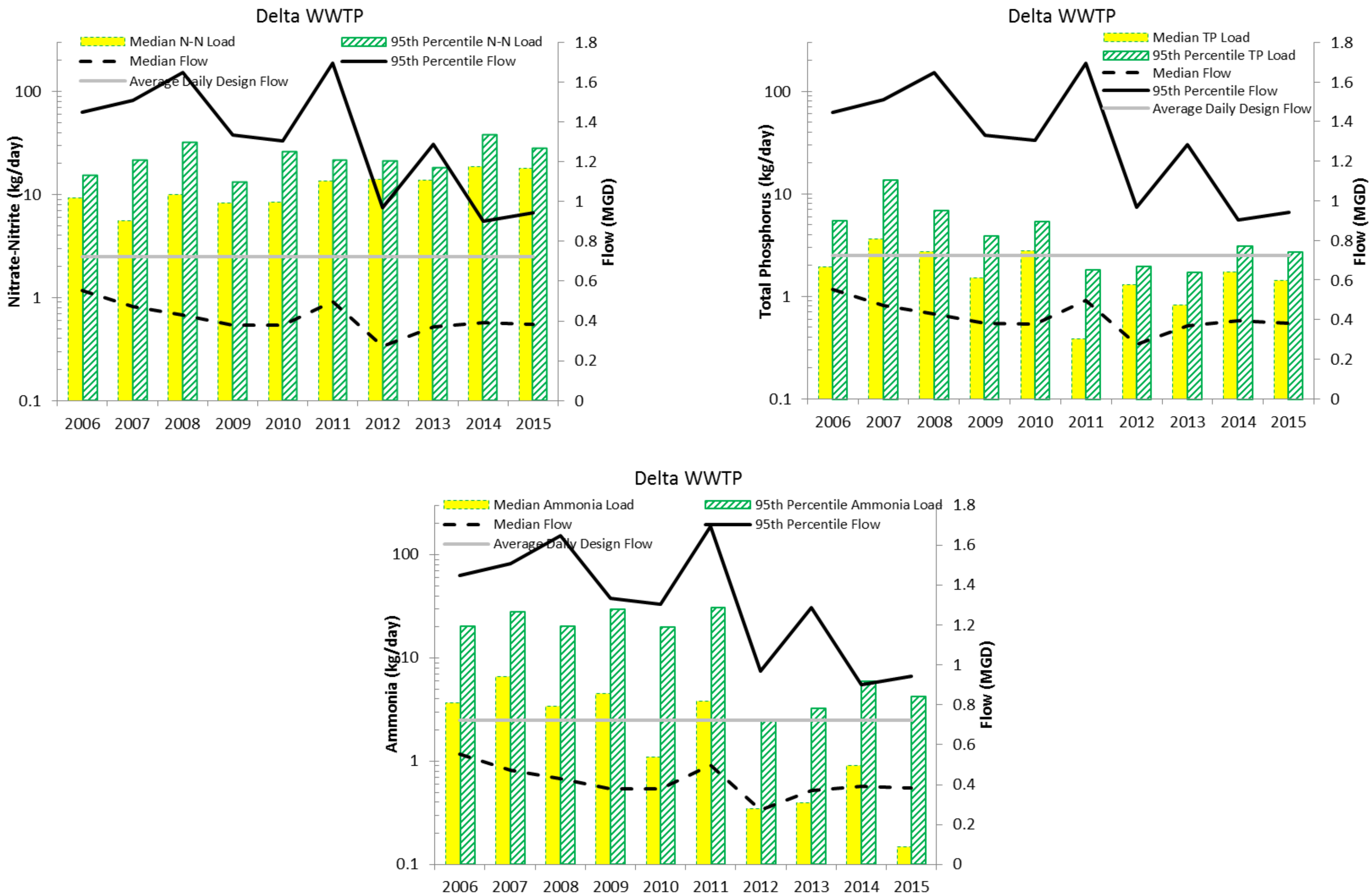


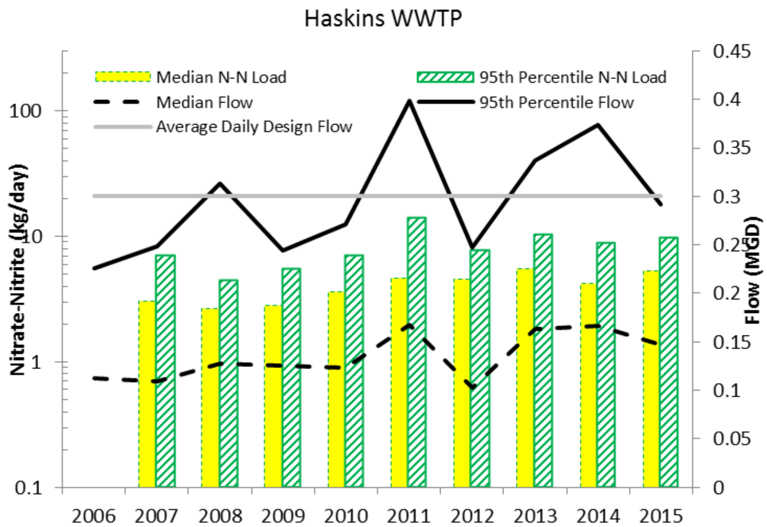
Figure 11 — Annual nitrate-nitrite (top-left), total phosphorus (top-right), and ammonia (bottom) loadings from the Delta WWTP, 2006-2015.

Village of Haskins WWTP (Ohio EPA Permit # 2PA00026)

The village of Haskins WWTP provides sanitary wastewater treatment to approximately 1,200 people. The plant consists of an SBR and ultraviolet disinfection with an average daily design flow of 0.3 MGD. The plant discharges into Liberty Hi Rd. Ditch at RM 0.86.

The collection system consists of 100 percent separate sewers and has a single SSO. The SSO did not discharge in 2015. The Haskins WWTP had a permit limit violation for *E. coli* in 2015.

Pollutant loadings from the village of Haskins WWTP between 2006 and 2015 were evaluated and annual statistics for nitrate-nitrate, total phosphorus and ammonia loadings are displayed in Figure 12. Flow data suggests that plant upgrades completed in accordance with the 2011 Director's Final Findings and Orders reduced the 95th percentile wet-weather flows being discharged from the plant. The annual nitrate-nitrite loadings have demonstrated an increasing trend while phosphorus and ammonia loads have decreased over the past 10 years.



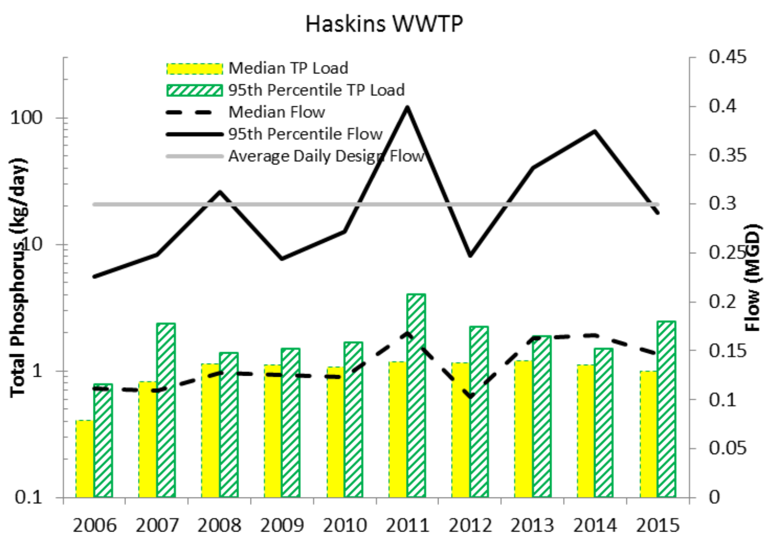


Figure 12 — Annual nitrate-nitrite (top) and total phosphorus (bottom) loadings from the Haskins WWTP, 2006 – 2015.

Village of Weston WWTP (Ohio EPA Permit # 2PB00011)

The village of Weston WWTP provides sanitary wastewater treatment to approximately 1,700 people. The plant consists of screening, comminution, activated sludge with extended aeration, clarification and ultraviolet disinfection with an average daily design flow of 0.28 MGD. The plant discharges into the West Branch Tontogany Creek at RM 8.1.

The sanitary sewer collection system for the village is made up of 100 percent separate sanitary sewers. In 2015, SSO discharges occurred on June 1, 16-17, 27-29 and July 1, 9-14. The facility had permit limit violations for total mercury (low-level), total suspended solids, CBOD5 and *E. coli* in 2015. Permit violations are summarized in

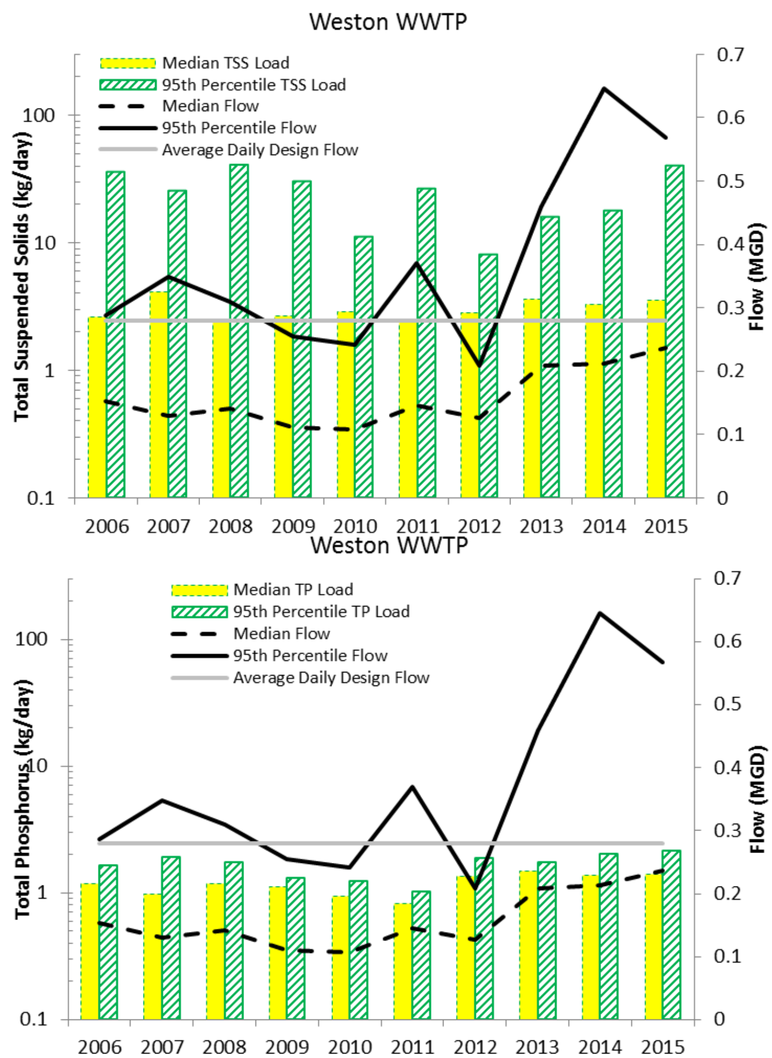


Figure 13 — Annual total suspended solids (top) and total phosphorus (bottom) from the Weston WWTP, 2006–2015.

Table 11.

Pollutant loadings from the village of Weston WWTP between 2006 and 2015 were evaluated and annual statistics for TSS and total phosphorus loadings are displayed in Figure 13. The median and 95th percentile flow from the plant remained steady until 2013 and then an increase can be observed for the last three years. The annual median TSS loadings have showed an increasing trend, while the 95th percentile loads have displayed a slightly decreasing trend. Permit limit violations for TSS occurred in May and March contributing to the increased load observed in 2015. Total phosphorus loads showed an increasing trend over the past 10 years.

Table 11 — Weston WWTP permit limit compliance, 2015.

Permit No	Station	Parameter	Limit Type	Limit	Reported Value	Violation Date
2PB00011*MD	001	TSS	7D Conc.	40	82.	3/8/2015
2PB00011*MD	001	TSS	7D Qty.	42.4	83.7999	3/8/2015
2PB00011*MD	001	TSS	30D Conc.	25	31.625	3/1/2015
2PB00011*MD	001	TSS	30D Qty.	26.5	31.0081	3/1/2015
2PB00011*MD	001	CBOD 5-day	7D Conc.	15	42.	3/8/2015
2PB00011*MD	001	CBOD 5-day	7D Qty.	15.9	42.9219	3/8/2015
2PB00011*MD	001	CBOD 5-day	30D Conc.	10	14.4375	3/1/2015
2PB00011*MD	001	CBOD 5-day	30D Qty.	10.6	14.9507	3/1/2015
2PB00011*MD	001	Mercury, Low-Level	30D Conc.	1.3	19.6	3/1/2015
2PB00011*MD	001	Mercury, Low-Level	30D Qty.	.0000	.00006	3/1/2015
2PB00011*MD	001	TSS	7D Conc.	40	44.	5/22/2015
2PB00011*MD	001	TSS	30D Qty.	26.5	30.8155	5/1/2015
2PB00011*MD	001	TSS	7D Qty.	42.4	75.1814	5/22/2015
2PB00011*MD	001	CBOD 5-day	7D Qty.	15.9	16.3341	5/8/2015
2PB00011*MD	001	*E. coli*	7D Conc.	362	4449.71	6/1/2015
2PB00011*MD	001	Mercury, Low-Level	30D Conc.	1.3	3.58	6/1/2015
2PB00011*MD	001	Mercury, Low-Level	30D Qty.	.0000	.00001	6/1/2015

Wastewater Treatment Lagoon Systems

Eleven wastewater treatment lagoon systems are in the study area (Figure 14). The 2015 annual discharge of these systems to the watershed was 241.53 million gallons. The villages of Antwerp, Sherwood, Hamler, and the Tontogany Area WWTP are continuous-discharge wastewater lagoon systems. The villages of Holgate, McClure, Deshler, Custar, Malinta and Florida, and the UMC Widewater Retreat are controlled-discharge lagoon systems. Select systems are discussed in detail below.

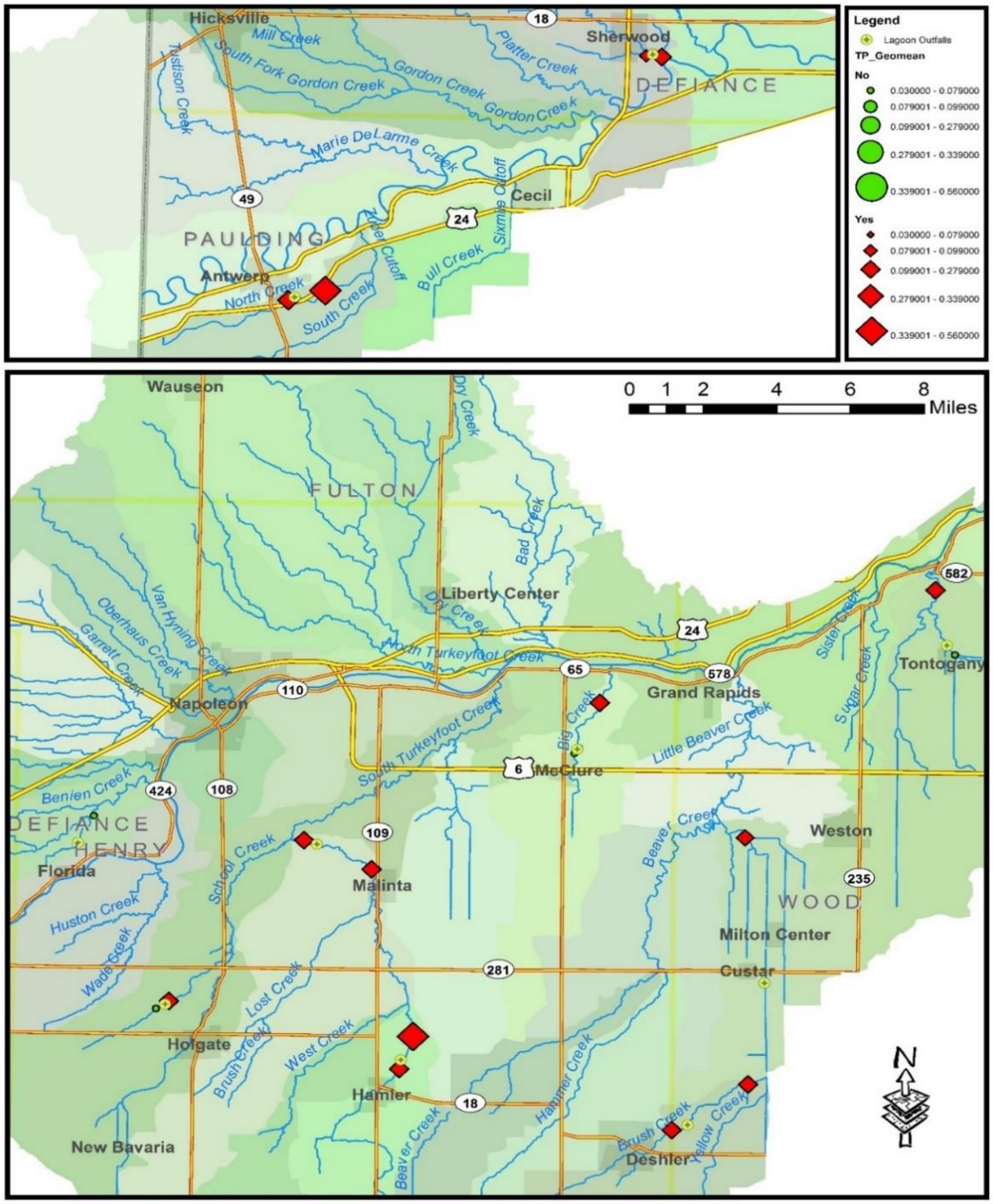


Figure 14 — Municipal wastewater treatment lagoon systems in the project study area, 2015. Monitoring locations upstream and downstream of the lagoon systems are depicted with gradated total phosphorus geometric mean results for samples collected during the summer index period (June 1 – Oct. 15). Green circles depict values that met the benchmark, while red diamonds exceeded the benchmark.

Village of Antwerp WWTP (Ohio EPA Permit # 2PA00037)

The village of Antwerp WWTP provides sanitary wastewater treatment to approximately 1,700 people. The municipal wastewater treatment plant consists of a continuous discharge aerated lagoon with an average daily design flow of 0.33 MGD. In 2015 the annual discharge from the lagoon was 84.311 million gallons based on DMR data submitted by the facility. The village's collection system is 100 percent separated and the plant discharges into North Creek at RM 2.7.

The Antwerp WWTP had permit limit violations for DO on Jan. 7, 2015 and *E. coli* violations on May 8, May 15, June 1, and July 8, 2015. No SSO discharges were documented in 2015.

Pollutant loadings from the village of Antwerp WWTP between 2006 and 2015 were evaluated and annual statistics for nitrate-nitrite and total phosphorus loadings are displayed in Figure 15. The median flow through the plant demonstrates a decreasing trend. The median annual nitrate-nitrite loadings have demonstrated an increasing trend while the phosphorus loads show a slight decrease.

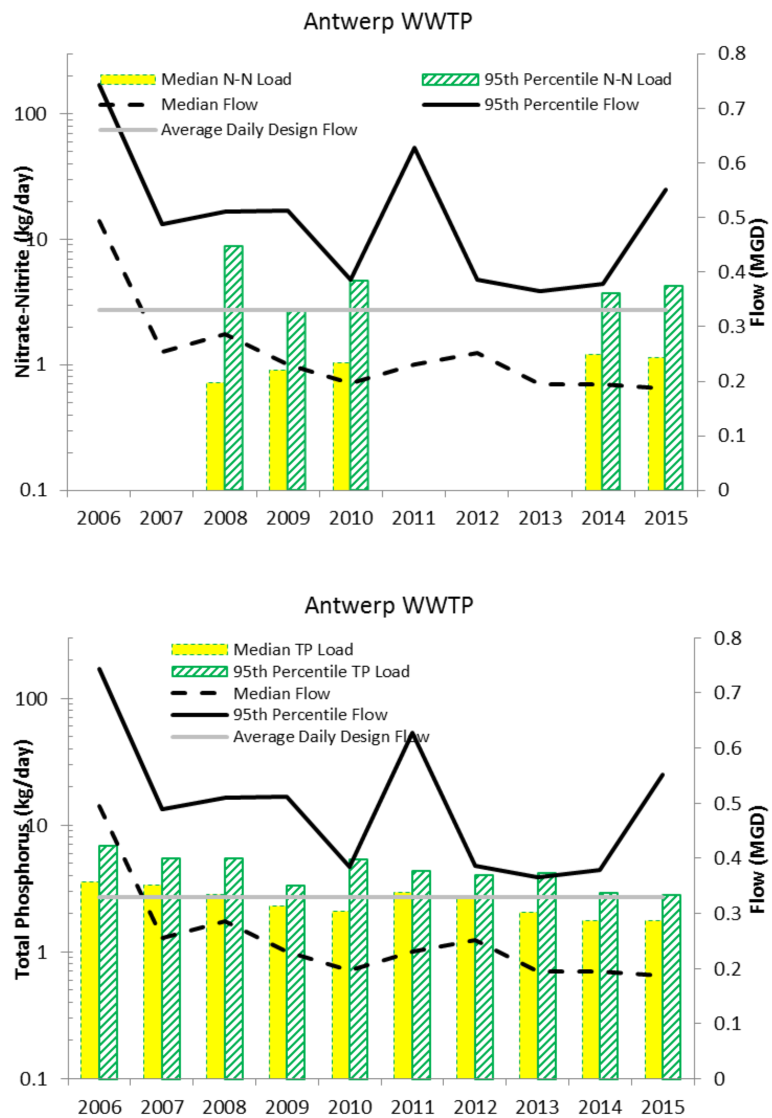


Figure 15 — Annual nitrate-nitrite (top) and total phosphorus (bottom) loadings from the Antwerp WWTP, 2006–2015.

Village of Sherwood WWTP (Ohio EPA Permit # 2PA00017)

The village of Sherwood WWTP provides sanitary wastewater treatment to approximately 1,900 people. The plant consists of a continuous discharge aerated lagoon with an average daily design flow of 0.16 MGD. The annual discharge from the lagoon in 2015 based on DMR data submitted by the facility was 39.242 million gallons. The village's collection system is 100 percent separated and the plant discharges into Sulphur Creek at RM 0.7.

The Sherwood WWTP had permit limit violations for ammonia, pH, and TSS during 2015. These permit limit violations are documented in Table 12. Ammonia, pH, and TSS violations have been consistently documented in the effluent from the Sherwood WWTP over the past 10 years. The village has improved treatment efficiency of the wastewater treatment lagoon and removed sources of inflow and infiltration resulting in a reduction in peak wet-weather flows, however, violations still occur annually at the plant. As of 2018, the facility is working on significant upgrades to their lagoons by changing the continuous discharging system into a controlled discharge.

Pollutant loadings from the village of Sherwood WWTP between 2006 and 2015 were evaluated and annual statistics for ammonia, total phosphorus and TSS loadings are displayed in Figure 16. As noted above, improvements have been made to the lagoons and to reduce inflow and infiltration which has resulted in a reduction in wet-weather flows that can be observed by the decreasing trend in flow. The annual ammonia, total phosphorus and TSS loadings have demonstrated this decreasing trend most significantly over the past four years.

Despite multiple permit limit violations recorded before and during 2015, no biological impairment was documented downstream from this facility and, in fact, has improved since 1997. Sulphur Creek maintains good habitat quality where evaluated and the positive habitat attributes and riparian shading likely help attenuate water chemistry issues emanating from this facility. Harmful, short-term episodes ranging from the onset of rapidly lethal conditions to a protracted chronic stress will generally be manifested in the response of resident biota. Thus, the biota can reveal the real-world effects of exceedances or violations and consequent harm more precisely than can be predicted or measured on a chemical or toxicity basis alone (Ohio EPA 1987).

Table 12 — Sherwood WWTP permit limit compliance, 2015.

Permit No.	Station	Parameter	Limit Type	Limit	Reported Value	Violation Date
2PA00017*ID	001	Ammonia	30D Conc.	9.1	9.975	3/1/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.16	4/30/2015
2PA00017*ID	001	Ammonia	30D Conc.	9.1	10.48	4/1/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.2	5/1/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.29	5/5/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.36	5/6/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.5	5/7/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.3	5/8/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.3	5/11/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.2	5/15/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.2	5/19/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.4	6/9/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.42	6/10/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.38	6/11/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.6	6/15/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.11	6/17/2015
2PA00017*ID	001	pH	1D Conc..	9.0	9.1	6/22/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.5	6/23/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.37	6/24/2015
2PA00017*ID	001	Ammonia	7D Conc.	3.3	3.79	6/1/2015
2PA00017*ID	001	Ammonia	7D Qty.	2.0	2.00258	6/1/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.22	7/1/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.3	7/7/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.2	7/9/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.1	7/14/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.1	7/16/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.3	7/20/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.4	7/21/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.3	7/28/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.3	7/29/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.28	7/30/2015

Permit No.	Station	Parameter	Limit Type	Limit	Reported Value	Violation Date
2PA00017*ID	001	TSS	7D Qty.	54	76.0391	7/8/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.1	8/3/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.1	8/6/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.4	8/10/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.3	8/11/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.6	8/17/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.1	8/18/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.2	8/19/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.2	8/31/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.2	9/1/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.2	9/3/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.25	9/8/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.2	9/9/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.3	9/11/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.2	9/15/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.2	9/18/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.07	9/24/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.01	9/25/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.24	9/29/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.3	9/30/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.2	10/5/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.28	10/7/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.5	10/9/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.1	10/15/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.4	10/19/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.36	10/21/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.2	10/22/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.17	10/28/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.1	10/30/2015
2PA00017*ID	001	TSS	7D Conc.	90	91	10/8/2015
2PA00017*ID	001	TSS	30D Conc.	65	85.875	10/1/2015
2PA00017*ID	001	TSS	7D Conc.	90	103.8	10/22/2015
2PA00017*ID	001	pH	1D Conc.	9.0	9.25	11/4/2015
2PA00017*ID	001	TSS	7D Conc.	90	92	11/1/2015

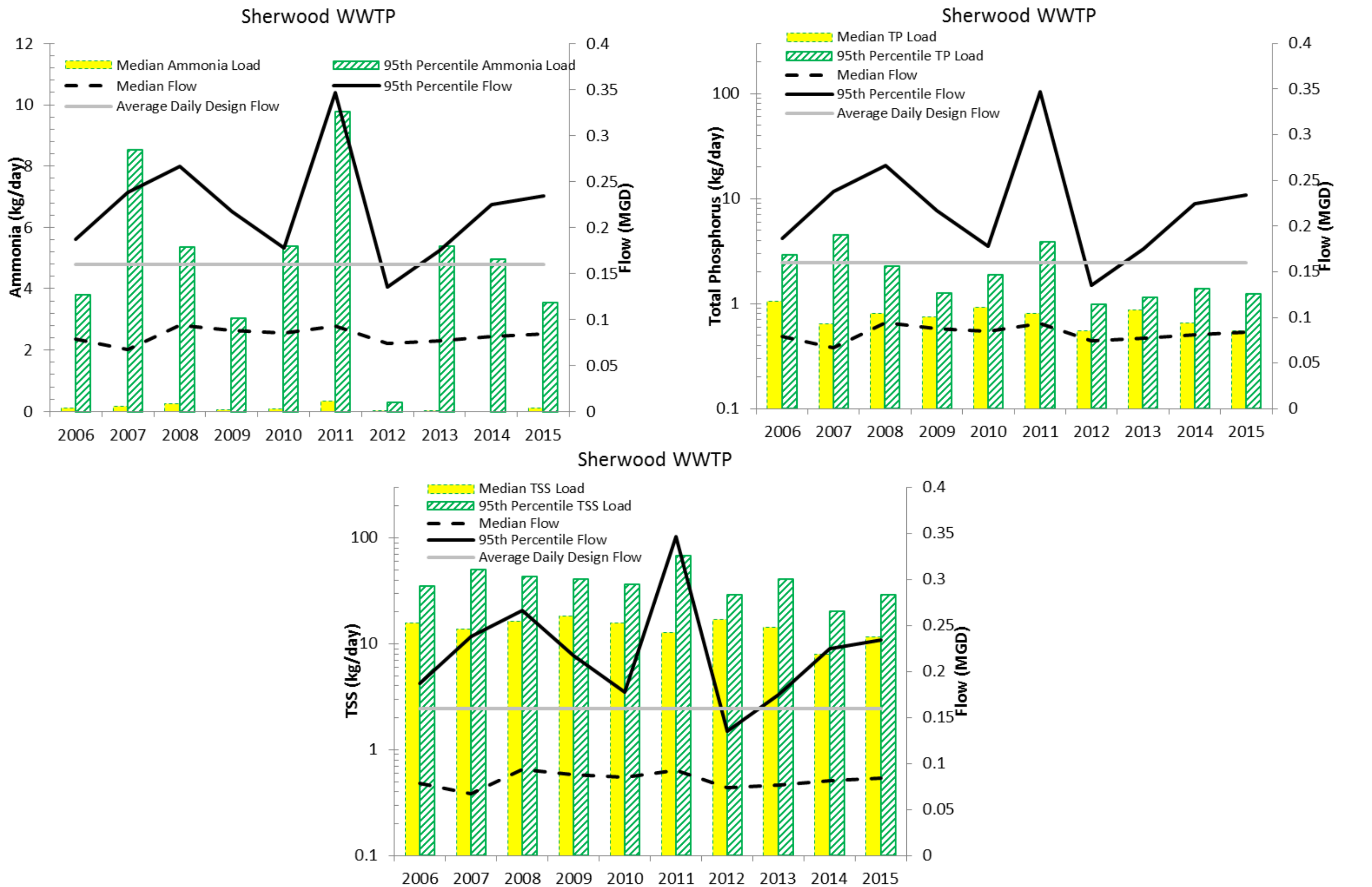


Figure 16 — Annual ammonia (top-left), total phosphorus (top-right), and total suspended solids (bottom) loadings from the Sherwood WWTP, 2006 – 2015.

Tontogany Area WWTP (Ohio EPA Permit # 2PB00024)

The Tontogany Area WWTP provides sanitary wastewater treatment to approximately 370 people. The plant consists of a continuous discharge aerated lagoon with an average daily design flow of 0.1 MGD. The 2015 annual discharge from the lagoon was 17.317 million gallons based on DMR data submitted by the facility. The associated collection system is 100 percent separated and the plant discharges into Tontogany Creek at RM 3.6.

The Tontogany Area WWTP had permit limit violations for ammonia, CBOD5, and TSS between Feb. 1 and May 8, 2015. These permit limit exceedances are documented in Table 13. Ammonia, CBOD5, and TSS violations have been consistently documented in the effluent from the Tontogany Area WWTP for the past 10 years. The facility is currently working on improving operations with the help of outside consultants.

Pollutant loadings from the Tontogany Area WWTP between 2006 and 2015 were evaluated and annual statistics for ammonia, CBOD5, and TSS loadings are displayed in Figure 17. Wet-weather flow discharging from the plant has mostly remained above the design flow and the trend has stayed generally consistent. The median annual ammonia and CBOD5 loadings have decreased over the past 10 years with the 95th percentile flows trending upward. The median and 95th percentile TSS loads have both displayed a decreasing trend. Only two years of nitrate-nitrite and total phosphorus data have been collected by the plant making it difficult to discuss trends for both parameters.

Table 13 — Tontogany Area WWTP permit limit compliance, 2015.

Permit No.	Station	Parameter	Limit Type	Limit	Reported Value	Violation Date
2PB00024*JD	001	Ammonia	30D Conc.	9.8	12.35	2/1/2015
2PB00024*JD	001	CBOD 5-day	30D Conc.	10	10.5	3/1/2015
2PB00024*JD	001	Ammonia	7D Conc.	14.7	19.1	3/1/2015
2PB00024*JD	001	Ammonia	30D Conc.	9.8	19.4	3/1/2015
2PB00024*JD	001	Ammonia	7D Conc.	14.7	19.7	3/15/2015
2PB00024*JD	001	Ammonia	30D Qty.	3.7	7.05505	3/1/2015
2PB00024*JD	001	Ammonia	7D Qty.	5.6	9.91708	3/15/2015
2PB00024*JD	001	TSS	30D Conc.	12	12.25	4/1/2015
2PB00024*JD	001	CBOD 5-day	7D Conc.	15	18	4/15/2015
2PB00024*JD	001	CBOD 5-day	30D Conc.	10	15.675	4/1/2015
2PB00024*JD	001	CBOD 5-day	7D Conc.	15	20	4/22/2015
2PB00024*JD	001	CBOD 5-day	30D Qty.	3.8	4.1565	4/1/2015
2PB00024*JD	001	Ammonia	7D Conc.	14.7	17.3	4/1/2015
2PB00024*JD	001	Ammonia	30D Conc.	9.8	13.75	4/1/2015
2PB00024*JD	001	CBOD 5-day	7D Conc.	15	22	5/1/2015
2PB00024*JD	001	CBOD 5-day	7D Conc.	15	23	5/8/2015
2PB00024*JD	001	CBOD 5-day	30D Conc.	10	14.75	5/1/2015

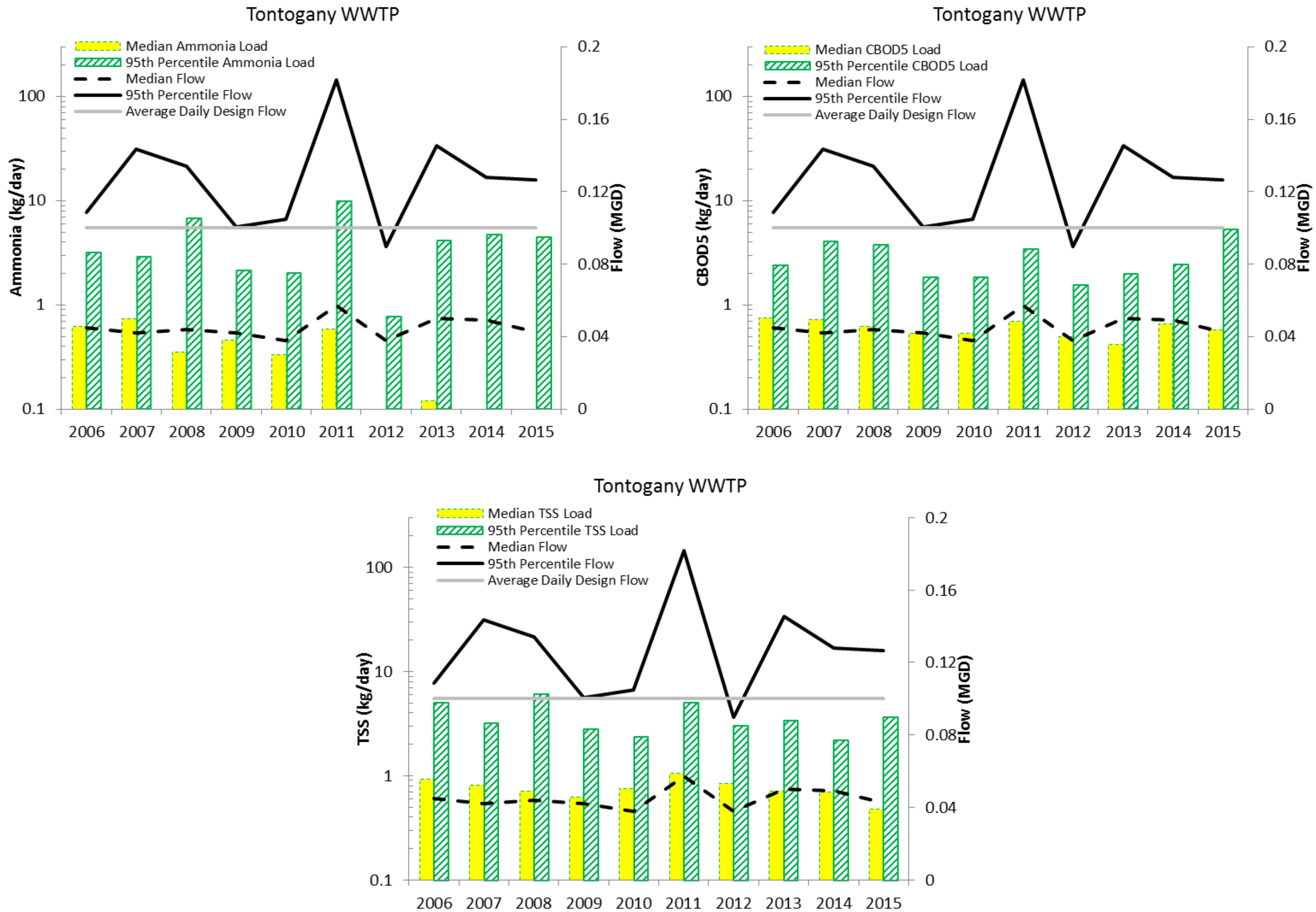


Figure 17 — Annual ammonia (top-left), CBOD5 (top-right), and total suspended solids (bottom) loadings from the Tontogany Area WWTP, 2006 – 2015.

Village of Holgate WWTP (Ohio EPA Permit # 2PB00041)

The village of Holgate WWTP provides sanitary wastewater treatment to approximately 1,150 people. The plant is a controlled discharge aerated lagoon with an average daily design flow of 0.247 MGD. The 2015 annual discharge from the lagoon was 25.17 million gallons based on DMR data submitted by the facility. The village's collection system is 100 percent separated and the plant discharges into Brinkman Ditch at RM 2.55.

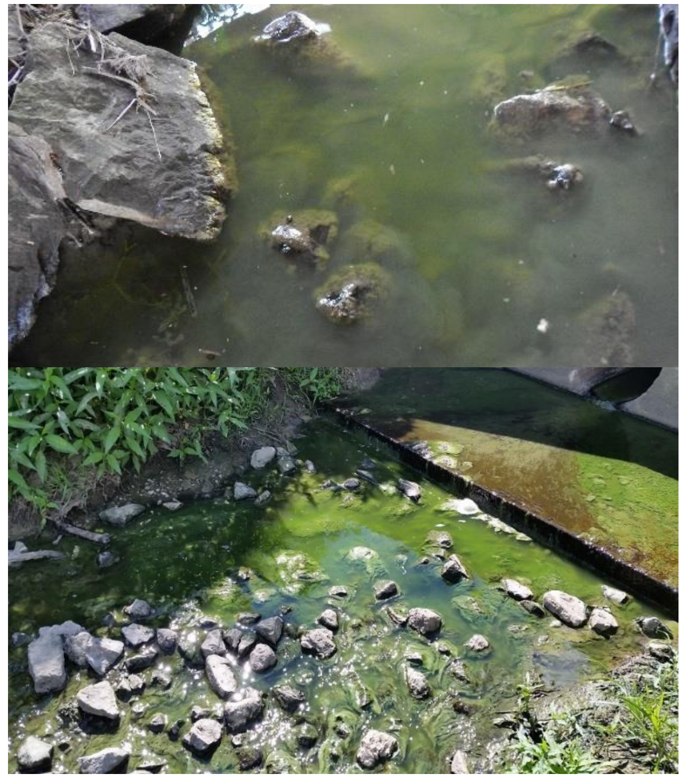


Figure 18 —Algae and sewage fungus on substrates downstream from the facility on 9/15/15 (top) and Holgate's WWTP discharge to stream on 8/12/15 (bottom). Brinkman Ditch was observed to be green at the downstream bridge on Co. Rd. H on the latter date.

Figure 19 — Brinkman Ditch at Co. Rd. H, downstream of the Holgate WWTP discharge on Sept. 16, 2015.

There were no permit limit violations documented in the compliance history for the plant in 2015. The village reported discharge from the lagoons from March 17-21, June 1-5, and June 15-19 in 2015. Ohio EPA staff documented discharges from the outfall to the stream on Aug. 12, 2015 and Oct. 7, 2015 (Figure 18). Brinkman Ditch was observed to be green at Co. Rd. H downstream of the outfall on Aug. 12, 2015, Sept. 16, 2015 (Figure 19), Oct. 7, 2015, and Oct. 14, 2015. Field data was collected upstream and downstream of the Holgate WWTP effluent discharge on Sept. 16, 2015, at Co. Rd. 15 and Co. Rd. H respectively. Specific conductivity increased from 592 µS/cm upstream of the outfall to 791 µS/cm downstream of the outfall. Dissolved oxygen decreased from 5.21 mg/l upstream of the outfall to 3.5 mg/l downstream. Diel sonde sampling from 2015 indicated over-enriched conditions both up and downstream from this facility (Figure 46), with observed DO swings as large as 15.9 mg/l and 14.09 mg/l, respectively. It is likely that inputs from this facility exacerbated already over-enriched conditions in this small stream.

The macroinvertebrate community did not meet WWH expectations up or downstream from this facility in 2015, but met upstream from the facility in 2016. No readily noticeable impacts to instream biology were documented in School Creek RM 0.9 (302994) downstream from the confluence with Brinkman Ditch. However, diel sonde monitoring from School Creek RM 0.9 did show a relatively minor depressed DO regime typically associated with an organic enrichment source; both average (4.3 mg/l) and minimum (3.3 mg/l) exceedances occurred here.

Village of McClure WWTP (Ohio EPA Permit # 2PA00056)

The village of McClure WWTP provides sanitary wastewater treatment to approximately 850 people. The plant is a controlled discharge aerated lagoon and based on DMR data discharged a total of 23.53 million gallons during 2015. The village reported discharge from the lagoons from Jan. 15–March 4, April 17–June 10, July 1–Aug. 31 and Nov. 2-30 in 2015. The village's collection system is 100 percent separated and the plant discharges into Big Creek at RM 3.4. There were no permit limit violations documented in the compliance history for the plant in 2015.

Village of Deshler WWTP (Ohio EPA Permit # 2PC00002)

The village of Deshler WWTP provides sanitary wastewater treatment to approximately 1,800 people. The plant is a controlled discharge aerated lagoon and based on DMR data discharged a total of 11.5 million gallons during 2015. The village reported discharge from the lagoons from April 8-30, 2015. The village's sanitary waste discharges into Brush Creek at RM 9.8.

The village is investigating to determine if cross-connections exist in the sewer system and to reduce inflow and infiltration. In 2015, CSO 002 discharged in March, April, June, July, and December for a total of 10.875 million gallons to Brush Creek. There were no permit limit violations documented in the compliance history for the plant in 2015. In the time since the field survey was completed, cross-connections have been located and eliminated and a large pump station has been built to help reduce/eliminate CSOs and SSOs in the system.

Village of Custar WWTP (Ohio EPA Permit # 2PA00090)

The village of Custar WWTP provides sanitary wastewater treatment to approximately 400 people. The plant is a controlled discharge aerated lagoon and based on DMR data discharged a total of 8.1 million gallons during 2015. The village reported discharge from the lagoons from January 2-5, 2015 and June 22-25, 2015. The village's sanitary waste is 100 percent separated and discharges into Jackson Cutoff at RM 5.9. There were no permit limit violations documented in the compliance history for the plant in 2015.

Surface Water Chemistry

Water Chemistry Overview

Surface water chemistry samples were collected from streams in the study area from March 2015 through October 2015 at 98 locations (Appendix G). Stations were established in free-flowing sections of the streams and were collected via bucket from bridge crossings or directly from the stream. Surface water samples were dispensed into appropriate containers, preserved and delivered to Ohio EPA's Environmental Services laboratory. Collection and preservation were completed using appropriate methods, as outlined in Ohio EPA's *Surface Water Field Sampling Manual* (Ohio EPA 2015f).

USGS gage data from the Maumee River near the city of Waterville was used to show flow trends in the watershed during the survey (Figure 20). Dates when chemistry, bacteria and sediment samples were collected in the study area are noted on the graph. While the Waterville gauge is downstream and represents a significantly larger drainage area, the graph still reflects the type of weather experienced over the 2015 sampling period, especially in comparison to the historic mean. Overall, flow conditions during the summer field season were much higher than the historic mean through the end of July. Water samples captured a variety of flow conditions in the study area during the field season. Bacteria was collected during the recreation use season (defined as May 1 through October 31).

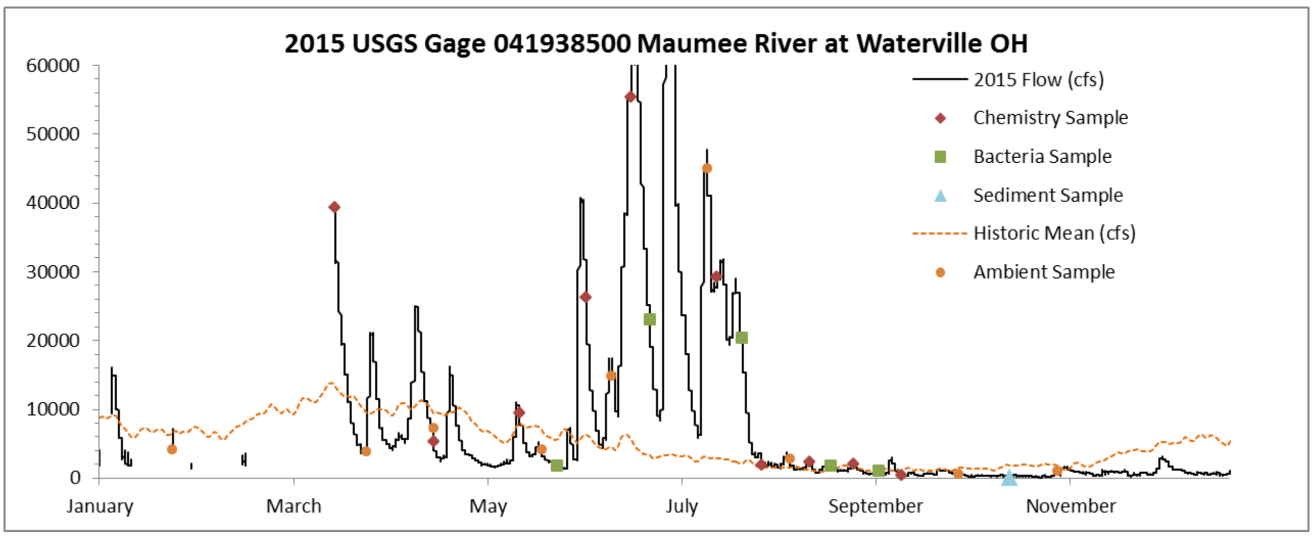


Figure 20 — Maumee River near Waterville, historic and 2014 flow data with sampling events.

Surface water samples were analyzed for metals, nutrients, semi-volatile organic compounds (s-VOCs), herbicides, bacteria, and total suspended (TSS) and dissolved solids (TDS). Temperature, pH, conductivity, dissolved oxygen (DO) concentration and percent saturation were measured in the field (Appendix G). Surface water chemistry sampling locations are displayed in Figure 21 and *Figure 22*. Geometric mean nutrient values are reported in Table 14. Parameters which were in exceedance of the Ohio WQS criteria are reported in Table 14. Bacteriological samples were collected from 60 locations in the study area (Figure 47 and Figure 48). The bacteriological results are reported with additional discussion in the ***Recreation Use*** section of this document.

A total of 24 single-sample DO concentrations were found below the minimum water quality criteria at 20 sampling locations during the 2015 sampling season (Table 15). Diel water quality sonde data also indicated numerous sampling locations with both minimum and 24-hour DO concentration exceedances and are detailed in the ***Diel Sonde Summary*** portion of this document (Table 19).

Dissolved oxygen fluctuates in a stream due to biological activity, water flow/turbulence, pollution, and temperature. During summer months, flow is decreased, pollutant sources are more concentrated, water temperatures are higher, and biological activities are increased. These conditions result in generally lower dissolved oxygen in the stream and larger daily variability.

Single-sample temperature levels were found above the daily maximum criteria 11 times at nine sites. A general lack of riparian cover throughout the study area resulting from a combination of historical, systematic channelization activities, current drainage maintenance projects, and flow regime alterations from tile drainage impact stream temperatures during summer months. Single-sample exceedances for iron, selenium, and TDS occurred at 17 sites across the watershed. These items are discussed in additional detail below and are detailed in Table 15.

Table 14 — Seasonal geometric mean values (mg/l) for nutrients calculated from grab samples collected in the study area. Shaded results are above statewide recommended benchmarks (Ohio EPA 1999). Benchmark concentrations relative to stream size class and ALU are displayed in Table 16.

River Mile	Station ID	Stream and Location	Nitrate-Nitrite	Total P
HUC 12 (Zuber Cutoff 04100005 02 01)				
2.95	P06W17	North Creek upst. Antwerp WWTP @ Barker Rd	0.81	0.22
1.6	P06W16	North Creek dst. Antwerp WWTP @ Murphy Rd.	0.91	0.53
3.7	302971	South Creek @ Co. Rd. 144	1.37	0.55
0.35	302970	South Creek @ Victory Rd.	2.00	0.54
HUC 12 (Marie DeLarme Creek 04100005 02 03)				
0.5	P06K24	Marie DeLarme Creek near mouth @ Twp. Rd. 192	0.56	0.04
1.6	P06K25	N. Br. Marie DeLarme Creek N of Antwerp @ Co. Rd. 45	0.99	0.06
1.3	P06K26	S. Br. Marie DeLarme Creek N of Antwerp @ Co. Rd. 45	0.87	0.11
HUC 12 (Sixmile Creek Cutoff 04100007 12 08)				
1.25	302845	Six Mile Cutoff Ditch @ Twp. Rd. 206	1.72	0.11
HUC 12 (Gordon Creek 04100005 02 04)				
6.67	P06S15	Gordon Creek SW of Mark Center @ Wonderly Rd. *	0.98	0.15
1.12	P06S04	Gordon Creek SW of Sherwood @ Countyline Rd. (lower crossing) *	0.63	0.04
9.62	302972	N. Fk. Gordon Creek @ Rosedale Rd. *	0.96	0.08
0.76	P06S16	M. Fk. Gordon Creek SE of Hicksville @ Rosedale Rd. *	1.69	0.25
0.1	P06W07	Mill Creek near mouth, adj. Fountain St. *	2.92	0.22
0.23	302973	S. Fork Gordon Creek @ Breininger Rd. *	0.85	0.06
HUC 12 (Platter Creek 04100005 02 06)				
7.95	303014	Platter Creek @ Wonderly Rd.	0.62	0.31
6.41	302975	Platter Creek @ Farmer Mark Rd.	0.93	0.27
5.4	302974	Platter Creek @ Fountain Rd.	1.06	0.22
1.7	303010	Platter Creek @ Jericho Rd. (west crossing)	0.61	0.07
0.78	303015	Tributary to Platter Creek (7.66) @ Wonderly Rd.	0.66	0.2
HUC 12 (Sulphur Creek – Maumee River 04100005 02 07)				
1.2	302976	Sulphur Creek upst. Sherwood WWTP @ Coy Rd.	0.24	0.09
0.13	P06W19	Sulphur Creek dst. Sherwood @ Roland Rd.	0.29	0.19
HUC 12 (Snooks Run – Maumee River 04100005 02 08)				
0.50	P06K17	Snooks Run @ Slough Rd.	0.69	0.22
HUC 12 (Preston Run – Maumee River 04100009 02 01)				
2.45	302977	Preston Run @ Standley Rd.	0.71	0.06
HUC 12 (Wade Creek – Maumee River 04100009 02 03)				
1.80	P09K22	Wade Creek SE of Florida @ Co. Rd. K	0.76	0.05
HUC 12 (Benien Creek 04100009 02 02)				
4.00	302978	Benien Creek @ Co. Rd. 17-C	0.88	0.06
2.30	P09K18	Benien Creek SW of Napoleon @ Twp. Rd. N	0.6	0.04
2.40	302979	Brubaker Creek @ Co. Rd. 17-D	0.72	0.04
0.50	P09K19	Brubaker Creek NE of Florida @ Twp. Rd. M-2	0.56	0.04
HUC 12 (Village of Napoleon – Maumee River 04100009 02 06)				
1.34	302980	Tributary to Maumee River (48.7) @ Twp. Rd. 16	0.43	0.05
HUC 12 (Garrett Creek 04100009 02 04)				
4.00	302981	Garrett Creek @ Twp. Rd. R	1.28	0.21
2.49	302982	Garrett Creek @ Twp. Rd. 16	0.72	0.13
0.70	P09K17	Garrett Creek near Napoleon @ Co. Rd. P	0.8	0.08
HUC 12 (Oberhaus Creek 04100009 02 05)				
2.5	P09K15	Oberhaus Creek near Napoleon @ Co. Rd. 15	1.28	0.13
0.40	302985	Oberhaus Creek in Napoleon @ Oakwood Ave.	0.76	0.15

River Mile	Station ID	Stream and Location	Nitrate-Nitrite	Total P
4.31	302984	Van Hyning Creek @ Twp. Rd. 15	1.15	0.12
0.75	302983	Van Hyning Creek in Napoleon @ Oakwood Ave.	0.64	0.06
HUC 12 (Creager Cemetery – Maumee River 04100009 02 07)				
0.40	302986	Tributary to Maumee River (42.2) @ St. Rte. 110	5.97	0.01
HUC 12 (Upper South Turkeyfoot Creek 04100009 01 02)				
23.65	302995	S. Turkeyfoot Creek @ Twp. Rd. D	1.17	0.22
20.94	P09S27	S. Turkeyfoot Creek @ Hamler @ Co. Rd. F	1.09	0.24
19.75	P09S26	S. Turkeyfoot Creek NW of Hamler @ Co. Rd. G	0.64	0.36
HUC 12 (Middle South Turkeyfoot Creek 04100009 01 04)				
13.18	P09W13	S. Turkeyfoot Creek @ Malinta @ Co. Rd. L	1.26	0.13
10.80	P09W12	S. Turkeyfoot Creek NW of Malinta @ Co. Rd. 11 (upper crossing)	0.96	0.14
HUC 12 (Lower South Turkeyfoot Creek 04100009 01 06)				
7.90	302836	S. Turkeyfoot Creek near Shunk @ Co. Rd. N	2.08	0.11
1.97	P09W11	S. Turkeyfoot Creek @ Twp. Rd. P-3	1.25	0.07
HUC 12 (West Creek 04100009 01 01)				
1.00	P10K07	West Creek N of Hamler @ St. Rte. 109	2.29	0.09
HUC 12 (Middle South Turkeyfoot Creek 04100009 01 04)				
6.39	302996	Lost Creek @ Co. Rd. 12	0.71	0.09
1.30	P09S09	Lost Creek SW of Malinta @ Co. Rd. 10	0.69	0.09
HUC 12 (School Creek 04100009 01 03)				
9.82	302992	School Creek upst. Holgate @ Co. Rd. F	0.65	0.07
7.00	302993	School Creek dst. Holgate @ Co. Rd. H	0.48	0.07
0.90	302994	School Creek @ Co. Rd. 12	0.68	0.11
2.80	P09K11	Brinkman Ditch upst. Holgate WWTP @ Co. Rd. 15	0.86	0.07
2.35	P09W17	Brinkman Ditch dst. Holgate WWTP @ Co. Rd. H	0.78	0.27
HUC 12 (Little Flatrock Creek 04100009 01 05)				
0.48	302843	L. Turkeyfoot Creek @ Twp. Rd. 04	0.73	0.04
2.65	302997	Tributary to Little Turkeyfoot Creek (2.45) @ Co. Rd. 7	1.23	0.08
HUC 12 (North Turkeyfoot Creek 04100009 04 02)				
19.06	P09S19	N. Turkeyfoot Creek upst. Wauseon WRF @ Reighard Park	2.74	0.08
17.85	P09S04	N. Turkeyfoot Creek dst. Wauseon WRF @ Co. Rd. 13	13.00	0.11
13.79	P09S03	N. Turkeyfoot Creek SE of Wauseon @ Co. Rd. C	10.58	0.05
9.67	P09K12	N. Turkeyfoot Creek NW of Liberty Center @ Co. Rd. V	9.71	0.03
5.50	302988	N. Turkeyfoot Creek @ Co. Rd. S	6.87	0.03
3.40	P09S01	N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	5.1	0.04
1.02	302989	Tributary to N. Turkeyfoot Creek (6.68) @ Co. Rd. 10	1.41	0.07
HUC 12 (Konzen Ditch 04100009 04 01)				
4.20	302987	Konzen Ditch @ Co. Rd. 12 *	1.04	0.08
0.65	P09K14	Konzen Ditch near mouth @ Co. Rd. S *	0.71	0.05
HUC 12 (Dry Creek – Maumee River 04100009 04 03)				
8.80	302848	Dry Creek @ Co. Rd. B	5.18	0.08
1.60	302990	Dry Creek dst. Liberty Center @ Co. Rd. S	1.75	0.07
HUC 12 (Lower Bad Creek 04100009 03 02)				
22.45	P11K48	Bad Creek upst. South Branch @ Co. Rd. K	9.27	0.03
17.51	P11W22	Bad Creek upst. Delta @ Co. Rd. H	6.71	0.05
10.46	P11S05	Bad Creek SE of Delta @ Co. Rd. D	8.18	0.09
8.07	P11K38	Bad Creek SE of Delta @ Co. Rd. 5	7.77	0.08
2.47	P11S04	Bad Creek S of Colton @ Co. Rd. T	6.08	0.08

River Mile	Station ID	Stream and Location	Nitrate-Nitrite	Total P
0.15	302991	Tributary to Bad Creek (20.85) @ Nash Rd.	5.13	0.04
HUC 12 (Upper Bad Creek 04100009 03 01)				
0.44	302849	S. Br. Bad Creek @ Co. Rd. 10	8.27	0.05
HUC 12 (Big Creek 04100009 05 01)				
3.51	P09S28	Big Creek @ McLure @ Woodlawn Ave.	0.97	0.06
1.30	P09K06	Big Creek N of McLure @ Twp. Rd. Q	0.84	0.14
HUC 12 (Upper Beaver Creek 04100009 05 03)				
20.15	302999	Beaver Creek @ Twp. Rd. 5	0.88	0.09
16.16	302998	Beaver Creek W of Custar @ Co. Rd. 2	0.99	0.11
HUC 12 (Middle Beaver Creek 04100009 05 08)				
8.30	P10K03	Beaver Creek upst. Jackson Cutoff Ditch @ Wapakoneta Rd.	0.58	0.10
HUC 12 (Lower Beaver Creek 04100009 05 09)				
6.80	P10P09	Beaver Creek W of Weston, dst. Cutoff Ditch @ Euler Rd.	0.96	0.09
2.73	P10K02	Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	1.53	0.08
HUC 12 (Hammer Creek 04100009 05 02)				
5.20	303001	Hammer Creek (a.k.a. E. Beaver Creek) @ Co. Rd. E	0.85	0.11
1.34	303000	Hammer Creek (a.k.a. E. Beaver Creek) @ Co. Rd. H	0.65	0.14
HUC 12 (Cutoff Ditch 04100009 05 07)				
6.60	303003	Jackson Cutoff Ditch dst. Yellow Creek @ Bays Rd.	0.86	0.13
1.15	510040	Jackson Cutoff Ditch near Weston @ Sand Ridge Rd.	1.16	0.12
HUC 12 (Upper Yellow Creek 04100009 05 04)				
8.02	500760	Yellow Creek S of Deshler @ Co. Rd. B *	1.46	0.10
HUC 12 (Yellow Creek 04100009 05 06)				
3.18	500780	Yellow Creek E of Deshler @ Roundhead Rd. *	1.87	0.15
HUC 12 (Upper Yellow Creek 04100009 05 04)				
0.9	500700	L. Yellow Creek NE of Leipsic @ Co. Rd. 2 **	1.66	0.21
HUC 12 (Yellow Creek 04100009 05 06)				
0.1	302840	West Creek (trib. to Yellow Creek) @ Hancock-Wood Co. Line Rd.	1.13	0.1
HUC 12 (Brush Creek 04100009 05 05)				
8.99	303002	Brush Creek N of Belmore @ Twp. Rd. A	1.69	0.24
3.47	P10P07	Brush Creek E of Deshler @ Henry/Wood Co. Line	1.24	0.23
0.58	P10P06	Brush Creek E of Deshler @ Custar Rd.	0.77	0.18
HUC 12 (Lower Beaver Creek 04100009 05 09)				
1.5	303004	Tributary to Beaver Creek upst. Hertzfeld Farm @ Poe Rd.	2.33	0.08
HUC 12 (Sugar Creek – Maumee River 04100009 06 02)				
1.06	303007	Sugar Creek @ Sugar Creek Rd.	1.46	0.04
HUC 12 (Tontogany Creek 04100009 06 01)				
4.15	303006	Tontogany Creek upst. Tontogany @ Tontogany Rd.	0.75	0.03
1.6	P10K01	Tontogany Creek N of Tontogany @ Robinson Rd.	2.55	0.10
0.72	303005	Tributary to W. Br. Tontogany Creek @ Long-Judson Rd.	1.37	0.05
3.42	P10P13	W. Br. Tontogany Creek SW of Tontagony @ Tuller Rd.	1.01	0.27
HUC 12 (Haskins Road Ditch – Maumee River 04100009 06 03)				
0.3	303009	Haskins Rd. Ditch upst. Haskins @ St. Rte. 582	0.63	0.04
0.05	303008	Liberty Hi Rd. Ditch dst. Haskins @ St. Rte. 65	1.89	0.12
All sites screened against the WWH benchmark unless otherwise noted; other ALUs include: * Modified Warmwater Habitat ** Limited Resource Waters				

Table 15 — Exceedances of Ohio Water Quality Standards criteria (OAC 3745-1) for chemical/physical parameters measured from sampling locations in streams in the study area, 2015.

River Mile	STORET	Location	Parameter
HUC 12 (Zuber Cutoff 04100005 02 01)			
2.95	P06W17	North Creek upst. Antwerp WWTP @ Barker Rd.	N/A
1.6	P06W16	North Creek dst. Antwerp WWTP @ Murphy Rd.	DO: 3.42; 2.92; Iron: 6010
3.7	302971	South Creek @ Co. Rd. 144	DO: 3.69
0.35	302970	South Creek @ Victory Rd.	DO: 3.55
HUC 12 (Marie DeLarme Creek 04100005 02 03)			
0.5	P06K24	Marie DeLarme Creek near mouth @ Twp. Rd. 192	N/A
1.6	P06K25	N. Br. Marie DeLarme Creek N of Antwerp @ Co. Rd. 45	N/A
1.3	P06K26	S. Br. Marie DeLarme Creek N of Antwerp @ Co. Rd. 45	DO: 3.62; 2.94
HUC 12 (Sixmile Creek Cutoff 04100007 12 08)			
1.25	302845	Six Mile Cutoff Ditch @ Twp. Rd. 206	N/A
HUC 12 (Gordon Creek 04100005 02 04)			
6.67	P06S15	Gordon Creek SW of Mark Center @ Wonderly Rd.	N/A
1.12	P06S04	Gordon Creek SW of Sherwood @ Countyline Rd. (lower crossing)	Iron: 10,500
9.62	302972	N. Fk. Gordon Creek @ Rosedale Rd.	N/A
0.76	P06S16	M. Fk. Gordon Creek SE of Hicksville @ Rosedale Rd.	N/A
0.1	P06W07	Mill Creek near mouth, adj. Fountain St.	Iron: 8,300
0.23	302973	S. Fork Gordon Creek @ Breininger Rd.	N/A
HUC 12 (Platter Creek 04100005 02 06)			
7.95	303014	Platter Creek @ Wonderly Rd.	N/A
6.41	302975	Platter Creek @ Farmer Mark Rd.	DO: 3.86
5.4	302974	Platter Creek @ Fountain Rd.	N/A
1.7	303010	Platter Creek @ Jericho Rd. (west crossing)	Iron: 14,500
0.78	303015	Tributary to Platter Creek (7.66) @ Wonderly Rd.	DO: 2.10; 3.50
HUC 12 (Sulphur Creek – Maumee River 04100005 02 07)			
1.2	302976	Sulphur Creek upst. Sherwood WWTP @ Coy Rd.	Temperature: 24.5
0.13	P06W19	Sulphur Creek dst. Sherwood @ Roland Rd.	Temperature: 25.7; Iron: 6,200; 8,690
HUC 12 (Snooks Run – Maumee River 04100005 02 08)			
0.50	P06K17	Snooks Run @ Slough Rd.	Temperature: 25.0
HUC 12 (Preston Run – Maumee River 04100009 02 01)			
2.45	302977	Preston Run @ Standley Rd.	N/A
HUC 12 (Wade Creek – Maumee River 04100009 02 03)			
1.80	P09K22	Wade Creek SE of Florida @ Co. Rd. K	N/A
HUC 12 (Benien Creek 04100009 02 02)			
4.00	302978	Benien Creek @ Co. Rd. 17-C	N/A
2.30	P09K18	Benien Creek SW of Napoleon @ Twp. Rd. N	DO: 3.68
2.40	302979	Brubaker Creek @ Co. Rd. 17-D	N/A
0.50	P09K19	Brubaker Creek NE of Florida @ Twp. Rd. M-2	N/A
HUC 12 (Village of Napoleon – Maumee River 04100009 02 06)			
1.34	302980	Tributary to Maumee River (48.7) @ Twp. Rd. 16	N/A
HUC 12 (Garrett Creek 04100009 02 04)			
4.00	302981	Garrett Creek @ Twp. Rd. R	Iron: 7,030; DO: 3.91; 2.56
2.49	302982	Garrett Creek @ Twp. Rd. 16	DO: 3.75
0.70	P09K17	Garrett Creek near Napoleon @ Co. Rd. P	Iron: 8,080
HUC 12 (Oberhaus Creek 04100009 02 05)			
2.5	P09K15	Oberhaus Creek near Napoleon @ Co. Rd. 15	DO: 1.90
0.40	302985	Oberhaus Creek in Napoleon @ Oakwood Ave.	Iron: 9,780; 5,280; DO: 2.77

River Mile	STORET	Location	Parameter
4.31	302984	Van Hyning Creek @ Twp. Rd. 15	N/A
0.75	302983	Van Hyning Creek in Napoleon @ Oakwood Ave.	Iron: 11,100
HUC 12 (Creager Cemetery – Maumee River 04100009 02 07)			
0.40	302986	Tributary to Maumee River (42.2) @ St. Rte. 110	N/A
HUC 12 (Upper South Turkeyfoot Creek 04100009 01 02)			
23.65	302995	S. Turkeyfoot Creek @ Twp. Rd. D	N/A
20.94	P09S27	S. Turkeyfoot Creek @ Hamler @ Co. Rd. F	N/A
19.75	P09S26	S. Turkeyfoot Creek NW of Hamler @ Co. Rd. G	N/A
HUC 12 (Middle South Turkeyfoot Creek 04100009 01 04)			
13.18	P09W13	S. Turkeyfoot Creek @ Malinta @ Co. Rd. L	N/A
10.80	P09W12	S. Turkeyfoot Creek NW of Malinta @ Co. Rd. 11 (Upper Crossing)	N/A
HUC 12 (Lower South Turkeyfoot Creek 04100009 01 06)			
7.90	302836	S. Turkeyfoot Creek near Shunk @ Co. Rd. N	Temperature: 22.3; DO: 3.03
1.97	P09W11	S. Turkeyfoot Creek @ Twp. Rd. P-3	N/A
HUC 12 (West Creek 04100009 01 01)			
1.00	P10K07	West Creek N of Hamler @ St. Rte. 109	Temperature: 24.5
HUC 12 (Middle South Turkeyfoot Creek 04100009 01 04)			
6.39	302996	Lost Creek @ Co. Rd. 12	N/A
1.30	P09S09	Lost Creek SW of Malinta @ Co. Rd. 10	N/A
HUC 12 (School Creek 04100009 01 03)			
9.82	302992	School Creek upst. Holgate @ Co. Rd. F	N/A
7.00	302993	School Creek dst. Holgate @ Co. Rd. H	N/A
0.90	302994	School Creek @ Co. Rd. 12	N/A
2.80	P09K11	Brinkman Ditch upst. Holgate WWTP @ Co. Rd. 15	N/A
2.35	P09W17	Brinkman Ditch dst. Holgate WWTP @ Co. Rd. H	DO: 3.50
HUC 12 (Little Flatrock Creek 04100009 01 05)			
0.48	302843	L. Turkeyfoot Creek @ Twp. Rd. 04	N/A
2.65	302997	Tributary to Little Turkeyfoot Creek (2.45) @ Co. Rd. 7	N/A
HUC 12 (North Turkeyfoot Creek 04100009 04 02)			
19.06	P09S19	N. Turkeyfoot Creek upst. Wauseon WRF @ Reighard Park	N/A
17.85	P09S04	N. Turkeyfoot Creek dst. Wauseon WRF @ Co. Rd. 13	N/A
13.79	P09S03	N. Turkeyfoot Creek SE of Wauseon @ Co. Rd. C	N/A
9.67	P09K12	N. Turkeyfoot Creek NW of Liberty Center @ Co. Rd. V	Temperature: 30.1
5.50	302988	N. Turkeyfoot Creek @ Co. Rd. S	N/A
3.40	P09S01	N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	Iron: 8,600
1.02	302989	Tributary to N. Turkeyfoot Creek (6.68) @ Co. Rd. 10	Temperature: 31.2
HUC 12 (Konzen Ditch 04100009 04 01)			
4.20	302987	Konzen Ditch @ Co. Rd. 12	N/A
0.65	P09K14	Konzen Ditch near mouth @ Co. Rd. S	Iron: 9,880
HUC 12 (Dry Creek – Maumee River 04100009 04 03)			
8.80	302848	Dry Creek @ Co. Rd. B*	N/A
1.60	302990	Dry Creek dst. Liberty Center @ Co. Rd. S	DO: 2.56; Iron: 14,300
HUC 12 (Lower Bad Creek 04100009 03 02)			
22.45	P11K48	Bad Creek upst. South Branch @ Co. Rd. K	N/A
17.51	P11W22	Bad Creek upst. Delta @ Co. Rd. H	N/A
10.46	P11S05	Bad Creek SE of Delta @ Co. Rd. D	Iron: 5,760
8.07	P11K38	Bad Creek SE of Delta @ Co. Rd. 5	N/A
2.47	P11S04	Bad Creek S of Colton @ Co. Rd. T	Iron: 7,360; DO: 3.81
0.15	302991	Tributary to Bad Creek (20.85) @ Nash Rd.	N/A
HUC 12 (Upper Bad Creek 04100009 03 01)			

River Mile	STORET	Location	Parameter
0.44	302849	S. Br. Bad Creek @ Co. Rd. 10	N/A
HUC 12 (Big Creek 04100009 05 01)			
3.51	P09S28	Big Creek @ McLure @ Woodlawn Ave.	N/A
1.30	P09K06	Big Creek N of McLure @ Twp. Rd. Q	DO: 2.77
HUC 12 (Upper Beaver Creek 04100009 05 03)			
20.15	302999	Beaver Creek @ Twp. Rd. 5	N/A
16.16	302998	Beaver Creek W of Custar @ Co. Rd. 2	N/A
HUC 12 (Middle Beaver Creek 04100009 05 08)			
8.30	P10K03	Beaver Creek upst. Jackson Cutoff Ditch @ Wapakoneta Rd.	TDS: 1,810; 2,210;
HUC 12 (Lower Beaver Creek 04100009 05 09)			
6.80	P10P09	Beaver Creek W of Weston, dst. Cutoff Ditch @ Euler Rd.	N/A
2.73	P10K02	Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	DO: 3.99
HUC 12 (Hammer Creek 04100009 05 02)			
5.20	303001	Hammer Creek (a.k.a. E. Beaver Ck.) @ Co. Rd. E	DO: 3.82
1.34	303000	Hammer Creek (a.k.a. E. Beaver Ck.) @ Co. Rd. H	DO: 1.52
HUC 12 (Cutoff Ditch 04100009 05 07)			
6.60	303003	Jackson Cutoff Ditch dst. Yellow Creek @ Bays Rd.	N/A
1.15	510040	Jackson Cutoff Ditch near Weston @ Sand Ridge Rd.	N/A
HUC 12 (Upper Yellow Creek 04100009 05 04)			
8.02	500760	Yellow Creek S of Deshler @ Co. Rd. B	N/A
HUC 12 (Yellow Creek 04100009 05 06)			
3.18	500780	Yellow Creek E of Deshler @ Roundhead Rd.	N/A
HUC 12 (Upper Yellow Creek 04100009 05 04)			
0.9	500700	L. Yellow Creek NE of Leipsic @ Co. Rd. 2	TDS: 1,770; Selenium: 5.6; 5.3
HUC 12 (Yellow Creek 04100009 05 06)			
0.1	302840	West Creek (trib. to Yellow Ck.) @ Hancock-Wood Co. Line Rd.	DO: 2.53
HUC 12 (Brush Creek 04100009 05 05)			
8.99	303002	Brush Creek N of Belmore @ Twp. Rd. A	N/A
3.47	P10P07	Brush Creek E of Deshler @ Henry/Wood Co. Line	N/A
0.58	P10P06	Brush Creek E of Deshler @ Custar Rd.	N/A
HUC 12 (Lower Beaver Creek 04100009 05 09)			
1.5	303004	Tributary to Beaver Creek upst. Hertzfeld Farm @ Poe Rd.	N/A
HUC 12 (Sugar Creek – Maumee River 04100009 06 02)			
1.06	303007	Sugar Creek @ Sugar Creek Rd.	TDS: 1,510
HUC 12 (Tontogany Creek 04100009 06 01)			
4.15	303006	Tontogany Creek upst. Tontogany @ Tontogany Rd.	N/A
1.6	P10K01	Tontogany Creek N of Tontogany @ Robinson Rd.	N/A
0.72	303005	Tributary to W. Br. Tontogany Creek @ Long-Judson Rd.	N/A
3.42	P10P13	W. Br. Tontogany Creek SW of Tontogany @ Tuller Rd.	Temperature: 32.2; 30.5; 26.9
HUC 12 (Haskins Road Ditch – Maumee River 04100009 06 03)			
0.3	303009	Haskins Road Ditch upst. Haskins @ St. Rte. 582	Temperature: 30.0
0.05	303008	Liberty Hi Rd. Ditch dst. Haskins @ St. Rte. 65	N/A

Dissolved Oxygen exceeds the Outside Mixing Zone Minimum Dissolved Oxygen criteria (WWH 4.0; MWH (HELP ecoregion) 2.5 mg/l) (OAC 3745-1-07 (Table 7-1)).
Temperature exceeds daily maximum temperature criteria (OAC 3745-1-07 (Table 7-14 G).
Total dissolved solids exceed the Outside Mixing Zone Average criteria of 1,500 mg/l (OAC 3745-1-07 (Table 7-1).
Selenium exceeds the Outside Mixing Zone Average Total criteria of 5.0 µg/l (total recoverable, OAC 3745-1-07 (Table 7/1)).
Reporting Values - Dissolved Oxygen: mg/l; TDS: mg/l; Iron, Selenium: µg/l; Temperature: degrees centigrade.

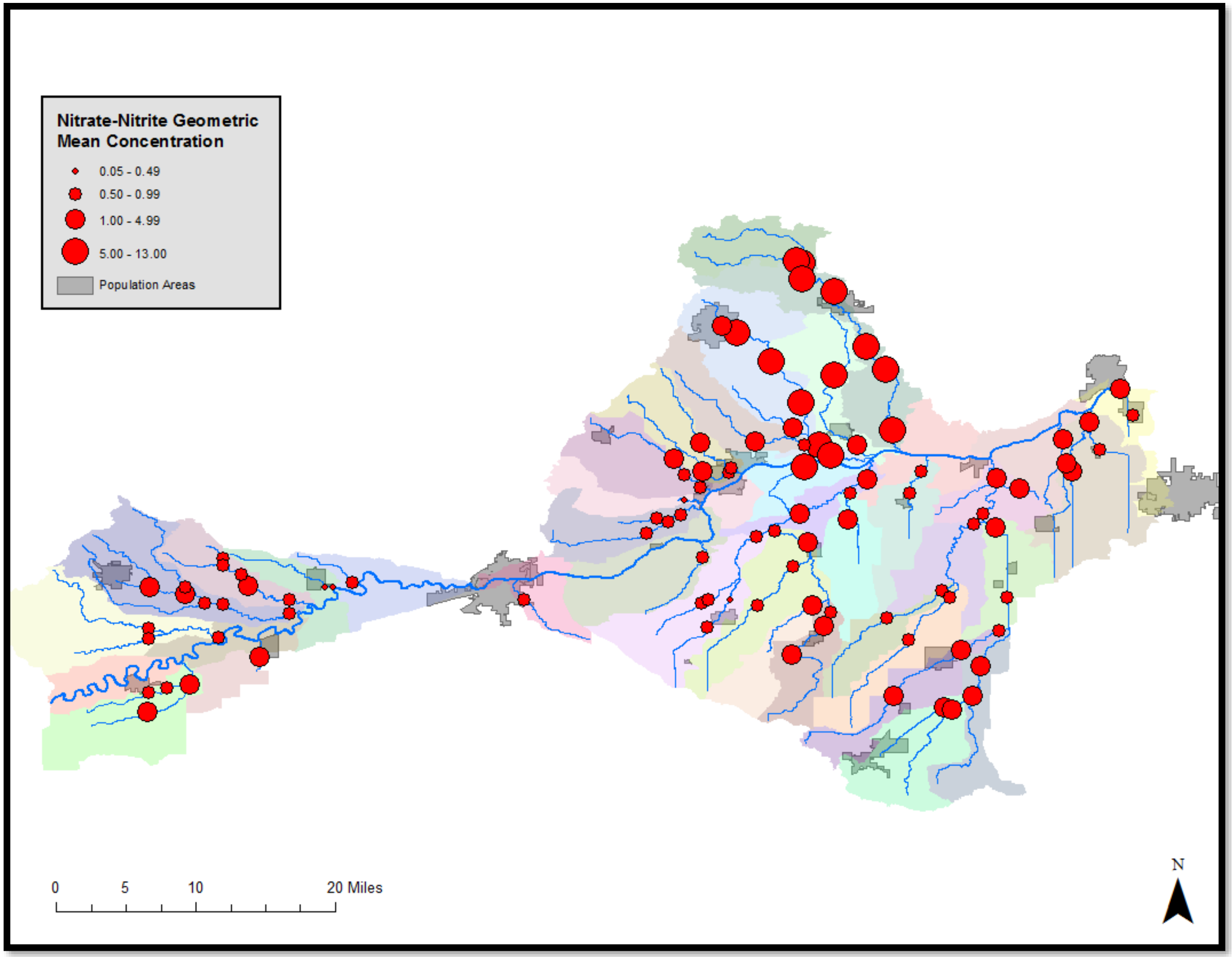


Figure 21 — Nitrate-nitrite geometric mean concentrations from sampling locations within the Minor Great Black Swamp Tributaries study area, 2015.

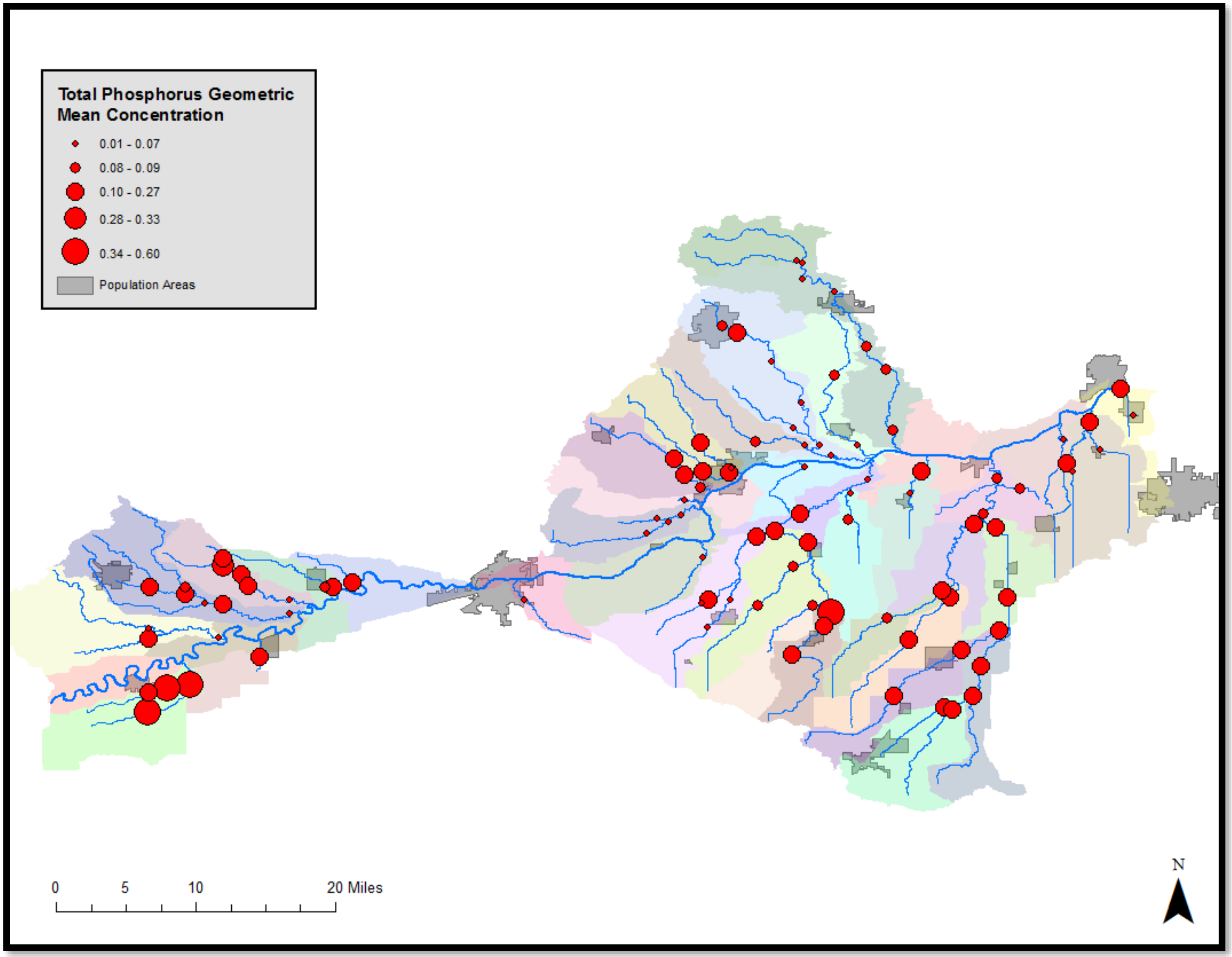


Figure 22 — Total phosphorus geometric mean concentrations from sampling locations within the Minor Great Black Swamp Tributaries study area, 2015.

Nutrient data is evaluated against the benchmark geometric mean during the nutrient index period (June 1 – Oct. 15). A total of 43 sampling locations (44 percent) were above the benchmark for total phosphorus and 47 sites (48 percent) were above the benchmark for nitrate-nitrite. Benchmarks for total phosphorus and nitrate-nitrite are detailed in

Stream Size	Total phosphorus (mg/l)			Nitrate-nitrite (mg/l)		
	WWH	MWH	LRW	WWH	MWH	LRW
Headwater	0.08	0.34	N/A	1.0	1.0	N/A
Wadeable	0.10	0.28	N/A	1.0	1.6	N/A
Small River	0.17	0.25	N/A	1.5	2.2	N/A

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Table 16 — Total phosphorus and nitrate-nitrite benchmarks.

	Total phosphorus (mg/l)			Nitrate-nitrite (mg/l)		
Stream Size	WWH	MWH	LRW	WWH	MWH	LRW
Headwater	0.08	0.34	N/A	1.0	1.0	N/A
Wadeable	0.10	0.28	N/A	1.0	1.6	N/A
Small River	0.17	0.25	N/A	1.5	2.2	N/A

Ammonia concentrations were elevated at multiple locations throughout the study area, though individual grab samples did not exceed the water quality standard during 2015. Figure 23 displays total ammonia geometric mean concentrations (mg/l) relative to concentrations from headwater and wading reference locations (Ohio EPA 1999). Unsewered areas and Ohio Department of Agriculture (ODA)-permitted confined animal feeding facilities (through manure application and subsequent runoff) are possible sources of ammonia to streams in the study area. Other smaller livestock operations that do not require a permit are not displayed in this figure but can also be sources of manure application and runoff from farm fields. High-densities of under-performing septic systems can also contribute ammonia loadings to streams. Though no ammonia exceedances occurred during the survey, elevated total ammonia concentrations (>95th percentile) often co-occurred with enriched conditions and may have contributed to impairment in areas where biological performance fell short of HELP-WWH expectations. NPDES-permitted facilities and CSO outfalls contained within this study area may have also contributed to elevated instream ammonia concentrations.

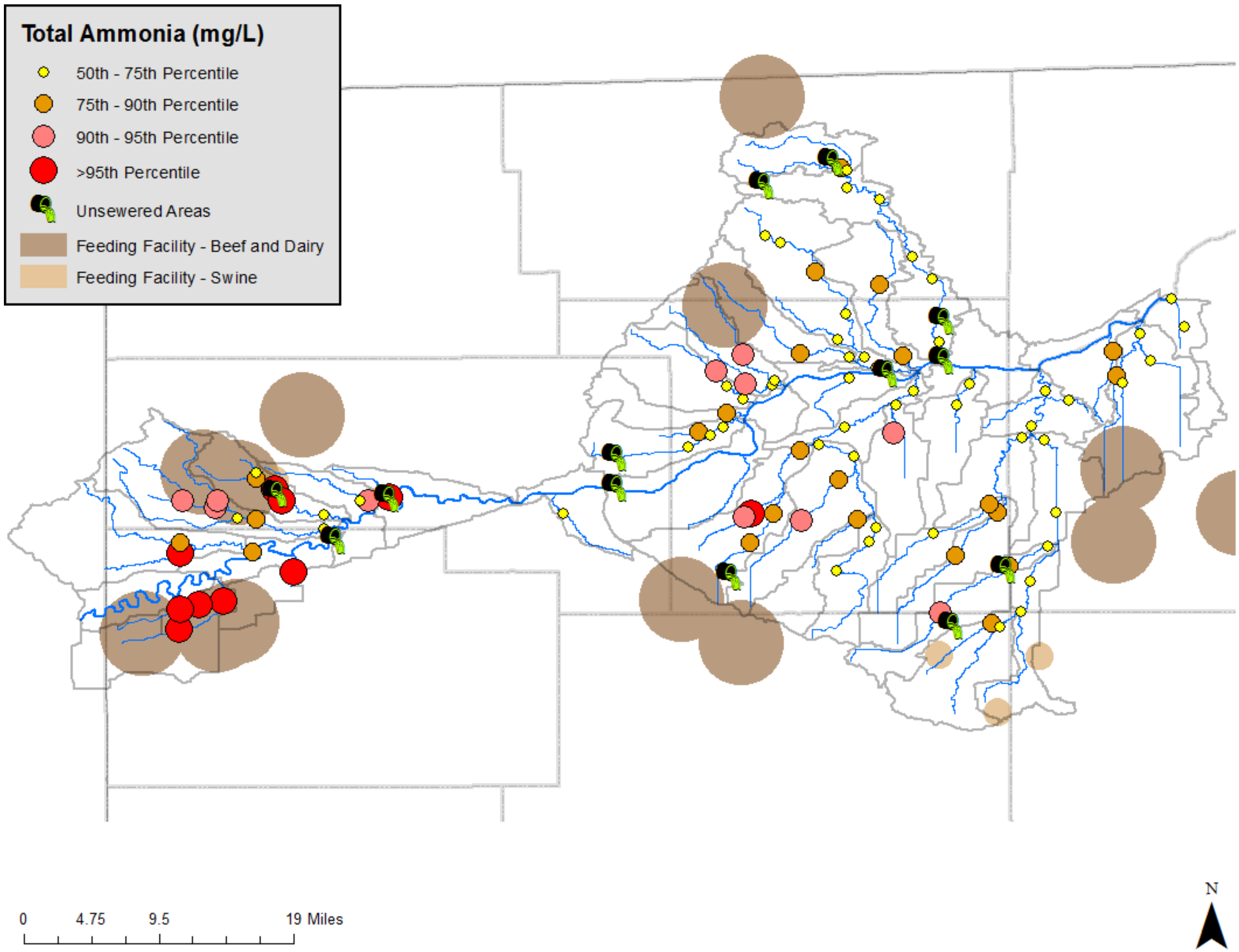

Figure 23 — Total ammonia geometric mean concentrations (mg/l) from sampling locations within the survey area, June-October 2015. Geometric mean concentrations were parsed into respective percentile ranges based total ammonia concentrations from headwater and wading reference sites from the HELP ecoregion (Ohio EPA 1999). Potential sources of ammonia are also displayed; these potential sources displayed are not all inclusive. A one-mile radius for swine and a three-mile radius for beef/dairy was used to display the potential for manure applications to farm fields and subsequent runoff to receiving sub-watersheds. Only larger, ODA-permitted beef/dairy and swine feeding facilities are displayed; smaller, non-permitted facilities are not displayed.

Zuber Cutoff (04100005 02 01)

North and South Creek join to create Zuber Cutoff in Paulding County, east of Antwerp. Both streams are typical agricultural streams, impacted by tile drainage and drainage maintenance activities, including the development of U.S. Route 24. There were four DO exceedances across three of the four sites regularly sampled in this HUC as a part of this study. South Creek produced the highest TP geometric mean values in the entire study area (Figure 22).

North Creek exceeded the WWH benchmark at both locations sampled, with values downstream of the Antwerp WWTP being higher than those found upstream. The upstream value is likely impacted by local agricultural land uses (Figure 24).

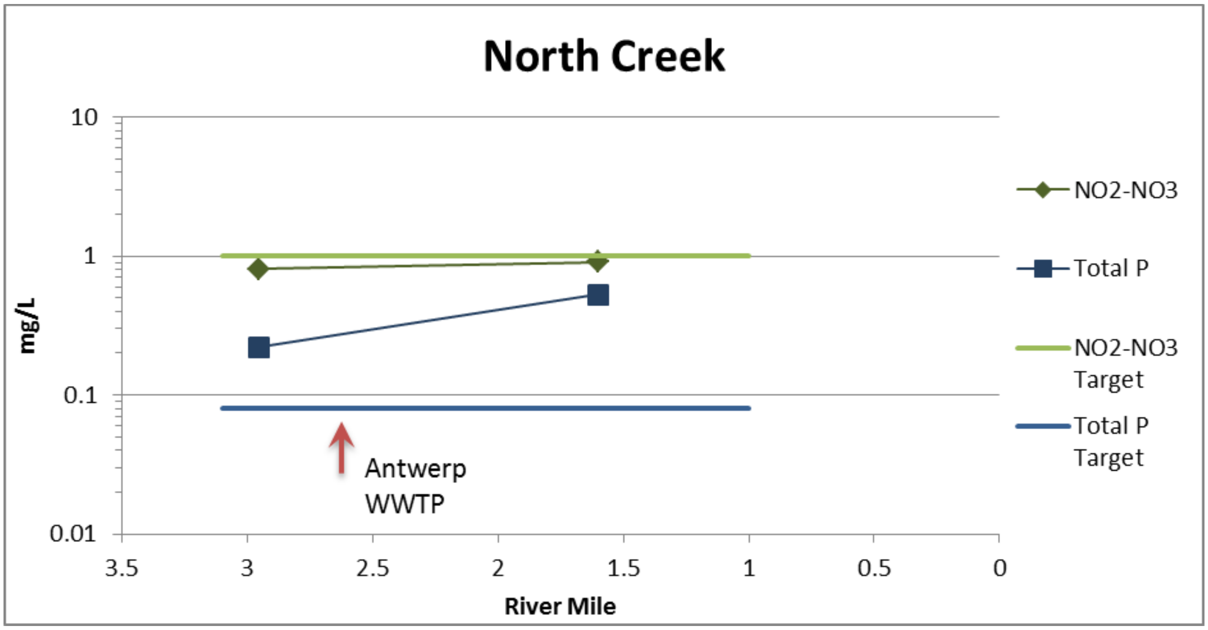

Figure 24 — Nitrate-nitrite (NO2-NO3) and total phosphorus (TP) geometric mean concentrations collected from North Creek from June 15 — Oct. 15, 2015. WWH benchmark concentrations are represented by appropriately colored horizontal lines.

While collecting surface water chemistry samples on Sept. 9, 2015, Ohio EPA staff discovered a fish kill on South Creek that persisted for several miles (Figure 55). The source of the spill was upstream of both sampling sites on South Creek. Additional samples were taken on September 9 and 10 and a multi-agency response including Ohio EPA, the Ohio Department of Natural Resources (ODNR) and ODA was initiated to investigate the upstream source of the spill.

Samples were taken upstream and downstream from a tile outlet at Co. Rd. 21 (Figure 25). An analysis of samples taken over the course of the summer display the impacts of the spill on nutrient concentrations within the stream (Figure 26). Additional diel sonde data and biological samples were collected in 2016 to help better quantify the spatial and temporal impacts of the spill and are discussed elsewhere in this document.

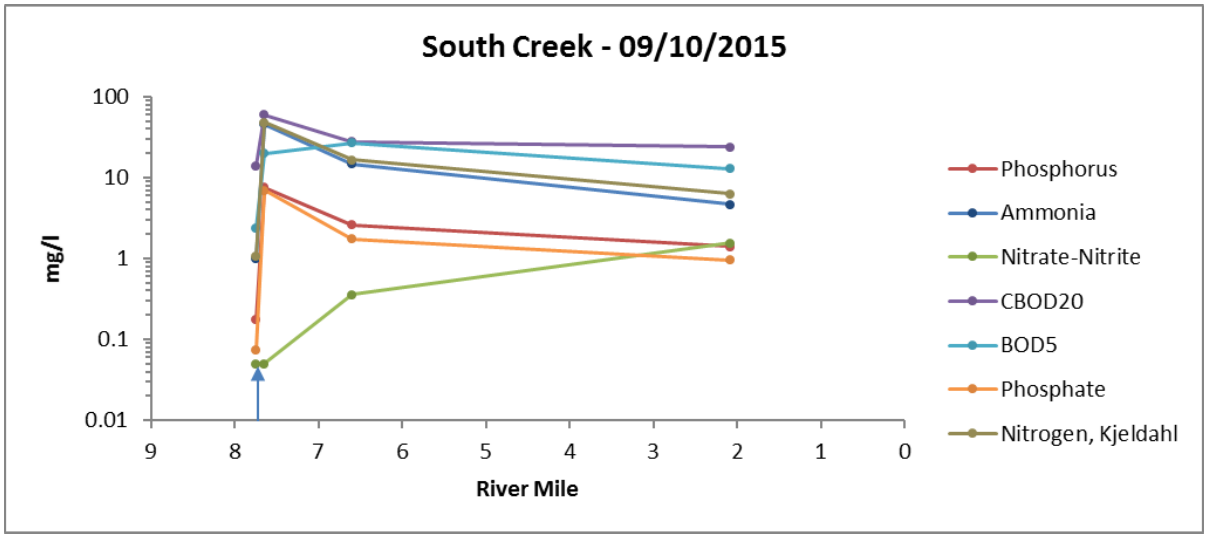

Figure 25 — South Creek, longitudinal single grab sample results, Sept. 10, 2015. Tile input is approximated by the blue arrow. Distance between first two upstream samples is exaggerated to 0.1 mi for visual clarity.

Ultimately, the Zuber Cutoff sub-basin (including South Creek) is a substantial source of total phosphorus to the Maumee River. Exceptionally high ammonia concentrations may be indicative of a lengthy release leading up to the September 9 fish kill. However, there may be chronic inputs into the Zuber Cutoff sub-basin given the highly elevated concentrations also found in North Creek and other area streams (Figure 23). Decreasing nitrate-nitrite levels are likely the results of the end of a wet early summer and in-stream production fueled in part by excess phosphorus in late summer (Figure 26).

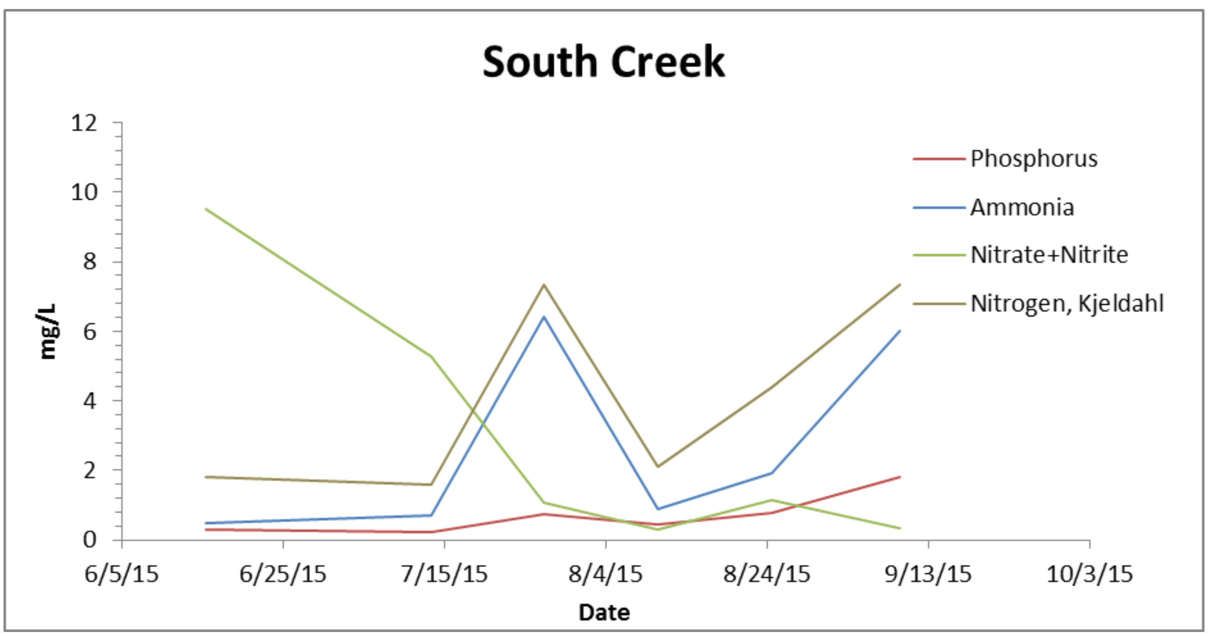

Figure 26 — South Creek, single grab sample results from six non-spill response sampling events, 2015.

The Antwerp WWTP also discharges to North Creek. There are also three dairies permitted by ODA and/or Ohio EPA currently in operation in the Zuber Cutoff watershed. They include Zylstra Dairy, Flatland Dairy (a.k.a. Oolman) and Schlinderink Dairy, with a combined 9,200 head. All of these facilities were constructed in the late 1990s through the early 2000s. In addition to direct impacts (spill/kill event), manure applications to surrounding farm fields and subsequent runoff to adjacent waterways, along with other agricultural nonpoint runoff likely contributed to the generally enriched nature in streams within this sub-watershed compared to other streams within the study area.

Gordon Creek (04100005 02 04)

Nutrient concentrations in the Gordon Creek sub-watershed were highest in Mill Creek and decreased downstream through Gordon Creek (Figure 27). While the Hicksville WWTP discharged in excess of 5 mg/l nitrate-nitrite, the temporal distribution of nitrate-nitrite and the rise in the geometric mean concentration in Middle Fork Gordon Creek downstream of its confluence with Mill Creek suggested inputs from sources other than the WWTP (Figure 28).

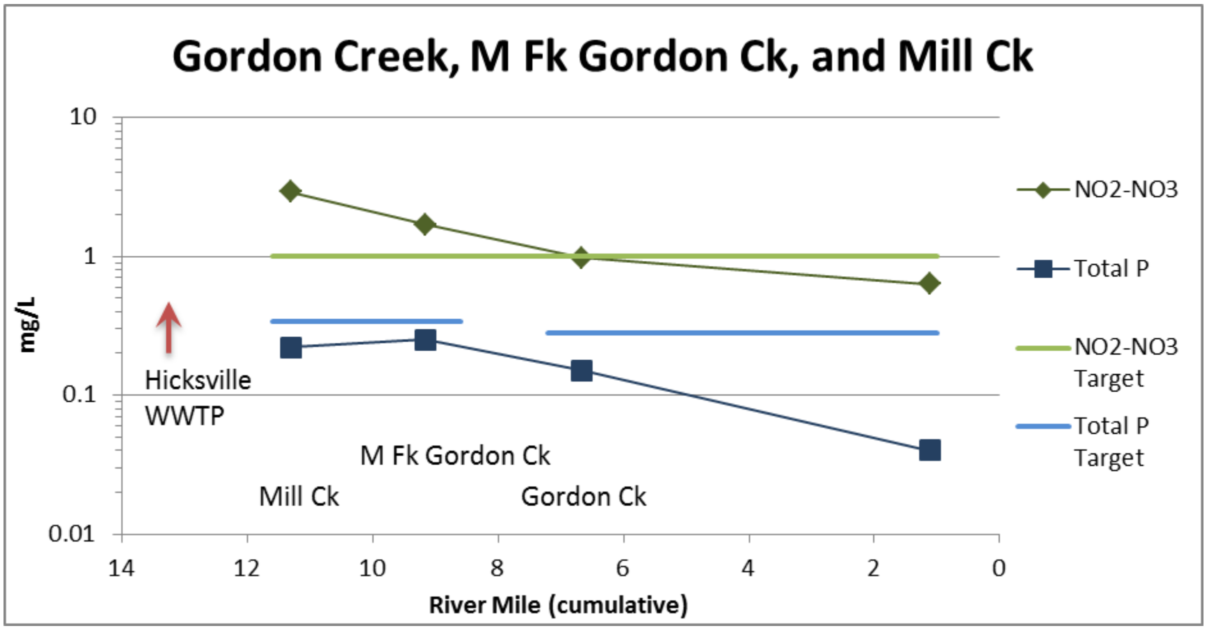

Figure 27 — Gordon Creek watershed, summer index period geometric means, 2015. WWH benchmark concentrations are represented by appropriately colored horizontal lines.

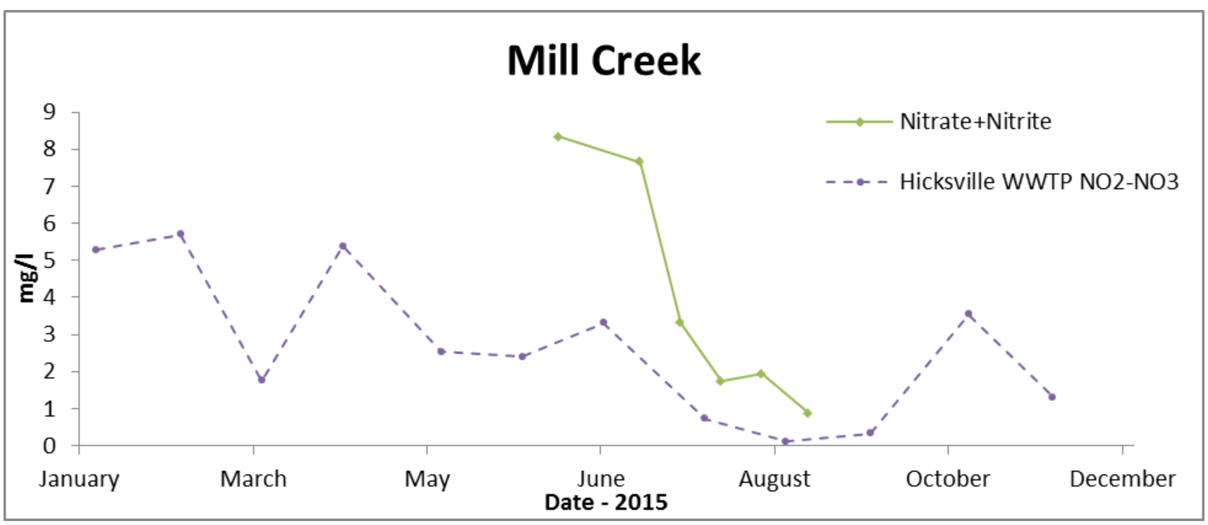

Figure 28 — Mill Creek nitrate-nitrite single grab concentrations and Hicksville WWTP monthly nitrate-nitrite effluent monitoring values, 2015.

Platter Creek (04100005 02 06)

Nitrate-nitrite and ammonia concentrations increased downstream from Mark Center. Mark Center is an unsewered community that was sampled during 2015 to evaluate the potential for bacterial contamination of Platter Creek (Figure 23, Figure 29). The results from bacteria sampling demonstrated a release of untreated wastewater to Platter Creek. Mark Center is one of several likely sources contributing to nutrient exceedances and elevated ammonia concentrations in Platter Creek (Figure 30).

Ohio EPA responded to a manure spill on July 6, 2015 from 5C Farms. A drop in was noted on the spill report, and aeration equipment was placed in the stream temporarily. The impact of the spill is not discernable within the data collected during the six sampling runs completed during the 2015 field season (Figure 31).

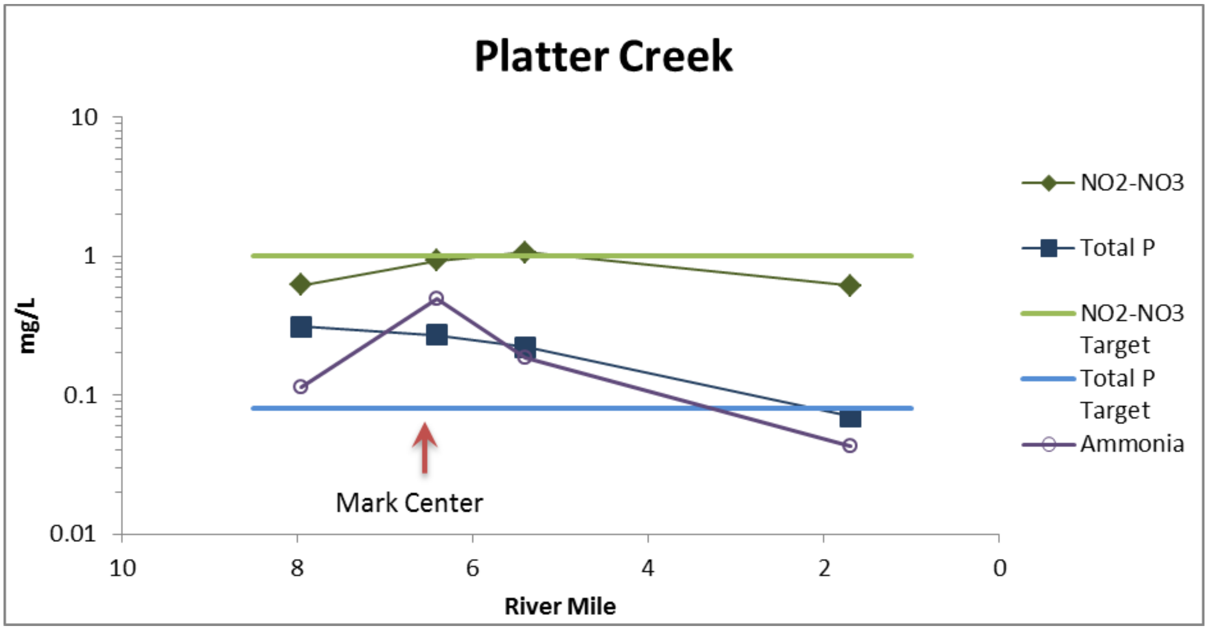

Figure 29 — Platter Creek nitrate-nitrate, total phosphorus and total ammonia geometric mean concentrations displayed longitudinally, June — October 2015. WWH benchmark concentrations are represented by appropriately colored horizontal lines.

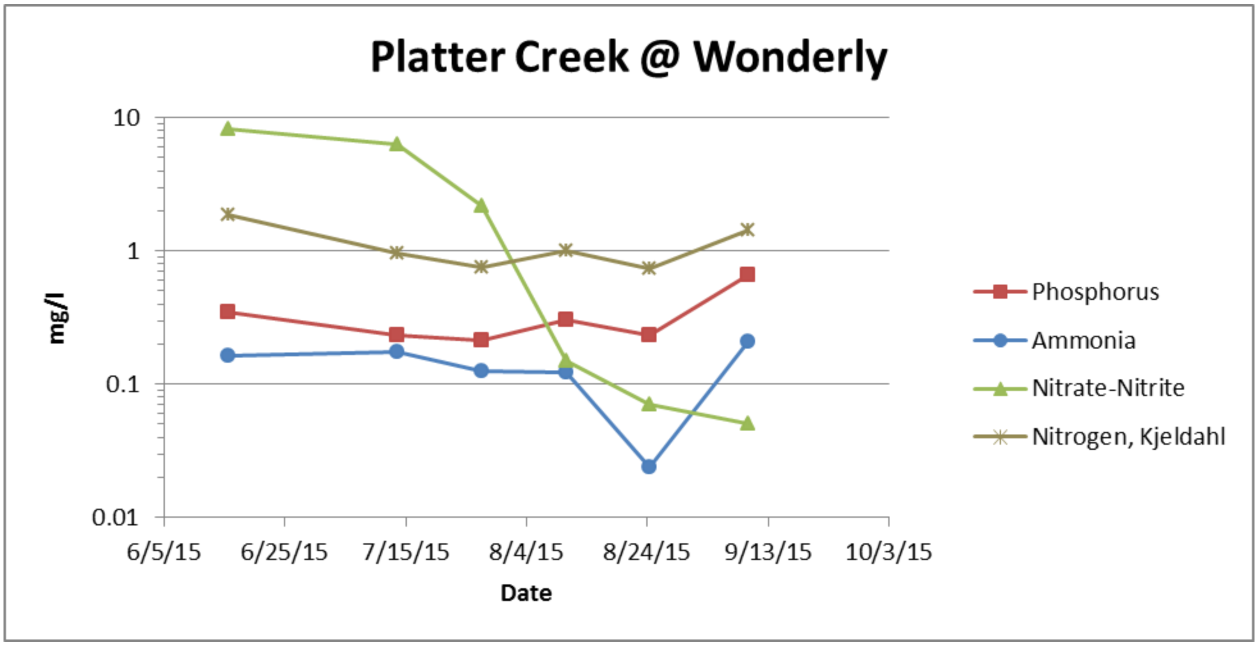

Figure 30 — Platter Creek at Wonderly Rd. (RM 7.95), summer index period geometric means, 2015.

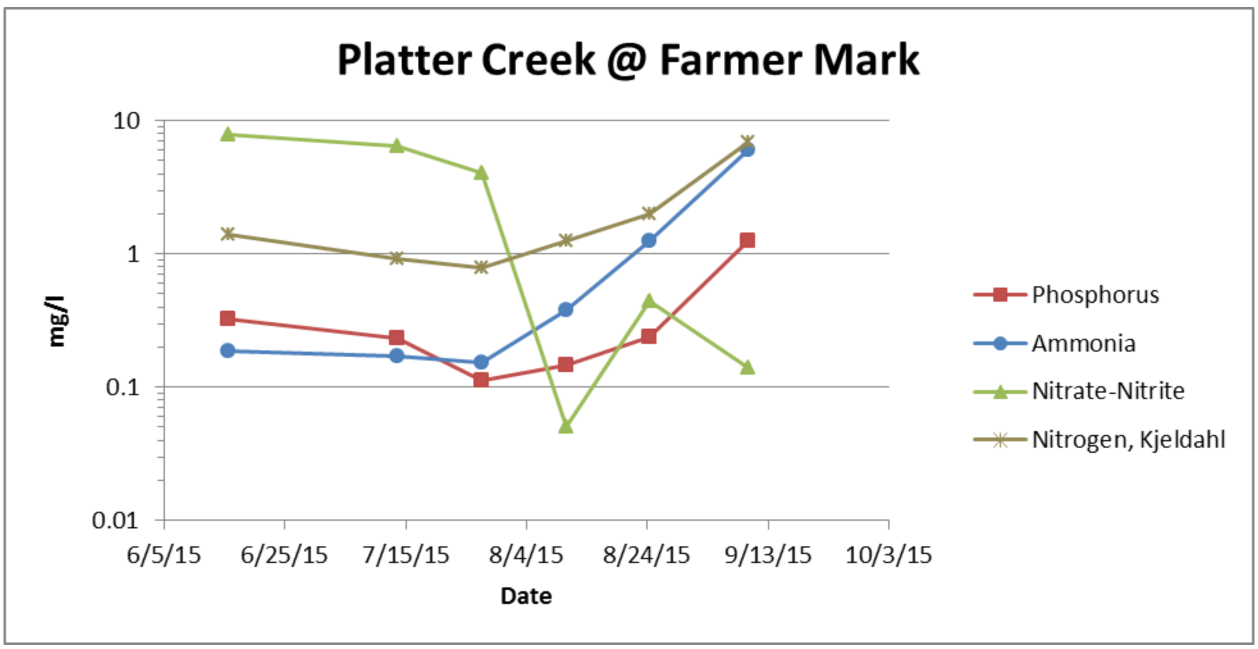

Figure 31 — Platter Creek at Farmer Mark Rd. (RM 6.41), single grab sample results from six sampling events, 2015.

South Turkeyfoot Creek (04100009 01 02, 04, 06)

Draining approximately 150 square miles, South Turkeyfoot Creek is among the largest streams in the project study area. Moving upstream to downstream, West Creek, Lost Creek, School Creek (including Brinkman Ditch), and Little Turkeyfoot Creek all drain to South Turkeyfoot Creek. The villages of Hamler, Malinta, and Holgate discharge their wastewater to the stream network.

TP concentrations at sampling locations in South Turkeyfoot Creek were above benchmarks at all but the most downstream sampling location (RM 3.2, 303388) and were above nitrate-nitrite benchmarks at all but two locations. Both sites that were below nitrate-nitrate benchmarks saw an increase in TP concentrations (Figure 21, Figure 22, Figure 32).

Though no exceedances occurred, total ammonia was elevated at numerous locations sampled in the South Turkeyfoot Creek basin (Figure 23).

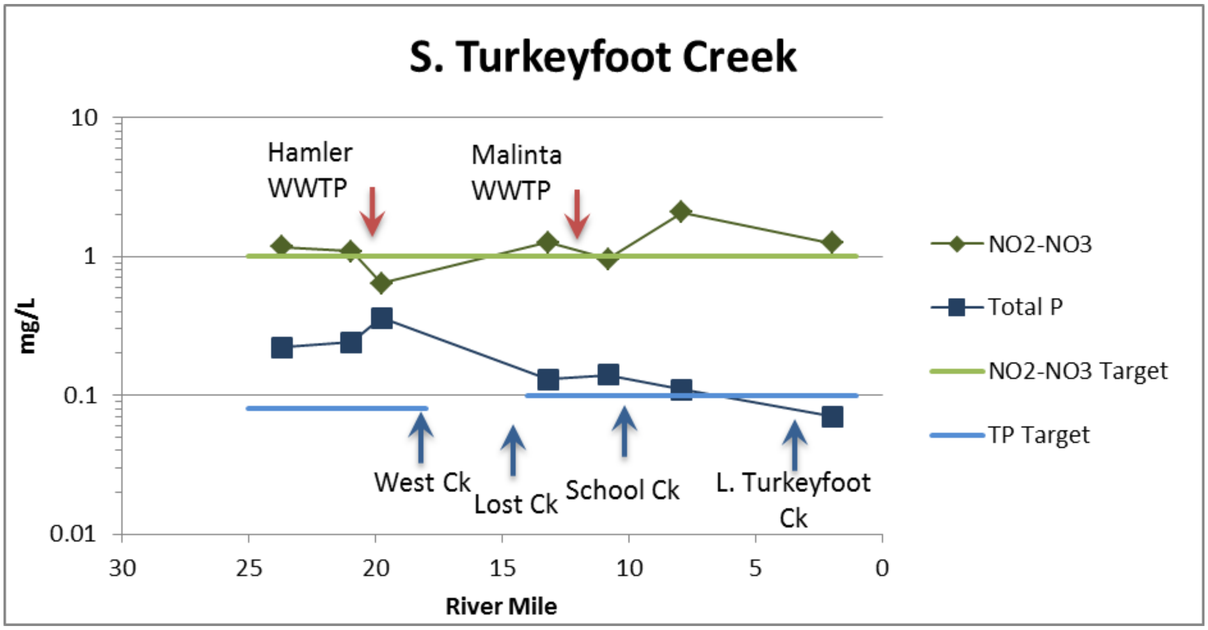

Figure 32 — South Turkeyfoot Creek, summer index period geometric means, 2015. Benchmark concentrations are represented by appropriately colored horizontal lines.

School Creek, Brinkman Ditch (04100009 01 03)

Both nitrate-nitrite and TP concentrations from School Creek fell below benchmark concentrations at two of three locations sampled, while the sampling location downstream from the confluence with Brinkman Ditch (RM 0.9, 302994) was above TP benchmark concentrations. Holgate's WWTP lagoon discharge (***see NPDES section for details***) into Brinkman Ditch provided a source of TP that impacted concentrations in Brinkman Ditch. TP concentrations were also elevated in School Creek downstream into Brinkman Ditch (Figure 22, Figure 33, Figure 34). Though no individual exceedances occurred, total ammonia was elevated throughout the School Creek sub-basin, and especially so both up and downstream from the Holgate WWTP lagoon system (Figure 23).

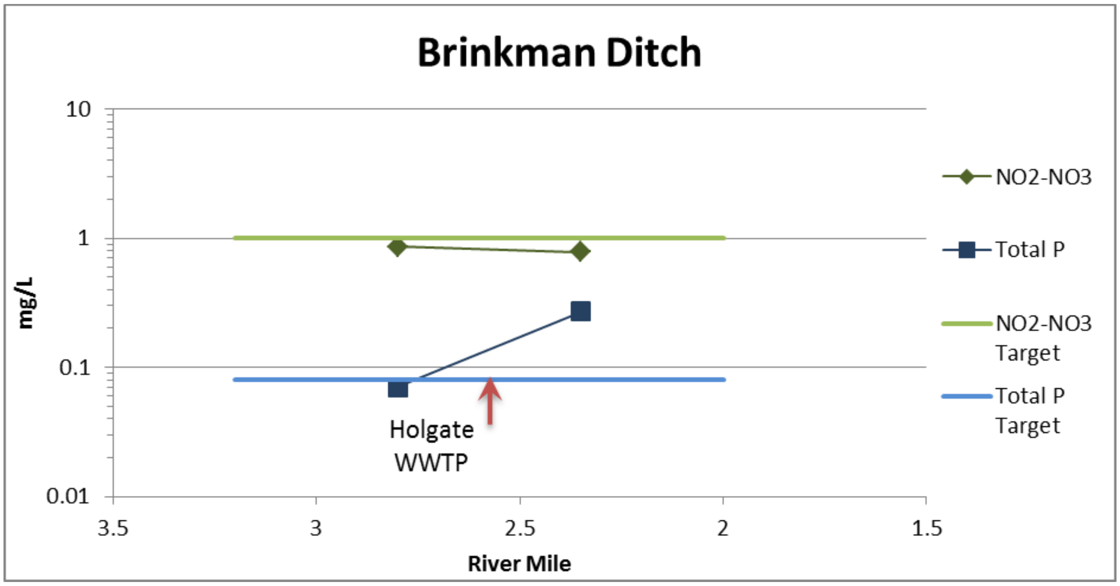

Figure 33 — Nitrate-nitrite and total phosphorus geometric mean concentrations from sampling locations in Brinkman Ditch, June — October 2015. Benchmark concentrations are represented by appropriately colored horizontal lines.

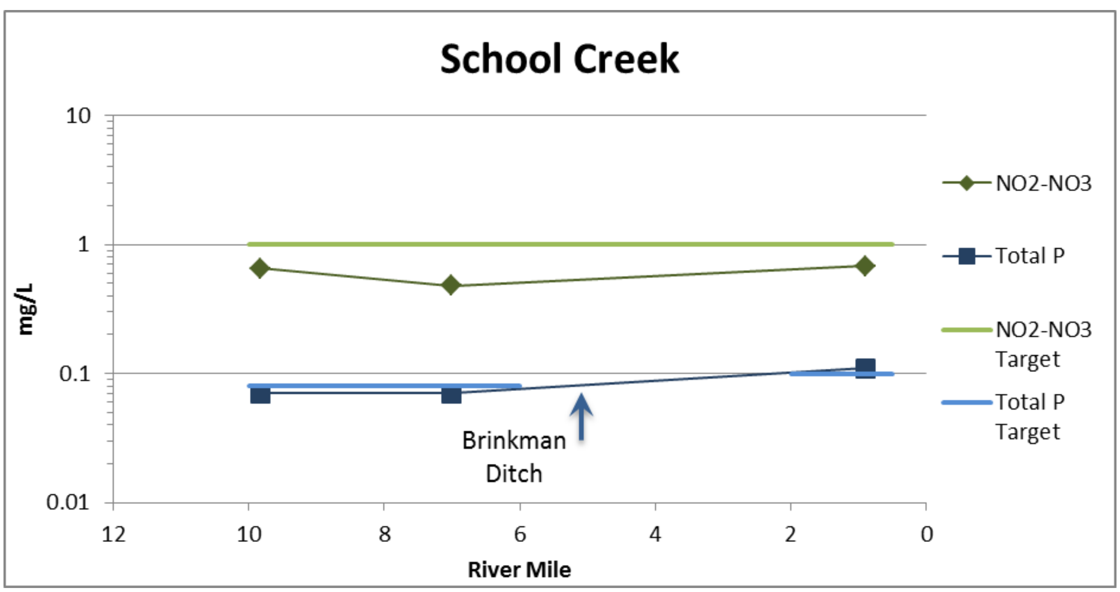

Figure 34 — Nitrate-nitrite and total phosphorus geometric mean concentrations from sampling locations in School Creek, June — October 2015. Benchmark concentrations are represented by appropriately colored horizontal lines.

North Turkeyfoot Creek (04100009 04 02)

Nitrate-nitrite concentrations in North Turkeyfoot Creek spiked downstream from the Wauseon WRF and remained well above 95th percentile concentrations from reference locations (Ohio EPA 1999) until the most downstream site (RM 3.4, P09S01), which is influenced by Konzen Ditch (Figure 35). Nitrate-nitrite concentrations in Konzen Ditch (24.7 mi² drainage) were as high as 16 mg/l in June but met the benchmark of 1.0 mg/l during all four visits in August through September.

While Konzen Ditch demonstrates typical agricultural nitrate-nitrite influences, single sample results from North Turkeyfoot at Co. Rd. 13, downstream of the Wauseon WRF, indicate a continuous source of nitrate-nitrite throughout the summer (Figure 36).

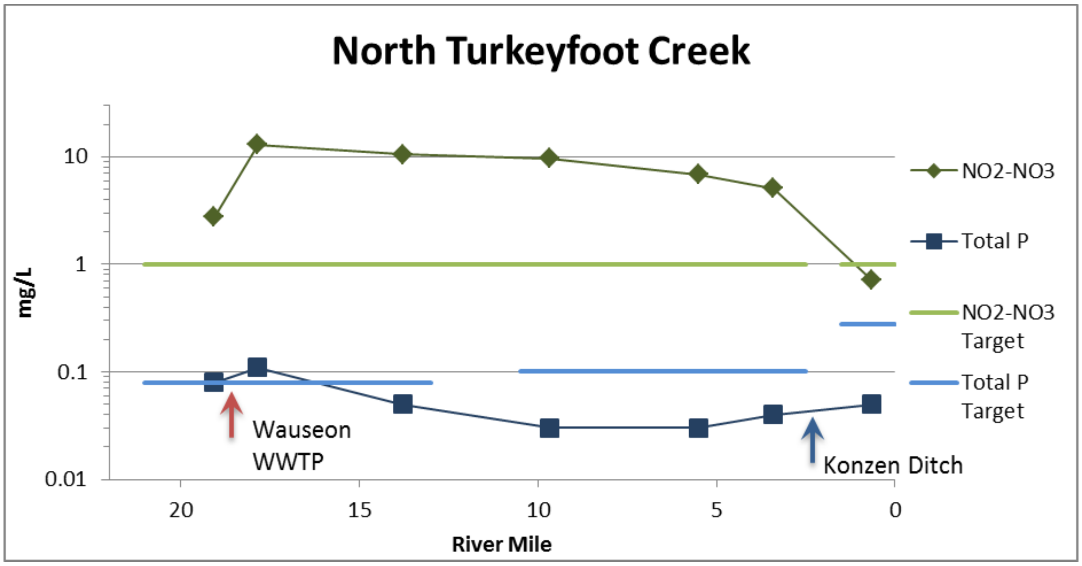

Figure 35 — Nitrate-nitrite and total phosphorus geometric mean concentrations from sampling locations in North Turkeyfoot Creek, June — October 2015. Benchmark concentrations are represented by appropriately colored horizontal lines.

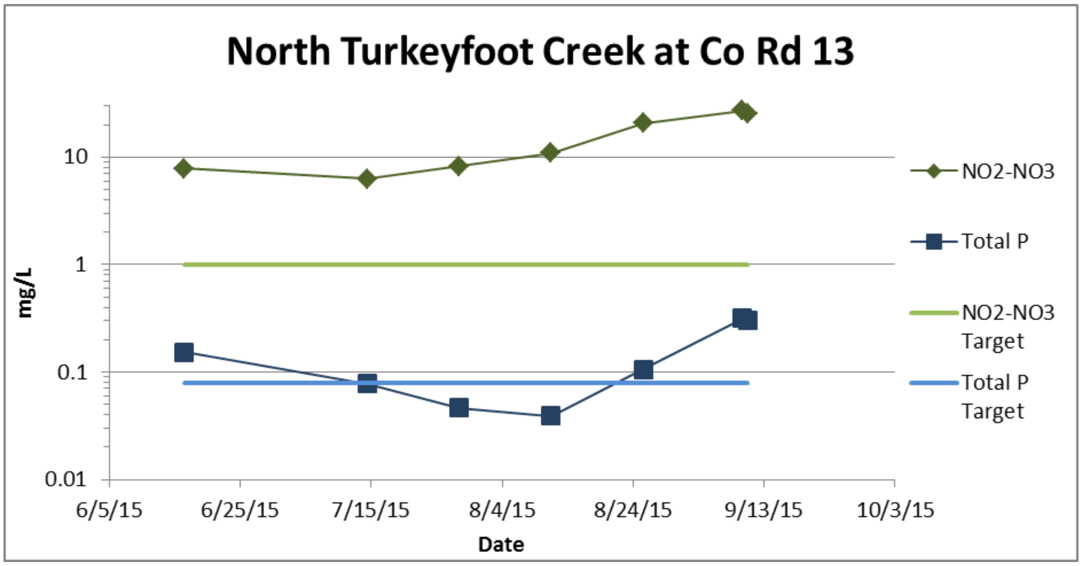

Figure 36 — North Turkeyfoot Creek at Co. Rd. 13 (downstream Wauseon WRF), single grab sample results, 2015. Benchmark concentrations are represented by appropriately colored horizontal lines.

Bad Creek (04100009 03)

Nitrate-nitrite concentrations in Bad Creek were above the benchmark concentration at all sampling locations and were among the highest concentrations found across the project area (Figure 37). Upstream sampling in South Branch Bad Creek provided similar results to Bad Creek. Agricultural and rural residential sources were most likely contributing to these high concentrations, which, while they dip dramatically, remained two to four times above the benchmark (1.0 mg/l) at their lowest point during the summer (Table 17).

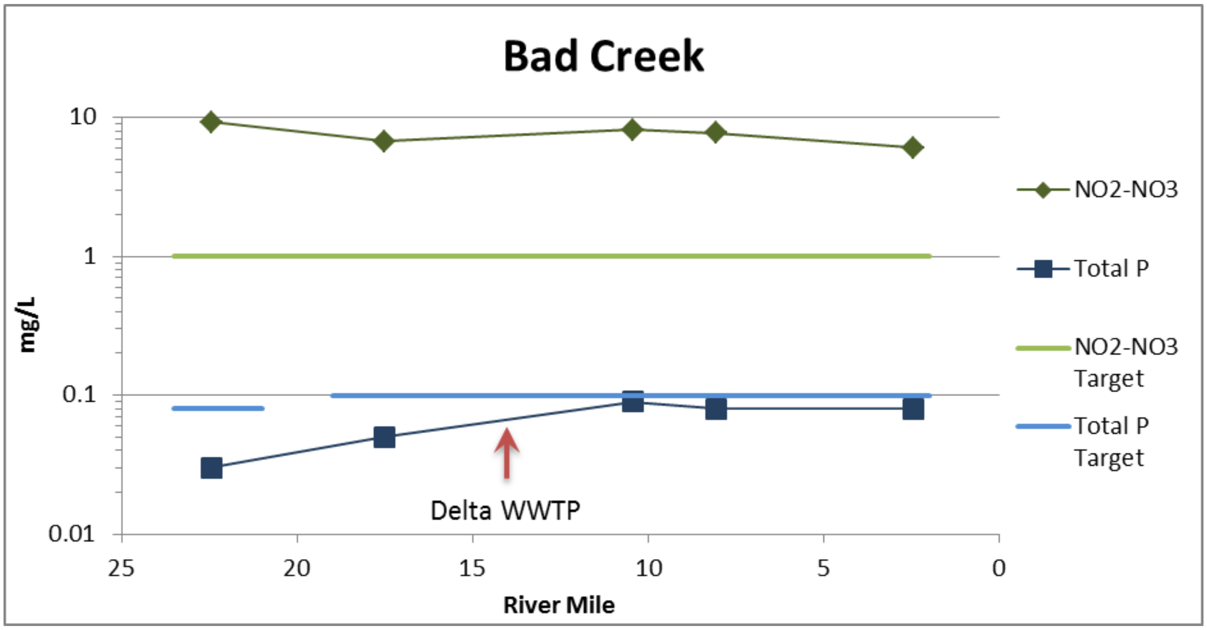

Figure 37 — Nitrate-nitrite and total phosphorus geometric mean concentrations from sampling locations in Bad Creek, June — October 2015. Benchmark concentrations are represented by appropriately colored horizontal lines.

Table 17 — Single grab sample nitrate-nitrate concentrations (mg/l) from Bad Creek, South Branch Bad Creek, and the tributary to Bad Creek (20.85), 2015. Italic rows are water sources that join Bad Creek in between the displayed sampling locations.

Stream	Location	RM in Bad Creek	Station	6/16	7/14	7/28	8/11	8/25	9/9	9/10
Bad Creek	Upst. tributaries	22.45	P11K48	23.6	12.6	9.47	8.99	7.1		3.52
S. Br. Bad Creek		(22.31)	302849	22.8	15.1	9.92	6.96	5.42		2.48
Trib. to Bad Creek		(20.85)	302991	14.7	14.1	9.2	5.63	3.26		0.52
Bad Creek	Upst. WWTP	17.51	P11W22	19.6	13.4	9.9	7.15	5.89	2.52	2.21
Delta WWTP outfall		(13.85)	P11S06							
Bad Creek	Dst. WWTP	10.46	P11S05	17.1	12.6	9.44	6.5810	5.84		3.84

Tontogany Creek (04100009 06 01)

While the downstream site at Robinson Road on Tontogany Creek had higher nitrate-nitrite concentrations than the upstream site, it is not likely the result of impacts from the Tontogany Area WWTP (Figure 38). Individual grab sample concentrations from the stream plotted against samples for nitrate-nitrate from the WWTP demonstrate that the instream concentrations were likely a result of nonpoint sources (Figure 39).

West Branch Tontogany Creek RM 3.42 (P10P13) had three of the 11 temperature exceedances recorded from June — October 2015, the highest single site total. An overall shallow depth coupled with near complete lack of riparian vegetative cover has left this segment of W. Br. Tontogany Creek vulnerable to excessive heat from the summer sun. Higher flows and cooler temperatures during early summer 2015 may have dampened stream temperatures relative to a typical summer.

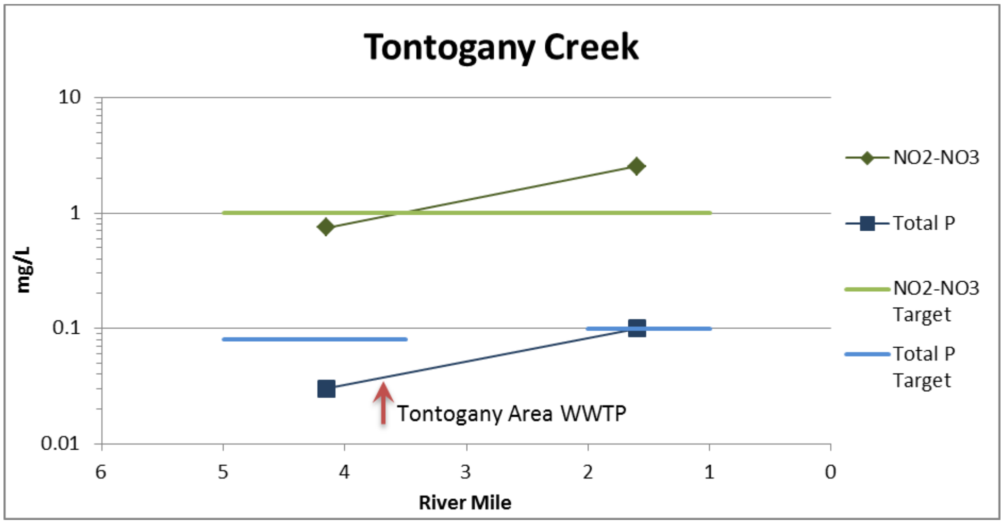

Figure 38 — Nitrate-nitrite and total phosphorus geometric mean concentrations from sampling locations in Tontogany Creek, June — October 2015. Benchmark concentrations are represented by appropriately colored horizontal lines.

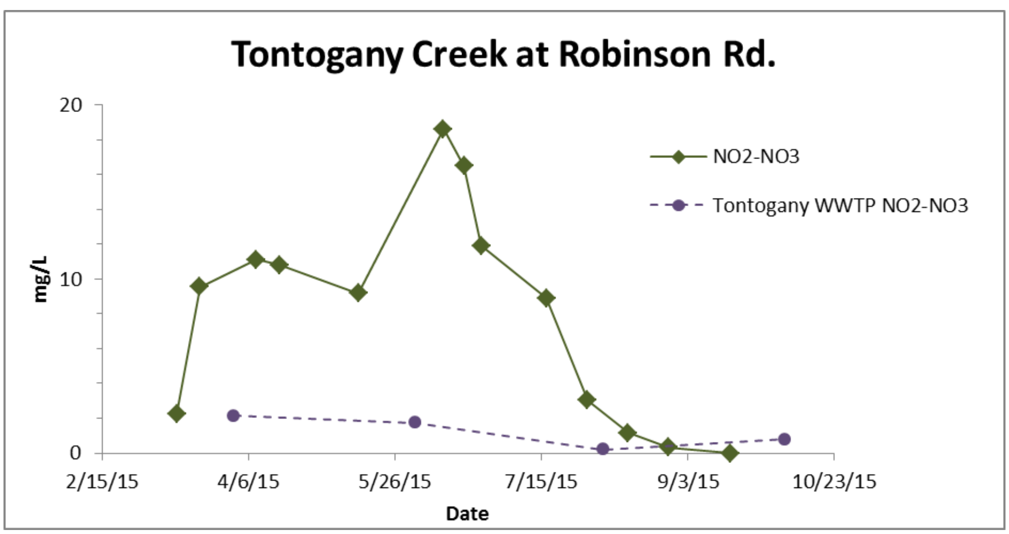

Figure 39 — Tontogany Creek nitrate-nitrite single grab concentrations at Robinson Rd. and Tontogany Area WWTP bi-monthly nitrate-nitrite effluent monitoring values, 2015.

Water Quality Sonde Exceedance Summary

Multi-parameter water quality sondes were deployed to monitor temperature, dissolved oxygen (DO), pH and specific conductance (conductivity). Temperature, DO and pH are influenced by diel patterns (fluctuations recurring on a 24-hour period). These diel patterns have the greatest impact for streams during a critical condition that includes stable, low streamflow. Specific conductance is not influenced by the same diel triggers but is monitored because it is a strong indicator of changes in streamflow. 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 may miss or not fully characterize parameters that exhibit diel patterns.

Diel patterns in temperature reflect air temperature, solar radiation, base flow (ground water), discharge, and shading. In general, diel fluctuations in temperature increase as base flow, discharge, and shading decrease. The inverse is also true.

Dissolved oxygen responds in a similar diel pattern to temperature, as it is affected by similar factors. In addition, DO trends are directly dependent on temperature. At high temperatures the solubility of oxygen in water decreases, resulting in an inverse relationship. Without the influence of other environmental conditions this would cause the two parameters to follow opposite trends. However, the DO produced by photosynthesis is, in most instances, enough to overwhelm the inverse relationship causing the trends to follow similar trajectories. Increasing diel fluctuation relates to an increase in productivity, resulting in DO reaching super saturation during the day with subsequent depletion by respiration at night. The result is a diel trend that typically reaches a maximum in the early evening and a minimum preceding sunrise. In some cases, DO does not exhibit strong diel trends in low-flow, warm conditions. Either primary productivity is limited or decomposition of organic matter in the stream is controlling the DO concentrations. Diel monitoring helps to identify DO trends that are more influenced by primary productivity or decomposition.

Stream pH is generally controlled by the local geology that determines the natural alkalinity and acidity of the system. However, diel patterns in pH result as a function of primary productivity. Carbon dioxide, which dissolves in water to form carbonic acid, is consumed during photosynthesis, raising the pH of the stream. The result is a maximum pH value observed at a similar time to the maximum DO

Forty-two sites were sampled with water quality sondes to represent the general watershed area as well as to target areas of concern (for example, point sources, impaired areas, etc.). The land use in the watershed is largely row crop agriculture, however, some point sources had localized impacts. Two of these point sources, Antwerp WWTPs discharge to North Creek and Holgate WWTPs discharge to Brinkman Ditch, were bracketed with sondes (sondes were placed both up and downstream of the discharge) to assess any impacts to water quality these facilities might have contributed. Sonde sampling was also conducted downstream from other permitted facilities, including the village of Leipsic WWTP and the city of Wauseon WRF. Samples upstream from these facilities could not be collected. Little Yellow Creek starts at the Leipsic WWTP and there is no channel upstream from this facility. The streamflow in North Turkeyfoot Creek upstream from the Wauseon facility was deemed too low to collect a sonde sample.

Critical conditions for temperature and DO are times when flows are low, temperatures are high and daylight is long. These are the times that streams are most sensitive to organic and nutrient enrichment. To capture these conditions, sondes are typically deployed during low-flow conditions from June to September. Four deployments occurred in the Maumee River tributaries watershed. The first was from

Aug. 4-7, 2015; 31 tributary sites were sampled. A second deployment took place at 16 sites, including a weekend, and resulted in 120 hours of data collection from Aug. 12-17, 2015. The third deployment collected data from 22 sites from Sept. 9-11, 2015. The fourth deployment collected data from 14 tributary sites the following year from June 14-15, 2016. This deployment was cut short a day from the normal 48 hours of sampling due to heavy rains overnight and in the morning of June 15. Figure 40 and Figure 41 display the flow and air temperature conditions during each survey and the normal conditions expected throughout each season. The air temperatures during three of the surveys were above normal which is an important component of the critical conditions. Summary plots of all data collected are included in Appendix E of this document. Those plots show hourly readings taken for temperature, DO, pH and specific conductance.

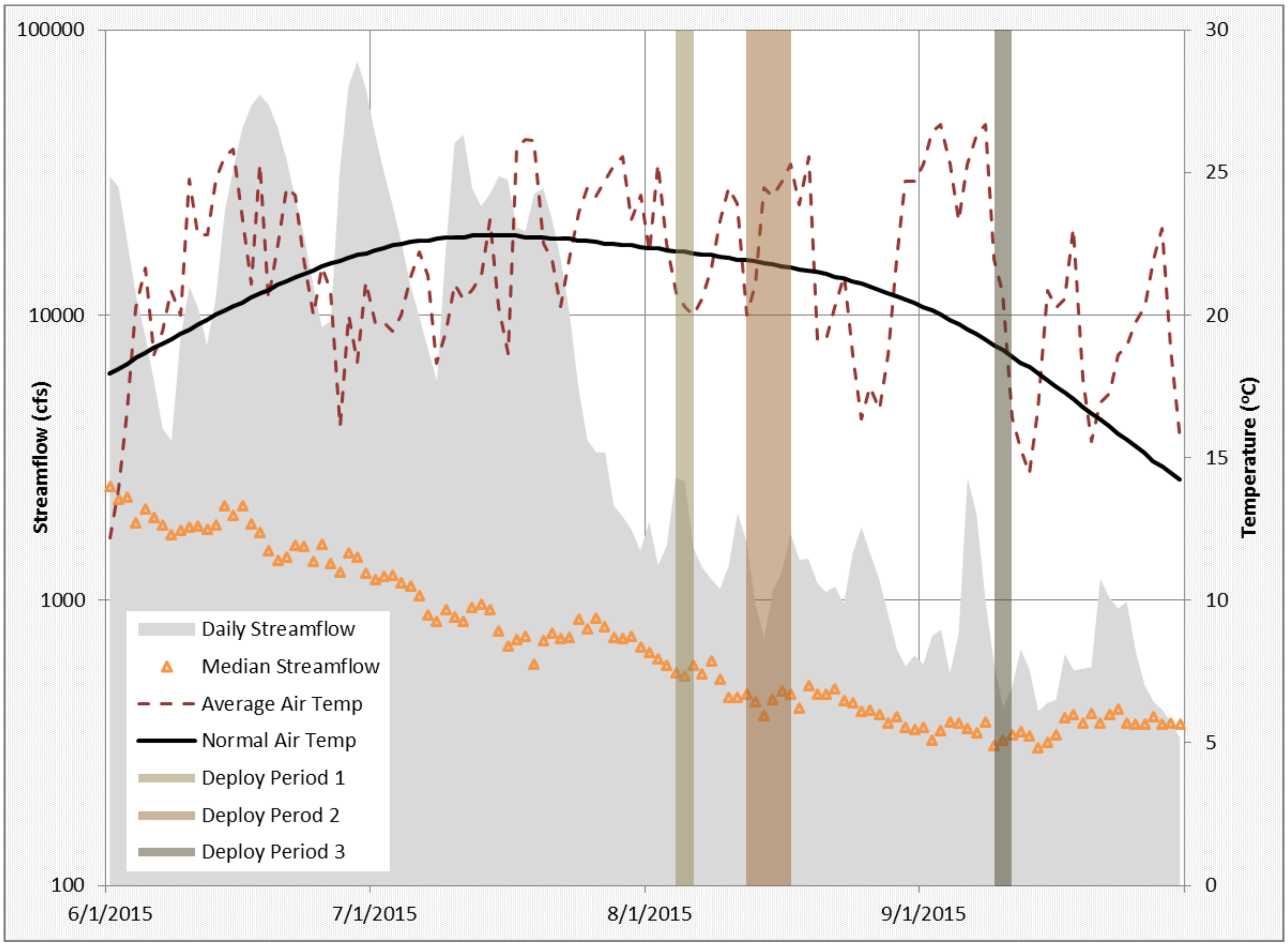

Figure 40 — Average daily and median streamflow (USGS 04192500 – Maumee River near Defiance, OH) including the average and normal daily air temperature (NOAA - GHCND: USW00004851) relative to sonde deployments, June — September 2015.

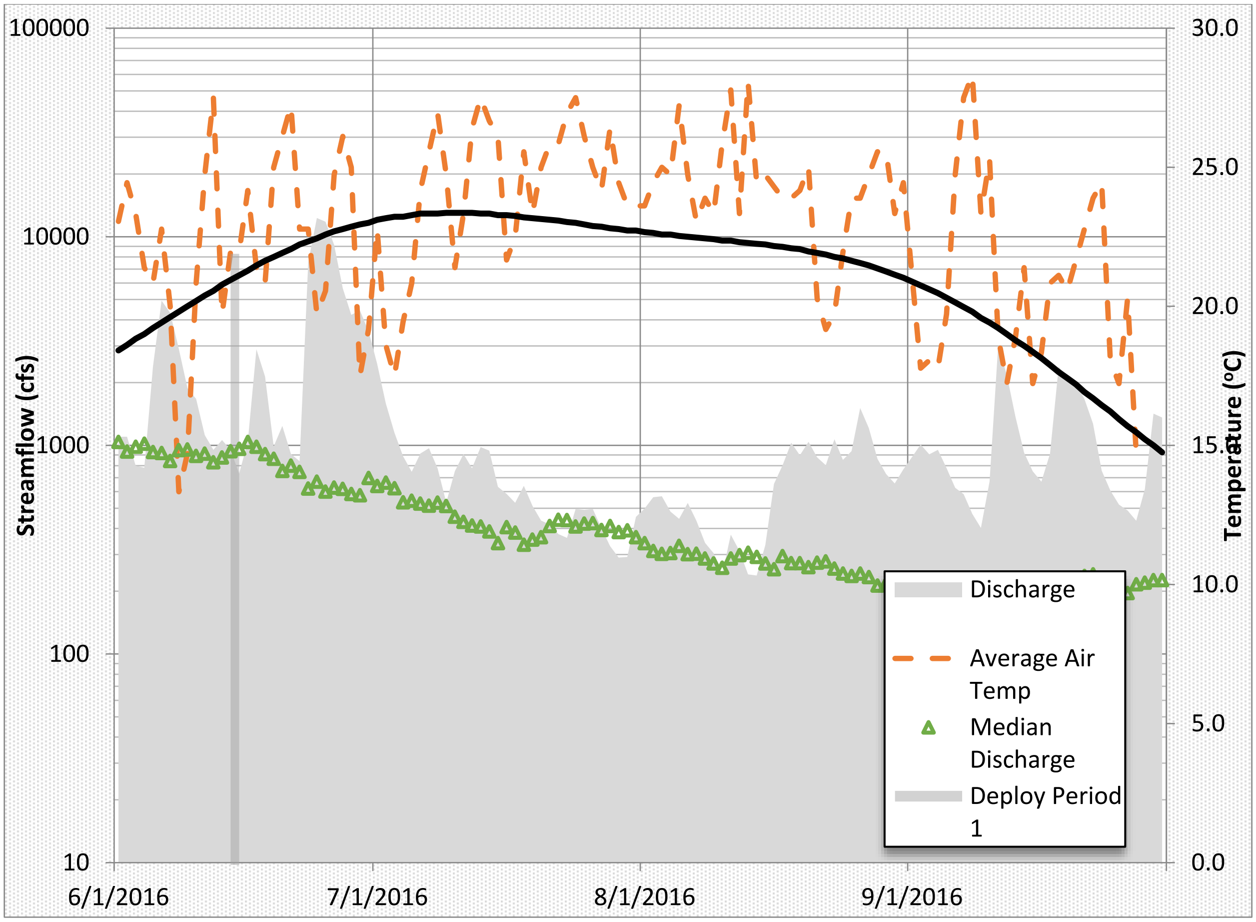

Figure 41 — Average daily and median streamflow (USGS 04192500 – Maumee River near Defiance, OH) including the average and normal daily air temperature (NOAA - GHCND: USW00004851) relative to sonde deployments, June — September 2016.

Ohio promulgates water quality standards through Ohio Administrative Code Chapter 3745-1. The data collected during the sonde deployments are sufficient to evaluate exceedances of the standards for the protection of aquatic life for: maximum daily temperature; minimum DO; 24-hour average DO; pH; and specific conductivity. Absolute minima or maxima 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. An exceedance of the water quality criteria does not represent stream impairment; rather if biological impairment is documented, exceedances help develop a body of evidence that identifies the conditions stressing aquatic life.

Table 18 displays pertinent water quality criteria, while Table 19 and Table 20 display WQS criteria exceedances observed by sonde water quality monitoring from 2015 and 2016, respectively. Sondes 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 criteria. The magnitude of an exceedance is presented as the most extreme value measured that exceeds the criteria. The duration is the count of consecutive hours that exceeded the criteria and is presented in parenthesis after the measure of magnitude. Applicable water quality criteria include minimum DO, average DO, maximum temperature, pH and specific conductance. On Table 19 and Table 20, footnotes indicate which sonde deployment that the criteria exceedances were observed.

Table 18 — Water quality criteria exceedances.

Parameter	Aquatic life use designation	Criteria
Minimum (instantaneous) DO	WWH	4.0 mg/l
	MWH[a]	2.5 mg/l
	LRW	2.0 mg/l
24-Hour average minimum DO	WWH	5.0 mg/l
	MWH	4.0 mg/l
	LRW	3.0 mg/l
maximum temperature	Varies by date; see OAC 3745-1-07, Table 7-14(G).	
pH	All	6.5-9.0 S.U.
specific conductance	All	2,400 µS/cm

[a] Specific to the HELP ecoregion of which all assessment sites are within

Table 19 — Exceedances of Ohio Water Quality Standards criteria (OAC 3745-1) for chemical and physical parameters derived from diel, sonde monitoring in 2015. Exceedances are evaluated against existing or recommended aquatic life beneficial uses. Aquatic life beneficial uses can be found in Table 3.

RM	Location	Parameter - extreme value (duration in hours)
South Creek		**Warmwater Habitat (Existing)**
0.35	Victory Rd.	DO min.: 2.3 (25)[c]; DO avg.: 3.9 (20)[c]
Zuber Creek		**Warmwater Habitat (undesignated)**
1.2	Co. Rd. 180	No exceedances in one deployment.
Marie DeLarme Creek		**Warmwater Habitat (Existing)**
0.50	Twp. Rd. 192	No exceedances in two deployments.
Gordon Creek		**Warmwater Habitat (Recommended)**
1.12	County Line Rd.	No exceedances in two deployments.
Platter Creek		**Warmwater Habitat (Existing)**
1.70	Jericho Rd.	No exceedances in two deployments.
Benien Creek		**Warmwater Habitat (Existing)**
2.30	Twp. Rd. N	DO min.: 2.0 (44)[c]; DO avg.: 2.8 (24)
Garrett Creek		**Warmwater Habitat (Existing)**
0.70	Co. Rd. P	DO min.: 3.6 (10)[c]; DO avg.: 4.6 (24)[c]
Van Hyning Creek		**Warmwater Habitat (Existing)**
0.75	Oakwood Ave.	DO min.: 1.9 (36)[b]; 2.7 (20)[c]; DO avg.: 2.7 (35)[b]; 4.4 (25)[c]
South Turkeyfoot Creek		**Warmwater Habitat (Existing)**
19.75	Co. Rd. G	DO min.: 1.7 (16)[a]; 0.7 (27)[c]; DO avg.: 4.5 (10)[a]; 2.9 (20)[c]
7.9	Co. Rd. N	No exceedances in three deployments.
West Creek		**Warmwater Habitat (Existing)**
1.00	St. Rte. 109	No exceedances in one deployment.
Lost Creek		**Warmwater Habitat (Existing)**
1.30	Co. Rd. 1.30	No exceedances in one deployment.
School Creek		**Warmwater Habitat (Recommended)**
0.90	Co. Rd. 12	DO min.: 3.3 (20)[b]; DO avg.: 4.3 (60)[b]
Little Turkeyfoot Creek		**Warmwater Habitat (Existing)**
0.48	Twp. Rd. 4	No exceedances in three deployments.
North Turkeyfoot Creek		**Warmwater Habitat (Existing)**
17.85	Co. Rd. 13	pH: 9.1 (1)[c]
3.4	Co. Rd. 8	No exceedances in two deployments.
Konzen Ditch		**Warmwater Habitat (Recommended)**
0.65	Co. Rd. S	No exceedances in two deployments.
Dry Creek		**Warmwater Habitat (Existing)**
1.60	Co. Rd. S	DO min.: 3.0 (28)[c]; DO avg.: 3.7 (23)[c]

RM	Location	Parameter - extreme value (duration in hours)
Bad Creek		**Warmwater Habitat (Existing)**
17.51	Co. Rd. H	No exceedances in three deployments.
10.46	Co. Rd. D	No exceedances in two deployments.
2.47	Co. Rd. T	No exceedances in three deployments.
Big Creek		**Warmwater Habitat (Existing)**
1.30	Twp. Rd. Q	DO min.: 3.3 (2)[d]; DO avg.: 4.9 (3)[d]
Beaver Creek		**Warmwater Habitat (Existing)**
8.30	Wapakoneta Rd.	DO avg.: 4.9 (5)[b]; 4.8 (16)[c]
2.73	Wintergreen Rd.	No exceedances in three deployments.
Hammer Creek		**Warmwater Habitat (Existing)**
1.34	Co. Rd. H	DO min.: 0.5 (43)[c]; DO avg.: 4.7 (14)[b]; 1.8 (24)[c]
Jackson Cutoff Ditch		**Warmwater Habitat (Existing)**
1.15	Sand Ridge Rd.	DO min.: 1.3 (35)[b]; DO avg.: 2.3 (34)[b]
Little Yellow Creek		**Warmwater Habitat (Recommended)**
0.9	Co. Rd. 2	Sp. conductance: 2,427 (3)[c]
West Creek (Yellow Ck. trib.)		**Warmwater Habitat (Existing)**
0.1	Co. Line Rd.	DO min.: 1.4 (47)[c]; DO avg.: 2.1 (24)[c]
Brush Creek		**Warmwater Habitat (Existing)**
0.58	Custer Rd.	No exceedances in one deployment.
Tontogany Creek		**Warmwater Habitat (Existing)**
1.60	Robinson Rd.	No exceedances in one deployment.
West Branch Tontogany Ck.		**Warmwater Habitat (Recommended)**
3.42	Tuller Rd.	Temperature: 30.4 (6)[a]
Liberty High Road Ditch		**Warmwater Habitat (Recommended)**
0.05	St. Rte. 65	No exceedances in one deployment.

[a] Exceedance during the first sonde deployment, 8/4-7/2015.
[b] Exceedance during the second sonde deployment, 8/12-17/2015
[c] Exceedance during the third sonde deployment, 9/9-11/2015
[d] Exceedance during the third sonde deployment, 9/9-11/2015, but only about half of the DO measurements typical for deployments were made due to probe malfunction.

Table 20 — Exceedances of Ohio Water Quality Standards criteria (OAC 3745-1) for chemical and physical parameters derived from diel, sonde monitoring in 2015. Exceedances are evaluated against existing or recommended aquatic life beneficial uses. Aquatic life beneficial uses can be found in Table 3.

RM	Location	Parameter: extreme value (duration in hours)
North Creek		***Modified Warmwater Habitat (Recommended)***
2.95	Barker Rd.	Temp. max.: 25.7 (2)
2.6	Murphy Rd.	Temp. max.: 26.4 (2)
South Creek		***Modified Warmwater Habitat (Recommended)***
5.42	Gasser Rd.	Temp. max.: 28.3 (2)
South Creek		***Warmwater Habitat (Existing)***
2.08	Victory Rd.	*No exceedances in one deployment.*
Platter Creek		***Warmwater Habitat***
5.4	Fountain Rd.	Temp. max.: 25.2 (4)
Snooks Run		***Warmwater Habitat (Existing)***
0.5	Slough Rd.	D. O. min.: 1.2 (20)
Lost Creek		***Warmwater Habitat (Existing)***
1.30	Co. Rd. 1.30	DO min.: 2.3 (5)
Brinkman Ditch		***Warmwater Habitat***
2.80	Co. Rd. 15	DO min.: 1.9 (9)
2.35	Cr. Rd. H	DO min.: 1.1 (9)
Little Yellow Creek		***Limited Resource Water (Existing)***
4.6	St. Rte. 65	Sp. conductance: 2,751 (10); DO min.: 1.8 (7) [a]
West Branch Tontogany Ck.		***Modified Warmwater Habitat (Recommended)***
3.42	Tuller Rd.	DO min.: 0.2 (12)
West Branch Tontogany Ck.		***Warmwater Habitat (Recommended)***
2.19	Rangeline Rd.	*No exceedances in one deployment.*

[a] Note that Little Yellow Creek at RM 4.6 is designated limited resource waters and is not in the segment being recommended for a beneficial use change. Therefore, this specific conductance value is not an exceedance of water quality criteria. It is only provided to provide insight into the recommended use change for the lower part of this stream, documented elsewhere in this report.

The five temperature exceedances of the general Lake Erie standards occurred in streams that were heavily modified with limited shading. These assessment sites all had modified channels and generally lacked wooded riparian corridors.

Numerous minimum and average DO exceedances were documented at multiple locations throughout the study area (Table 19, Table 20). In some instances, background stressors common to the HELP ecoregion help explain these DO exceedances. The primary natural stressor is low stream gradients which are a result of ***glacial geomorphological processes***. Low gradient streams have limited reaeration and export organic material slowly. They are naturally prone to organic enrichment and additional anthropogenic sources of organic material are poorly assimilated. Anthropogenic sources of organic material include point sources such as municipal wastewater treatment plants and nonpoint source inputs such as wash-off of crop residue or unsewered communities. Internal organic loading occurs through primary (algal) production and is exacerbated by nutrient loadings. In cases of excess primary production, especially when reaeration is limited, exceedances of the water quality criteria for minimum DO are common in the early morning hours. This stressor pattern was exhibited in the following streams: Lost; Garrett; Benien; Van Hyning; School; Dry; Big; Beaver; Hammer; West (trib. to Yellow Creek) creeks; and Jackson Cutoff Ditch. It should be noted that the sonde monitoring of Jackson Cutoff Ditch took place in the pool of a small dam at this assessment site, while the biological monitoring was collected downstream from the impoundment. Low DO stemming from stagnant conditions in this small dam pool stood in stark contrast to the well-developed (and well-aerated) reaches of Jackson Cutoff below this impoundment.

Of those streams, biological impairment occurred at the single sampling location in Lost Creek. Though minimum DO exceedances occurred in Lost Creek during the 2016 deployment, no exceedance occurred during the 2015 deployment. Also, the severity of the 2016 DO exceedances were relatively minor compared to other streams with a more substantial organic signature. Impairment was attributed to a combination of low flows and excessive siltation.

The same organic enrichment processes described above occurred in Snooks Run, though to a more intense degree. DO concentrations recorded during 2016 were below 3.0 mg/l for 20 straight hours and dipped as low as 1.2 mg/l. Concentrations only increased from this low due to an intense precipitation event. Low overall flows were likely exacerbating enrichment issues in this system. Macroinvertebrate community scores from Snooks Run fell short of WWH criteria, despite habitat generally sufficient to support WWH communities. Potential sources of enrichment relative to Snooks Run are displayed in Figure 23.

In some streams, the same background factors that lower DO due to organic enrichment are present, but are greatly exacerbated by diel fluctuations due to primary production. This is the case for the DO minimum exceedances on assessment sites at South Creek, South Turkeyfoot Creek, West Branch Tontogany Creek, and Brinkman Ditch. South Creek also had an average DO exceedance during one sonde survey. Additionally, excessive primary production can also cause diel fluctuations in stream pH due to carbon dioxide consumption for photosynthesis. A pH criteria exceedance in North Turkeyfoot Creek was documented due to this phenomenon. The degree of nutrient enrichment of these assessment sites is more closely examined in the ***Trophic State Evaluation*** portion of this report.

Specific conductance generally met the water quality standards. However, monitoring in Little Yellow Creek found elevated conductance. The site at RM 0.9 (500700) assessed in 2015 is included in the reach being recommended for an aquatic life use upgrade, and with the future upgrade, an exceedance of the water quality standard (2,400 µS/cm) would have been observed. Follow-up survey work in 2016 upstream at RM 4.6 also found elevated conductance in the stream. This information does help confirm that the Leipsic WWTP discharge is the source of this stream's excessive conductance. This facility's discharge (RM 6.4) is only a very short distance upstream from RM 4.6 and is the "start" of Little Yellow Creek. Due to the nature of its waste stream and MOR data, this plant is known to discharge an elevated dissolved solids load.

Weight of Evidence Nutrient Assessment

The purpose of the nutrient assessment in this report is to consider the effect of nutrients on the biological conditions in the local streams. There is considerable concern in the larger western Lake Erie Basin about gross annual and spring phosphorus loads, to which the Maumee River tributaries contribute. There are separate efforts being undertaken by state agencies and international agreements aimed at addressing these issues. While excess nutrients may be sourced from watersheds, they are often effectively transported to the downstream receiving waterbodies without causing localized impairment.

Identification of nutrients as a cause of impairment to aquatic life in streams requires positioning the stream on a trophic gradient. A gradient exists between the autotrophic state and the heterotrophic state (Dodds 2007). Generally, the autotrophic state represents primary production and the heterotrophic state represents respiration. The trophic status is generally split into three categories: oligotrophic; mesotrophic; and eutrophic (Dodds *et al.* 1998). Oligotrophic systems, uncommon in Ohio, are described as having low nutrients, low algal biomass and high clarity. Conversely, eutrophic systems are rich in nutrients, have high algal biomass, and likely have large DO swings. Mesotrophic systems have intermediate characteristics between oligotrophic and eutrophic systems. The transition from oligotrophic to eutrophic generally reflects a system that has shifted from heterotrophic dominance to autotrophic dominance in a process commonly referred to as eutrophication. For the purposes of this evaluation, eutrophication will be defined as the process by which a stream becomes enriched with nutrients, resulting in wide diel DO swings or high chlorophyll-*a* concentrations (USGS 2014). The objective of a trophic status evaluation is to position a stream along the trophic continuum and identify streams that are influenced by over-enrichment.

Ohio and other states have been developing nutrient reduction strategies in recent years to address cultural eutrophication (U.S. EPA 2015, Ohio EPA 2014, Miltner 2010, Heiskary and Markus 2003). Wide diel DO ranges associated with eutrophication are caused by excessive photosynthesis (O_2 production) during daylight hours and respiration 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 conditions in Ohio streams and are likely over-enriched (Ohio EPA 2014).

Chlorophyll-*a* concentrations from benthic algae (attached to bottom substrates) and sestonic algae (suspended in the water column) are both collected. Physical factors such as width-depth ratio, time of travel, and longitudinal gradient may largely determine whether sestonic or benthic algae drive production and respiration. However, sestonic algae typically dominate streams defined as large rivers, and benthic algae typically dominate in smaller streams. Miltner (2010) identified benthic chlorophyll levels that broadly demarcate enrichment status relative to Ohio. Streams with less than ~90 mg/m^2 can be considered least disturbed and atypical for Ohio. Benthic chlorophyll 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 levels exceeding 320 mg/m^2 characterize over-enrichment or nuisance conditions. A review of studies on sestonic chlorophyll-*a* by Dodds (2006), which included some Midwestern streams, suggest that concentrations of 40-100 µg/l sestonic chlorophyll-*a* identify eutrophic conditions while concentrations >100 µg/l indicate hyper-eutrophic conditions.

Nutrient concentrations/loadings, alone, are not a reliable indicator of over-enriched conditions within a given stream system. As previously discussed, excess nutrients beyond what can be adequately assimilated within that stream system are often transported downstream to receiving waterbodies. Thus, impacts stemming from excessive nutrient inputs into a stream (diel DO swings) may not be fully manifested immediately within that system. However, elevated nutrient concentrations and loadings can help elucidate sources contributing to nutrient enrichment in larger receiving waterbodies (Lake Erie) or aid in assessing the potential for more localized enrichment impacts in that water body. Ultimately, elevated nutrient concentrations/loadings within a stream system increases the risk of eutrophication in these streams, but alone, do not serve to identify eutrophic conditions. Because of this, Ohio EPA has not adopted nutrient concentrations into rule as WQS criteria.

Seasonality is an important consideration when examining eutrophication. Two factors influencing eutrophication are related to seasonality: light availability and temperature. When streams are turbid due to storm events, light penetration is not adequate to allow enough production of algae to cause eutrophic conditions. Dodds (2006) documents streams experiencing eutrophication in late spring/early summer before leaf canopy shades a stream. Then those same streams have drops in algal production, ameliorating the deleterious effect of excess nutrients once the canopy shades the stream channel. Streams that are of sufficient width or lack a wooded riparian due to anthropogenic management practices (channelization) do not have adequate canopy coverage to subdue photosynthetic primary production. Photosynthesis is a chemical reaction that is impacted by temperature; however, the kinetics are complicated because they involve biological organisms that have optimal temperature ranges as well. Dauta et al. (1990) examined four freshwater algae species and found maximal growth at 25 – 30° C and a reduction in growth to the point of being insignificant around 10° C. These factors complicate the definition of a critical time-period for monitoring algae as indicators of eutrophication. However, DO is most impacted during summer low flows due to warmer temperatures and limited reaeration. While this may not always correspond to maximum algal biomass, Ohio EPA typically samples chlorophyll-*a* and diel DO at the same time. The advantage of coupling the two sampling efforts is that the algae sampled represent the productivity reflected in the diel DO regime. In addition, while DO and chlorophyll-*a* sampling benchmarks low-flow critical conditions, ideal conditions are not always achieved. If conditions during a survey are less than ideal, an additional sampling event is often planned to capture low flow conditions.

Ohio EPA designates nutrient sites where benthic and/or sestonic chlorophyll-*a* concentrations and diel DO ranges are monitored. These sites coincide with grab sampling for chemistry, which are then used to characterize the seasonal nutrient availability. In the Maumee River tributaries study area, this consisted of 42 locations where sondes were deployed in and the algal community was sampled. A sonde failure occurred at one of these sites and no DO range data is available. Due to limitations of sampling methods for benthic chlorophyll-*a*, which requires coarse substrates be collected and algae scraped off, only 26 of these sites have an associated benthic chlorophyll-*a* sample. Attempts were made to collect the sonde and benthic algae data during summertime, low-flow critical conditions. Some sites were monitored more than once to verify results. Shifting weather conditions affecting the critical condition also required repeated monitoring.

Three principal surveys were completed to assess the trophic conditions in the Maumee River tributary study area in the 2015 survey year. Most assessments involve deploying the sonde for a 48-hour period in a three-day survey. The benthic algae sample, and often additional water quality samples, were collected at some point during that three-day survey. The first assessment occurred on August 4-5. Due to resource logistics, the second survey involved deploying the sondes over a weekend covering August 12-16. Algal samples were collected during the last two days of that survey. The third assessment occurred on September 9-11.

At the end of the 2015 survey year, preliminary data review determined that trophic indicator data was needed at 12 additional assessment sites that were not included in the three initial surveys. Sonde data from these sites were measured on June 14-15, 2016. Heavy precipitation fell on June 15, 2016 forcing field staff to pull the sonde equipment early during that survey. The resulting rapidly increasing stream flows prevented sampling of benthic algae at most of these sites and sestonic algae from all sites during this survey.

The data collected during these four surveys are compiled on Figure 42 through Figure 46. Assessment sites are shown as vertical bin within each figure. These summary figures represent the potential of primary production. For each assessment site, a DO box plot shows the period with the largest diel (24-hours) range of the sonde data. The box plots identify the minimum, maximum, average, median, 75th percentile and 25th percentile of concentration values measured. Summary plots from all sonde deployments are included in Appendix E. The benthic and/or sestonic chlorophyll-*a* sample results are shown if they were measured during each survey. Instream nutrient concentrations are also considered as a contributing factor for assessing the trophic status. The total phosphorus and dissolved inorganic nitrogen (DIN) sample concentration results from the 2015 assessment period (May-October) are shown. A symbol indicates the geometric mean of these parameters.

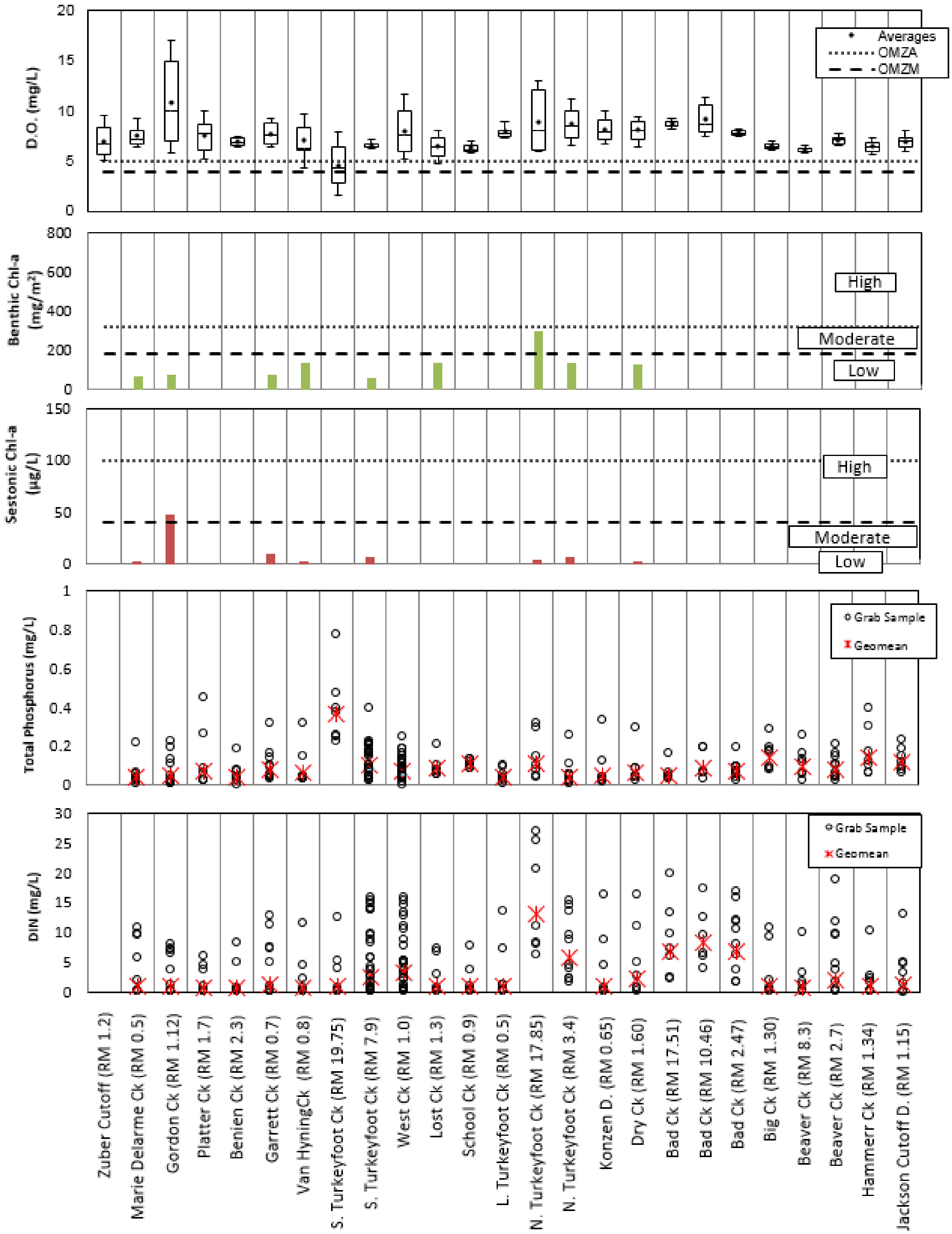

Figure 42 — Representation of DO, benthic/sestonic chlorophyll-a, TP, and nitrate-nitrite concentrations considered for a trophic assessment for streams within the study area. Relevant standards for DO and benchmarks for chlorophyll-a concentrations (Dodds 2006, Miltner 2010, Ohio EPA 2014) are presented within their respective plots. The dissolved oxygen and chlorophyll-a data were collected from Aug. 4-6, 2015. Chemistry grab samples are from the period of May 1 – Oct. 31, 2015.

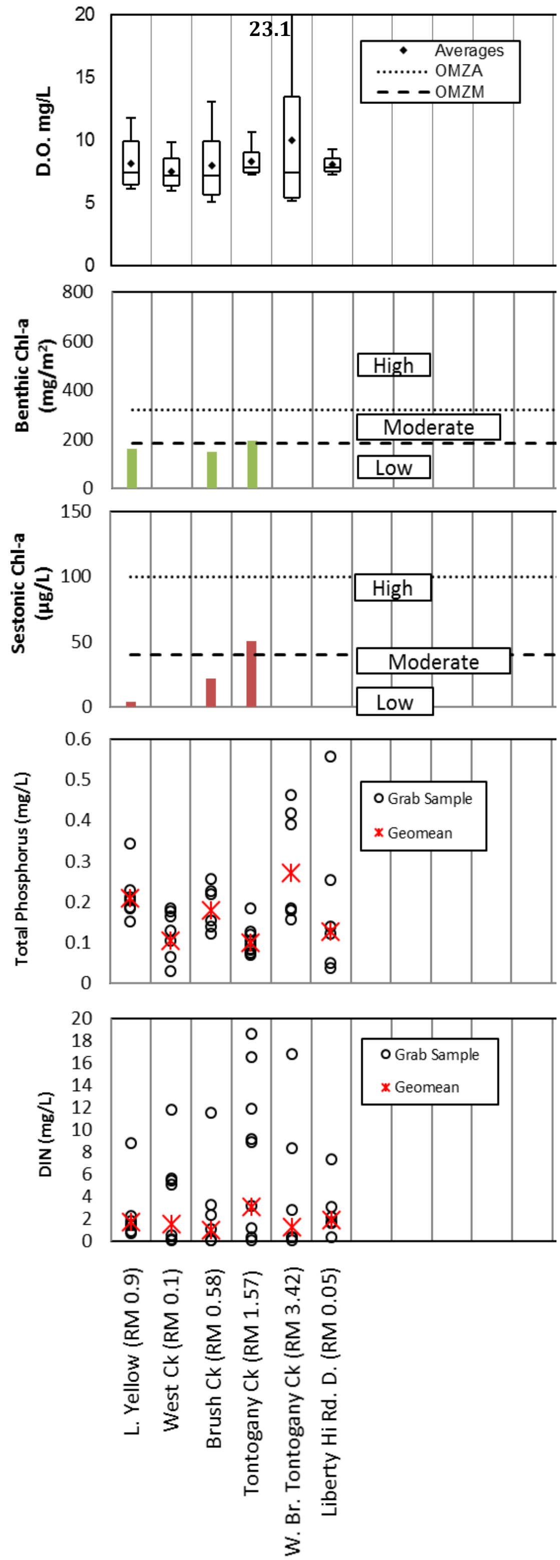

Figure 43 — Representation of DO, benthic/sestonic chlorophyll-a, TP, and nitrate-nitrite concentrations considered for a trophic assessment for streams within the study area. Relevant standards for DO and targets for chlorophyll-a concentrations (Dodds 2006, Miltner 2010, Ohio EPA 2014) are presented within their respective plots. The dissolved oxygen and chlorophyll-a data were collected from Aug. 4-6, 2015. Chemistry grab samples are from the period of May 1 – Oct. 31, 2015.

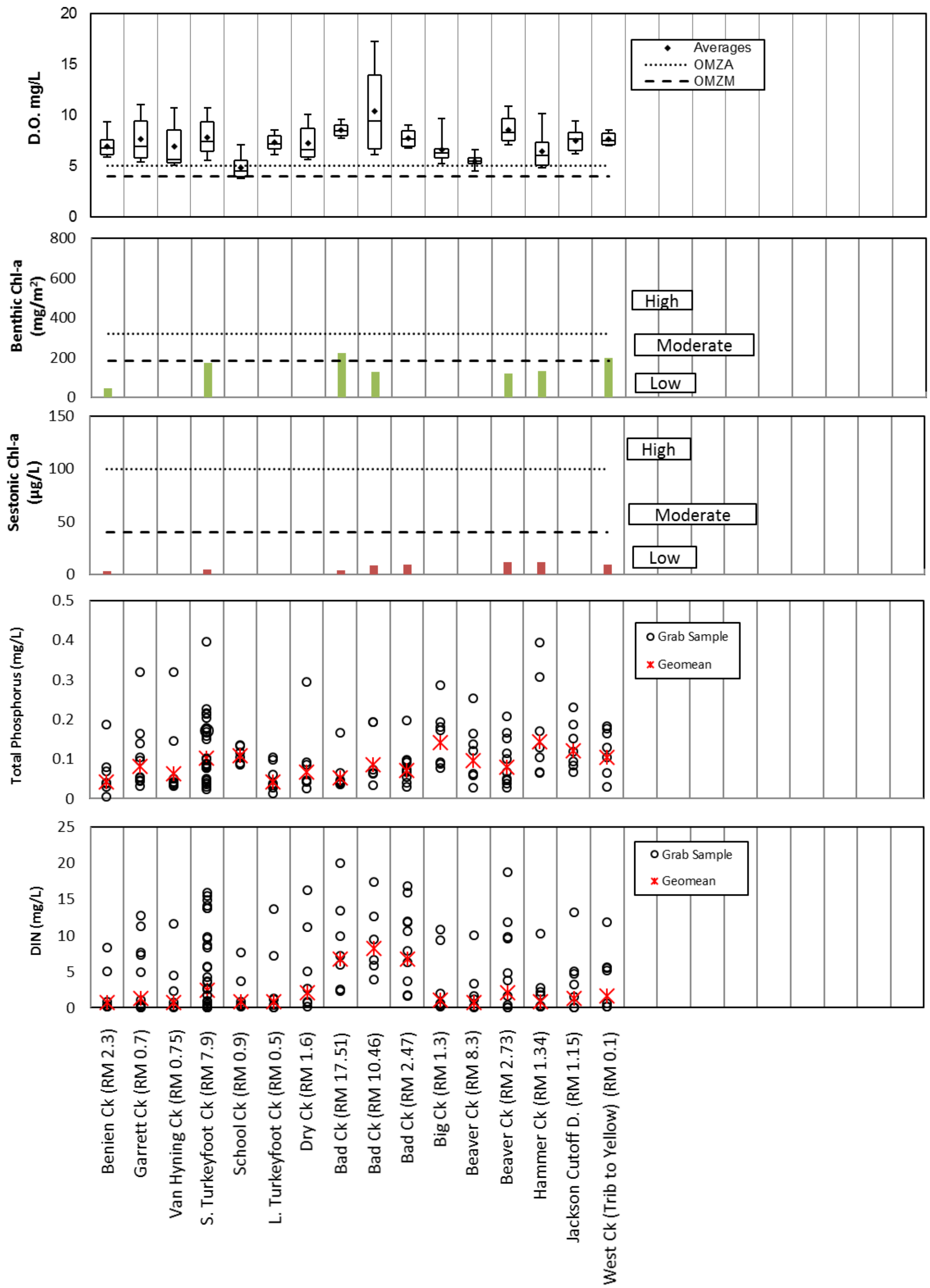

Figure 44 — Representation of DO, benthic/sestonic chlorophyll-a, TP, and nitrate-nitrite concentrations considered for a trophic assessment for streams within the study area. Relevant standards for DO and targets for chlorophyll-a concentrations (Dodds 2006, Miltner 2010, Ohio EPA 2014) are presented within their respective plots. The dissolved oxygen and chlorophyll-a data were collected from Aug. 12-16, 2015. Chemistry grab samples are from the period of May 1 – Oct. 31, 2015.

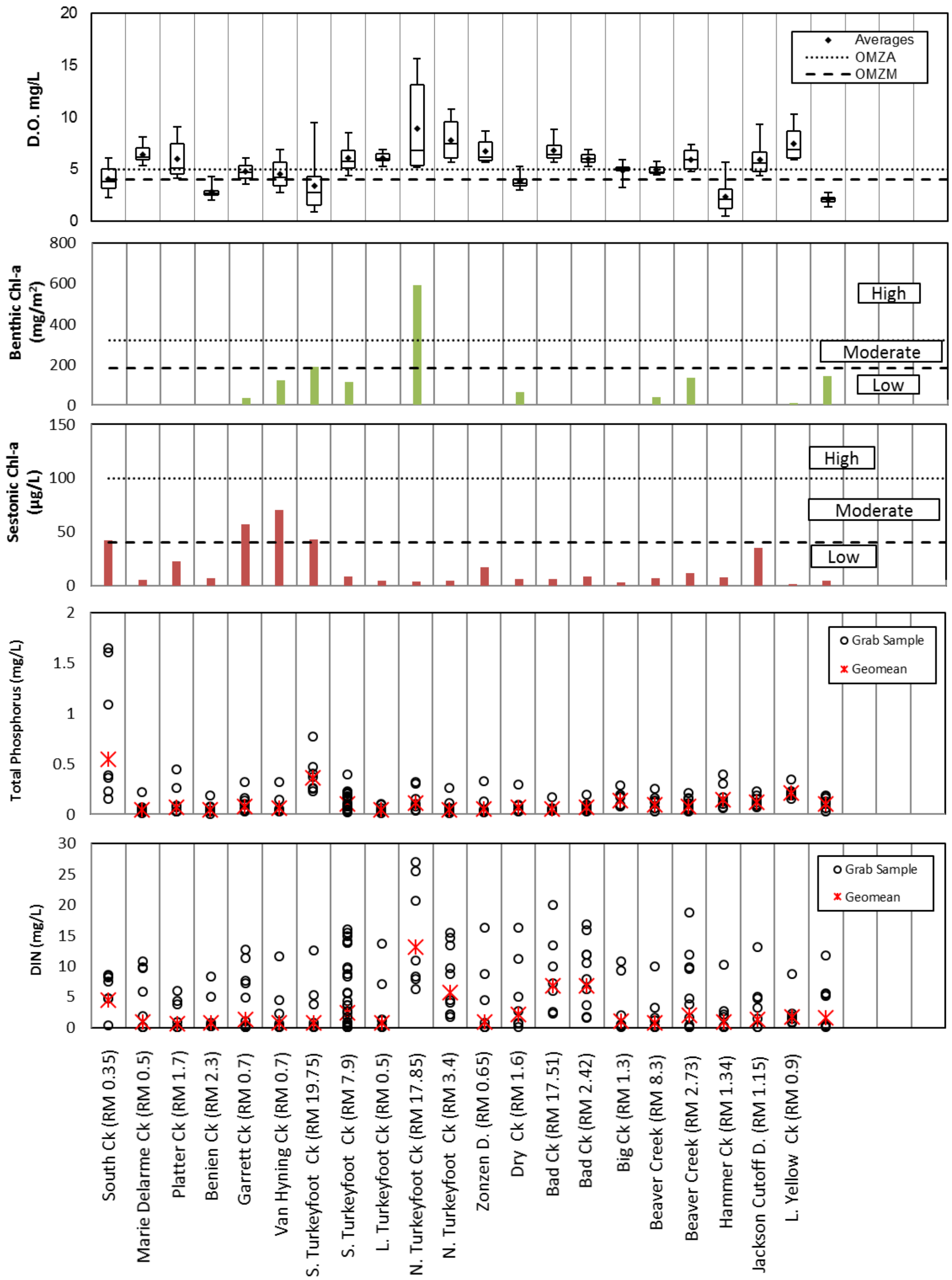

Figure 45 — Representation of DO, benthic/sestonic chlorophyll-a, TP, and nitrate-nitrite concentrations considered for a trophic assessment for streams within the study area. Relevant standards for DO and targets for chlorophyll-a concentrations (Dodds 2006, Miltner 2010, Ohio EPA 2014) are presented within their respective plots. The dissolved oxygen and chlorophyll-a data were collected from Sept. 9-11, 2015. Chemistry grab samples are from the period of May 1 – Oct. 31, 2015.

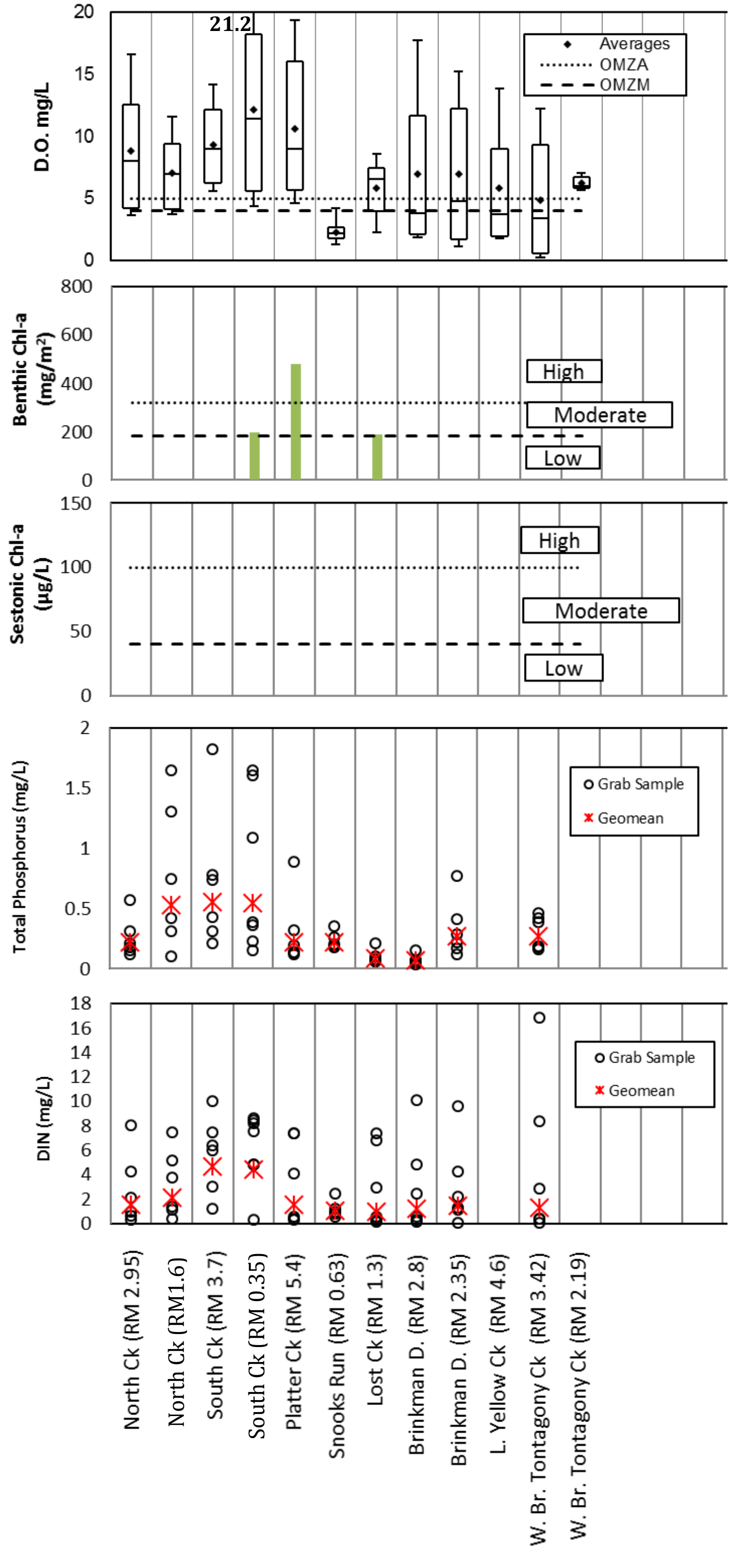

Figure 46 — Representation of DO, benthic/sestonic chlorophyll-a, TP, and nitrate-nitrite concentrations considered for a trophic assessment for streams within the study area. Relevant standards for DO and targets for chlorophyll-a concentrations (Dodds 2006, Miltner 2010, Ohio EPA 2014) are presented within their respective plots. The dissolved oxygen and chlorophyll-a data were collected from June 14-15, 2016. Chemistry grab samples are from the period of May 1 – Oct. 31, 2015.

A weight of evidence approach was used to determine: 1) if nutrient enrichment caused or contributed to observed impairments to aquatic life ***OR*** 2) the potential for enriched conditions to lead to future impairments to aquatic life in those areas not impaired during the current survey. This approach primarily considers the attainment status of aquatic life in conjunction with the primary indicators of nutrient enrichment, namely diel DO and algae communities. Additionally, biological performance scores relative to instream habitat conditions and historical sampling efforts (if available) were considered. Other system stressors were also considered to identify situations where, even in the presence of nutrient over-enrichment, nutrient controls will not result in improvement to the aquatic life. Table 22 summarizes relevant data used to make these determinations.

Diel DO ranges and benthic chlorophyll-*a* concentrations are the primary indicators of eutrophication. If both indicators exhibit an elevated range, there is strong evidence that the stream is exhibiting an advanced eutrophic state. If one or the other indicator is in an elevated range there is evidence of a system imbalance, but it is less conclusive regarding a eutrophic state. Some of the reasons for inconclusive results could be less than ideal sampling conditions or one sample misrepresenting the total character of the stream. For that reason, several assessment sites on Table 21 show the DO range and benthic chlorophyll-*a* sampling result from more than one sonde deployment. After the two indicators identify the location of the stream on the trophic spectrum, nutrient concentrations in the stream are evaluated. The response to excess nutrients varies from stream to stream so using nutrient concentrations as an assessment endpoint is not always effective. However, elevated nutrients that co-occur with high chlorophyll levels and wide DO swings demonstrate that the nutrient load is not being adequately assimilated, and an increased risk of harm from eutrophication exists. Sites are assessed following this logic and those demonstrating eutrophication are identified.

If sampling locations displayed biological impairment in conjunction with one or more eutrophication indicators above levels of concern, then nutrient enrichment is or is likely causing or contributing to the observed impairment. However, the presence of eutrophication signatures does not necessarily assure that locations will be considered impaired due to nutrient enrichment. In situations where biological indices (IBI, MIwb, ICI) are consistent with ecoregional and aquatic life use expectations, but nutrient enrichment signatures are present, additional factors related to fish and macroinvertebrate community performance are considered. In this circumstance, biological community indices and characteristics of macroinvertebrate communities (EPT taxa) are further examined to determine if biological performance underperformed relative to existing instream habitat quality (QHEI). Biological communities are also examined to determine if there are declining trends in performance through time. Together, these factors are regarded in conjunction with enrichment signatures to determine the potential for future impairment to aquatic communities stemming from nutrient enrichment.

In the survey area, 15 of 42 locations had diel DO ranges that fell into the elevated range (>6.5 mg/l). Five of those 15 sites have an associated benthic chlorophyll-*a* sample that also exceeded the benchmark, reflecting an elevated condition. However, many sites did not have enough coarse substrates to collect a benthic chlorophyll-*a* sample using Ohio EPA's collection methodology. Where benthic chlorophyll could not be sampled, elevated algal production was likely present and driving the elevated diel DO range at the remaining sites, which is often corroborated with visual observations in the field. Additionally, three sites exceed the benthic algae benchmark, but elevated DO ranges were not documented.

Summaries of relevant information from locations assessed are discussed in further detail below and in Table 21.

Zuber Cutoff sub-basin

Fish community performance fell short of HELP WWH criteria in Zuber Cutoff and only marginally met at both locations in North Creek (Figure 52). Fish community performance in South Creek fully met HELP WWH criteria before the kill event in 2015 and after the event in 2016. Though meeting criterion in 2016, fish community quality had declined substantially compared to pre-kill conditions in 2015 and still showed signs of recovery from the event. Since 1997, fish community performance has declined in Zuber Cutoff and has remained in the poor range in upper North Creek (Table 28). Macroinvertebrate communities fell short of HELP WWH expectations at all five locations in North and South Creek (Table 2) and community performance in North Creek has declined since 1997.

Nutrient enrichment signatures were documented throughout the Zuber Cutoff sub-basin, with diel DO swings as high as 16.9 mg/l and 7.9 mg/l in lower South and North Creeks, respectively (Figure 46). Though no direct diel DO or chlorophyll-*a* concentrations were collected from either North Creek RM 0.3 (303746) or Zuber Cutoff RM 1.1 (P06K13), it would be reasonable to expect enrichment signatures documented a very short distance upstream in these systems extended downstream to these locations. Habitat quality was also generally deficient throughout much of the upper stream reaches evaluated (poor development, deficient riparian area, etc.) and was among the worst quality of all locations in the study area (Figure 49). High-influence negative habitat attributes were pervasive throughout the upper reaches of this sub-watershed (Appendix F). Poor habitat quality ultimately decreases instream assimilative capacity and these conditions likely exacerbated nutrient enrichment issues within this relatively small sub-watershed.

Potential sources of nutrients in this small watershed are numerous and pervasive. The land use within the small sub-watershed is primarily row crop agriculture and largely has not changed through decades preceding the 2015 survey. The construction of several permitted animal feeding facilities since biological sampling last occurred in 1997 has had both direct (kill event) and likely indirect impacts (manure application and runoff to streams) on water quality and biological performance in this small sub-watershed (Figure 23).

Additionally, North Creek and subsequently lower South Creek and Zuber Cutoff also receive effluent from the Antwerp WWTP, which has no nutrient removal technology or permit limits. North Creek exceeded the TP WWH benchmark throughout, with values downstream of the Antwerp WWTP being higher than those found upstream (Figure 24). Already over-enriched conditions existed upstream from the Antwerp WWTP and nutrient inputs from this facility likely exacerbated enriched conditions.

While habitat quality may have played a role in limiting biological performance in areas within this sub-basin, nutrient enrichment issues is this small sub-watershed were still evident and were undoubtedly contributing to documented impairments throughout this sub-watershed. Habitat quality should be sufficient to support biological communities consistent with WWH expectations in South Creek RM 0.35, North Creek RM 0.3, and Zuber Cutoff RM 1.1. Fish communities from Zuber Cutoff met WWH criteria in 1997 (Table 28).

Brinkman Ditch

Macroinvertebrate community performance fell short of WWH expectations both up (RM 2.8, P09K11) and downstream (RM 2.35, P09W17) from this facility in 2015, but marginally met upstream from the facility in 2016 despite evidence of over-enriched conditions (Figure 46). Macroinvertebrate community performance at RM 2.35 has declined since 1997. Fish community performance met criterion both up and downstream from this facility.

Brinkman Ditch at RM 2.35 (P09W17) was identified as having nutrient enrichment as the sole cause of impairment. This site is situated downstream from the Holgate WWTP, a controlled discharge lagoon. Field evidence of episodic discharges from this facility (Figure 18, Figure 19) were confirmed with the self-reported DMRs from the facility. Diel sonde monitoring from 2016 indicated over-enriched conditions both up and downstream from this facility (Figure 46), with observed DO swings as large as 15.9 mg/l and 14.09 mg/l, respectively. Inputs from this facility likely exacerbated already over-enriched conditions in this small stream. Somewhat better habitat quality was noted upstream at RM 2.8 compared to RM 2.35 (Table 25). Habitat quality alone, however, should not preclude biological communities from fully attaining criteria at the downstream locations, as other area stream reaches with similar habitat quality fully attained ecoregional expectations. Nutrient enrichment was likely the primary cause of impairment to biological communities downstream from the Holgate WWTP. Nutrient enrichment also appeared to cause undue stress to these communities upstream from this facility, even before the additions of nutrient rich wastewater (Table 21).

Platter Creek

Biological communities in Platter Creek fell short of HELP WWH criteria at RM 5.4 in 2016. Nutrient enrichment signatures were evident at RM 5.4, but appear adequately attenuated longitudinally, as signatures were not elevated at RM 1.7 (Table 21).

Habitat quality throughout the upper reaches of Platter Creek was in the poor range, however, did not preclude attainment of biological communities at RM 6.4 (upstream from unsewered community). Biological communities fell short of both WWH and MWH-C criteria at RM 7.95 and intermittent to nearly dry conditions in 2016 precluded attainment at this location. Continuous flow was observed at RM 5.4 in 2016, though habitat quality was in the poor range here. Though limiting habitat features may be present throughout these reaches of Platter Creek, strong enrichment signatures coupled with communities in full attainment upstream at RM 6.5 suggest that factors in addition to habitat contributed to observed impairment. Poor habitat quality, though, at RM 5.4 (poor development, deficient riparian area, etc.) likely exacerbated enrichment present at this location.

Potential sources of nutrients within this small sub-watershed included an unsewered community, several large animal feeding operations, and other nonpoint source agricultural runoff.

Potential for future, nutrient-derived impairment to aquatic life

Table 21 additionally identifies other locations throughout the study area where biological communities were fully attaining applicable criteria and both diel sonde monitoring and chlorophyll-*a* samples were collected, or for which collection attempts were made. These locations were evaluated for the potential for future nutrient-derived impairments to aquatic life using the process described above.

Aside from locations in stream systems already addressed in the above sub-sections, nine additional locations fully attaining the ALU, but displaying nutrient enrichment signatures were evaluated for the potential for future, nutrient-derived impairments to aquatic life. These are locations that were fully attaining ecoregional criteria, but displayed elevated nutrient enrichment signatures. These sites are orange shaded in Table 21; factors considered are also discussed within this table.

Biological community performance at eight of these nine locations displayed a stable or improving trajectory relative to historical sampling efforts. Where applicable, stable or improving biological performance was documented downstream from these locations and enrichment signatures were adequately attenuated longitudinally (Table 21). Thus, the potential for near-term impairments to aquatic life at and downstream from these locations is comparatively low and not likely.

Of these nine locations in streams displaying elevated enrichment signatures, only North Turkeyfoot Creek displayed declines in biological community performance relative to historical sampling efforts in 1997. Overall trends in ***macroinvertebrate community performance throughout North Turkeyfoot Creek*** were mixed. Macroinvertebrate community performance has improved immediately up and downstream from the Wauseon WRF. However, community performance from the lower 16 miles of North Turkeyfoot Creek has declined from 1997 to 2015. The lower three sampling locations in 1997 scored ICIs of 50 or more, an average of 10 points higher compared to the 2015 results (Figure 75). Decreases in macroinvertebrate community performance appeared more related to far-field enrichment impacts than near-field toxicity impacts related to poorly treated effluent (**Error! Reference source not found.** - Figure 78). ***Fish community performance*** has actually improved throughout since 1997 but appeared more related to basin-wide recovery seemingly realized through modern tillage practices and the diminution of excessive silt loads to streams (Figure 61). However, the fish community immediately downstream from the Wauseon WRF (RM 17.85, P09S04) was anomalous compared to other sampling locations in North Turkeyfoot Creek (Figure 60) and appears to have reflected the *highly* enriched conditions documented at this specific location (Table 21).

North Turkeyfoot Creek receives effluent from the Wauseon WRF at RM 18.6. The average daily design flow for this facility is 1.5 MGD. Given the drainage area of North Turkeyfoot Creek upstream from the Wauseon WRF discharge (5.5 mi^2), the plant dominates stream baseflow, especially during low-flow conditions in the summer. Nutrient concentrations displayed distinct longitudinal patterns in North Turkeyfoot Creek. DIN concentrations spiked significantly downstream from the Wauseon WRF and the geometric mean was above 95^{th} percentile of reference concentrations (Ohio EPA 1999) throughout the remainder of North Turkeyfoot Creek (Figure 21). Total phosphorus concentrations also spiked downstream from the Wauseon WRF, but was utilized quickly longitudinally (*Figure 22*, Table 14). Given the general habitat stressors present in this system (reduced riparian shading, simplified stream habitat stemming from channelization, etc.) and over-abundance of DIN, it was not surprising to see both available instream TP concentrations utilized so quickly longitudinally and DIN concentrations remain highly elevated through RM 3.4.

Corresponding nutrient enrichment signatures including elevated diel DO ranges (11.16 mg/l) and highly elevated benthic chlorophyll-*a* concentrations (593 mg/m^2) were well-documented downstream from the

Wauseon WRF at RM 17.85 (Figure 45). Additionally, a pH exceedance documented at this location was further evidence of over-enriched conditions (Table 19). The was the only pH exceedance documented during the survey. Though no sonde or chlorophyll-*a* samples were collected between RM 17.85 to RM 3.4, several DO grab samples at RM 9.67 (P09K12) were elevated, with a single afternoon concentration as high as 16.2 mg/l recorded. Several chemistry grab samples from RM 9.67 also revealed DO supersaturation ranging from 142-200 percent. The absence of elevated nutrient enrichment signatures at RM 3.4 suggests that instream, over-enriched conditions did not extend downstream to this sampling location (Table 21).

The Wauseon WRF has permit limits to treat TP and only had one permit limit violation during 2015. The annual nitrate-nitrite loadings from the Wauseon WRF have remained relatively steady, however, annual discharge concentrations were high (Figure 8). Despite permit limits already in place, this facility still supplies ample phosphorus to fuel algal growth in low-flow conditions. If declining trends in macroinvertebrate community performance continue, future nutrient-derived impairments may arise.

The near-adjacent Bad Creek sub-watershed (*Figure 4*) provided a good comparison sub-basin because of several attributes common to both systems. North Turkeyfoot Creek (74.9 mi^2) and Bad Creek (64.7 mi^2) are similar in drainage area at their confluence with the Maumee River and share many of the same physiographic features (Figure 5, Figure 6). Habitat quality was very similar between these systems. The *bank erosion and riparian condition* metric trended slightly better in Bad Creek, but application of Wilcoxon-Mann-Whiney non-parametric treatment suggest differences were not statistically significant ($p=0.28$). DIN and TP concentrations and the longitudinal uptake pattern of these nutrients were somewhat similar in both sub-watersheds, with both systems displaying highly elevated DIN concentrations throughout and available TP being utilized quickly (Figure 21, Figure 22).

Additionally, municipal wastewater systems discharge to both sub-basins. The Delta WWTP discharges to Bad Creek and is about half of the daily design capacity of the Wauseon WRF (0.725 MGD vs. 1.5 MGD). Additionally, more drainage area lies upstream from the Delta facility (41.6 mi^2) than does the Wauseon facility (5.5 mi^2), providing more dilution overall for the former. The size of each facility coupled with its placement longitudinally within these sub-basins may help explain why declines in macroinvertebrate community performance were only documented in North Turkeyfoot Creek, despite enrichment signatures being recorded downstream from both facilities (Table 21).

Table 21 — Weight of evidence summary table used to assess potential for nutrient enrichment. Biological conditions presented in the table are discussed more thoroughly in the Fish and Macroinvertebrate Community Overview portions of this document. See footnote for color-coding.

Stream RM	Aquatic Life Attain. Status	Exceed DO bench-mark? (Range)[A]	Exceed Benthic Chlorophyll benchmark? (conc.)[B]	Sestonic Chlorophyll (conc.)	Potential for future impairment to aquatic life related to nutrient enrichment?	Are stressors other than nutrients responsible for biological non-attainment?	Nutrient Geomean TP (Conc.) DIN (Conc.)
Zuber Cutoff 1.1	PARTIAL	No sonde data at this specific location. Sonde data from upstream sites suggests nutrient enrichment likely causing or contributing to impairment.				Yes. Fish community was still recovering from documented kill event. However, habitat was sufficient to support WWH community and well-documented enrichment impacts immediately upstream may hinder or preclude full recovery from kill.	Not collected
North Creek 2.9	PARTIAL	**Yes (13.0)**	Unable to collect	Not collected	-	Yes. Habitat, but nutrient stressors must be addressed to restore biological condition.	TP (0.22) DIN (1.52)
North Creek 1.6	FULL	**Yes (7.9)**	Potential (14.8, but Pheophytin-a of 147.0)	Not collected	Possible. Biological performance fell short of WWH criterion, but met the recommended MWH-C criteria. Fish community performance has remained in the poor range since sampled in 1997.	Yes. Habitat, but nutrient stressors must be addressed to restore biological condition.	TP (0.53) DIN (2.10)
North Creek 0.3	PARTIAL	No sonde data at this specific location. Sonde data from upstream sites suggests nutrient enrichment likely causing or contributing to impairment.				No. Habitat quality better than upstream and should be sufficient to support WWH communities.	Not collected
South Creek 3.7	PARTIAL	**Yes (8.6)**	Unable to collect	Not collected	-	Yes. Habitat, but nutrient stressors must be addressed to restore biol. condition.	TP (0.55) DIN (4.67)
South Creek 0.35	PARTIAL	**Yes (16.9)**	**Yes (199)**	Not collected	-	Yes - a fish kill. However, nutrient stressors must be addressed to restore biol. condition.	TP (0.54) DIN (4.45)
Marie DeLarme 0.5	FULL	No (2.78)	No (65.9)	3.0	Not likely. Biological performance has improved since historical sampling. Nutrient enrichment signatures not elevated.	-	TP (0.04) DIN (0.98)
Gordon Creek 1.1	FULL	**Yes (11.3)**	No (74.8)	47.8	Not likely. Biological community performance met expectations relative to instream habitat and has improved relative to historical data.	-	TP (0.05) DIN (0.95)

Stream RM	Aquatic Life Attain. Status	Exceed DO bench-mark? (Range)[A]	Exceed Benthic Chlorophyll benchmark? (conc.)[B]	Sestonic Chlorophyll (conc.)	Potential for future impairment to aquatic life related to nutrient enrichment?	Are stressors other than nutrients responsible for biological non-attainment?	Nutrient Geomean TP (Conc.) DIN (Conc.)
Platter Creek 5.4	PARTIAL	**Yes (14.8)**	**Yes (482)**	Not collected	-	Yes. Habitat, but nutrient stressors must be addressed to restore biol. condition.	TP (0.22) DIN (1.56)
Platter Creek 1.7	FULL	No (4.88)	No (22.1)	Not collected	Not likely. Biological communities were fully attaining criteria. Fish community has improved since 2001. Nutrient enrichment signatures were not elevated. Nutrient concentrations attenuated longitudinally along Platter Creek.	-	TP (0.07) DIN (0.70)
Snooks Run 0.63	PARTIAL	No (2.99)	Unable to collect	Not collected	-	Organic enrichment.	TP (0.22) DIN (1.03)
Benien Creek 2.3	FULL	No (3.46)	No (45.7)	2.9	Not likely. Biological communities were fully attaining criteria. Nutrient enrichment signatures not above elevated thresholds.	-	TP (0.04) DIN (0.73)
Garrett Creek 0.7	FULL	No (2.85) (2.51)	No (75.6) (36.7)	9.2 57.0	Not likely. Biological communities were fully attaining criteria. Nutrient enrichment signatures not above elevated thresholds.	-	TP (0.08) DIN (1.28)
Van Hyning Creek 0.75	FULL	No (5.42) (4.15)	No (135.0) (124.0)	2.9 70.4	Not likely. Biological communities were fully attaining criteria. Nutrient enrichment signatures not above elevated thresholds.	-	TP (0.06) DIN (0.76)
South Turkeyfoot 19.75	FULL	**Yes (8.59)**	**Yes (191)**	42.8	Not likely. Biological communities were fully attaining criteria. Fish community has improved throughout South Turkeyfoot Creek, while macroinvertebrate community performance was stable or improved. Nutrient enrichment signatures attenuated longitudinally along the stream.	Organic influences. Though diel DO range elevated, it is also generally depressed relative to other areas displaying elevated ranges. Likely resulted from generally deep, pooled condition at this location.	TP (0.36) DIN (0.81)
South Turkeyfoot 7.9	FULL	No (4.12)	No (113.0)	8.3	Not likely. Biological communities were fully attaining criteria and were stable or improved in throughout stream. Nutrient enrichment signatures were not elevated. Enrichment signatures documented upstream adequately attenuated.	-	TP (0.10) DIN (2.39)
West Creek 1.0	FULL	**Yes (6.55)**	Unable to collect	Not collected	Not likely. Biological communities exceeded ecoregional criteria. Fish community performance has improved since 2002.	-	TP (0.07) DIN (3.28)

Stream RM	Aquatic Life Attain. Status	Exceed DO bench-mark? (Range)[A]	Exceed Benthic Chlorophyll benchmark? (conc.)[B]	Sestonic Chlorophyll (conc.)	Potential for future impairment to aquatic life related to nutrient enrichment?	Are stressors other than nutrients responsible for biological non-attainment?	Nutrient Geomean TP (Conc.) DIN (Conc.)
Lost Creek 1.3	PARTIAL	No (6.32)	**Yes (190.0)**	Not collected	-	Low flows and siltation. Diel DO swings were below elevated threshold, while benthic chlorophyll-*a* was low to moderate in two sonde deployments. Causes other than nutrient enrichment were likely primarily responsible for impairment.	TP (0.09) DIN (0.98)
School Creek 0.9	FULL	No (3.35)	Unable to collect	Not collected	Not likely. Biological communities were fully attaining criteria. Nutrient enrichment signatures were not elevated.	-	TP (0.11) DIN (0.86)
Brinkman Ditch 2.8	FULL	**Yes (15.9)**	Unable to collect	Not collected	Possible. Large diel DO swings were observed. Biological performance met criteria, though macroinvertebrate community performance only marginally met. Biological performance was consistent with expectations relative to instream habitat. Fish community was stable to improving throughout Brinkman Ditch, while macroinvertebrate communities were somewhat stable upstream from Holgate WWTP, but have declined downstream relative to historical sampling.	-	TP (0.07) DIN (1.19)
Brinkman Ditch 2.35	PARTIAL	**Yes (14.09)**	Unable to collect	Not collected	-	No. Nearby sampling locations of similar size with similar instream habitat were fully meeting criteria.	TP (0.27) DIN (1.45)
L. Turkeyfoot Creek 0.5	FULL	No (2.44)	Unable to collect	Not collected	Not likely. Biological communities were fully attaining criteria. Nutrient enrichment signatures were not elevated.	-	TP (0.04) DIN (0.84)

Stream RM	Aquatic Life Attain. Status	Exceed DO bench-mark? (Range)[A]	Exceed Benthic Chlorophyll benchmark? (conc.)[B]	Sestonic Chlorophyll (conc.)	Potential for future impairment to aquatic life related to nutrient enrichment?	Are stressors other than nutrients responsible for biological non-attainment?	Nutrient Geomean TP (Conc.) DIN (Conc.)
N. Turkeyfoot Ck. 17.85	FULL	**Yes (10.53)**	**Yes (593)**	3.9	Possible. Biological community performance met criteria and was consistent with available instream habitat, despite elevated diel DO ranges and highly elevated benthic chl.-a. Macroinvertebrate community performance has improved immediately up and downstream from the Wauseon WRF, but has declined at further downstream locations compared to sampling in 1997. Signatures from macroinvertebrate community suggest instream conditions have become more enriched since 1997. Fish community performance has generally improved throughout North Turkeyfoot Creek, though was anomalous at this location.	-	TP (0.11) DIN (13.08)
N. Turkeyfoot Ck. 3.4	FULL	No (4.7)	No (132)	7.3	Not likely. Though declines in macroinvertebrate community performance were evident, biological communities still firmly met ecoregional criteria at this location. Nutrient enrichment signatures not elevated.	-	TP (0.04) DIN (5.73)
Konzen Ditch 0.65	FULL	No (3.05)	Unable to collect	16.6	Not likely. Biological communities were fully attaining criteria and have improved substantially over historical samples. Nutrient enrichment signatures not elevated.	-	TP (0.05) DIN (0.89)
Dry Creek 1.6	FULL	No (2.95)	No (128)	2.7	Not likely. Biological communities were fully attaining criteria and fish community performance improved dramatically since 1997. Nutrient enrichment signatures were not elevated.	-	TP (0.07) DIN (2.10)
Bad Creek 17.51	FULL	No (1.88)	**Yes (223)**	3.3	Not likely. Biological communities were fully attaining criteria. Nutrient enrichment signatures were not elevated.	-	TP (0.05) DIN (6.79)
Bad Creek 10.46	FULL	**Yes (11.16)**	No (128)	8.4	Not likely. Despite elevated diel DO ranges, biological communities were fully attaining criteria and performance was stable or improved since 1997. Enrichment signatures were adequately attenuated along length of Bad Creek; DO ranges were not elevated at downstream locations.	-	TP (0.09) DIN (8.27)
Bad Creek 2.47	FULL	No (2.32)	Unable to collect	9.1	Not likely. Though slight declines in macroinvertebrate community performance were evident at this location, biological communities still firmly met ecoregional criteria. Nutrient enrichment signatures documented upstream were seemingly attenuated.	-	TP (0.07) DIN (6.78)

Stream RM	Aquatic Life Attain. Status	Exceed DO bench-mark? (Range)[A]	Exceed Benthic Chlorophyll benchmark? (conc.)[B]	Sestonic Chlorophyll (conc.)	Potential for future impairment to aquatic life related to nutrient enrichment?	Are stressors other than nutrients responsible for biological non-attainment?	Nutrient Geomean TP (Conc.) DIN (Conc.)
Big Creek 1.3	FULL	No (4.43)	Unable to collect	Not collected	Not likely. Biological communities fully attaining criteria. Nutrient enrichment signatures were not elevated.	-	TP (0.14) DIN (1.05)
Beaver Creek 8.3	FULL	No (1.32)	No (38.1)	6.6	Not likely. Biological communities fully attaining criteria. Nutrient enrichment signatures not elevated.	-	TP (0.10) DIN (0.72)
Beaver Creek 2.73	FULL	No (3.8)	No (118)	11.5	Not likely. Biological communities fully attaining criteria and have improved substantially over historical samples. Nutrient enrichment signatures were not elevated.	-	TP (0.08) DIN (2.03)
Hammer Creek 1.34	FULL	No (5.37)	No (132)	11.7	Not likely. Biological communities fully attaining criteria. Nutrient enrichment signatures were not above thresholds.	-	TP (0.14) DIN (0.87)
Jackson Cutoff Ditch 1.15	FULL	No (5.01)	Unable to collect	35.0	Not likely. Biological communities fully attaining criteria. Nutrient enrichment signatures were not elevated.	-	TP (0.12) DIN (1.27)
Little Yellow Creek 4.6	FULL	**Yes (12.1)**	Unable to collect	Not collected	Not likely. Biological communities were fully attaining criteria and exceeded WWH expectations further downstream. Biological community performance has improved throughout Little Yellow Creek relative to historical sampling.	-	No water quality collected at this location.
Little Yellow Creek 0.9	FULL	No (5.65)	No (161)	3.5	Not likely. Biological communities exceeded WWH expectations and have improved substantially relative to historical samples. Nutrient enrichment signatures were not elevated.	-	TP (0.21) DIN (1.77)
West Creek 0.1	FULL	No (1.55)	Yes (200)	9.5	Not likely. Biological communities fully attaining criteria. Diel DO ranges were not elevated.	-	TP (0.10) DIN (1.58)
Brush Creek 0.58	FULL	**Yes (7.99)**	No (149)	21.8	Not likely. Biological communities were fully attaining criteria and met expectations for available habitat. Fish community performance has improved since 2001.	-	TP (0.18) DIN (1.00)
Tontogany Creek 1.57	FULL	No (3.38)	Yes (193)	50.0	Not likely. Biological communities were fully attained criteria. Fish community performance has improved since 1997. Diel DO ranges were not elevated.	-	TP (0.10) DIN (3.14)

Stream RM	Aquatic Life Attain. Status	Exceed DO bench-mark? (Range)[A]	Exceed Benthic Chlorophyll benchmark? (conc.)[B]	Sestonic Chlorophyll (conc.)	Potential for future impairment to aquatic life related to nutrient enrichment?	Are stressors other than nutrients responsible for biological non-attainment?	Nutrient Geomean TP (Conc.) DIN (Conc.)
West Branch Tontogany 3.42	FULL	**Yes (18.00)**	Not collected	Not collected	Not likely. Biological community performance met the recommended ALU at this location. Enrichment signatures attenuated in a downstream progression quickly as stream size increased. No biological data to assess historical trends. Very poor habitat quality at this location likely exacerbated enriched conditions and precluded higher biological performance.	-	TP (0.27) DIN (1.01)
West Branch Tontogany 2.19	FULL	No (1.36)	Not collected	Not collected	Not likely. Biological communities were fully attaining criteria. Nutrient enrichment indicators were not elevated. Elevated signatures documented upstream appear adequately attenuated.	-	TP (0.27) DIN (1.27)
Liberty Hi Road Ditch 0.05	FULL	No (2.02)	Not collected	Not collected	Not likely. Biological communities were fully attaining criteria. Diel DO ranges were not elevated.	-	TP (0.13) DIN (1.94)

A Dissolved oxygen range benchmark is exceeded if the 24-hour range is greater than 6.5 mg/l.

B Benthic chlorophyll-*a* benchmark is exceeded if a sample value greater than 182 mg/m^2 is reported (values in excess of 320 mg/m2 characterize over-enrichment and/or nuisance conditions).

PRELIMINARY ASSESSMENT KEY

Red	ALU impaired; likely nutrient enriched
Tan	ALU impaired; cause other than nutrients likely.
Yellow	ALU attaining; aquatic life possibly threatened.
Green	ALU attaining; aquatic life likely not threatened.

Recreation Use

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

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

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

Portions of the Maumee River Basin Select Tributaries watershed are designated as primary contact recreation (PCR) use in OAC Rule 3745-1-07 and 3745-1-11. Water bodies with a designated recreation use of PCR "...are suitable for one or more full-body contact recreation activities such as, but not limited to, wading, swimming, boating, water skiing, canoeing, kayaking, and scuba diving" [OAC 3745-1-07 (B)(4)(b)]. There are three classes of PCR use to reflect differences in the potential frequency and intensity of use. Streams designated PCR class A support, or potentially support, frequent primary contact recreation activities. Streams designated PCR class B support, or potentially support, occasional primary contact recreation activities. All PCR streams in the study area are designated as Class B Primary Contact Recreation waters. All other streams included in the study area are designated secondary contact recreation (SCR) waters. SCR waters, "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."

The *E. coli* criterion that applies to PCR class B streams is a seasonal geometric mean of ≤161 colony forming units (cfu)/100 ml. The *E. coli* criterion that applies to SCR streams is a seasonal geometric mean of ≤1,030 cfu/100 ml. The geometric mean is based on two or more samples and is used as the basis for determining the attainment status of the recreation use (Table 22).

Fifty-nine locations in the watershed were tested for *E. coli* levels five times between May 21, 2015 and Sept. 8, 2015. The complete bacteria result dataset is reported in Appendix I, Figure 47 and Figure 48. Evaluation of *E. coli* results revealed that 50 of the 59 locations sampled failed to meet the applicable geometric mean criterion, indicating non-attainment of the recreation use at these locations. All nine sampling locations attaining were SCR waters with seasonal geometric means ranging from 414 to 1,029 cfu/100 ml. The four highest seasonal geometric means were: Oberhaus Creek in Napoleon at Oakwood Ave. (RM 0.4, 302985); South Creek at Co. Rd. 144 (RM 3.7, 302971); unnamed tributary to Beaver Creek at Poe Rd. (RM 1.5, 303004); and Brush Creek E. at Henry/Wood County Line Rd. (RM 3.47, P10P07), with geometric means of 2,661, 2,240, 2,109 and 1,808 respectively. South Creek and the tributary to Beaver Creek sites are downstream from areas dominated by rural residential and agricultural uses.

The Oberhaus Creek and Brush Creek sampling locations are in areas with CSOs/cross-connections from the city of Napoleon and the village of Deshler, respectively. No biological impairment was documented downstream from the CSOs in Oberhaus or Brush Creek. Fish community performance in Oberhaus Creek decreased from good to fair at sites located up and downstream from the CSOs, while macroinvertebrate communities remained in the marginally good range throughout. Biological performance was similar at the two sites up and downstream from the CSOs in Brush Creek.

Potential sources of *E. coli* contamination at locations not attaining the recreation use criteria are failing HSTS, livestock pasture land runoff, agricultural runoff, CSOs/cross-connections, and wildlife accumulations. Many of the sites sampled had extensive amounts of agricultural land and drastically reduced riparian buffer along the streams resulting in the streams being more susceptible to surface runoff. Areas listed in non-attainment of the recreation use standard for failing HSTS may need individual system improvements to reduce the discharge of bacteria. Runoff from livestock manure application and livestock grazing areas could be improved by the installation of additional buffers and/or livestock exclusion fencing between the activity and the stream.

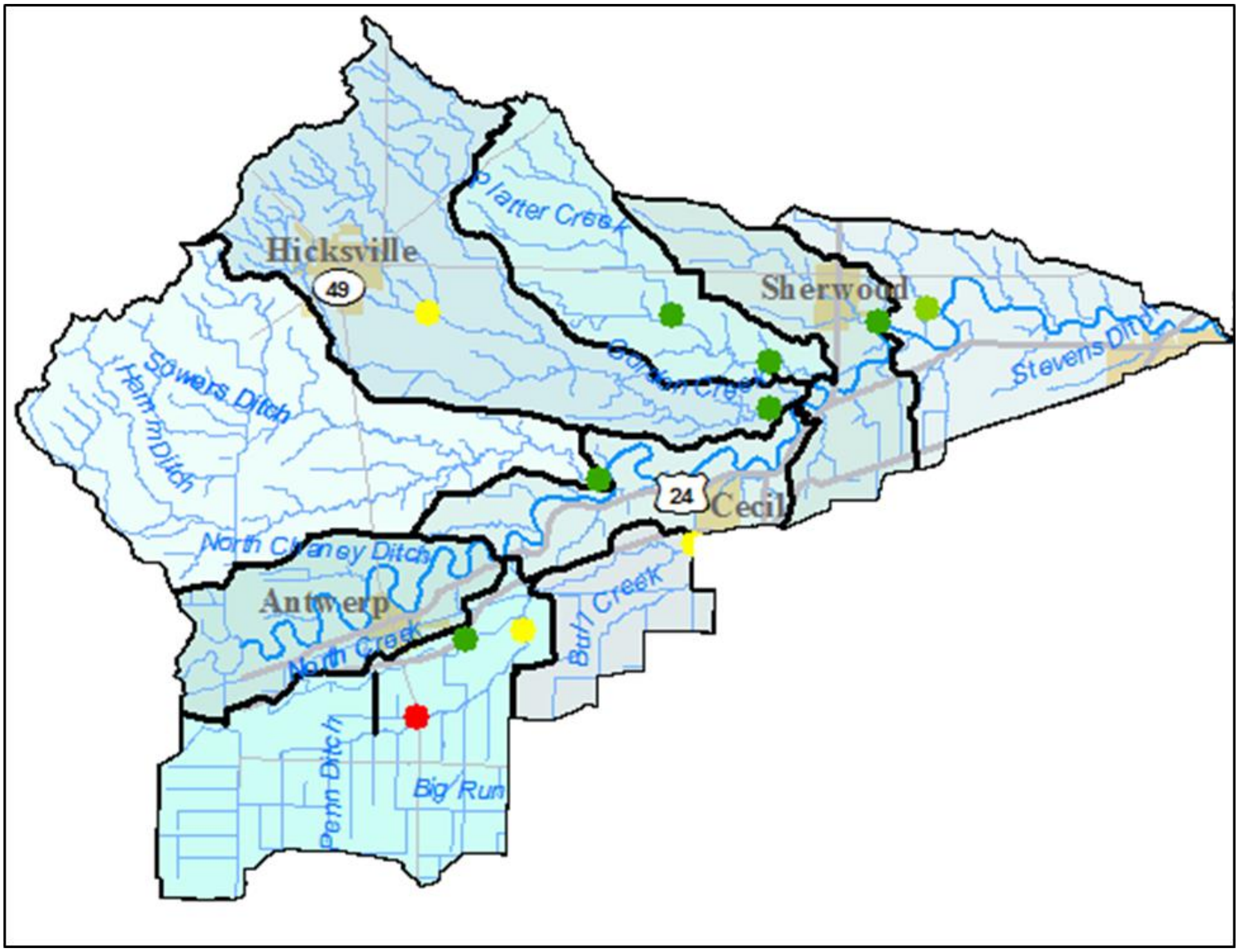

Figure 47 — E. coli samples within the Upper Maumee Watershed for the select tributaries watershed project. Relative seasonal geometric mean values are represented by a graduated color scheme. Dark green represents the low end of the values, yellow represents moderate values, while red represents the high-end values.

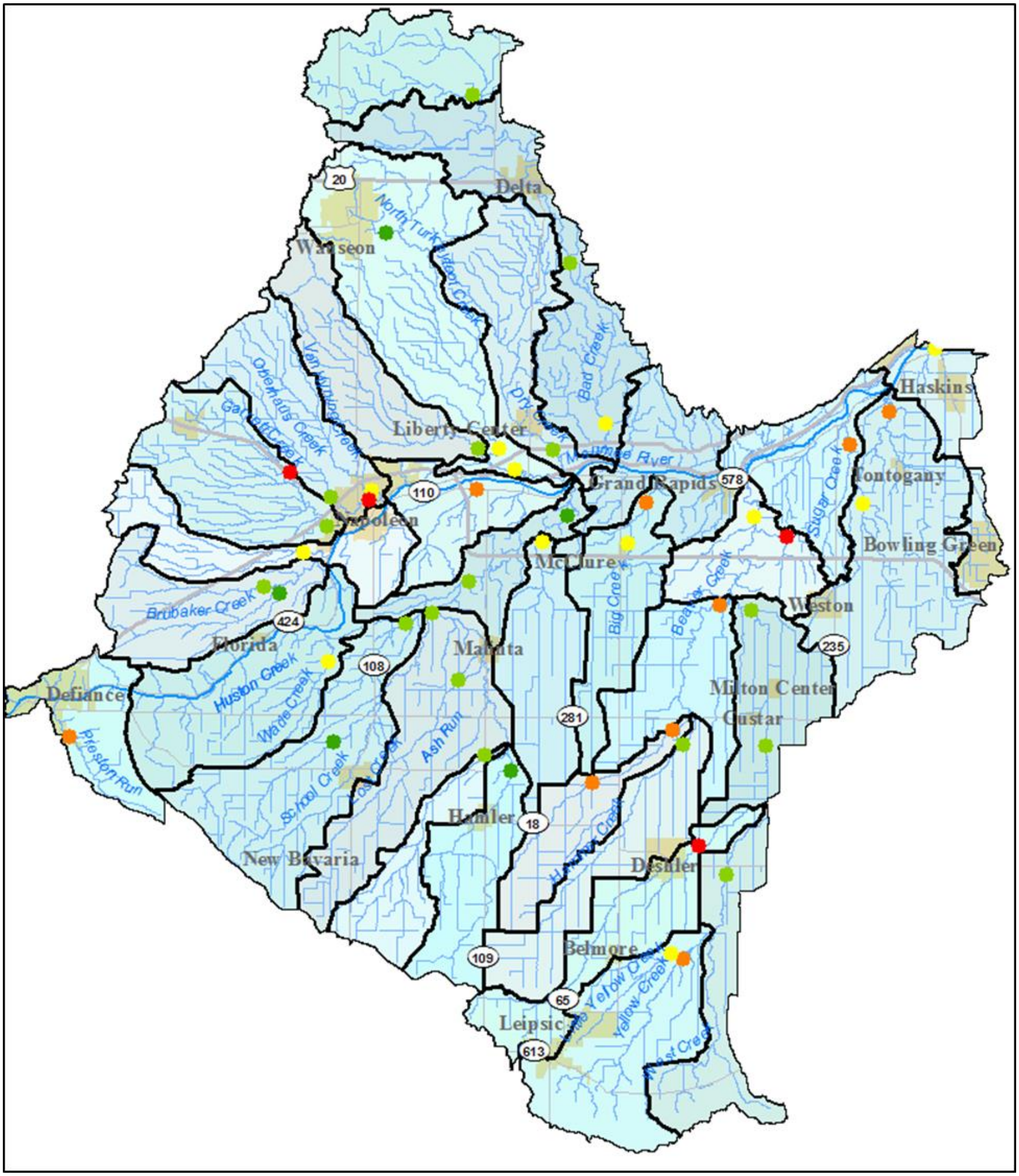

Figure 48 — E. coli samples within the Lower Maumee Watershed for the select tributaries watershed project. Relative seasonal geometric mean values are represented by a graduated color scheme. Dark green represents the low end of the values, yellow represents moderate values, while red represents the high-end values.

Table 22 — Recreation beneficial use attainment table for 59 locations in the Maumee River select tributaries watershed, May 1 — Oct. 31, 2015. All E. coli values are expressed as colony forming units (cfu) per 100 ml of water. Shaded values exceed applicable criteria. Exceedances are evaluated against existing designated recreational beneficial use designations.

Location	River Mile	Rec Class*	Number of Samples	Geometric Mean†	Attainment Status
HUC 12 (Zuber Cutoff 04100005 02 01)					
North Creek dst. Antwerp WWTP @ Murphy Rd. (P06W16)	1.60	B	5	388	NON
South Creek @ Victory Rd. (302970)	0.35	B	5	806	NON
South Creek @ Co. Rd. 144 (Gasser Rd.) (302971)	3.7	B	5	2,240	NON
HUC 12 (Marie DeLarme Creek 04100005 02 03)					
Marie DeLarme Creek near mouth @ Twp. Rd. 192 (P06K24)	0.50	B	5	229	NON
HUC 12 (Sixmile Creek Cutoff 04100007 12 08)					
Six Mile Cutoff @ Twp. Rd. 206 (302845)	1.24	B	5	808	NON
HUC 12 (Gordon Creek 04100005 02 04)					
Gordon Creek SW of Sherwood @ County Line Rd. (Lower Crossing) (P06S04)	1.12	B	5	246	NON
Mill Creek near mouth, adj. Fountain Street Rd. (P06W07)	0.10	SCR	5	1,029	FULL
HUC 12 (Platter Creek 04100005 02 06)					
Platter Creek @ Fountain Rd. (302974)	5.40	B	5	316	NON
Platter Creek @ Jericho Rd. (W Crossing) (303010)	1.70	B	5	324	NON
HUC 12 (Sulphur Creek – Maumee River 04100005 02 07)					
Sulphur Creek dst. Sherwood @ Roland Rd. (P06W19)	0.13	B	5	423	NON
HUC 12 (Snooks Run – Maumee River 04100005 02 08)					
Snooks Run @ Slough Rd. (P06K17)	0.50	B	5	583	NON
HUC 12 (Preston Run – Maumee River 04100009 02 01)					
Preston Run @ Standley Rd. (302977)	2.45	B	5	1,171	NON
HUC 12 (Wade Creek – Maumee River 04100009 02 03)					
Wade Creek SE of Florida @ Co. Rd. K (P09K22)	1.80	B	5	891	NON
HUC 12 (Benien Creek 04100009 02 02)					
Benien Creek @ Co. Rd. 17-C (302978)	4.00	B	5	656	NON
Brubaker Creek NE of Florida @ Twp. Rd. M-2 (P09K19)	0.50	B	5	430	NON
HUC 12 (Village of Napoleon – Maumee River 04100009 02 06)					
Trib. to Maumee River @ RM 48.7 @ T-16 (302980)	1.34	B	5	999	NON
HUC 12 (Garrett Creek 04100009 02 04)					
Garrett Creek @ Twp. Rd. R (302981)	4.00	B	5	1,729	NON
Garrett Creek near Napoleon @ Co. Rd. P (P09K17)	0.70	B	5	588	NON
HUC 12 (Oberhaus Creek 04100009 02 05)					
Oberhaus Creek near Napoleon @ Co. Rd. 15 (P09K15)	2.50	B	5	617	NON

Location	River Mile	Rec Class*	Number of Samples	Geometric Mean†	Attainment Status
Oberhaus Creek in Napoleon @ Oakwood Ave. (302985)	0.40	B	5	2,661	NON
Van Hyning Creek in Napoleon @ Oakwood Ave. (302983)	0.75	B	5	970	NON
HUC 12 (Creager Cemetery – Maumee River 04100009 02 07)					
Trib. to Maumee River (42.2) @ St. Rte. 110 (302986)	0.40	B	5	1,119	NON
HUC 12 (Upper South Turkeyfoot Creek 04100009 01 02)					
S. Turkeyfoot Creek NW of Hamler @ Co. Rd. G (P09S26)	19.75	B	5	232	NON
HUC 12 (Middle South Turkeyfoot Creek 04100009 01 04)					
S. Turkeyfoot Creek NW of Malinta @ Co. Rd. 11 (Upper Crossing) (P09W12)	10.80	B	5	719	NON
HUC 12 (Lower South Turkeyfoot Creek 04100009 01 06)					
S. Turkeyfoot Creek near Shunk @ Co. Rd. N (302836)	7.90	B	5	599	NON
S. Turkeyfoot Creek @ Twp. Rd. P-3 (P09W11)	1.97	B	5	342	NON
HUC 12 (West Creek 04100009 01 01)					
West Creek N of Hamler @ St. Rte. 109 (P10K07)	1.00	B	5	470	NON
HUC 12 (Middle South Turkeyfoot Creek 04100009 01 04)					
Lost Creek SW of Malinta @ Co. Rd. 10 (P09S09)	1.30	B	5	697	NON
HUC 12 (School Creek 04100009 01 03)					
School Creek @ Co. Rd. 12 (302994)	0.90	B	5	525	NON
Brinkman Ditch dst. Holgate WWTP @ Co. Rd. H (P09W17)	2.35	B	5	285	NON
HUC 12 (Little Flatrock Creek 04100009 01 05)					
Little Turkeyfoot @ Twp. Rd. 04 (302843)	0.48	B	5	851	NON
HUC 12 (North Turkeyfoot Creek 04100009 04 02)					
N. Turkeyfoot Creek dst. Wauseon WRF @ Co. Rd. 13 (P09S04)	17.85	SCR	5	442	FULL
N. Turkeyfoot Creek @ Co. Rd. S (302988)	5.50	SCR	5	838	FULL
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8 (P09S01)	3.40	SCR	5	787	FULL
HUC 12 (Konzen Ditch 04100009 04 01)					
Konzen Ditch @ Co. Rd. 10 (Site Moved to P09K14)	1.55	SCR	1	540	
Konzen Ditch near Mouth @ Co. Rd. S (P09K14)	0.65	SCR	4	494	FULL
HUC 12 (Dry Creek – Maumee River 04100009 04 03)					
Dry Creek dst. Liberty Center @ Co. Rd. S (302990)	1.60	B	5	482	NON
HUC 12 (Lower Bad Creek 04100009 03 02)					
Bad Creek SE of Delta @ Co. Rd. D (P11S05)	10.46	SCR	5	563	FULL
Bad Creek S of Colton @ Co. Rd. T (P11S04)	2.47	B	5	976	NON
HUC 12 (Upper Bad Creek 04100009 03 01)					
S. Br. Bad Creek @ Heller-Lyons Rd. (302849)	0.44	SCR	5	726	FULL
HUC 12 (Big Creek 04100009 05 01)					

Location	River Mile	Rec Class*	Number of Samples	Geometric Mean†	Attainment Status
Big Creek @ McClure @ Woodlawn Ave. (P09S28)	3.51	B	5	877	NON
Big Creek N of McClure @ Twp. Rd. Q (P09K06)	1.30	B	5	1,065	NON
HUC 12 (Upper Beaver Creek 04100009 05 03)					
Beaver Creek @ Twp. Rd. 5 (302999)	20.15	B	5	1,160	NON
Beaver Creek W of Custar @ Co. Rd. 2 (302998)	16.16	B	5	1,317	NON
HUC 12 (Middle Beaver Creek 04100009 05 08)					
Beaver Creek upst. Cutoff Ditch @ Wapakoneta Rd. (P10K03)	8.30	B	5	1,458	NON
HUC 12 (Lower Beaver Creek 04100009 05 09)					
Beaver Creek SE of Grand Rapids @ Wintergreen Rd. (P10K02)	2.73	B	5	933	NON
HUC 12 (Hammer Creek 04100009 05 02)					
Hammer Creek @ Co. Rd. H (303000)	1.34	B	5	666	NON
HUC 12 (Cutoff Ditch 04100009 05 07)					
Jackson Cutoff Ditch dst. Yellow Creek @ Bays Rd. (303003)	6.60	B	5	626	NON
Jackson Cutoff Ditch near Weston @ Sand Ridge Rd. (510040)	1.15	B	5	482	NON
HUC 12 (Upper Yellow Creek 04100009 05 04)					
Yellow Creek S of Deshler @ Co. Rd. B (500760)	8.02	SCR	5	1,299	NON
HUC 12 (Yellow Creek 04100009 05 06)					
Yellow Creek E of Deshler @ Roundhead Rd. (500780)	3.18	SCR	5	540	FULL
HUC 12 (Upper Yellow Creek 04100009 05 04)					
L. Yellow Creek NE of Leipsic @ Co. Rd. 2 (500700)	0.90	SCR	5	1,038	NON
HUC 12 (Brush Creek 04100009 05 05)					
Brush Creek N of Belmore @ Twp. Rd. A (303002)	8.99	SCR	5	414	FULL
Brush Creek E of Deshler @ Henry/Wood Co. Line (P10P07)	3.47	SCR	5	1,808	NON
HUC 12 (Lower Beaver Creek 04100009 05 09)					
Upst. to Beaver Creek upst. Hertzfeld Farm @ Poe Rd. (303004)	1.50	B	5	2,109	NON
HUC 12 (Sugar Creek – Maumee River 04100009 06 02)					
Sugar Creek @ Sugar Creek Rd. (303007)	1.06	B	5	1,140	NON
HUC 12 (Tontogany Creek 04100009 06 01)					
Tontogany Creek N of Tontagony @ Robinson Rd. (P10K01)	1.60	B	5	1,101	NON
Upst. to W. Br. Tontogany Creek @ Long-Judson Rd. (303005)	0.72	B	5	781	NON
W. Br. Tontogany Creek SW of Tontagony @ Tuller Rd. (P10P13)	3.42	B	5	459	NON
HUC 12 (Haskins Road Ditch – Maumee River 04100009 06 03)					
Liberty Hi Rd. Ditch dst. Haskins @ St. Rte. 65 (303008)	0.05	B	5	991	NON

Instream Sediment Chemistry

Sampling locations were selected during the study planning process to determine background sediment chemistry quality, assess the impact from point sources and urban nonpoint runoff, and evaluate downstream transport and recovery. Samples were collected following the *Sediment Sampling Guide and Methodologies, 3rd Edition* (Ohio EPA 2012b). The goal is to collect a representative sample that is composed of > 30 percent 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.

Most streams within the 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 sampling stations P10P07, P08W19, P09K19, P10K02, P10K01, P11S05, 302981, 302989, 302983, and 302985.

A total of five sediment samples were collected. Samples were collected in South Creek @ Co. Rd. 144 (302971), Mill Creek near mouth adjacent to Fountain Street Rd. (P06W07), N. Turkeyfoot Creek downstream Wauseon WRF @ Co. Rd. 13 (P09S04), School Creek downstream Holgate @ Co. Rd. H (302993), and L. Yellow Creek NE of Leipsic @ Co. Rd. 2. Sediment samples were analyzed for percent solids, TOC, metals, total phosphorus, and semi volatile organic compounds (s-VOCs) like polycyclic aromatic hydrocarbons (PAHs). Sediment samples were analyzed for PCBs at the School Creek and L. Yellow Creek locations.

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

Heavy metals and PAHs are common contaminants in urban areas because of vehicular emissions, asphalt pavement, and their use in industrial processes. For example, mercury is used in the production of chlorine gas and caustic soda, and in the manufacture of batteries and compact fluorescent light bulbs. It is also common in the atmosphere from coal burned to produce electricity. Besides urban storm water runoff and atmospheric deposition, other likely sources include municipal and industrial wastewater, and combined sewer overflows in municipal sewage collection systems.

A summary of parameters measured above SQGs are presented in

Table 23, while a complete listing of all sediment sampling locations and parameter results can be found in Appendix H. Metals that were above their threshold effect concentration (TEC), but that did not exceed their SRV are not displayed. Harmful effects are unlikely below the TEC and more likely above the probable effect concentration (PEC).

Table 23 — Chemical parameters measured above SQGs in surficial sediment samples collected by Ohio EPA in the Maumee River select tributaries 2016. SRV, TEC and PEC concentrations shaded within the table indicate values over respective benchmarks.

Parameter	Result (mg/kg)	SRV (mg/kg)	TEC (mg/kg)	PEC (mg/kg)
HUC 12 (04100005-02-04) Gordon Creek				
P06W07 - Mill Creek near mouth, adj. Fountain Street Rd. (RM 0.1)				
Cadmium (mg/kg)	0.977	0.96	0.99	4.98
Copper (mg/kg)	42.3	42	31.6	149
Silver (mg/kg)	0.732	0.43 (statewide)	--------	--------
HUC 12 (04100009-04-02) North Turkeyfoot Creek				
P09S04 - N. Turkeyfoot Creek dst. Wauseon WRF @ Co. Rd. 13 (RM 17.85)				
Cadmium (mg/kg)	1.04	0.96	0.99	4.98
Silver (mg/kg)	0.456	0.43 (statewide)		
Total PAH	**11.31**	**--------**	**1.61**	**22.8**

As described in Ohio EPA 2010a, a Tier II evaluation was completed for simultaneously extracted metals (silver, zinc, cadmium, copper, nickel, and lead) at all sample locations that exceeded the SRV and/or the TEC. No exceedances of the PEC were observed. The Tier II evaluation resulted in the calculated potential metals toxicity in the sediment as having little to no risk to aquatic life at all sites evaluated.

Total PAH at North Turkeyfoot Creek downstream from Wauseon WRF @ Co. Rd. 13 exceeded the TEC level at which we would predict no adverse effects. However, the level detected is below the PEC at which the potential for adverse effects exists. Additionally, the fact that the aquatic life use was in full attainment at this site suggests that these low-level sediment contaminants are not causing any impairment.

Stream Physical Habitat

Yellow Creek at Riegel Rd. - RM 4.5

Stream physical habitat is evaluated using the Qualitative Habitat Evaluation Index (QHEI), which is a qualitative, visual habitat assessment method correlated with fish community condition (Ohio EPA 2006, 1989). 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) (Ohio EPA 1989, Rankin 1995); a complete list of positive and negative habitat features is listed in Appendix E. 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.

Streams segments with mean QHEI values of at least 60 typically indicate a level of macrohabitat quality sufficient to support an assemblage of aquatic organisms fully consistent with the WWH aquatic life use designation; reach averages with values greater than 75 are generally considered adequate to fully support EWH (Ohio EPA 1989, Rankin 1995). Reach averages with values between 45 and 60 indicate limiting components of habitat are present and may be negatively influencing biological performance. Values below 45 indicate a higher probability of habitat-derived aquatic life use impairment, but should not be viewed as determinant. Due to the potential for compensatory stream features (strong ground water connectivity) or other attributes, average QHEI scores below 60 do not necessarily preclude these streams from fully supporting WWH or even EWH assemblages (Figure 49).

As habitat quality shifts from a natural to a more modified state, attendant water quality issues (nutrient/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), excess nutrients may not adequately assimilate and can result in more severe impacts to instream biological communities than in a stream with more natural habitat features. Conversely, a more natural stream system is generally able to assimilate various pollutants more effectively, and thus, a similar amount of pollutants may not have as severe an impact on instream biological communities.

Generally low relief and naturally poor draining soils throughout the study area have required extensive, basin-wide hydrological manipulation to meet drainage needs that support modern human land uses. During the late 19th and early 20th centuries many streams throughout this study area were systematically modified to support these drainage needs. Modifications may have included removal of natural meanders, relocation of active channels, dredging activities, and removal of riparian vegetation. Though systematic, basin-wide channel modifications have not been conducted for some time, many of these drainage modifications have been maintained to some extent. Numerous streams throughout this study area currently receive some form of active maintenance to facilitate drainage needs (Figure 7). These various types of stream maintenance activities have negative influences on stream habitat quality, with varying impacts relative to the nature of the maintenance activities.

Stream physical habitat was evaluated at 89 fish sampling locations throughout the Minor Great Black Swamp Tributaries study area in 2015 and 2016 (Figure 49, Figure 51, Table 25, Appendix F). QHEI scores ranged from 16 to 80.5, with corresponding narrative evaluations ranging from very poor to excellent (Figure 51, Table 25). Mean QHEI values from wading sites ($\bar{x}$=60.1, n=33) indicated generally good habitat quality where evaluated, while habitat quality at headwater sites ($\bar{x}$=47.1, n=59), collectively, were in the fair range. QHEI scores generally showed a positive correlation to drainage area (stream size) (Figure 49). As stream drainage area increased throughout the study area, instream habitat quality also tended to improve. Despite less than ideal habitat conditions at numerous locations throughout the study area and numerous stream reaches on active maintenance (Figure 7), biological communities fully met applicable criteria at a majority of locations (Table 2).

Figure 49 displays QHEI scores by drainage area throughout the survey parsed into existing or recommended aquatic life uses. QHEI scores displayed in red are those sites that corresponded to impaired biological samples.

Stream reaches with QHEI scores of 60 generally indicate a level of macrohabitat quality sufficient to support warmwater biological assemblages. Zuber Cutoff was the only location (RM 1.1, P06K13) whose habitat score was above 60, but is displayed impairment to the fish community. Fish community sampling occurred in 2016 after a documented fish kill in 2015 in South Creek that extended downstream through Zuber Cutoff. The fish community was still recovering from the kill in 2016. It is not likely that habitat quality at this location is contributing to impairment or precluding recovery throughout this reach.

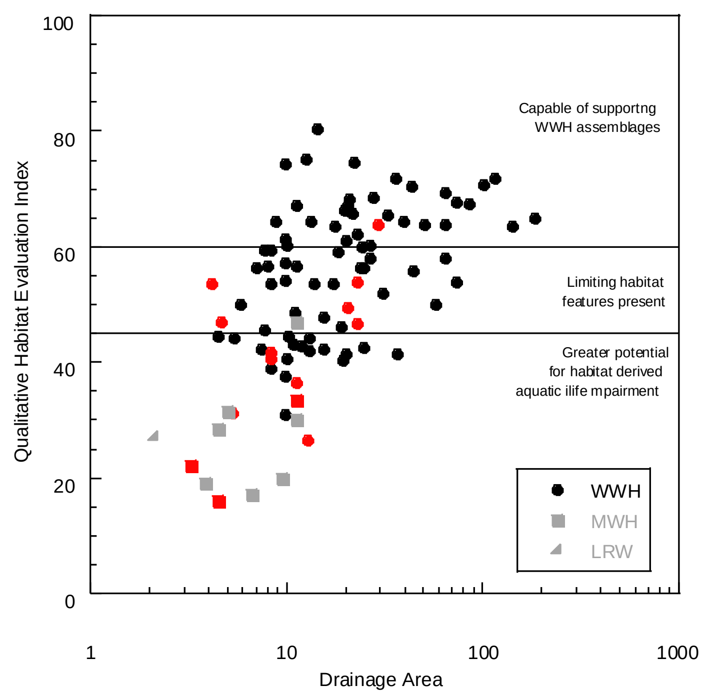

Figure 49 — QHEI scores displayed by drainage area from the Minor Great Black Swamp Tributaries study area, 2015 and 2016. Scores are parsed according to existing or recommended aquatic life use. Values in red are impaired locations.

Numerous streams throughout the study area displayed QHEI scores less than the benchmark of 60, but still fully supported HELP WWH communities (Figure 49). However, five locations within this range displayed aquatic life use impairment. These areas include North Creek RM 0.3 (303746), South Creek RM 0.35 (302970), Snooks Run RM 0.5 (P06K17), and Lost Creek RM 1.3 (P09S09). While limiting habitat features are present, stressors other than instream habitat quality were attributed to aquatic life use impairment at these locations except for Lost Creek RM 1.3. Impairment in Lost Creek RM 1.3 stemmed from consistent underperformance of the macroinvertebrate community and is attributed to a combination of excessive siltation smothering natural substrates coupled with low overall stream flows.

For those stream reaches with QHEI scores less than 45, there is a greater potential for habitat-derived impairment. However, stream reaches with QHEI scores in this range did not preclude full attainment at numerous locations throughout the study area (Figure 49). The overwhelming majority of sampling locations in this category are less than 20 mi^2 drainage. Given the significant history of systematic channel modifications throughout the HELP ecoregion, it is not surprising to see these smaller streams, collectively, have lower habitat quality than larger systems. Impaired stream reaches whose habitat scores fall within this range likely have some sort of habitat limitations contributing to or causing impairment. Impaired sampling locations in this range include: North Creek RM 2.95 (P06W17); Middle Fk. Gordon Ck. RM 3.8 (P06S18); Platter Creek RMs 7.95 (303014) and 5.4 (302974); Brinkman Ditch RM 2.35 (P09W17); and Dry Creek RM 8.8 (302848). Additionally, all stream sampling locations where either the MWH-C and LRW aquatic life use exist or are being recommended fell within this category. Causes of impairment to these locations are listed in Table 2, while a complete list of negative habitat attributes affecting these locations is found in Appendix F.

The general lack of paired historical stream data limited certain trend analysis. The largest historical survey effort in this area occurred in 1996/97. Since this represented the first *major* survey effort for many streams in this study, locations with paired historical data were somewhat limited. Fifteen stream locations had data collected both in 1996-97 and 2015-16.

Habitat metrics and IBI scores from paired location (n=15) in 1996/97 and 2015/16 were evaluated (Table 24). Both QHEI and IBI scores from paired locations were higher in 2015/16 than in 1996/97. Application of Wilcoxon-Mann-Whiney non-parametric treatment suggest these differences were statistically significant (see table below). The substrate and all other QHEI metrics also trended higher at these locations, some of which were also statistically significant. Some of the differences in QHEI sub-metric scoring may be attributable to slight differences in sampling location (upstream vs. downstream from a bridge), but some improvements are also likely attributable to the substantial positive trend in habitat and biological quality documented throughout the study area.

Table 24 – Summary of QHEI historical trend analysis results.

Metric	1996-97 Ave.	2015-16 Ave.	P value
IBI	27.8	35.4	**0.001**
QHEI	38.6	48.6	**0.01**
Substrate	7.3	8.1	0.255
Cover	7.4	10.8	**0.013**
Channel	9.2	10.8	**0.023**
Riparian	3.9	4.3	0.43
Pool	4.9	6.7	**0.018**
Riffle	1.1	2.2	0.007

Causes and sources of impairment at the other locations, ancillary to habitat influences, are discussed in the ***Fish***, ***Macroinvertebrate***, and ***Sonde Summary*** and ***Trophic Evaluation*** portions of this document.

Figure 50 — Photographs from Platter Creek RM 1.7 (left) and RM 7.95 (right). Note the presence of various natural habitat features present at RM 1.7 (some functional sinuosity, relatively wide and forested riparian, more instream cover for fish) and some connectivity to the adjacent riparian floodplain present at RM 1.7.

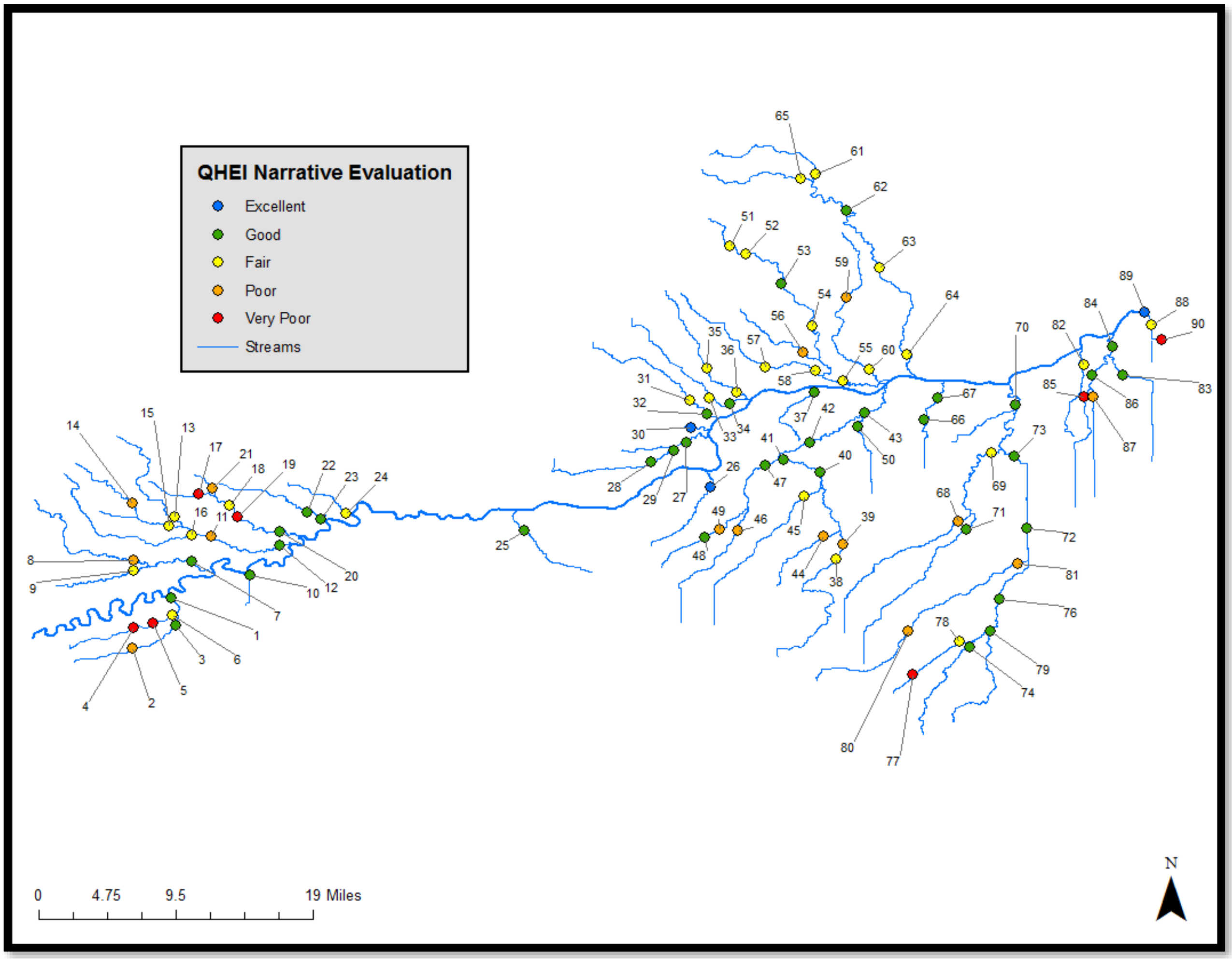

Figure 51 — Physical habitat sampling locations and narrative evaluations for sites within the Minor Great Black Swamp Tributaries study area, 2015-2016. Narrative evaluations correspond to values from sites listed in Table 25. Site numbers correspond to those listed in Table 1.

Table 25 — Summary of QHEI metric scores from streams within the Minor Great Black Swamp Tributaries study area, 2015 and 2016. Values denoted by [brackets] were collected in 2016.

STORET	Stream	River Mile	Drainage Area	QHEI	Substrate	Instream Cover	Channel	Riparian	Pool	Riffle	Gradient
[P06K13]	[Zuber Cutoff Ditch]	[0.3]	[29.5]	[63.75]	[10]	[15]	[12]	[5.75]	[7]	[4]	[10]
[302971]	[South Creek]	[3.7]	[11.3]	[30.25]	[8]	[4]	[7]	[3.25]	[2]	[0]	[6]
302971	South Creek	3.7	11.3	33.5	5	5	8	3	5	1.5	6
[302970]	[South Creek]	[0.35]	[23.1]	[46.75]	[8]	[14]	[9.5]	[5.25]	[4]	[0]	[6]
302970	South Creek	0.35	23.1	62.25	11.5	13	10.5	4.75	11	5.5	6
302970	South Creek	0.35	23.1	54	11.0	12	10	4.5	7	3.5	6
P06W17	North Creek	3	4.3	22	0	4	8	3	2	1	4
P06W16	North Creek	1.6	5.4	19	0	2	5	3	3	2	4
[303746]	[North Creek]	[0.3]	[6.1]	[49]	[8]	[11]	[10]	[3]	[4.5]	[2.5]	[10]
303387	Marie DeLarme Creek	2.1	26.8	60.25	11.5	8	14	9.25	5	2.5	10
P06K25	North Branch Marie DeLarme	1.6	8.4	39	8	7	9	3	5	3	4
P06K26	South Branch Marie DeLarme	1	7.2	42.25	10	6	9	6.25	4.5	2.5	4
303386	Six Mile Cutoff	0.3	11.2	67.25	11	15	13	5.75	10	4.5	8
P06S15	Gordon Creek	6.6	37	41.5	9	5	11	3.5	5	4	4
P06S04	Gordon Creek	1.1	43.4	70.5	14.5	16	14.5	6.5	12	3	4
302972	North Fork Gordon Creek	1.25	11.1	48.75	8.5	11	11	4.25	5	3	6
[P06S18]	[Middle Fork Gordon Creek]	[3.8]	[5.3]	[31.25]	[0]	[11]	[6]	[2.25]	[6]	[0]	[6]
P06S16	Middle Fork Gordon Creek	0.8	13	44.25	10.5	6	9.5	3.25	6	3	6
302973	South Fork Gordon Creek	0.2	10.9	43.25	7	10	10.5	2.75	4	3	6
[303014]	[Platter Creek]	[7.95]	[4.5]	[16]	[0]	[3]	[8]	[2]	[-1]	[0]	[4]
303014	Platter Creek	7.95	4.5	28.5	5	3	8.5	4	4	0	4
302975	Platter Creek	6.4	11.9	42.75	10.5	9	7.5	3.25	5.5	3	4
[302974]	[Platter Creek]	[5.4]	[12.8]	[26.5]	[0]	[6]	[8.5]	[3]	[4]	[1]	[4]
303010	Platter Creek	1.7	20	61	11.5	12	15	6	8	4.5	4
303015	Trib. to Platter Creek (7.66)	0.8	5	31.5	5	6	8	4.5	4	0	4
302976	Sulphur Creek	1	8.9	64.5	14	14	13	8.5	7	0	8
P06W19	Sulphur Creek	0.1	9.9	61.25	9.5	13	13	7.75	9	1	8
P06K17	Snooks Run	0.6	4.2	53.5	11	14	11.5	4	5	0	8
302977	Preston Run	2.5	7.7	59.5	10.5	13	13	6.5	5	3.5	8
P09K22	Wade Creek	1.8	9.8	74.25	15.5	16	15	8.75	9	0	10
P09K18	Benien Creek	2.3	21.6	65.75	9.5	14	14.5	6.75	8	3	10
302979	Brubaker Creek	2.4	8.4	59.5	11.5	15	12	3	8	4	6
P09K19	Brubaker Creek	0.5	9.9	57.25	10.5	11	12.5	5.25	8	0	10

STORET	Stream	River Mile	Drainage Area	QHEI	Substrate	Instream Cover	Channel	Riparian	Pool	Riffle	Gradient
302980	Trib. to Maumee (48.7)	1.3	12.6	75.25	15.5	15	16	5.75	10	3	10
302982	Garrett Creek	2.5	17.2	53.75	9	14	8.5	5.25	7	0	10
P09K17	Garrett Creek	0.7	27.8	68.5	13	13	14	5	8	5.5	10
P09K15	Oberhaus Creek	2.5	8.3	53.5	10.5	12	10.5	4	4.5	4	8
302985	Oberhaus Creek	0.4	10.1	60.25	14.5	14	10	5.75	5	3	8
302984	Van Hyning Creek	4.3	9.8	54.25	10.5	13	11	5.25	3.5	1	10
302983	Van Hyning Creek	0.8	13.8	53.5	11	11	10	5	6	4.5	6
302986	Trib. to Maumee (42.2)	0.4	7	56.25	10	14	14	4.75	7.5	2	4
P09S27	South Turkeyfoot Creek	20.9	18.9	46.25	8.5	9	10	2.75	6	4	6
P09S26	South Turkeyfoot Creek	19.8	20.2	41.5	5	12	9.5	3	8	0	4
P09W13	South Turkeyfoot Creek	13.2	65	69.25	12.5	17	15	4.25	11	3.5	6
P09W12	South Turkeyfoot Creek	10.8	73	67.75	10	16	15	7.75	11	2	6
302836	South Turkeyfoot Creek	7.9	116	71.75	13	14	15	5.25	11	5.5	8
303388	South Turkeyfoot Creek	3.2	143	63.5	11	14	14.5	6	10	2	6
P10K07	West Creek (trib. to South Turkeyfoot Ck.)	1	15.4	42.25	2	13	10	3.25	6	2	6
P09S09	Lost Creek	1.3	20.7	49.5	10.5	15	10.5	4.5	3	0	6
302993	School Creek	7	9.8	37.5	4	7	9	2.5	5	0	10
302994	School Creek	0.9	32.7	65.5	9.5	15	14.5	6	11	5.5	4
P09K11	Brinkman Ditch	2.8	8	56.75	10	15	13.5	3.25	7	2	6
P09W17	Brinkman Ditch	2.4	8.3	41.75	9	10	10	3.75	5	0	4
302843	Little Turkeyfoot Creek	0.5	22.1	74.75	10.5	14	16.5	7.75	11	5	10
P09S19	North Turkeyfoot Creek	19.1	4.5	44.5	9.5	7	8.5	6.5	6	1	6
P09S04	North Turkeyfoot Creek	17.9	5.8	50	10	8	10	3.5	6	4.5	8
P09S03	North Turkeyfoot Creek	13.8	19.6	66.25	13.5	16	13	4.25	10	3.5	6
P09K12	North Turkeyfoot Creek	9.7	31	52	10.5	9	9	3	7	3.5	10
P09S01	North Turkeyfoot Creek	3.4	73	54	10	14	9.5	4.5	10	2	4
302989	Trib. to North Turkeyfoot Creek (4.65)	1	9.9	31	4.5	3	9	2.5	2	0	10
302987	Konzen Ditch	4.2	15.6	47.75	10.5	9	9	2.25	6	1	10
P09K14	Konzen Ditch	0.7	24.7	56.5	11	12	11	8	6	2.5	6
302848	Dry Creek	8.8	11.3	36.5	9.5	8	8.5	2.5	4	0	4
302990	Dry Creek	1.6	23.9	56.5	9.5	14	12	5.5	8	1.5	6
P11K48	Bad Creek	22.5	12	42.75	4	8	8	3.75	4	5	10
P11W22	Bad Creek	17.5	36	71.75	12.5	15	16	4.75	9	4.5	10
P11S05	Bad Creek	10.5	44	55.75	10.5	14	11	5.25	7	2	6
P11S04	Bad Creek	2.5	58	50	8.5	9	13	7.5	8	0	4
302849	South Branch Bad Creek	0.4	10.2	44.5	8.5	12	8	3	4	3	6

STORET	Stream	River Mile	Drainage Area	QHEI	Substrate	Instream Cover	Channel	Riparian	Pool	Riffle	Gradient
P09S28	Big Creek	3.5	17.8	63.5	10	15	11	5	8	4.5	10
P09K06	Big Creek	1.3	20.7	67.25	16	13	10.5	8.25	5.5	4	10
302998	Beaver Creek	16.2	19.4	40.25	0	12	10	4.25	5	3	6
P10K03	Beaver Creek	8.3	65	58	10	15	13	4.5	10	1.5	4
P10K02	Beaver Creek	2.7	184	65	11	15	14	7.5	10	1.5	6
303000	East Beaver Creek (a.k.a. Hammer Creek)	1.3	24.3	60	11	15	12	4	8	4	6
303003	Jackson Cutoff Ditch	6.6	86.3	67.5	14	17	9.5	3.5	10	5.5	8
510040	Jackson Cutoff Ditch	1.2	101	70.75	14.5	14	13.5	4.25	11	3.5	10
500760	Yellow Creek	8	18.3	63.25	12.5	15	11	4.75	10	0	10
500780	Yellow Creek	3.2	51	63.75	11.5	14	12.5	4.75	12	5	4
[P10W08]	[Little Yellow Creek]	[4.6]	[2.1]	[27]	[4]	[6]	[7]	[3]	[3]	[0]	[4]
500700	Little Yellow Creek	0.9	7.7	45.5	9.5	9	8.5	4.5	6	2	6
302840	West Creek (trib. to Yellow Creek)	0.1	13.3	64.5	10.5	11	13.5	5.5	9	5	10
303002	Brush Creek	9	10	40.5	7.5	5	9	2	6	1	10
P10P06	Brush Creek	0.6	24.6	42.5	9.5	8	8.5	2	6	4.5	4
303007	Sugar Creek	1.1	5.4	44.25	10	6	10	3.75	5	1.5	8
303006	Tontogany Creek	4.2	11.2	56.75	10.5	9	12.5	6.25	6	2.5	10
P10K01	Tontogany Creek	1.6	39.4	64.5	11	14	14.5	7	10	2	6
P10P13	West Br. Tontogany	3.4	6.6	17.25	0	3	5.5	2.75	2	0	4
[P10P14]	[West Br. Tontogany]	[2.2]	[20.8]	[68.25]	[12]	[16]	[13]	[4.75]	[9]	[3.5]	[10]
303005	Trib. to W. Br. Tontogany Creek (3.2)	0.7	13.1	42	4	13	10	3	5	1	6
[303622]	[Liberty Hi Rd. Ditch]	[1.2]	[11.3]	[47]	[10]	[11]	[8]	[3.5]	[4]	[4.5]	[6]
303008	Liberty Hi Rd. Ditch	0.1	14.4	80.5	15.5	16	17.5	9	9.5	5	8
303009	Haskins Rd. Ditch	0.3	9.6	20	0	4	5	3	2	0	6

General narrative ranges assigned to QHEI scores.			
Narrative Rating		QHEI Range	
		Headwaters (≤20 mi²)	Larger Streams
Excellent	(blue)	≥70	≥75
Good	(green)	55 to 69	60 to 74
Fair	(yellow)	43 to 54	45 to 59
Poor	(orange)	30 to 42	30 to 44
Very Poor	(red)	<30	<30

Fish Community - Overview and Trends

Survey Area Overview

Approximately 94,511 individual fish representing 61 unique species and four hybrids were collected from 89 locations throughout streams within the study area from June to October during the 2015 and 2016 sampling periods. The current sampling effort represented the first comprehensive survey for many of these streams conducted by Ohio EPA.

Eastern Sand Darter (Ammocrypta pellucida), Bad Creek RM 2.47

Limited amounts of historical data are available for streams within this study area. Most historical data available for streams within the study area are from 1997. Lesser amounts of historical data were collected at selected locations throughout the 1980s. Additionally, ODNR collected samples from several streams in 2001 and 2002. Contemporary and historical fish criteria scores from all streams within the Minor Great Black Swamp Tributaries study area are presented in Table 28 and will be discussed further in the trends portion of this section.

Table 26 — Average IBI and MIwb scores for all streams within the Minor Great Black Swamp Tributaries study area, 2015-16.

Stream Size	Avg. IBI	Avg. MIwb
Headwater (<20mi^2 drainage), n=59	36.6	N/A
Wading (>20mi^2 drainage), n=34	37.5	8.33

Relative numbers, biomass, and species collected per location are presented in Appendix C and IBI and MIwb scores are presented in Appendix D. Fish numbers and biomass are standardized to a distance of 0.3 km for headwater and wading sites and 1 km for boat sites; these standardized values will herein be referred to as relative abundance and relative biomass. No samples were collected using boat electrofishing methods during the current survey. Sampling locations were evaluated using one or more of the following ALU designations: WWH; MWH-C; or LRW. All streams in the Minor Great Black Swamp Tributaries study area were evaluated against HELP ecoregion biological criteria. Contemporary and historical fish biocriteria scores are presented in Table 28. A summary of the fish community data is presented in Table 29.

The fish community was evaluated at 89 sampling locations encompassing 50 streams within the Minor Great Black Swamp Tributaries study area. IBI and MIwb scores as they pertain to respective drainage areas are displayed in Figure 52, while average IBI and MIwb scores for all locations in the study area are displayed in Table 26. Average IBI and MIwb scores from the study area indicate marginally good to good overall fish community performance. Individual sites ranged from very poor to exceptional. The singular very poor fish score (IBI=12) occurred in South Creek RM 0.35 (302970) after a documented fish kill. Overall, both IBI and MIwb scores met existing or recommended HELP criteria at a majority of locations sampled (Figure 52).

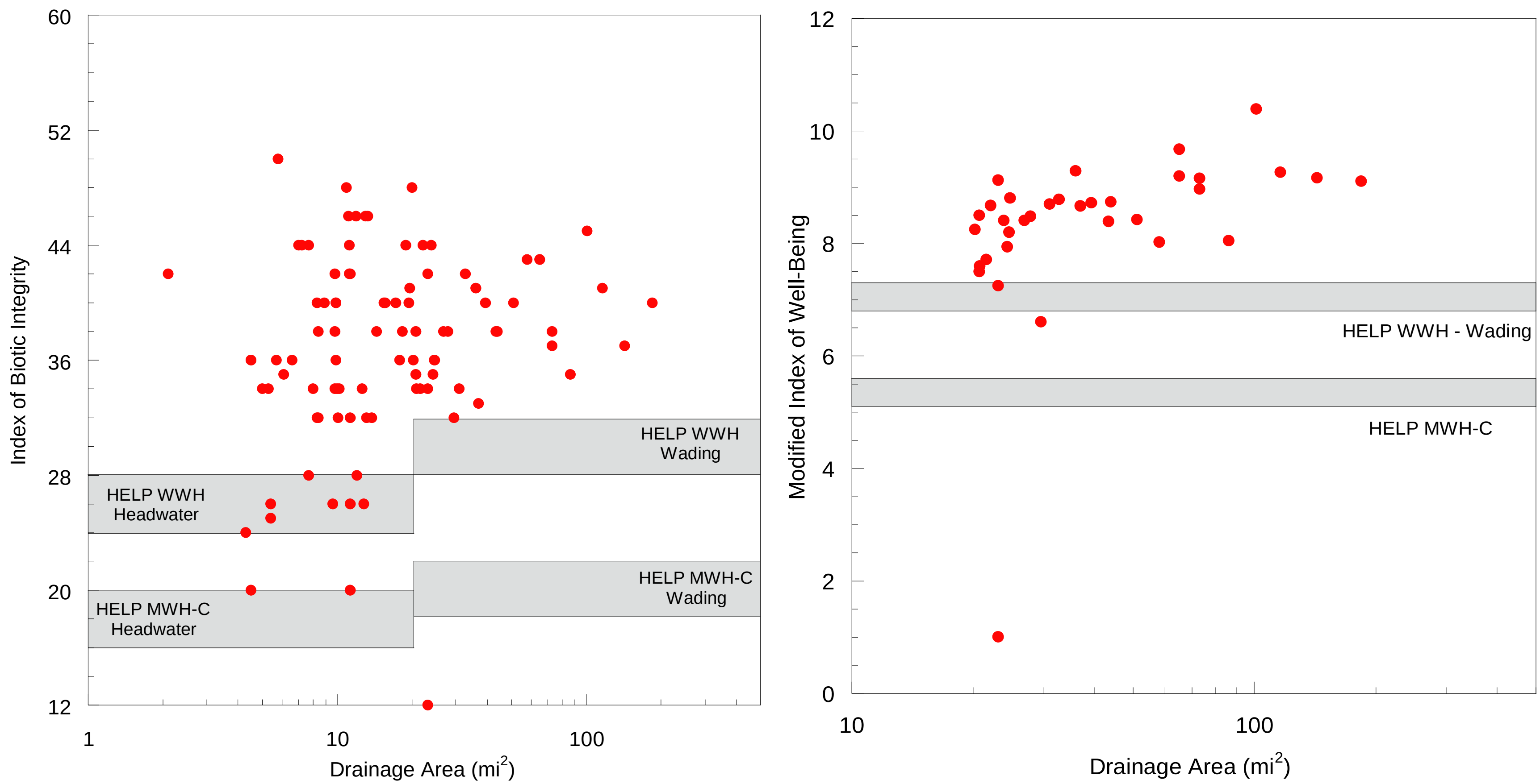

Figure 52 — Scatter plot of IBI (left) and MIwb (right) scores from stream sampling locations throughout the Minor Great Black Swamp Tributaries study area displayed by drainage area, 2015 and 2016. Shaded areas represent indicated biocriteria and areas of non-significant departure from noted criteria.

Two state-listed species (ODNR 2015) were collected during the 2015 sampling efforts, including the western banded killifish (endangered) and the eastern sand darter (species of concern). In 2015, a relatively large, but isolated population of western banded killifish was collected from the uppermost site in the West Branch Tontogany Creek (RM 3.4, P10P13); one additional individual was collected downstream in Tontogany Creek (RM 1.6, P10K01). Additional sampling in West Branch Tontogany Creek (RM 2.19, P10P14) in 2016 did not yield any additional western banded killifish. Less the individuals collected during this survey, one of the largest inland populations of western banded killifish occur throughout some tributaries of the adjacent Portage River watershed (Bull Creek, Needles Creek, Rader Creek). Given these locations' proximity to the Tontogany watershed and the absence of this species in other places within the survey area, it is most likely that the individuals collected from the Tontogany watershed "spilled over" into this basin during one of the areas frequent flooding events.

Western Banded Killifish (Fundulus diaphanous), West Br. Tontogany Creek RM 3.42

Northern Longear Sunfish (Lepomis megalotis peltastes), Dry Creek RM 8.8

Two eastern sand darter specimens were collected from Bad Creek RM 2.5 (P11S04) and Beaver Creek RM 2.7 (P10K02). The eastern sand darter is exceptionally sensitive to excessive siltation and sedimentation. Historically, the eastern sand darter was widespread throughout the Maumee River and the lower portions of its tributaries, but was nearly eliminated by the early 1900s due to habitat degradation and changes in land use practices that accelerated delivery of silts and clays to river systems (Trautman 1981). Only recently has there been documented recovery of eastern sand darter populations throughout the Maumee River drainage system (Tessler et al. 2012, Ohio EPA 2015 a, b, c) which is seemingly related to improvements to substrate quality and reduced siltation throughout and excessive sediment discharge to the Maumee River watershed (Myers et al. 2000, and Richards et al. 2009).

Other intolerant, rare, or generally noteworthy taxa collected included: northern longear sunfish from numerous locations; two dusky darter individuals from Bad Creek RM 2.5 (P11S04) and Beaver Creek RM 8.3 (P11K03); stonecat madtom from numerous locations; and brindled madtom from Gordon Creek RM 1.1 (P06S04) (Appendix C).

Survey Area Trends

For many streams in this study area, this survey represented the first major, comprehensive effort to assess ambient water quality and biological condition. As such, there is generally a lesser amount of existing historical data from streams than might otherwise be present for other survey areas. Historical fish community data was limited to smaller efforts in the mid-1980s and 1996-97 in select streams, while ONDR also collected some fish community data from several streams in 2001 and 2002. Historical and contemporary IBI and MIwb scores from streams in this study area are displayed in Table 28.

Fish community performance in streams that did have both contemporary and historical data have shown improvements. IBI scores from streams in the study area have increased drastically since the 1980s and 1990s (Table 28). IBI scores from paired stream reaches indicated recovery over the array of stream sizes sampled, denoting improved function in both smaller and larger streams. The median IBI score has increased 10 points, from 28 (low fair) to 38 (marginally good - good) since 1997, while 25th and 75th percentile of scores also increased in a similar fashion. Fish community performance that historically hovered just at WWH criteria or in the non-significant WWH departure range is now largely exceeding WWH expectations, with only outliers dropping below WWH criterion into the non-significant departure range (Figure 53).

Furthering this point, Figure 54 displays IBI scores from five locations in the study areas with data existing from three collection time-periods (1980s, 1990s, 2010s): Konzen Ditch RM 0.7; Gordon Creek RM 6.6; and M. Fk. Gordon Ck. RM 3.8 are regional MWH-C reference sites. IBI scores from the 1980s to the 1990s remained similar or very slightly improved, but all improved substantially in

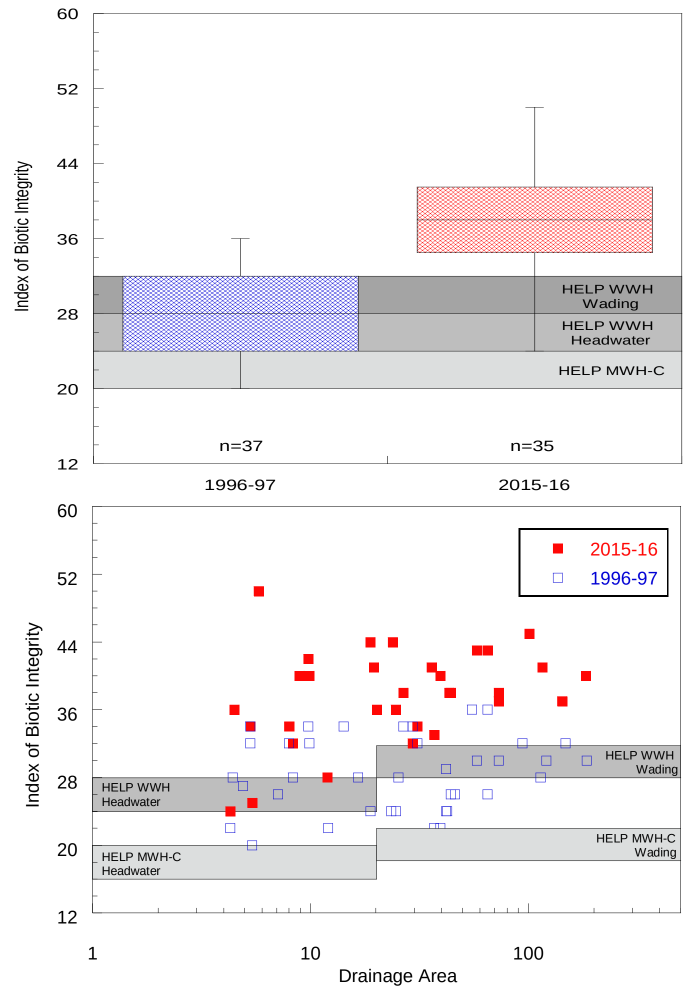

Figure 53 — Plots of IBI scores from paired stream segments within the study area aggregated by year (top) and parsed by drainage area (bottom), 1996-97 and 2015-16.

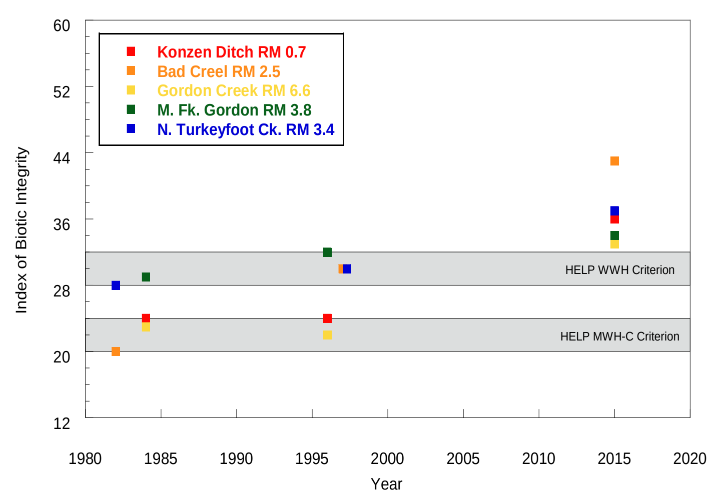

Figure 54 — IBI scores from the five indicated sampling locations through time. Multiple IBI scores within a given year were averaged.

2015 compared to historical scores. An increased number of darter species present at each location is among the improvements in the fish community common to these three locations.

The cumulative number of darter species from all five of these locations are displayed in Table 27. Darter species collected during this survey, excluding the blackside, orangethroat and johnny darter, are classified either moderately intolerant or rare-intolerant. Collectively these categories are referred to as (pollution) sensitive species. Additionally, all darter species collected except for the johnny darter are classified as simple lithophilic species (substrate sensitive) species, or those that that are sensitive to excessive amounts of siltation smothering of natural substrates because of feeding and/or breeding requirements. Simple lithophilic species are among the most sensitive of the various fish spawning/breeding guilds because of this susceptibility to habitat disturbance, and particularly, siltation.

Similar to IBI trends at these locations, the cumulative number of darter species collected at each location was similar between the early-1980s and mid-1990s, but has increased substantially from the 1990s to 2015. The most commonly collected darters in the 80s and 90s at these locations were the johnny darter and blackside darter, while 2015 survey results indicated the presence of several additional sensitive darter species at these locations (Table 27). The average number of darter species collected across all fish sampling locations increased in 2015 ($\bar{x}$=3.4) compared to the mid-1990s ($\bar{x}$=1.7). The presence of the highly intolerant eastern sand darter and relatively rare (in the Lake Erie drainage basin) dusky darter in Bad Creek (and Beaver Creek) ultimately highlights the increased darter diversity in these streams. The significance of simple lithophilic species relative to modern tillage practices is discussed in further detail below, while the importance of the eastern sand darter as an indicator species is discussed above.

Table 27 — Darter species collected from the indicated sampling locations from the given time periods.

	Darter Species Collected		
Stream and RM	1980s	1990s	2015
Konzen Ditch, RM 0.7	johnny	johnny	blackside, greenside, johnny, logperch, orangethroat
Bad Creek RM, 2.6	blackside, johnny	blackside	blackside, dusky, eastern sand, greenside, johnny, logperch
Gordon Creek, RM 6.6	blackside, johnny	blackside, orangethroat	blackside, greenside, johnny, logperch, orangethroat
M. Fk. Gordon Creek, RM 3.8	-	johnny	johnny
N. Turkeyfoot Creek, RM 3.4	johnny	johnny	blackside, greenside, johnny, logperch

Improvements in fish community performance throughout the indicated time period (here and elsewhere throughout the state) do not appear stochastic or otherwise random. Large-scale recovery of fish community performance beginning in the mid-1990s and becoming more fully realized over the ensuing decades parallels trends observed in other tributaries systems to the Maumee River (Ohio EPA 2015 a, b, c, g). Multiple and interrelated factors are likely responsible for this and would include gradual natural rehabilitation of previously modified segments, reduced siltation, and improved water quality.

The cumulative effects of the full suite of modern tillage and related soil and water conservation practices has resulted in significant reduction in gross erosion documented at national and regional scales since the late 1970s (USDA 2013). Studies within the Maumee River basin (and other watersheds) have demonstrated an association between agricultural BMPs, reduced soil loss, in-stream sedimentation, and finally, a concurrent positive response from the ambient biology (Barton and Farmer 1997, Meyer et al. 2000, Yoder et al. 2004, Richards et al. 2009, and Tessler et al. 2012, Miltner 2015).

Taxa richness, recruitment, and the performance of other important measures of ecological function and organization of lotic fish and invertebrate communities are closely linked to the particle size of streambed sediments. The most immediate and consequential effect of excessive sedimentation upon riverine habitat is the smothering or embedding of coarser bed material by sands, clayey silts and related fines, resulting in loss or diminution of substrate interstices. It is through the associated loss or degradation of living space (critical feeding and breeding substrates) that aquatic communities are primarily negatively affected by sediment (Fajen and Layzer 1993, Waters 1995).

These findings parallel emerging phenomena Ohio EPA has observed state-wide regarding the reestablishment of not only formerly imperiled, substrate-sensitive fish taxa (for example, bigeye chub and sand darter), but large and positive community shifts toward lithophilic and specialist insectivorous species in general, with a corresponding decline in ecological generalists. The on-going, naturally directed restoration of aquatic taxa acutely sensitive to the ecological effects of sedimentation has served as a broad and functional indicator of ultimate effects of modern tillage practices.

In very general terms, the adoption of modern tillage practices and related conservation measures on agricultural lands within Ohio's portion of the survey area have remained around 50-60 percent since the mid-2000s (USDA 2010). Although this does not represent either a radical recent shift to, or a steady increase in, modern tillage over the past 21 years, these landscape treatments none-the-less appeared very consequential over the period of record. It is not difficult to comprehend nor is it reckless to contend that the lag time between the initial, large-scale adoption of modern tillage through the late 1980s and early 1990s, and measurable in-stream effects is conceptually very large. Limiting or otherwise reducing the delivery of clayey silts to adjacent waterbodies represents only the first step, as it may well take years to work through the vast amount of fine sediment entrained drainage networks, the rate and efficiency dependent upon multiple physical and hydrological variables. The eventual coarsening of the stream bed should, over time, stimulate a biological response in the form of the recruitment of substrate sensitive taxa, and an eventual restructuring of the entire assemblage. Although the rate of adoption of conservation measures throughout the study area has likely remained relatively stable over the past 21 years, the associated benefits or ultimate in-stream effects of reduced soil loss are protracted, or may only be fully realized over the long term. Keys to success appear to be an initial broad adoption and the persistence of the adopted land treatments over long periods of time.

It is important to highlight successes conservation tillage and other agricultural BMPs have had in reducing soil erosion and sediment loading to streams and rivers, not only because of improved environmental conditions, but because of the significant amounts of money invested in these programs. The following quote from Myers et al. (2000) characterizes the situation well*: "Without direct evidence of improving water quality, farmers and others may become indifferent to the voluntary use of these practices and programs. This, in turn, could negate the apparent success of these programs and the investments made by federal, state, and local natural-resource managers."* Unequivocal improvements in fish community performance, highlighted by re-establishment of substrate-sensitive eastern sand darter here and throughout the Maumee River basin, are helpful pieces of information to highlight the apparent successes of these investments in water quality.

Waterbody Specific Discussion and Trends

Zuber Cutoff sub-basin

Zuber Cutoff is "formed" by the confluence of North and South Creek just east of Antwerp. Fish community performance was evaluated in 2015 and 2016 at a total of six locations: one in Zuber Cutoff; three in North Creek; and two in South Creek. Fish community performance, collectively, was among the lowest of the entire survey area (Figure 52). Primary sampling occurred in 2015, while 2016 sampling was conducted to assess the spatial and temporal impacts on the September 2015 fish kill event (Figure 55).

Figure 55 — South Creek fish kill, Co. Rd. 176 (Victory Rd), 10:02 a.m., Sept. 9, 2015.

Fish community performance at both locations in South Creek met WWH expectations in 2015 before the kill event and in 2016 after the kill event. Despite meeting criteria at both locations in 2016, community quality had declined substantially compared to pre-kill conditions and still showed signs of recovery from the event (lower overall relative abundance, high proportions of highly tolerant and pioneering species, lagging MIwb performance). Sampling at RM 0.35 (302970) a week after the kill event on Sept. 15, 2015 revealed a near-complete fish kill. Only 13 total individuals encompassing six species (four native, five highly tolerant, zero sensitive) were collected, compared to 766 total individuals encompassing 22 species (20 native, two sensitive). Fish community performance at RM 3.7 (302971) was additionally influenced by low flow conditions during 2016 sampling.

Fish community performance from Zuber Cutoff in 2016 fell short of ecoregional WWH expectations and, like lower South Creek, is still exhibiting signs of recovery from a significant fish kill that started in the headwaters of South Creek and extended downstream through Zuber Cutoff.

Fish community performance in North Creek at RMs 2.95 (P06W17) and 1.6 (P06W16) marginally met HELP WWH expectations, though were still among the lowest scores in the entire survey (

Figure 66). Though an average IBI of 25 was noted at RM 1.6, community quality declined from 32 to 18 between the two sampling events. Substantially less streamflow was noted during the second sampling event and several, relatively fresh dead fish were observed. Very poor habitat quality throughout the uppermost reaches of North Creek, coupled with impacts from nutrient enrichment throughout the remainder of North Creek stemming from multiple sources undoubtedly had negative influences on biological communities. The Antwerp WWTP discharges to North Creek between RMs 2.95 and 1.6. Over-enriched conditions were documented at RM 2.95, before the Antwerp WWTP joins North Creek (Table 21). It is likely that additional inputs from this facility are exacerbating already over-enriched conditions.

Aside from the acutely toxic impacts from the spill/kill event, nutrient over-enrichment and deficient instream habitat were evident in these streams and had negative influences on overall biological community performance. Likely sources of nutrient input include: row crop agriculture; manure application and runoff; and municipal point sources (Figure 14, Figure 21, Table 21).

Gordon Creek sub-basin

Fish community samples were collected from two locations in Gordon Creek mainstem and four total locations in the North, Middle, and South Forks to Gordon Creek. The Gordon Creek sub-watershed generally has more existing historical data than many other streams within this study area (Table 29).

Fish community performance throughout this sub-watershed largely exceeded HELP WWH expectations and some of the smaller tributary sampling locations were among the best performing sites compared to locations of similar size. Fish community performance throughout streams in the Gordon Creek sub-watershed has improved substantially through every reach sampled. Historical fish community samples were often just at or well below HELP WWH criteria (Figure 56). Improvements to fish community performance throughout the sub-watershed generally included: increased number of native species present at each location; increased number of sensitive species at mainstem locations; an increased percentage of insectivores coupled with decreased percentage of omnivorous individuals comprising fish community; and an overall decrease in the percentage of highly tolerant individuals comprising the fish community. Accrual of several sensitive darter species (Table 27) and the first ever records of the intolerant brindled madtom in this small sub-watershed dating back to 1887 (Trautman and Gartman 1974) highlight improved conditions within the Gordon Creek sub-basin.

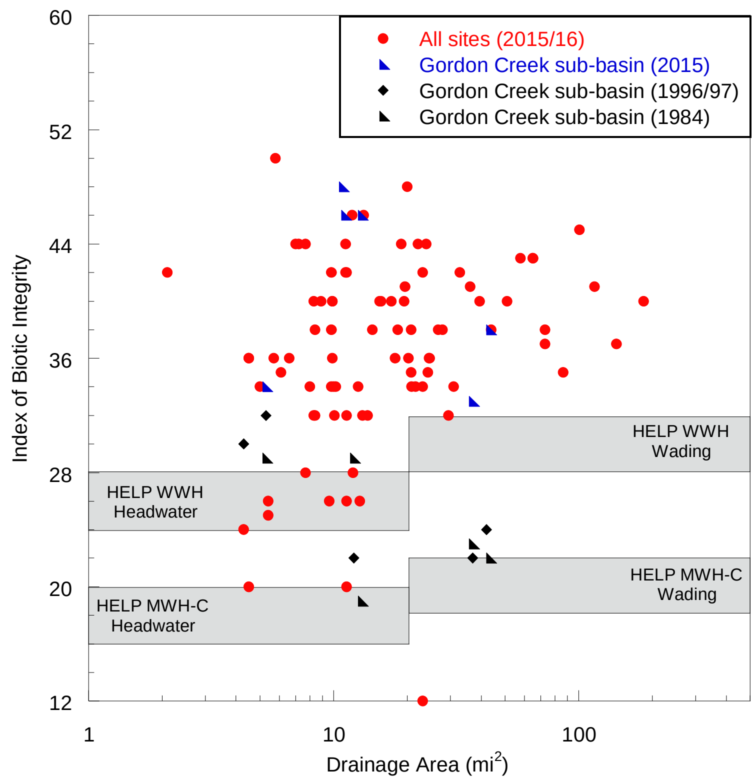

Figure 56 — Scatter plot of contemporary and historical IBI scores from stream locations evaluated within the Gordon Creek sub-basin. All sites sampled in 2015 and 2016 are displayed for reference. Shaded areas represent indicated biocriteria and areas of non-significant departure from noted criteria.

South Turkeyfoot Creek sub-basin

Fish community samples were collected from six locations in South Turkeyfoot mainstem and from seven locations in five tributary streams including: West Creek; Lost Creek; School Creek; Brinkman Ditch; and Little Turkeyfoot Creek. Fish community performance met applicable biocriteria at all locations in both South Turkeyfoot Creek and these tributaries (Figure 57, Figure 58, Table 2).

Both IBI and MIwb scores from South Turkeyfoot Creek have improved dramatically since 1997. Fish community performance in 1997 was largely below or only marginally met ecoregional criteria, while performance largely exceeded criteria in 2015 (Figure 58, Table 28). Impacts to structural components of the fish community documented downstream from the Malinta WWTP and School Creek/Brinkman Ditch confluence in 1997 were not evident in 2015, denoting improvements throughout this reach (Figure 58).

Improvements in fish community performance were also evident in other tributaries to South Turkeyfoot Creek (Figure 57). Fish community performance in Brinkman Ditch was similar to 1997 and did not appear to be significantly impacted by documented water chemistry issues (Figure 19, Table 20, Table 21).

Accrual of sensitive species such as the stonecat madtom and an increased abundance of darter species are some of the positive fish community trends in this sub-basin. The first records of the native central mudminnow throughout the South Turkeyfoot Creek sub-basin, a species formerly widespread throughout the Maumee River watershed (Trautman 1981, Trautman and Gartman 1974), highlights the improved conditions generally observed throughout South Turkeyfoot Creek.

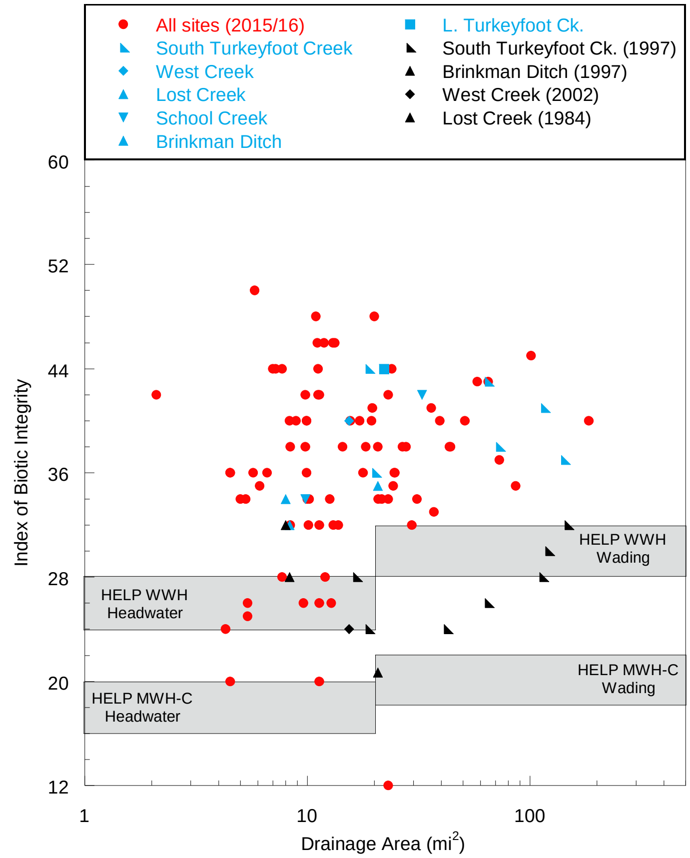

Figure 57 — Scatter plot of contemporary (blue-shaded) and historical (black-shaded) IBI scores from stream locations evaluated within the South Turkeyfoot Ck. sub-basin. All scores from 2015/16 are displayed for reference. Shaded areas represent indicated biocriteria and areas of non-significant departure from noted criteria.

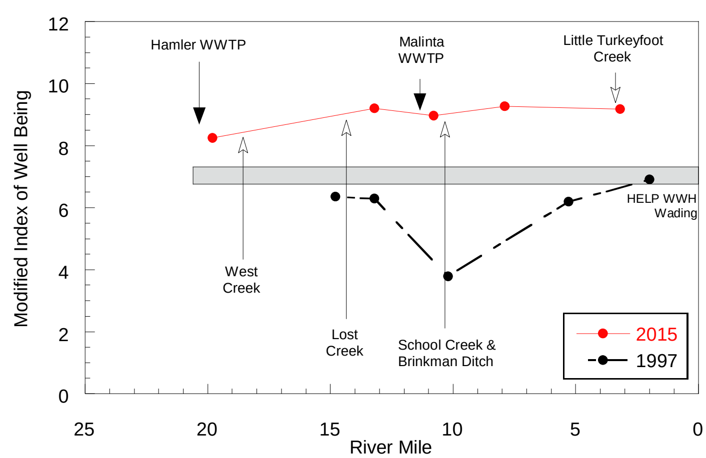

Figure 58 — Longitudinal MIwb scores from South Turkeyfoot Creek, 2015 and 1997. Shaded areas represent indicated biocriteria and areas of non-significant departure from noted criteria.

North Turkeyfoot Creek sub-basin

Fish community samples were collected from five locations in North Turkeyfoot mainstem and from three locations in two tributary streams. Fish community performance largely met ecoregional expectations in the mainstem and both tributaries (Figure 59, Table 28). Slight improvements to fish community performance were evident in North Turkeyfoot (Table 28).

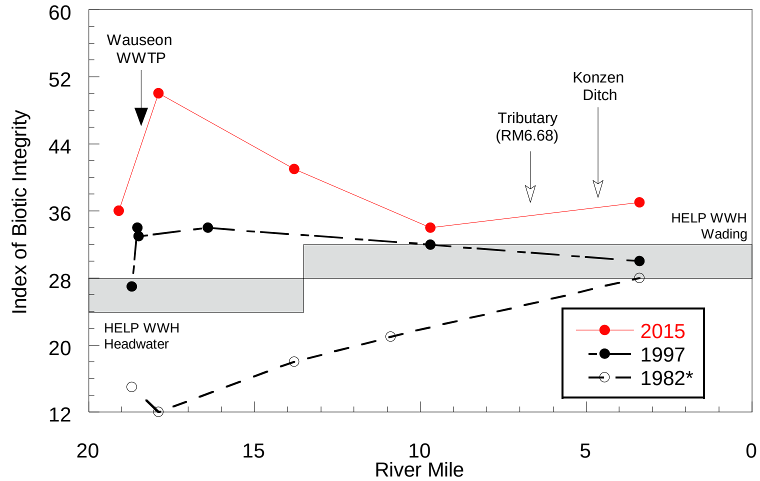

Figure 59 — Longitudinal IBI scores from North Turkeyfoot Creek, 2015, 1997, and 1982. Shaded areas represent indicated biocriteria and areas of non-significant departure from noted criteria. Samples from 1982 were collected using an archaic sampling collection type (backpack/seine); IBI scores are valid, though numeric summaries of abundances may be skewed.

The IBI score downstream from the Wauseon WRF (RM 17.85, P09S04) was the highest individual score recorded during the survey (Figure 52, Figure 59), despite over-enriched conditions documented at this location (Table 21). Though not always the case, it appears that highly elevated benthic chl.-*a* concentrations (593 mg/m^2) at this location may have facilitated an anomalously high abundance of stoneroller minnows. Stonerollers are herbivorous and feed almost exclusively on algae and detritus (ODNR 2012). Both the benthic chl.-*a* concentrations and the percent composition of stoneroller minnows of the fish community (47.5 percent) were the highest recorded in the entire study area. Only one individual stoneroller (2 fish/0.3 km) was collected at the upstream sampling location (RM 19.06, P09S19), despite similar habitat and substrate characteristics. Historical abundances of stoneroller minnows were very similar in other reaches sampled in North Turkeyfoot Creek (Figure 60). An experimental IBI treatment was explored by excluding all but one stoneroller from the IBI headwater metric calculation to evaluate the influences on proportional metrics (percent highly tolerant, sensitive, insectivores, pioneering) this species had. Because stonerollers comprised such a large abundance of the community at this location and don't fall into any of the aforementioned categories, they disproportionately influenced the various proportional metrics in the traditional IBI calculation.

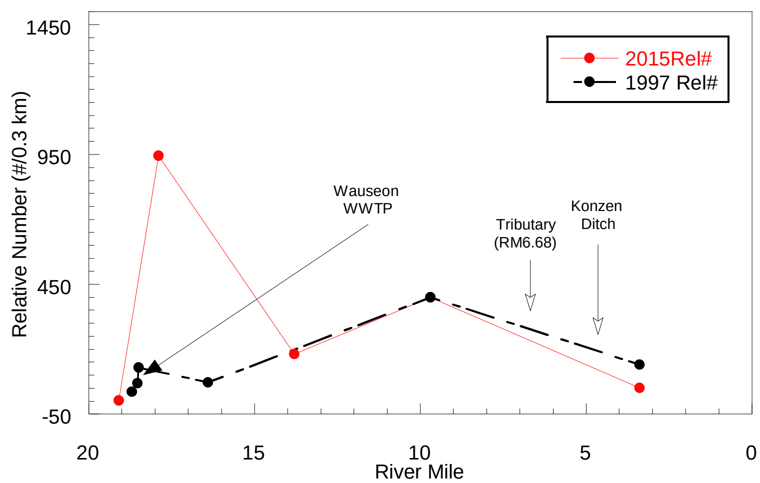

Figure 60 — Relative abundance (# of fish/0.3 km) of the central stoneroller minnow at locations in North Turkeyfoot Creek displayed longitudinally, 2015 and 1997.

The experimental IBI treatment downstream from the Wauseon WRF (40) was similar to the IBI score recorded upstream at RM 19.06 (36). This suggests that the nominally higher IBI score of 50 may not have been reflective of the resource condition at this location in the traditional sense (higher score ≠ better quality), however, was still reflective of the obvious over-enriched conditions documented at this location (Table 21).

Improvements in fish community performance at other locations throughout North Turkeyfoot Creek appear related to trends in improving substrate quality recorded throughout the Maumee basin related to modern tillage practices discussed earlier. The percent abundance of sensitive species was generally higher in 2015, while the proportion of highly tolerant species, overall, was very similar between 1997 and 2015. Additionally, the percentage of simple lithophilic species has also increased over the same time period (Figure 61). Logperch and greenside darters, both sensitive and simple lithophilic species, were absent from North Turkeyfoot Creek in 1997, but were widespread in 2015 and were collected at nearly all locations (Appendix C). The first records of two species of sensitive, simple lithophilic round bodied suckers (shorthead and golden redhorse) were collected at RM 3.4 (P09S01).

Fish community performance in the two tributaries to North Turkeyfoot Creek fully met ecoregional criteria. Performance throughout Konzen Ditch improved substantially in 2015 compared to historical scores (Table 2, Table 28).

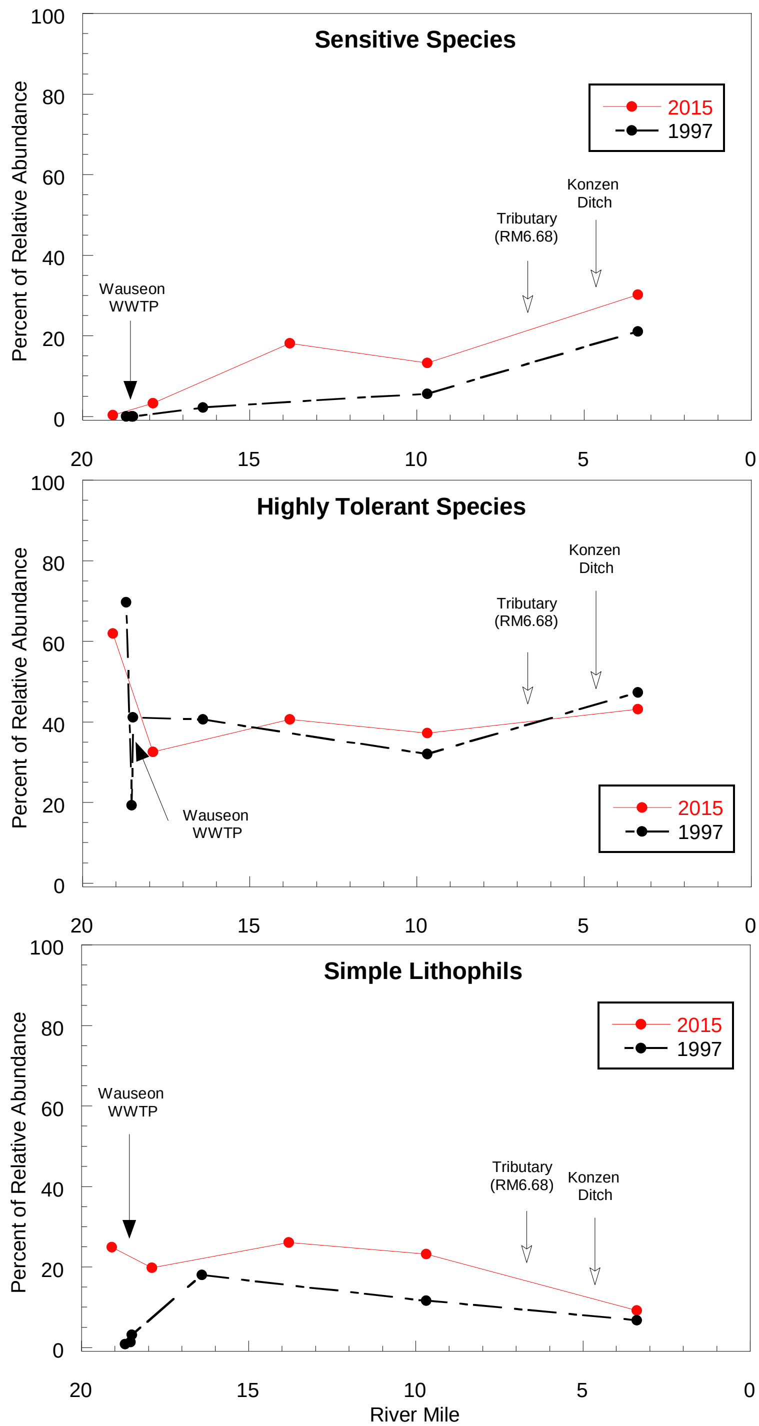

Figure 61 — Percent of the fish community comprised by sensitive (top), highly tolerant (middle), and simple lithophilic (bottom) species from sampling locations in North Turkeyfoot Creek displayed longitudinally, 1997 and 2015.

Bad Creek sub-basin

Fish community samples were collected from five locations in Bad Creek and one location in South Branch Bad Creek and fully met ecoregional criteria at all locations (Table 2). Fish community performance has improved drastically compared to historical samples collected in the 1980s and 1990s (Figure 62).

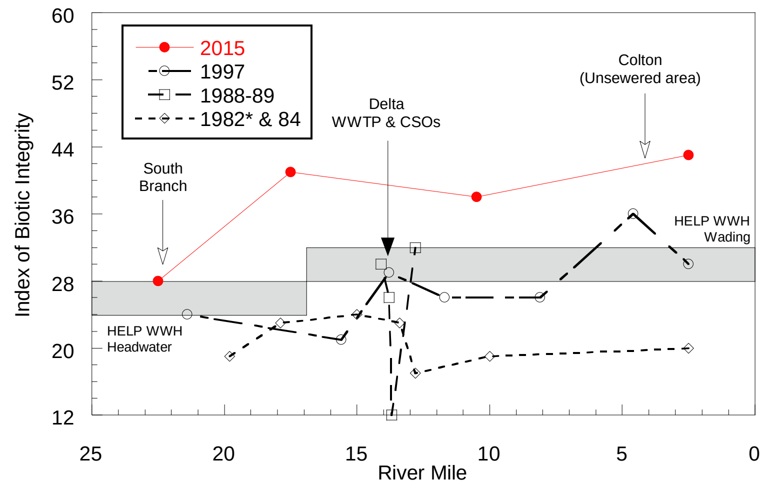

Figure 62 — Longitudinal IBI scores from Bad Creek from indicated time period. Shaded areas represent indicated biocriteria and areas of non-significant departure from noted criteria. Samples from 1982 were collected using an archaic sampling collection type (backpack/seine); IBI scores are valid, though estimates of numeric summaries of abundances may be skewed.

Bad Creek provides a very unique opportunity to evaluate recovery within a system because of the relatively complete nature of the dataset longitudinally with somewhat paired reaches from the 1980s, 1990s, and 2010s. Additionally, this system has experienced impacts from both municipal point sources, CSOs, and nonpoint sediment and nutrient inputs. Looking closely at IBI scores from Bad Creek since the 1980s, several trends reveal themselves.

The earliest sampling results from Bad Creek throughout the early and late 1980s documented fish community quality that largely fell short of HELP WWH criteria, especially in the early 1980s. Substantial declines in community quality were documented downstream from the Delta WWTP and CSOs in Bad Creek (Figure 62). Additionally, impacts from erosion and pervasive instream siltation in many streams in agricultural Ohio were largely still present throughout the 1980s (USDA 2013, Miltner 2015).

Fish community performance from 1997 was mixed. Substantial recovery was documented downstream from the Delta WWTP and CSO outfalls, while very little or no recovery was documented upstream from these sources over the same period (Figure 62). This would suggest that recovery of fish community performance compared to the early 1980s to 1997 was most likely related to better wastewater treatment at this facility and subsequent improved water quality conditions downstream. The lack of recovery upstream from these areas suggest that factors other than those stemming from poor water quality were limiting fish community performance in this reach.

Sampling from 2015 noted substantial recovery in fish community performance, both up and downstream from the Delta WWTP. While some of the improvements in community condition may be related to improved effluent quality, recovery both up and downstream from this facility suggest that factors in addition to further improvements to effluent quality were likely. This increase in fish community performance over this time period is likely reflective of reduced siltation/sedimentation stemming from the adoption of modern tillage practices beginning in the late 1980s and extending through the 1990s and subsequent recovery of biological condition (Richards et. al 2009, Miltner 2015).

Highlighting the improved fish community condition is the ubiquitous presence of the greenside darter throughout Bad Creek. The greenside darter is now relatively common throughout the Maumee River watershed and is a sensitive and simple lithophilic species. Despite significant historical sampling efforts throughout Bad Creek since the 1980s, only one individual greenside darter was collected in 1989 and none in either 1997, 1988, 1984, or 1982, despite the majority of sampling locations being in an ideal stream size range for this species. Samples from 2015 collected substantial amounts of greenside darters at all but the uppermost location in Bad Creek. Greenside darters comprised 11 percent, 10.3 percent and 22.1 percent, respectively, of the overall fish community at the other three sampling locations (RMs 17.51, 10.46, 2.47). Further highlighting the latest period of recovery are the first records of the highly intolerant eastern sand darter (species of concern), dusky darter (sensitive), and stonecat madtom (intolerant) in 2015. The first records of these species, all of which directly or indirectly have a degree of sensitivity to excessive siltation (Trautman 1981), further highlight recovery in this basin as it related to diminution of excess silt and sediment since 1997.

The pattern of recovery in fish community performance documented throughout Bad Creek since the early 1980s parallels trends in resource quality documented in other streams throughout the state, with a "first round" of recovery following major investment in wastewater infrastructure in the 1980s, followed by a later "second round" of recovery that has occurred since the mid-1990s seemingly related to modern tillage/conservation practices and reduced erosion and sediment runoff (Richards et. al 2009, Miltner 2015). Macroinvertebrate community performance shows a similar recovery trend (Figure 81) since 1997, though limited amounts of historical data is available from the 1980s.

Beaver Creek and Jackson Cutoff sub-basin

Beaver Creek was the largest tributary system sampled during the survey and drains just over 186 mi² at its confluence with the Maumee river. Beaver Creek is unique because just over 100 mi² of additional drainage area was "added" to this system around 1880 for drainage purposes (Grant 2015). Drainages from several major stream systems that formerly drained to the Portage River watershed were poached and re-routed through Jackson Cutoff to join Beaver Creek at RM 7.5. The streams that formerly flowed into the Portage watershed included Yellow Creek and tributaries Brush, Little Yellow and West Creek.

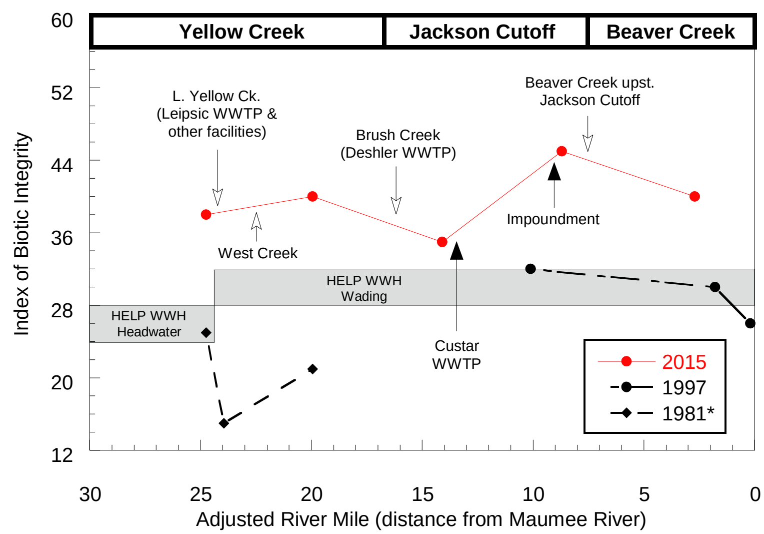

Figure 63 — IBI scores from Beaver Creek, Jackson Cutoff, and Yellow Creek displayed longitudinally by river mile distance from the Maumee River. 2015, 1997, and 1981. Shaded areas represent indicated biocriteria and areas of non-significant departure from noted criteria. Samples from 1982 were collected using an archaic sampling collection type (backpack/seine); IBI scores are valid, though estimates of numeric summaries of abundances may be skewed.

Figure 63 displays IBI scores from Beaver Creek, Jackson Cutoff, and Yellow Creek longitudinally with respect to their distance in river miles from the confluence with the Maumee river. The collection of sites displayed in Figure 63 were chosen because they comprise the contiguous set of sites longitudinally that represent the greatest drainage area. At the confluence with Jackson Cutoff, Beaver Creek drains just over 65 mi², while Jackson Cutoff represents over 100 mi². Similarly, Yellow Creek (56.3 mi²) and Brush Creek (24.6 mi²) join at their confluence to functionally form Jackson Cutoff.

Fish community samples were collected from 13 locations in seven streams within this sub-basin. All locations fully met and generally exceeded HELP WWH criteria. Fish community performance has improved substantially relative to existing historical data throughout all reaches within this sub-basin (Figure 63, Table 28).

Fish community distribution was noticeably influenced at sampling locations within this sub-basin up and downstream from an impoundment near the mouth of Jackson Cutoff (see ***Recommendations***). Sunfish community diversity was reduced upstream from this impoundment despite sufficient instream habitat to support more species. Bluegill, northern longear, rock bass, and orangespotted sunfish were relatively abundant at sites downstream from this impoundment; all four of these species were present in Jackson Cutoff immediately downstream from the impoundment, but only orangespotted sunfish and rock bass occurred sporadically in low abundances upstream from this impoundment (three total individuals from three of seven locations). Bluegill and longear sunfish were absent from the fish community upstream from this impoundment. Highly tolerant green sunfish were also more abundant at upstream locations (Appendix C). Several other species were only collected downstream from this impoundment but could be reasonably expected to spawn or persist upstream in moderate or low abundances given their presence elsewhere in this sub-basin. These species included: logperch darter; tadpole madtom; shorthead and silver redhorse; channel catfish; flathead catfish; white bass; freshwater drum; gizzard shad; smallmouth bass; and dusky darter. This impoundment is an obsolete structure historically used to draw drinking water for the village of Weston in the late 1960s before the village began to source drinking water from other sources in the early 1970s (A. Phillips, pers. comm.).

Fish community performance fully met HELP WWH expectations at both locations in Yellow Creek and has improved substantially since last sampled in 1981 (Table 26). Highly tolerant species, such as the creek chub, were reduced in abundance throughout Yellow Creek. Additionally, sensitive species were functionally absent from the fish community in 1981, comprising only 0.37 percent of the fish community at RM 3.2 and zero percent of the community at RMs 7.2 and 8. Sensitive species comprised 10 percent and 3.1 percent of the community at RMs 3.2 and 8.0, respectively. The proportion of simple lithophilic species also increased substantially at both locations from 1981 to 2015.

The fish community in Little Yellow Creek displayed distinct differences between the up and downstream sampling locations. Fish community performance at RM 0.9 (500700) has improved substantially since 1981 and fully met HELP WWH criteria. Sensitive and simple lithophilic species were well represented and comprised nine percent and 18.3 percent, respectively. Four simple lithophilic species were present, two of which were darter species. Habitat quality in this reach was characterized as fair.

Fish community performance nominally met HELP WWH expectations (IBI=42). However, the community here was anomalous compared to other sampling locations and performance scores did not fully reflect the resource quality condition at this location. The overwhelming abundance of blackstripe topminnows at this location (66 percent) was anomalous compared to other sampling locations (Figure 64). This species, though not categorized as tolerant, is morphologically adapted for utilizing the thin layer of oxygen-rich water at the atmosphere-water interface and is well suited for occupying habitats that are characterized by periodic or continuous oxygen depletion, such as those documented at this location (Table 21). The other two locations in the study area with noticeably high proportions of this species included North Creek RM 2.95 (47.1 percent) and Haskins Rd. Ditch RM 0.3 (41.4 percent). All three of these locations had very poor habitat quality and showed signs of enrichment. Additionally, sampling at Little Yellow Creek RM 4.6 documented low species diversity, extremely low abundances of species other than the blackstripe topminnow, and complete absence of other important fish species groups (darters, sensitive species) otherwise present downstream in Little Yellow and Yellow Creek.

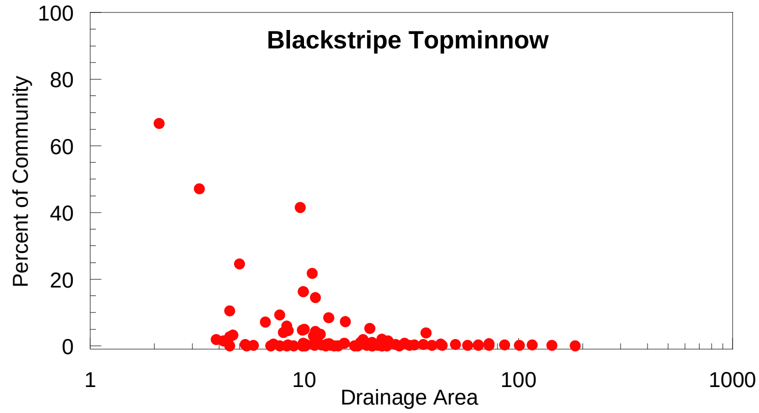

Figure 64 — Percentage of fish community comprised by blackstripe topminnow from all sampling locations, 2015.

The potential for a more balanced and better structured fish community in upper Little Yellow Creek is functionally precluded by both very poor habitat quality coupled with flow influences from the major municipal discharger outfall that "starts" Little Yellow Creek just a short distance upstream. The uppermost reaches of Little Yellow Creek are a functional effluent channel. The benefits of augmented stream baseflow and improved habitat quality were reflected in fish community performance and are realized in the downstream reaches. The upper reaches of Little Yellow Creek would likely be dry or interstitial if this constant source of flow were not present.

Other Tributary Systems

Other direct Maumee River tributary system with fish community samples collected included (listed upstream to downstream): Marie DeLarme Creek and tributaries; Sixmile Cutoff; Platter Creek and tributary; Sulphur Creek; Snooks Run; Preston Run; Wade Creek; Benien and Brubaker creeks; Tributary to the Maumee River (48.7); Garret Creek; Oberhaus and Van Hyning creeks; Tributary to Maumee River (42.2); Dry Creek; Big Creek; Sugar Creek; Tontogany Creek and tributaries; Liberty Hi Rd. Ditch; and Haskins Rd. Ditch. Fish community performance fully met applicable criteria at all locations sampled in these streams (Table 2) and has generally increased or been stable throughout reaches with existing historical data (Table 28).

Fish assemblages in upper Liberty Hi Rd. Ditch fell short of HELP WWH expectations. Additionally, performance in Haskins Rd. Ditch, a tributary to Liberty Hi Rd. Ditch, was also among the lowest scoring streams in the study area (Figure 52). Community performance in these stream segments was reflective of the highly modified instream habitat present. More substantial recovery throughout this system is precluded by the highly modified habitat in the upper reaches, coupled with a significant barrier to fish passage located on Liberty Hi Rd. Ditch at the King Ave. bridge culvert. Fish community performance in Sugar Creek (RM 1.06, 303007) met HELP WWH expectations, but was heavily influenced by downstream ponds/impoundments near the confluence with the Maumee River.

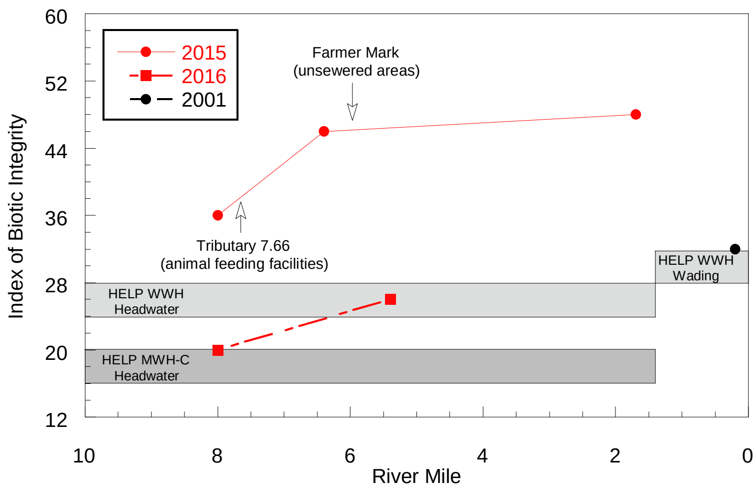

Figure 65 — Longitudinal IBI scores from Platter Creek, 2016, 2015 and 2001. Shaded areas represent indicated biocriteria and areas of non-significant departure from noted criteria.

Fish community performance in Platter Creek was mixed. Community performance met HELP WWH expectation in 2015 at all locations. Follow up sampling was conducted at two locations in 2016 to document whether there were lingering impacts from a fish kill stemming a leaking manure lagoon in July 2015 and documented generally lower community performance overall (Figure 65). Lower community performance at RM 7.95 (303014) in 2016 was attributed to substantially lower flow conditions than observed in 2015. Intermittent flows and a nearly dry stream segment were noted during 2016 sampling, while moderate and slow flows were documented at the same location in 2015. Pioneering species comprised more than 97 percent of the fish community at this location. In contrast to RM 7.95, continuous flow was noted at RM 5.4 during sampling. Sampling from 2016 in the middle reaches at RM 5.4 (302974) occurred downstream from an unsewered area whose potential influence was not originally captured by 2015 sampling at RM 6.4 (302975).

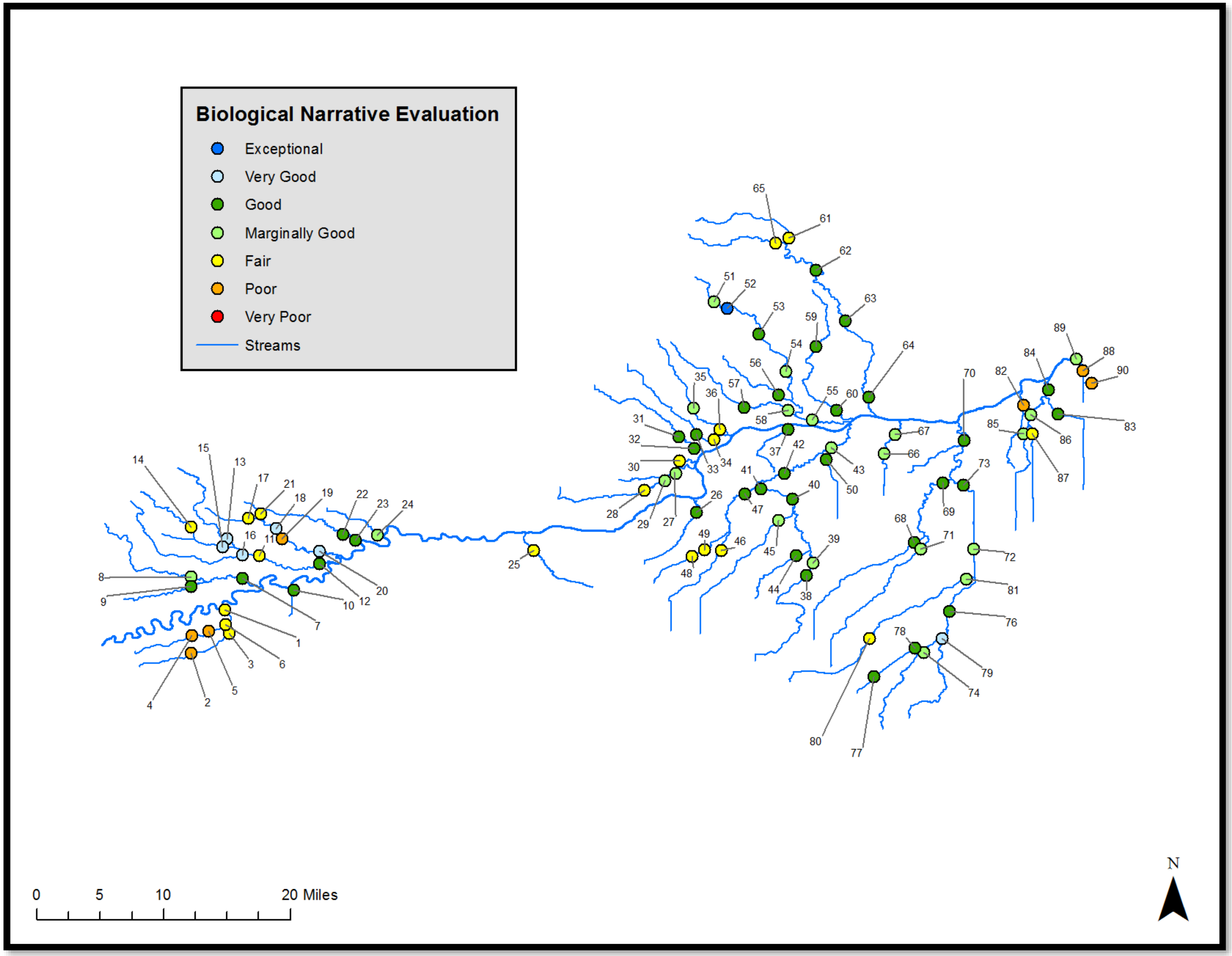

Figure 66 — Fish community sampling locations and narrative evaluations for streams within the Minor Great Black Swamp Tributaries study area, 2015-2016. The narrative evaluation is based off the lowest scoring fish biocriteria index, either IBI or MIwb. Site numbers correspond to those listed in Table 1.

Table 28 — Contemporary and historical IBI and MIwb scores from streams within the Minor Great Black Swamp Tributaries study area for the indicated years. IBI and MIwb scores are unique to each individual sampling event; if multiple sampling events occurred within a given year, an average of scores was taken. Determinations of significant and non-significant departure for historical data is based on current or recommended ALU. Colors displayed within this table correspond to the colors and associated narrative ranges noted in Figure 66.

River Mile	STORET	1981	1982	1984		1988	1989	1996		1997		2001	2002	2015		2016	
Zuber Cutoff Ditch (04-001-009)																	
1.1	P06K13															32	6.61*
0.3	P06K13									34	7.56						
North Creek (04-061-000)																	
3.0	P06W17									22				24			
2.6	P06K16									28							
1.6	P06W16									20				25			
0.3	303746															35	
South Creek (04-062-000)																	
3.7	302971													32		26	
0.35	302970													42	9.13	34	7.25^{NS}
Marie DeLarme Creek (04-056-000)																	
2.1	303387													38	8.41		
0.5	P06K24									34	6.16*						
North Branch Marie DeLarme Creek (04-057-000)																	
1.6	P06K25												30	38			
South Branch Marie DeLarme Creek (04-060-000)																	
1.3	P06K26												30				
1.0	P06K26													44			
Six Mile Cutoff Ditch (04-001-011)																	
0.3	303386													44			
Gordon Creek (04-052-000)																	
6.6	P06S15			23*	8.06			22*	5.94*					33	8.67		
2.8	P06K21									24*	7.24^{NS}						
1.1	P06S04			22*	5.59*									38	8.39		
North Fork Gordon Creek (04-054-000)																	
1.25	302972													46			
Middle Fork Gordon Creek (04-055-000)																	
3.8	P06S18			29				32						34			
2.8	P06K27			29						22*							
0.8	P06S18			19*										46			

River Mile	STORET	1981	1982	1984	1988	1989	1996	1997	2001	2002	2015	2016
South Fork Gordon Creek (04-052-000)												
7.4	P06K23							30				
0.2	302973										48	
Platter Creek (04-051-000)												
8.0	303014										36	20
6.4	302975										46	
5.4	302974											26^{NS}
1.7	303010										48	
0.2	P06K20								32 6.70*			
Trib. to Platter Creek (7.66) (04-051-001)												
0.8	303015										34	
Sulphur Creek (04-050-000)												
1.2	P06K19							26^{NS}				
1.0	302976										40	
0.1	P06W19							32			40	
Snooks Run (04-049-000)												
0.6	P06K17								24^{NS}		36	
Preston Run (04-047-000)												
2.5	302977										28	
Wade Creek (04-045-000)												
0.1	P09K21							34			42	
Benien Creek (04-042-000)												
2.3	P09K18								34 6.86^{NS}		34 7.72	
Brubaker Creek (04-043-000)												
2.4	302979										36	
0.5	P09K19								26^{NS}		32	
Trib. to Maumee River (04-001-012)												
1.3	302980										34	
Garrett Creek (04-041-000)												
2.5	302982										40	
0.7	P09K17								34 5.9*		38 8.48	
Oberhaus Creek (04-039-000)												
2.5	P09K15								26^{NS}		40	
0.4	302985										32	
Van Hyning Creek (04-040-000)												

River Mile	STORET	1981	1982	1984		1988	1989	1996	1997		2001	2002	2015		2016
4.3	302984												38		
2.0	P09K16										32				
0.8	302983												32		
Trib. to Maumee River (42.2) (04-001-013)															
0.4	302986												44		
South Turkeyfoot Creek (04-029-000)															
22.5	P09W15								28						
21.0	P09S27								24^{NS}				44		
19.8	P09S26												36	8.25	
14.8	P09W14								24*	6.36*					
13.2	P09W13								26*	6.29*			43	9.20	
10.8	P09W12												38	8.97	
10.2	P09K08								28^{NS}	3.79*					
7.9	302836												41	9.26	
5.3	P09K07								30^{NS}	6.19*					
3.2	303388												37	9.17	
2.0	P09W11								32	6.91^{NS}					
West Creek (04-033-000)															
1.0	P10K07											24^{NS}	40		
Lost Creek (04-031-000)															
1.3	P09S09			20.7*	4.39*								35	8.50	
School Creek (04-035-000)															
7.0	302993												34		
0.9	302994												42	8.79	
Brinkman Ditch (04-036-000)															
2.8	P09K11								32				34		
2.35	P09W17								28				32		
Little Turkeyfoot Creek (04-030-000)															
0.5	302843												44	8.67	
North Turkeyfoot Creek (04-037-000)															
19.1	P09S19												36		
18.7	P09S06		15*						27^{NS}						
18.54	P09K23								34						
18.5	P09W02								33						
17.9	P09S04		12*										50		
16.4	P09K13								34						

River Mile	STORET	1981	1982	1984		1988		1989		1996		1997		2001	2002	2015		2016
13.8	P09S03		18*													41		
10.9	P09S02		21*															
9.7	P09K12											32	8.71			34	8.70	
3.4	P09S01		28^{NS}									30^{NS}	7.94			37	9.16	
Trib. to North Turkeyfoot Creek (6.68) (04-037-001)																		
1.0	302989															40		
Konzen Ditch (04-038-000)																		
4.2	302987															40		
1.6	301662		30^{NS}															
0.7	P09K14			24*	5.34*					24*	7.11^{NS}					36	8.81	
Dry Creek (04-028-000)																		
8.8	302848															42		
1.6	302990															44	8.41	
1.2	P11K50											28^{NS}	5.57*					
Bad Creek (04-026-000)																		
22.5	P11K48															28		
21.4	P11K47											24*	6.56*					
19.8	P11S09			19*	3.85*													
17.9	P11K45		23*															
17.5	P11W22															41	9.29	
15.6	P11S08											21*	6.05*					
15.0	P11K44		24*															
14.1	P11S07							30^{NS}	7.85			29^{NS}	4.35*					
13.8	P11W03							26*	5.2*									
13.7	P11W24					12*												
13.4	P11W04					23*												
12.8	P11S10		17*			32	6.7*											
11.7	P11S05											26*	7.82					
10.5	P11S056															38	8.75	
10.0	P11K39		19*															
8.1	P11K38											26*	7.55					
4.6	P11K37											36	6.74*					
2.5	P11S04		20*									30^{NS}	6.73*			43	8.03	
South Branch Bad Creek (04-027-000)																		
0.4	302849															34		

River Mile	STORET	1981	1982	1984	1988	1989	1996	1997		2001		2002	2015		2016
Big Creek (04-024-000)															
3.5	P09S28												36		
1.3	P09K06									24*	5.1*		38	7.51	
Beaver Creek (04-015-000)															
16.2	302998												40		
8.3	P10K03							36	7.00^{NS}				43	9.67	
2.7	P10K02												40	9.11	
1.8	P10P02							30^{NS}	5.37*						
0.2	P10W10							26*	7.13^{NS}						
Hammer Creek (A.K.A. East Beaver Creek) (04-022-000)															
1.3	303000												35	7.94	
Jackson Cutoff Ditch (04-017-000)															
6.6	303003												35	8.05	
2.6	P10K05							32	7.68						
1.2	510040												45	10.40	
Yellow Creek (04-019-000)															
8.0	500760	25^{NS}											38		
7.2	500770	15*													
3.2	500780	21*											40	8.43	
Little Yellow Creek (04-021-000)															
5.5	500720	15													
4.6	P10W08														42
3.8	500710	19*													
0.9	500700	18*											44		
West Creek (04-020-000)															
0.1	302840												46		
Brush Creek (04-018-000)															
9.0	303002												34		
0.6	P10P06									18*	4.9*		36	8.20	
Sugar Creek (04-001-014)															
1.1	303007												26^{NS}		
Tontogany Creek (04-013-000)															
4.2	303006												42		
1.6	P10K01							22*	6.3*				40	8.73	
West Branch Tontogany Creek (04-013-001)															
3.4	P10P13												36		

River Mile	STORET	1981	1982	1984	1988	1989	1996	1997	2001	2002	2015		2016
2.2	P10P14										34	7.60	
Trib. to West Branch Tontogany Creek (3.2) (04-013-002)													
0.7	303005										32		
Liberty Hi Road Ditch (04-001-015)													
1.2	303622										20^NS		
0.1	303008										38		
Haskins Road Ditch (04-001-016)													
0.3	303009										26		

* Significant departure from (not achieving) applicable biocriteria.
NS Nonsignificant departure from (achieving) existing or recommended biocriterion (≤4 IBI units; ≤0.5 MIwb units).

Index – Site Type	Biological Criteria - HELP		
	WWH	MWH-C	LRW
IBI – Headwater and Wading	32/28	24	18
MIwb – Wading	7.3	5.6	4.5

Table 29 — Fish community summaries based on pulsed D.C. electrofishing sampling conducted by Ohio EPA throughout the Minor Great Black Swamp Tributaries study area during the 2015 and 2016 sampling index periods. If two samples were collected from one location within the same year, results were averaged.

STORET	Stream Name	Year	River Mile	Drainage Area	Relative number of all spp. (#/0.3km)	Relative number minus tolerant (#/0.3km)	Cumulative number of species	Cumulative number of sensitive species	QHEI	Latitude	Longitude
P06K13	Zuber Cutoff	2016	0.3	29.5	1,104	347	19	1	63.75	41.200600	-84.689700
P06W17	North Creek	2015	3	4.3	34	22	6	0	22.00	41.171100	-84.727200
P06W16	North Creek	2015	1.6	5.4	271	95	13	0	19.00	41.175600	-84.708100
303746	North Creek	2016	0.3	6.1	1,217	530	14	0	49.00	41.183368	-84.688659
302971	South Creek	2015	3.7	11.3	1,148	318	21	0	33.50	41.150650	-84.728340
302971	South Creek	2016	3.7	11.3	1,360	302	10	0	30.25	41.150650	-84.728340
302970	South Creek	2015	0.35	23.1	1,532	1,088	22	2	62.25	41.179298	-84.683836
302970	South Creek	2015*	0.35	23.1	26	2	6	0	54.00	41.179298	-84.683836
302970	South Creek	2016	0.35	23.1	1,706	422	17	1	46.75	41.179298	-84.683836
303387	Marie DeLarme Creek	2015	2.1	26.8	1,787	1,104	23	2	53.51	41.236683	-84.669392
P06K26	South Branch Marie DeLarme	2015	1	7.2	1,978	1,394	18	1	42.25	41.227500	-84.727800
P06K25	North Branch Marie DeLarme	2015	1.6	8.4	2,232	1,468	17	2	39.00	41.238100	-84.727800
303386	Six Mile Cutoff	2015	0.3	11.2	1,354	906	22	1	67.25	41.223092	-84.610364
P06S15	Gordon Creek	2015	6.6	37	2,211	1,426	26	4	41.50	41.262200	-84.650000
P06S04	Gordon Creek	2015	1.1	43.4	2,132	1,560	31	4	70.50	41.252812	-84.581443
302972	North Fork Gordon Creek	2015	9.6	11.1	1,278	972	18	1	48.75	41.280830	-84.689570
P06S18	Middle Fork Gordon Creek	2016	3.8	5.3	688	228	16	1	31.25	41.295000	-84.728100
P06S16	Middle Fork Gordon Creek	2015	0.8	13	1,826	1,140	22	3	44.25	41.274025	-84.689464
302973	South Fork Gordon Creek	2015	0.2	10.9	1,944	1,538	19	1	43.25	41.263520	-84.669260
303014	Platter Creek	2015	8	4.5	616	330	16	1	28.50	41.303427	-84.650037
303014	Platter Creek	2016	8	4.5	222	39	4	0	16.00	41.303427	-84.650037
302975	Platter Creek	2015	6.4	11.9	1,546	1,200	21	2	42.75	41.293210	-84.630920
302974	Platter Creek	2016	5.4	12.8	1,761	678	14	1	26.50	41.281630	-84.623900
303010	Platter Creek	2015	1.7	20	2,924	2,462	22	1	61.00	41.267300	-84.581420
303015	Trib. to Platter Creek (7.66)	2015	0.8	5	204	112	12	1	31.50	41.310023	-84.649978
302976	Sulphur Creek	2015	1	8.9	980	462	23	1	64.50	41.281095	-84.543958
P06W19	Sulphur Creek	2015	0.1	9.9	524	332	19	2	61.25	41.280841	-84.535588
P06K17	Snooks Run	2015	0.6	4.2	852	394	19	1	53.50	41.285471	-84.514882
302977	Preston Run	2015	2.5	7.7	1,884	540	15	1	59.50	41.268020	-84.336590

STORET	Stream Name	Year	River Mile	Drainage Area	Relative number of all spp. (#/0.3km)	Relative number minus tolerant (#/0.3km)	Cumulative number of species	Cumulative number of sensitive species	QHEI	Latitude	Longitude
P09K22	Wade Creek	2015	1.8	9.8	814	494	17	1	74.25	41.311400	-84.150600
P09K18	Benien Creek	2015	2.3	21.6	985	488	23	1	65.75	41.355800	-84.173900
302979	Brubaker Creek	2015	2.4	8.4	1,041	259	14	0	59.50	41.336640	-84.209820
P09K19	Brubaker Creek	2015	0.5	9.9	1,230	566	18	2	57.25	41.348100	-84.186700
302980	Trib. to Maumee River (48.7)	2015	1.3	12.6	1,309	669	21	2	75.25	41.370570	-84.170220
302982	Garrett Creek	2015	2.5	17.2	966	534	20	0	68.50	41.397760	-84.170590
P09K17	Garrett Creek	2015	0.7	27.8	1,458	827	22	3	53.75	41.384700	-84.153600
P09K15	Oberhaus Creek	2015	2.5	8.3	1,968	1,108	12	0	53.50	41.400600	-84.151100
302985	Oberhaus Creek	2015	0.4	10.1	1,428	340	19	2	60.25	41.399190	-84.123700
302984	Van Hyning Creek	2015	4.3	9.8	1,544	800	13	0	54.25	41.430660	-84.153680
302983	Van Hyning Creek	2015	0.8	13.8	638	266	15	0	53.50	41.404520	-84.121760
302986	Trib. to Maumee (42.2)	2015	0.4	7	1,104	384	28	4	56.25	41.406170	-84.045800
P09S27	South Turkeyfoot Creek	2015	20.9	18.9	2,636	2,232	18	1	46.25	41.239700	-84.024700
P09S26	South Turkeyfoot Creek	2015	19.8	20.2	1,263	638	22	2	41.50	41.254207	-84.017610
P09W13	South Turkeyfoot Creek	2015	13.2	65	1,606	939	33	5	69.25	41.326700	-84.041100
P09W12	South Turkeyfoot Creek	2015	10.8	73	1,054	635	31	4	67.75	41.338900	-84.076700
302836	South Turkeyfoot Creek	2015	7.9	116	1,269	851	32	4	71.75	41.356556	-84.050397
303388	South Turkeyfoot Creek	2015	3.2	143	1,959	1,249	31	7	63.50	41.385561	-83.996458
P10K07	West Creek (trib. to S. Turkeyfoot Creek)	2015	1	15.4	1,965	1,129	22	2	42.25	41.261900	-84.036700
P09S09	Lost Creek	2015	1.3	20.7	1,401	768	23	2	49.50	41.302216	-84.056659
302993	School Creek	2015	7	9.8	1,296	612	17	0	37.50	41.268120	-84.122640
302994	School Creek	2015	0.9	32.7	1,405	762	29	3	65.50	41.332990	-84.095750
P09K11	Brinkman Ditch	2015	2.8	8	806	394	14	1	56.75	41.264400	-84.152200
P09W17	Brinkman Ditch	2015	2.4	8.3	610	295	18	1	53.48	41.267800	-84.145600
302843	Little Turkeyfoot Creek	2015	0.5	22.1	1,195	757	27	3	74.75	41.378480	-83.998055
P09S19	North Turkeyfoot Creek	2015	19.1	4.5	794	302	15	1	44.50	41.552200	-84.130800
P09S04	North Turkeyfoot Creek	2015	17.9	5.8	1,989	1,342	21	4	50.00	41.544400	-84.115300
P09S03	North Turkeyfoot Creek	2015	13.8	19.6	1,452	863	25	4	66.25	41.515300	-84.079700
P09K12	North Turkeyfoot Creek	2015	9.7	31	1,892	1,189	22	4	52.00	41.472200	-84.048600
P09S01	North Turkeyfoot Creek	2015	3.4	73	1,942	1,103	33	6	54.00	41.417500	-84.018300
302989	Trib. to North Turkeyfoot Creek (4.65)	2015	1	9.9	1,762	986	17	2	31.00	41.445780	-84.057210

STORET	Stream Name	Year	River Mile	Drainage Area	Relative number of all spp. (#/0.3km)	Relative number minus tolerant (#/0.3km)	Cumulative number of species	Cumulative number of sensitive species	QHEI	Latitude	Longitude
302987	Konzen Ditch	2015	4.2	15.6	1,955	1,253	24	2	47.75	41.431510	-84.095870
P09K14	Konzen Ditch	2015	0.7	24.7	2,876	1,634	24	3	56.50	41.428364	-84.045671
302848	Dry Creek	2015	8.8	11.3	708	430	19	1	36.50	41.501219	-84.013956
302990	Dry Creek	2015	1.6	23.9	954	613	22	2	56.50	41.428600	-83.991000
P11K48	Bad Creek	2015	22.5	12	1,090	590	11	0	42.75	41.617937	-84.047349
P11W22	Bad Creek	2015	17.5	36	1,825	961	29	5	71.75	41.588300	-84.014200
P11S05	Bad Creek	2015	10.5	44	2,046	1,418	23	3	55.75	41.530383	-83.980969
P11S04	Bad Creek	2015	2.5	58	481	428	27	6	50.00	41.443473	-83.953970
302849	South Branch Bad Creek	2015	0.4	10.2	1,054	724	13	0	44.50	41.620161	-84.053808
P09S28	Big Creek	2015	3.5	17.8	1,597	538	17	1	63.50	41.378600	-83.936100
P09K06	Big Creek	2015	1.3	20.7	863	405	22	2	67.25	41.400800	-83.923300
302998	Beaver Creek	2015	16.2	19.4	1,122	592	18	2	40.25	41.277430	-83.902030
P10K03	Beaver Creek	2015	8.3	65	1,369	1,022	36	7	58.00	41.345600	-83.869200
P10K02	Beaver Creek	2015	2.7	184	973	719	37	10	65.00	41.393600	-83.845000
303000	Hammer Creek (a.k.a. E. Beaver Creek)	2015	1.3	24.3	904	542	18	2	60.00	41.269500	-83.894360
303003	Jackson Cutoff Ditch	2015	6.6	86.3	1,222	683	25	5	67.50	41.269760	-83.834150
510040	Jackson Cutoff Ditch	2015	1.2	101	3,413	2,613	35	8	70.75	41.342800	-83.846100
500760	Yellow Creek	2015	8	18.3	884	429	19	3	63.25	41.153100	-83.892200
500780	Yellow Creek	2015	3.2	51	1,318	1,005	24	4	63.75	41.198900	-83.861400
P10W08	Little Yellow Creek	2016	4.6	2.1	222	180	12	0	27.00	41.123900	-83.947900
500700	Little Yellow Creek	2015	0.9	7.7	931	679	15	2	45.50	41.155800	-83.900000
302840	West Creek (trib. to Yellow Creek)	2015	0.1	13.3	1,262	954	17	2	64.50	41.167835	-83.869879
303002	Brush Creek	2015	9	10	1,708	1,000	14	1	40.50	41.167300	-83.952600
P10P06	Brush Creek	2015	0.6	24.6	914	538	24	4	42.50	41.235135	-83.842490
303007	Sugar Creek	2015	1.1	5.4	114	38	5	0	44.25	41.433978	-83.776809
303006	Tontogany Creek	2015	4.2	11.2	2,662	1,884	22	1	56.75	41.423720	-83.737820
P10K01	Tontogany Creek	2015	1.6	39.4	1,358	826	32	8	64.50	41.451900	-83.748600
P10P13	West Branch Tontogany Creek	2015	3.4	6.6	224	202	8	1	17.25	41.408589	-83.772497
P10P14	West Branch Tontogany Creek	2016	2.2	20.8	1,056	563	15	2	68.25	41.423381	-83.768212
303005	Trib. to West Br. Tontogany Creek (3.2)	2015	0.7	13.1	648	270	18	1	42.00	41.401407	-83.767102

STORET	Stream Name	Year	River Mile	Drainage Area	Relative number of all spp. (#/0.3km)	Relative number minus tolerant (#/0.3km)	Cumulative number of species	Cumulative number of sensitive species	QHEI	Latitude	Longitude
303622	Liberty Hi Rd. Ditch	2016	1.2	11.3	232	26	6	0	47.00	41.473218	-83.709050
303008	Liberty Hi Rd. Ditch	2015	0.1	14.4	1,010	540	17	3	80.50	41.486800	-83.716480
303009	Haskins Rd. Ditch	2015	0.3	9.6	690	288	7	0	20.00	41.459180	-83.703640

* This sample from South Creek at RM 0.35 (302970) was collected after a documented fish kill and is presented separately from data collected in 2015 prior to the fish kill.

Macroinvertebrate Community – Overview and Trends

Acerpenna pygmaea (one of the most common sensitive mayfly taxa collected at better quality sites). Macroinvertebrate Biocriterion – overall 91 percent meeting criteria, nine percent not meeting

Macroinvertebrate communities were evaluated at 90 locations within 50 different streams throughout the survey area from June to October 2015 and 2016. Primary sampling occurred in 2015, while additional sampling occurred in 2016 to either gather more information from select streams or elucidate causes or sources of aquatic life use impairment where necessary.

Qualitative sampling was conducted at all sampling locations, and quantitative Hester-Dendy artificial substrate samples were collected from 25 streams at 40 locations. A summary of the macroinvertebrate community sampling results is presented in Table 30. Collection results from each sampling site and ICI/metric results are found in Appendix A and B, respectively.

Overall, 81 of 90 (90 percent) of sites met applicable biocriterion for the existing or recommended ALU: 90 percent of WWH sites (72 of 80); 89 percent of MWH–C sites (8 of 9); and one LRW site. Water quality trends have improved. As noted above, Acerpenna spp. (A. pygmaea or A. macdunoughi), was the most commonly sampled moderately intolerant (MI) mayfly collected during this 2015-16 survey. In this survey Acerpenna spp. mayflies were collected in 78% of total samples, a substantial increase from only 21% of total samples during the 1996-97 survey. Also, overall EPT and sensitive taxa totals have increased over time. The survey work in the 1980's documented an average of 4-5 EPT taxa and 0-1 sensitive taxa per site. The 1996-7 survey average totals were 8-9 EPT and 4 sensitive taxa collected per site. The 2015-16 survey (which included many more smaller tributaries than previous surveys) average still increased slightly to 9-10 EPT and 4-5 sensitive taxa collected per site.

Fourteen streams or stream segments did not have a designated ALU prior to the current survey. Ten undesignated streams or stream segments are recommended WWH and met the biocriterion: Zuber Cutoff Ditch; Six-mile Cutoff Ditch; Trib. to Maumee River (48.7); Trib. to Maumee River (42.2); School Creek; Trib. to North Turkeyfoot Creek (6.68); Sugar Creek; lower West Branch Tontogany Creek; Trib. to West Branch Tontogany Creek (3.2); and the lower reach of Liberty Hi Rd. Ditch. Four undesignated streams or stream segments sampled are recommended designated MWH-C and met applicable biocriterion: Trib. to Platter Creek (7.66); the upper reaches of West Branch Tontogany Creek; and the upper reach of both Liberty Hi Rd. Ditch and Haskins Rd. ditches (Table 30).

There were 29 streams or stream segments sampled that maintained a designated/unverified ALU prior to this survey that were either confirmed or recommended to be WWH. Seven of these streams remained unverified despite having historical data: North Creek; Marie DeLarme Creek; Sulphur Creek; Wade Creek; South Turkeyfoot Creek; Brinkman Ditch; and Beaver Creek. From these 29 unverified WWH streams, there were 39 sample sites with full attainment that met applicable WWH biocriterion. Seven sites did not meet applicable WWH biocriterion. Confirmed or recommended WWH streams (previously unverified) that met the WWH biocriterion were: South Creek (RM 0.35 in 2015); Marie DeLarme Creek and tributaries; and two of three sites in Platter Creek (Table 30).

Platter Creek at RM 1.65 met applicable WWH biocriterion, despite substantial drainage maintenance activities that occurred during the survey. Figure 67 and Figure 68 depict pre- and post-instream maintenance with back hoe tracks and material (gravel, rocks, and woody debris) removed from the channel (Figure 68). Artificial macroinvertebrate colonizers were deployed on July 8, 2015 to attempt a quantitative sample collection but were inadvertently buried/removed from the stream prior to retrieval likely resulting from stream maintenance activities. Despite meeting WWH, qualitative sampling indicated a more diverse community overall prior to maintenance activities. Though these specific impacts are somewhat localized and relatively acute in terms of temporal influences, the cumulative influences from various stream maintenance activities (for example, sediment dipping, vegetative controls) within a given stream and throughout a watershed or sub-watershed have the potential for profound negative influences. It would be beneficial, here and throughout the study area, to have a "lighter touch" when conducting maintenance activities and to follow the recommendations of the Rural Drainage Committee and guidelines of the Rural Drainage Committee (ODNR 2008, 2009).

Figure 67 — Platter Creek downstream from Jericho Rd. (west crossing) at RM 1.65 before stream maintenance Hester Dendy setting (7/8/2015).

Figure 68 — Platter Creek RM 1.65 post-stream maintenance upstream and downstream (8/20/15).

Other streams or stream segments designated or recommended WWH that met applicable biocriterion were: Sulphur Creek; Preston Run; Wade Creek; Benien Creek; Brubaker Creek; Oberhaus Creek; Van Hyning Run; South Turkeyfoot Creek; West Creek (trib. to South Turkeyfoot Creek); Lost Creek; Brinkman Ditch (upstream from RM 2.8); Little Turkeyfoot Creek; lower Dry Creek; Big Creek; Beaver Creek; Hammer Creek; Jackson Cutoff Ditch; West Creek (trib. to Yellow Creek); and Tontogany Creek. Six non-attaining sites among the designated or recommended WWH streams were: North Creek at RM 0.3; South Creek at RM 0.35 (2016); Platter Creek at RM 5.4; Snooks Run; Lost Creek; Brinkman Ditch at RM 2.35; and Dry Creek RM 8.8 (302848).

Seven streams or stream segments whose ALU is recommended to be upgraded to WWH from MWH-C aquatic life use based on their biological performance documented during the survey were fully meeting applicable criterion: Gordon Creek; North Fork Gordon Creek; South Fork Gordon Creek; the lower reach of Middle Fork Gordon Creek; Konzen Ditch; Yellow Creek; and the lower reach of Little Yellow Creek.

Community quality in these steams ranged from good to an ICI of 46 (exceptional). The upstream site (RM 3.9) on Middle Fork Gordon Creek was the only non-attaining macroinvertebrate score among these streams.

Eight of 9 recommended MWH-C stream sites and one LRW stream met the biological criteria during sampling in 2015 and 2016. Streams or stream segments that met the recommended MWH-C or LRW ALU included: North Creek RM 1.60; upper South Creek (2016); upper Platter Creek (2016); Trib. to Platter Creek (7.66); upper West Branch Tontogany Creek; upper Liberty Hi Rd. Ditch; and Haskins Rd. Ditch. Upper Little Yellow Creek at RM 4.6 met the LRW biocriterion with a fair quality community (Table 30). The upper site on North Creek (RM 2.95) did not meet the MWH criterion with a low-fair quality assessment in 2015.

Table 30 — Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in selected Maumee River tributary survey samples. Primary sampling occurred from June-October 2015, with 2016 follow-up sampling denoted by [brackets]. Non-attaining scores are denoted with an asterisk. Poor scores are highlighted red. Colors displayed within this table correspond to the colors and associated narrative ranges noted in

Figure 66.

River Mile	Drain. Area (mi²)	Total Taxa	Quant. Taxa	Qual. Taxa	EPT Taxa (Qual./ Total)	Sensitive Taxa (Qual./ Total)	Cold-water Taxa	Qual. Tolerant Taxa	Relative Density (Qual. - Quant.)	Predominant Organisms on the Natural Substrates with Tolerance Category(-ies)	ICI	Narrative Evaluation
Zuber Cutoff Ditch (04-001-009)										**Undesignated - WWH Recommended**		
[1.1]	[29.0]	[36]	-	[36]	[9/9]	[2/2]	[0]	[13]	[M]	[Hydropsychid caddisflies (F)]	[G]	[Good]
North Creek (04-061-000)										**WWH Existing - Unverified/MWH-C Recommended**		
2.9	3.2	26	-	26	3/3	0/0	0	18	M - L	Midges (F, T), fingernail clams (F)	LF*	Low Fair*
1.6	3.9	33	-	33	3/3	0/0	0	17	M - H	Midges (F, MT, T), fingernail clams (F)	HF	High Fair
North Creek (04-061-000)										**WWH Existing - Unverified/WWH Recommended**		
[0.3]	[4.6]	[26]	-	[26]	[3/3]	[0/0]	[0]	[10]	[M]	[Hydroptilid caddisflies (F), flatworms (F)]	[F*]	[Fair*]
South Creek (04-062-000)										**WWH Existing - Unverified/MWH-C Recommended**		
3.7	11.3	18	-	18	2/2	0/0	0	14	M - L	Midges (T), snails (*Physella, Planorbella* spp.) (MT, T)	P*	Poor*
[3.7]	[11.3]	[24]	-	[24]	[3/3]	[1/1]	[0]	[14]	[H – L]	[Physella snails (T), beetles (MT, T), corixids (MT)]	[HF]	[High Fair]
South Creek (04-062-000)										**WWH Existing - Unverified/WWH Recommended**		
0.35	23.1	71	47	46	9/12	2/5	2	20	M – H/ 1,311/ft.²	Hydropsychid caddisflies (F, MI), baetid mayflies (F, MT, MI), fingernail clams (F)	42	Very Good
[0.35]	[23.1]	[31]	-	[31]	[5/5]	[1/1]	[0]	[16]	[M]	[*Stenonema femoratum* (F), *Caenis* sp. mayflies (F)]	[F*]	[Fair*]
Marie DeLarme Creek (04-057-000)										**WWH Existing – Unverified/Confirmed**		
3.65	25.0	62	33	43	8/10	5/7	0	11	M/ 268/ft.²	Hydroptilid caddisflies (F), baetid and heptageneid mayflies (F, MI), fingernail clams (F)	34	Good
North Branch Marie DeLarme Creek (04-057-000)										**WWH Existing – Unverified/Confirmed**		
1.6	8.4	45	-	45	9/9	2/2	0	18	M - H	Hydropsychid caddisflies (F), *Polypedilum* spp. midges (F, T), *Stenacron* sp./*Stenonema femoratum* (F), *Orconectes* crayfish (F)	G	Good
South Branch Marie DeLarme Creek (04-060-000)										**WWH Existing – Unverified/Confirmed**		

River Mile	Drain. Area (mi²)	Total Taxa	Quant. Taxa	Qual. Taxa	EPT Taxa (Qual./ Total)	Sensitive Taxa (Qual./ Total)	Cold-water Taxa	Qual. Tolerant Taxa	Relative Density (Qual. - Quant.)	Predominant Organisms on the Natural Substrates with Tolerance Category(-ies)	ICI	Narrative Evaluation
1.0	7.2	42	-	42	8/8	3/3	0	16	M - L	Hydropsychid caddisflies (F), *Orconectes* crayfish (F), fingernail clams (F)	MG^{NS}	Marginally Good
Six-mile Cutoff Ditch (04-001-011)										**Undesignated - WWH Recommended**		
0.25	11.2	45	-	45	9/9	4/4	0	18	M - L	Baetid mayflies (F), hydropsychid caddisflies (F, MI)	MG^{NS}	Marginally Good
Gordon Creek (04-052-000)										**MWH-C Existing/WWH Recommended**		
6.67	37.0	73	41	56	12/16	7/12	0	15	M – H/ 2,665/ft.^{2}	Hydropsychid caddisflies (F, MI), *Polypedilum flavum*, *Dicrotendipes neomodestus*, and tanytarsini midges (F), baetid mayflies (F, MI), *Petrophila* moth larvae (MI)	44	Very Good
2.15	42.8	65	40	44	12/15	10/13	0	9	M/ 555/ft.^{2}	Hydropsychid and *Hydroptila* caddisflies (F)	42	Very Good
North Fork Gordon Creek (04-054-000)										**MWH-C Existing/WWH Recommended**		
1.25	11.1	34	-	34	10/10	4/4	0	9	M	Baetid mayflies (F), Hydropsychid caddisflies (F, MI), *Sphaerium* sp. (fingernail clams) (F)	G	Good
Middle Fork Gordon Creek (04-055-000)										**MWH-C Existing/WWH Recommended**		
[3.9]	[5.3]	[26]	-	[26]	[7/7]	[2/2]	[0]	[9]	[M]	[Midges (*mostly Chironomus (C.) decorus gr.* with others) (T, F), baetid mayflies (mainly *Callibaetis* sp. with others) (MT, F, MI)]	[F*]	[Fair*]
0.76	13.0	72	50	47	10/13	5/9	1	14	M – H/ 2,092/ft.^{2}	Hydropsychid and *Hydroptila* caddisflies (F, MI), midges (mostly *Polypedilum flavum* and tanytarsini midges with others) (F, MT, T, MI)	44	Very Good
South Fork Gordon Creek (04-055-000)										**MWH-C Existing/WWH Recommended**		
0.23	10.9	42	-	42	10/10	4/4	0	16	M	Fingernail clams (*Sphaerium* sp.) (F)	G	Good
Platter Creek (04-051-000)										**WWH Existing - Unverified/MWH Recommended**		
7.95	4.5	42	-	42	4/4	0/0	0	22	H – M	Midges (*Cricotopus bicinctus*, *Polypedilum illinoense* (T) and *Conchapelopia* sp., *Paratanytarsus* sp. (F)), isopods (F)	LF*	Low Fair*
[7.95]	[4.5]	[25]	-	[25]	[3/3]	[0/0]	[0]	[18]	[M – L]	[Beetles (F, T), corixids (MT, T)]	[HF]	[High Fair]

River Mile	Drain. Area (mi²)	Total Taxa	Quant. Taxa	Qual. Taxa	EPT Taxa (Qual./ Total)	Sensitive Taxa (Qual./ Total)	Cold-water Taxa	Qual. Tolerant Taxa	Relative Density (Qual. - Quant.)	Predominant Organisms on the Natural Substrates with Tolerance Category(-ies)	ICI	Narrative Evaluation
Platter Creek (04-051-000)										**WWH Existing - Unverified/Confirmed**		
6.41	11.9	38	-	38	10/10	2/2	0	18	H - M	Hydropsychid caddisflies (F, MI), midges (F, T), *Simulium* sp. (F)	MG^NS	Marginally Good
[5.40]	[12.8]	[31]	-	[31]	[7/7]	[1/1]	0	[13]	[H – M]	[Fingernail clams (*Sphaerium* sp.) (F), flatworms (F), hydroptilid caddisflies (F), Bryozoa (F)]	[F*]	[Fair*]
1.65	20.0	26	-	26	10/10	4/4	0	3	M - L	Hydropsychid caddisflies (F, MI), heptageneid mayflies (F), baetid mayflies (F, MI), *Polypedilum flavum* (F)	G	Good
Trib. to Platter Creek (7.66) (04-051-001)										**Undesignated/MWH Recommended**		
0.78	5.0	24	-	24	2/2	0/0	0	16	L	Hydropsychid caddisflies (F), *Callibaetis* sp. mayflies (MT), midges (F, MT, T), *Physella* sp. snails (T)	F	High Fair
Sulphur Creek (04-050-000)										**WWH Existing - Unverified/Confirmed**		
0.95	8.9	32	-	32	9/9	1/1	0	7	M - H	Hydropsychid caddisflies (F), *Sphaerium* sp. (fingernail clams) (F)	G	Good
0.13	9.9	44	-	44	7/7	0/0	0	16	M - L	Baetid mayflies (F), hydropsychid caddisflies (F), midges (F, MT, T)	MG^NS	Marginally Good
Snooks Run (04-049-000)										**WWH Existing - Unverified/Confirmed**		
0.7	4.1	35	-	35	3/3	0/0	1	21	L	Scuds (F), hydropsychid caddisflies (F), water mites (F)	F*	Fair*
Preston Run (04-047-000)										**WWH Existing - Unverified/Confirmed**		
2.45	7.7	48	-	48	10/10	1/1	0	18	M - H	Flatworms (F), hydropsychid caddisflies (F)	MG^NS	Marginally Good
Wade Creek (04-045-000)										**WWH Existing - Unverified/Confirmed**		
1.8	9.8	28	-	28	9/9	5/5	0	9	M - L	Hydropsychid caddisflies (F), baetid mayflies (F, MI), heptageneid mayflies (F, MI)	G	Good
Benien Creek (04-042-000)										**WWH Existing - Unverified/Confirmed**		
2.30	21.6	50	29	43	8/9	3/4	0	11	M/ 677/ft.²	Hydropsychid caddisflies (F), baetid mayflies (F, MI)	38	Good
Brubaker Creek (04-042-000)										**WWH Existing - Unverified/Confirmed**		

River Mile	Drain. Area (mi²)	Total Taxa	Quant. Taxa	Qual. Taxa	EPT Taxa (Qual./ Total)	Sensitive Taxa (Qual./ Total)	Cold-water Taxa	Qual. Tolerant Taxa	Relative Density (Qual. - Quant.)	Predominant Organisms on the Natural Substrates with Tolerance Category(-ies)	ICI	Narrative Evaluation
2.40	8.4	44	-	44	9/9	2/2	0	16	M - L	Hydropsychid caddisflies (F), baetid mayflies (F), heptageneid mayflies (F)	G	Good
0.45	9.9	65	-	65	13/13	6/6	0	24	M - L	Midges (F, MT, T, MI), damselflies (F, T), hydropsychid caddisflies (F), baetid mayflies (F, MI)	G	Good
Trib. to Maumee River (48.7) (04-001-012)										**Undesignated/WWH Recommended**		
1.3	12.6	50	31	37	8/8	4/4	1	9	M/ 1,187/ft.²	Hydropsychid caddisflies (F), flatworms (F), *Polypedilum flavum* and other spp. (F, T), and tanytarsini midges (F, MI)	36	Good
Garrett Creek (04-041-000)										**WWH Existing - Unverified/Confirmed**		
2.49	17.2	33	26	17	3/6	1/3	0	4	L/ 155/ft.²	Heptageneid mayflies (F, MI), midges (*Corynoneura lobata*, tanypodes including *Ablabesmyia mallochi*, and *Polypedilum* and tanytarsini midges (F, T), hydropsychid caddisflies (F)	MG[NS]	Marginally Good
0.70	27.8	41	32	28	6/7	2/4	0	5	M – L/ 730/ft.²	Baetid mayflies (F, MI), hydropsychid caddisflies (F), heptageneid mayflies (F, MI)	MG[NS]	Marginally Good
Oberhaus Creek (04-039-000)										**WWH Existing - Unverified/Confirmed**		
2.5	8.3	29	-	29	6/6	1/1	1	9	M - H	Baetid mayflies (F), hydropsychid caddisflies (F, MI), *Stenonema femoratum* mayflies (F)	MG[NS]	Marginally Good
0.40	10.1	30	-	30	7/7	3/3	1	8	M	Baetid mayflies (F, MI), isopods (MT), hydropsychid caddisflies (F, MI)	MG[NS]	Marginally Good
Van Hyning Creek (04-040-000)										**WWH Existing - Unverified/Confirmed**		
4.31	9.8	49	-	49	9/9	6/6	0	15	M	Baetid mayflies (F, MI), hydropsychid caddisflies (F, MI)	G	Good
0.75	13.8	30	-	30	10/10	4/4	1	3	M	Hydropsychid caddisflies (F, MI), baetid mayflies (F, MI), *Stenonema femoratum* mayflies (F)	G	Good
Trib. to Maumee River (42.2) (04-001-012)										**Undesignated/WWH Recommended**		

River Mile	Drain. Area (mi²)	Total Taxa	Quant. Taxa	Qual. Taxa	EPT Taxa (Qual./ Total)	Sensitive Taxa (Qual./ Total)	Cold-water Taxa	Qual. Tolerant Taxa	Relative Density (Qual. - Quant.)	Predominant Organisms on the Natural Substrates with Tolerance Category(-ies)	ICI	Narrative Evaluation
0.85	6.7	34	-	34	9/9	2/2	0	7	M	Baetid mayflies (F, MI), hydropsychid caddisflies (F), hydroptilid caddisflies (F)	G	Good
South Turkeyfoot Creek (04-029-000)										**WWH Existing - Unverified/Confirmed**		
20.94	18.9	57	37	43	8/8	6/7	0	13	L – H/ 5,265/ft.²	*Polypedilum flavum* and other spp. (F, T), and tanytarsini midges (F), fingernail clams (*Sphaerium* sp.) (F), flatworms (F)	36	Good
19.75	20.0	62	45	40	7/10	1/3	0	18	H – M/ 1,435/ft.²	Midges (F, MT, T), damselflies (F, T)	40	Good
13.18	65.0	48	-	48	12/12	7/7	0	11	M - L	Midges (F, MT, T), baetid mayflies (MI)	G	Good
10.85	73	71	42	54	14/15	13/15	0	8	M – L/ 476/ft.²	Baetid mayflies (MI, F), hydropsychid caddisflies (MI, F), and midges (F, MT, T, MI)	38	Good
7.90	116	60	34	44	12/16	9/13	0	8	M/ 1,428/ft.²	Hydropsychid caddisflies (F, MI), midges (tanytarsini (F, MI) and *Polypedilum* spp. (F, T)), heptageneid mayflies (F, MI)	40	Good
3.2	143	53	-	53	12/12	10/10	1	10	M	Baetid mayflies (F, MI), hydropsychid caddisflies (F, MI)	VG	Very Good
West Creek (04-033-000)										**WWH Existing - Unverified/Confirmed**		
1.0	15.4	54	38	36	13/15	4/5	0	12	H – M/ 1,363/ft.²	Hydropsychid caddisflies (F, MI), baetid mayflies (*Acerpenna pygmaea* (MI) and *Baetis intercalaris* (F)	52	Exceptional
Lost Creek (04-031-000)										**WWH Existing - Unverified/Confirmed**		
1.30	20.7	32	-	32	5/5	1/1	0	13	M	Midges (F, MT, T), fingernail clams (F), *Stenacron* sp. (F), isopods (F)	Fair*	Fair*
School Creek (04-035-000)										**Undesignated/WWH Recommended**		

River Mile	Drain. Area (mi²)	Total Taxa	Quant. Taxa	Qual. Taxa	EPT Taxa (Qual./ Total)	Sensitive Taxa (Qual./ Total)	Cold-water Taxa	Qual. Tolerant Taxa	Relative Density (Qual. - Quant.)	Predominant Organisms on the Natural Substrates with Tolerance Category(-ies)	ICI	Narrative Evaluation
7.0	9.8	53	-	53	11/11	4/4	0	19	M	Hydropsychid caddisflies (F), *Caenis* sp. and heptageneid mayflies (F), midges (F, MT, T)	G	Good
0.9	32.7	37	-	37	7/7	3/3	0	9	M - L	Heptageneid mayflies (F), scuds (MT), *Sphaerium* sp. clams (F), dragonflies (F), damselflies (F, T)	MG^{NS}	Marginally Good
Brinkman Ditch (04-036-000)										**WWH Existing - Unverified/Confirmed**		
2.80	8.0	27	-	27	4/4	0/0	0	14	M - L	Midges (F, MT, T), *Sphaerium* sp. clams (F), damselflies (T)	F*	Fair*
[2.80]	[8.0]	[43]	-	[43]	[9/9]	[1/1]	[0]	[22]	[M – L]	[Hydropsychid caddisflies (F), riffle beetles (F), midges (F, T)]	[MG^{NS}]	Marginally Good
2.35	8.3	33	-	33	3/3	0/0	0	24	M - L	Damselflies (T), planorbid snails (MT, T), midges (F, MT, T)	F*	Fair*
Little Turkeyfoot Creek (04-030-000)										**WWH Existing - Unverified/Confirmed**		
0.5	22.1	52	34	35	13/15	6/8	0	7	H – M/ 1,002/ft.²	Baetid mayflies (*Acerpenna pygmaea* (MI) and *Baetis intercalaris* (F)), hydropsychid caddisflies (F, MI)	46	Exceptional
North Turkeyfoot Creek (04-037-000)										**WWH Existing**		
19.15	4.5	48	33	33	7/8	1/1	0	10	M/ 846/ft.²	Hydropsychid caddisflies (F, MI), baetid mayflies (F), *Sphaerium* sp. clams, damselflies (F, T)	34	Good
17.85	5.8	46	31	33	7/8	1/1	0	12	H/ 1,733/ft.²	Hydropsychid caddisflies (F, MI), baetid mayflies (F)	42	Very Good
13.85	19.6	58	30	49	12/13	8/9	0	8	M – H/ 1,701/ft.²	Hydropsychid caddisflies (MI, F), baetid mayflies (F, MI), *Polypedilum* spp. (F) and tanytarsini (F) midges	40	Good
9.7	31.0	65	34	53	12/13	9/11	0	10	M – H/ 4,870/ft.²	Tanytarsini and *Polypedilum flavum* midges (F), hydropsychid caddisflies (F, MI), baetid mayflies (MI, F), damselflies (F, T)	46	Exceptional

River Mile	Drain. Area (mi²)	Total Taxa	Quant. Taxa	Qual. Taxa	EPT Taxa (Qual./ Total)	Sensitive Taxa (Qual./ Total)	Cold-water Taxa	Qual. Tolerant Taxa	Relative Density (Qual. - Quant.)	Predominant Organisms on the Natural Substrates with Tolerance Category(-ies)	ICI	Narrative Evaluation
3.4	73.0	70	40	50	10/16	10/16	0	11	M - L/ 848/ft.^{2}	Baetid mayflies (*Acerpenna pygmaea* (MI) and *Baetis intercalaris* (F)), midges (F, MT, T)	42	Very Good
Trib. to North Turkeyfoot Creek (6.68) (04-037-001)										**Undesignated/WWH Recommended**		
1.02	9.9	42	-	42	7/7	1/1	0	18	M	Damselflies (F, T), flatworms (F), hydropsychid caddisflies (F)	MG[NS]	Marginally Good
Konzen Ditch (04-038-000)										**MWH-C Existing/WWH Recommended**		
4.15	15.6	51	33	44	7/7	1/1	0	14	M/ 920/ft.^{2}	*Hydroptila* sp. and hydropsychid caddisflies (F), baetid mayflies (*Acerpenna pygmaea* (MI) and *Baetis intercalaris* (F))	34	Good
1.55	24.0	57	39	34	9/10	4/7	0	10	M – H/ 1,219/ft.^{2}	Hydropsychid and *Hydroptila* sp. caddisflies (F), baetid and heptageneid mayflies (F)	42	Very Good
Dry Creek (04-028-000)										**WWH Existing - Unverified/Confirmed**		
8.8	11.3	36	-	36	5/5	1/1	0	22	M - L	Isopods (MT), midges (T, F, MT)	F*	Fair*
1.6	23.9	62	42	38	9/13	4/10	0	12	M/ 2,629/ft.^{2}	Hydropsychid caddisflies (F, MI), tanytarsini (F, MI) and *Polypedilum flavum* (F) midges, baetid mayflies (F, MI)	54	Exceptional
Bad Creek (04-026-000)										**WWH Existing**		
22.45	12.0	60	45	38	14/15	7/10	0	6	M/ 857/ft.^{2}	Hydropsychid (F, MI), leptocerid (MI), and hydroptilid caddisflies (F)	48	Exceptional
17.51	36.0	50	-	50	13/13	10/10	0	8	M - H	Hydropsychid caddisflies (MI, F), heptageneid mayflies (F, MI)	VG	Very Good
10.3	44	58	41	41	11/12	7/ 11	0	6	M/ 862/ft.^{2}	Hydropsychid caddisflies (F, MI)	42	Very Good
2.47	58	72	41	56	10/13	10/15	1	14	M/ 566/ft.^{2}	Hydropsychid caddisflies (F, MI), tanytarsini (F, MI) and *Polypedilum* spp. (F, T, MI) midges, heptageneid mayflies (F, MI)	VG	Very Good
South Branch Bad Creek (04-027-000)										**WWH Existing**		

River Mile	Drain. Area (mi²)	Total Taxa	Quant. Taxa	Qual. Taxa	EPT Taxa (Qual./ Total)	Sensitive Taxa (Qual./ Total)	Cold-water Taxa	Qual. Tolerant Taxa	Relative Density (Qual. - Quant.)	Predominant Organisms on the Natural Substrates with Tolerance Category(-ies)	ICI	Narrative Evaluation
0.44	10.2	58	41	42	5/6	3/6	0	12	M/ 1,728/ft.^{2}	Hydropsychid caddisflies (F, MI), tanytarsini (F, MI) and *Polypedilum flavum* (F) midges, fingernail clams (F, MT)	42	Very Good
Big Creek (04-024-000)										**WWH Existing - Unverified/Confirmed**		
3.51	17.8	64	44	32	11/11	5/7	0	6	M/ 381/ft.^{2}	Baetid mayflies (F, MI), hydropsychid caddisflies (F, MI), heptageneid mayflies (F)	38	Good
1.30	20.7	41	-	41	9/9	3/3	0	10	M	Heptageneid mayflies (F), hydropsychid caddisflies (F), baetid mayflies (F, MI)	G	Good
Beaver Creek (04-015-000)										**WWH Existing - Unverified/Confirmed**		
16.2	19.4	47	38	22	5/6	0/3	0	6	M/ 82/ft.^{2}	Hydropsychid caddisflies (F), heptageneid mayflies (F), crayfish (F)	30^{NS}	Marginally Good
8.3	65	54	37	38	6/10	2/6	0	3	M/ 358/ft.^{2}	Hydropsychid caddisflies (F, MI), heptageneid mayflies (F, MI), midges (F, MT, T, MI)	38	Good
2.7	184	72	37	56	16/16	18/20	0	7	M – H/ 1,529/ft.^{2}	Baetid mayflies (F, MI), hydropsychid caddisflies (F, MI), heptageneid mayflies (MI, F)	46	Exceptional
Hammer Creek (a.k.a. East Beaver Creek) (04-022-000)										**WWH Existing - Unverified/Confirmed**		
1.4	24.2	58	40	37	7/9	3/6	0	16	L/ 176/ft.^{2}	Heptageneid mayflies (F), isopods (MT), midges (F, MT, T, MI)	36	Good
Jackson Cutoff Ditch (04-017-000)										**WWH Existing - Unverified/Confirmed**		
6.6	86.3	69	41	48	17/17	11/14	0	12	M/ 359/ft.^{2}	Midges (F, MT, T, MI), heptageneid and baetid mayflies (F, MI)	40	Good
1.10	101	61	-	61	16/16	12/12	0	12	M - H	Hydropsychid caddisflies (MI, F), heptageneid mayflies (MI, F)	E	Exceptional
Yellow Creek (04-019-000)										**MWH-C Existing/WWH Recommended**		
4.5	49.7	71	47	61	17/18	12/14	0	9	M/ 780/ft.^{2}	Hydropsychid caddisflies (F, MI), *Helicopsyche* caddisflies (MI)	46	Exceptional
3.18	51	63	38	48	14/17	11/16	0	8	Moderate	Baetid mayflies (F, MI), hydropsychid s (F, MI)	46	Exceptional
Little Yellow Creek (04-021-000)										**LRW Existing**		

River Mile	Drain. Area (mi²)	Total Taxa	Quant. Taxa	Qual. Taxa	EPT Taxa (Qual./ Total)	Sensitive Taxa (Qual./ Total)	Cold-water Taxa	Qual. Tolerant Taxa	Relative Density (Qual. - Quant.)	Predominant Organisms on the Natural Substrates with Tolerance Category(-ies)	ICI	Narrative Evaluation
[4.6]	[2.1]	[30]	[19]	[19]	[3/5]	[0/1]	[0]	[13]	[M/ 241/ft.²]	[Hydropsychid caddisflies (F), *Berosus* beetles (MT), midges (T, F)]	[28]	[Fair]
Little Yellow Creek (04-021-000)										**LRW Existing/WWH Recommended**		
0.9	7.7	56	-	56	10/10	5/5	0	20	M - H	*Helicopsyche* caddisflies (MI), *Sphaerium* fingernail clams (F), midges (F, MT, T)	G	Good
West Creek (04-020-000)										**WWH Existing - Unverified/Confirmed**		
0.4	13.2	62	36	50	11/11	6/8	1	11	M/ 256/ft.²	Hydropsychid caddisflies (F, MI), *Helicopsyche* caddisflies (MI)	38	Good
Brush Creek (04-018-000)										**WWH Existing**		
8.99	10.0	55	41	38	8/11	2/5	0	16	M – H/ 1,991/ft.²	*Hydroptila* sp. (F) and *Helicopsyche* caddisflies (MI), baetid mayflies (*Acerpenna pygmaea* (MI) and *Baetis* spp. (F)), *Sphaerium* clams (F)	48	Exceptional
0.58	24.6	74	39	63	13/15	7/9	0	22	M – H/ 2,076/ft.²	Hydropsychid caddisflies (F, MI), baetid mayflies (F, MI), *Helicopsyche* caddisflies (MI), midges (F, T, MI)	44	Very Good
Sugar Creek (6.68) (04-001-014)										**Undesignated/WWH Recommended**		
1.1	5.4	41	-	41	12/12	5/5	0	11	M	Baetid mayflies (F, MI), Hydropsychid caddisflies (F, MI), heptageneid mayflies (F, MI)	G	Good
Tontogany Creek (04-013-000)										**WWH Existing - Unverified/Confirmed**		
4.15	11.2	60	36	41	12/12	4/5	0	8	M/ 605/ft.²	Baetid mayflies (MI, F), flatworms (F), *Helicopsyche* caddisflies (MI), heptageneid mayflies (F)	42	Very Good
1.57	39.4	48	-	48	10/10	6/6	0	11	M	Heptageneid mayflies (F, MI), hydropsychid caddisflies (F, MI), *Triaenodes* caddisflies (MI), scuds (MT)	G	Good
West Branch Tontogany Creek (04-013-001)										**Undesignated/ MWH-C Recommended**		

River Mile	Drain. Area (mi^2)	Total Taxa	Quant. Taxa	Qual. Taxa	EPT Taxa (Qual./ Total)	Sensitive Taxa (Qual./ Total)	Cold-water Taxa	Qual. Tolerant Taxa	Relative Density (Qual. - Quant.)	Predominant Organisms on the Natural Substrates with Tolerance Category(-ies)	ICI	Narrative Evaluation
3.42	6.6	25	-	25	7/7	1/1	0	11	M	Hydropsychid caddisflies (F, MI), beetles (MT, T), *Cipangopaludina japonica* snails (MT), heptageneid mayflies (F, MI)	HF	High Fair
West Branch Tontogany Creek (3.2) (04-013-001)										**Undesignated/WWH Recommended**		
[2.19]	[20.8]	[55]	[32]	[39]	[9/13]	[8/10]	[1]	[9]	[M/ 358/ft.^{2}]	[Heptageneid mayflies (F, MI), riffle beetles (*Stenelmis* sp.) (F)]	[42]	[Very Good]
Trib. to West Branch Tontogany Creek (3.2) (04-013-002)										**Undesignated/WWH Recommended**		
0.72	13.1	41	-	41	7/7	2/2	0	13	M	*Sphaerium* fingernail clams (F), baetid mayflies (MI, F), heptageneid mayflies (F)	MG^{NS}	Marginally Good
Liberty Hi Road Ditch (04-001-015)										**Undesignated/ MWH-C Recommended**		
[1.15]	[11.3]	[29]	-	[29]	[7/7]	[3/3]	[0]	[15]	[M – H]	[Physella snails (T), heptageneid mayflies (F), flatworms (F), riffle beetles (F) and other beetles (MT, T)]	[HF]	[High Fair]
Liberty Hi Rd. Ditch (04-001-015)										**Undesignated/WWH Recommended**		
0.05	14.4	47	-	47	12/12	8/8	0	6	M	*Sphaerium* fingernail clams (F), tanytarsini midges (F), *Stenacron* sp. mayflies (F)	G	Good
Haskins Rd. Ditch (04-001-016)										**Undesignated/ MWH-C Recommended**		
0.3	9.6	37	-	37	4/4	0/0	0	19	M	Baetid mayflies (F, MI), isopods (MT), *Simulium* sp. (F), tanytarsini midges (F, MI)	HF	High Fair

Quant. and Qt..: Quantitative sample collected on Hester-Dendy artificial substrates, relative density is expressed in organisms per square foot.
Qual. and Ql.: Qualitative sample collected sampling all available natural habitats which indicated presence and predominance where relative density listed as: L=Low; M=Moderate; H=High.
EPT taxa are the total taxa collected from the mayfly (Ephemeroptera) family, the stonefly family (Plecoptera) and caddisfly family (Trichoptera) combined.
Sensitive Taxa: Taxa listed on Ohio EPA's Macroinvertebrate Taxa List as MI (moderately intolerant) or I (intolerant).
CW: Coldwater organisms designated from Ohio EPA's Macroinvertebrate Taxa List.
Tol.: Tolerant organisms listed on Ohio EPA's Macroinvertebrate Taxa List as VT=Very Tolerant, T=Tolerant, MT=Moderately Tolerant.
Tolerance Categories: VT=Very Tolerant; T=Tolerant; MT=Moderately Tolerant; F=Facultative; MI=Moderately Intolerant; I=Intolerant.

Macroinvertebrate Community Impairment Discussion

A short discussion of non-attaining sites sampled during this survey follows:

North Creek

Macroinvertebrate community performance in North Creek fell short of applicable biocriteria at RM 2.95 (P06W17) and RM 0.2 (303746). Macroinvertebrate community performance at North Creek RM 2.95 fell short of both WWH and MWH-C criteria, with a low-fair quality assessment in 2015. Tolerant midges predominated at RM 2.95. Taxa collected in moderate to high densities included: *Chironomus (C.) decorus* group; *Polypedilum (P.) illinoense; and Cricotopus (I.) sylvestris* group. The predominance of these midges indicated likely inputs of organic waste and/or excess nutrients, resulting in over-enriched conditions. Macroinvertebrate community performance at this location has declined slightly since 1997 sampling recorded a fair quality community, with more EPT taxa (four) present in 1997 than 2015.

Macroinvertebrate community performance at RM 0.2 was in the fair range, with hydroptilid caddisflies and flatworms predominant. Only three EPT taxa were collected at this location. Most caddisfly taxa present had pupated and hatched prior to sampling (*Oecetis*, hydropsychids, and most hydroptilids). Premature hatching of various taxa can be an indicator of recent stressful water quality conditions. Despite over-enriched conditions and other water quality stressors throughout North Creek, the midge community at RM 0.3 was still relatively intact, and the Giant Floater mussel (*Pyganodon grandis*) was present at this location.

Documented water quality stressors throughout North Creek included elevated ammonia concentrations, nutrient over-enrichment and siltation from channelization and manure runoff related to agriculture (Table 21, Figure 23).

South Creek

South Creek RM 0.35 (302970) met the macroinvertebrate WWH biocriterion in 2015 but was sampled again in 2016 to assess the continuing severity of both biological and water quality impacts from a documented manure runoff and kill event in September 2015. In 2015, an ICI of 42 (VG) was documented with 12 EPT and five sensitive taxa collected, including: MI caddisflies *Chimarra obscura* and *Hydropsyche (H.) simulans*; MI mayflies *Acerpenna pygmaea* and *A. macdunnoughi*; and MI midge *Polypedilum (P.) laetum group*. Three facultative mussels, including the Giant Floater (*Pyganodon grandis*), Lilliput (*Toxolasma parvum*) and Cylindrical Papershell (*Anodontoides ferussacianus*) were also collected - the former was a fresh dead specimen and the latter two were live specimens.

Resampling at RM 0.35 in 2016 indicated decreased community quality and diversity. There was a large reduction in EPT (12 to five) and sensitive taxa (five to one) collected in 2015 compared to 2016. The *Heptageniid* and *Caenis* sp. mayflies remaining in 2016 were mostly observed on the undersides of rocks. This is a coping strategy often observed in these organisms to better protect themselves from exposure to the irregular toxic conditions. The only sensitive taxa collected, the case-building caddisfly *Triaenodes marginata*, has a life history strategy (resides in root mats or root wads above the stream bottom) that will leave this species more protected from periodic toxic exposure in its habitat than other sensitive taxa. Conversely, midges are typically found on rock surfaces or in the substrates and are generally more exposed to these types of stressors and generally lower quality conditions. Midge diversity decreased from 29 taxa collected in 2015 to only three midge taxa in 2016. Like the fish community, the macroinvertebrate community performance in 2016 still had not recovered to levels recorded in 2015 and was still recovering from the 2015 kill event.

Platter Creek

Figure 69 — Platter Creek at Fountain Rd. (RM 5.40).

Macroinvertebrate community sampling from Platter Creek RM 5.4 (302974) was in the fair range and performance fell short of HELP WWH expectations. An abundance of facultative filterers and scrapers (fingernail clams, flatworms, and Bryozoa) predominated and were reflective of the highly over-enriched conditions that occur throughout upper Platter Creek. Multiple sources of nutrient inputs (manure application runoff, a manure spill in 2015, an unsewered community just upstream, other nonpoint nutrient inputs), coupled with sub-optimal habitat quality throughout this reach are likely contributing to impairment at this location.

Snooks Run

Macroinvertebrate community performance from Snooks Run RM 0.7 (P06K17) was in the fair range and fell short of WWH expectations. Instream habitat available to macroinvertebrates consisted mostly of two- to three-foot-deep interstitial glide/pools and were sparsely populated largely by tolerant midges (*Dicrotendipes simpsoni, Glyptotendipes (G.) sp. and Chironomus (C.) decorus gr.*). These taxa are notable because they can inhabit sewage, toxic, and low oxygen environments (Simpson and Bode 1980). Scuds (*Hyalella azteca*) were the predominant organism and only three EPT taxa were collected (Table 30). Hydropsychid caddisfly distribution throughout the sampling reach was limited and they were only collected in gravels from the singular, small interstitial riffle within the reach. Most collected taxa were inhabiting the margin shallows or roots. The macroinvertebrate community is reflective of the depressed DO regime stemming from organic enrichment and low flows recorded at this location.

Lost Creek

Macroinvertebrate community performance from Lost Creek RM 1.30 (P09S09) was in the fair range and fell short of WWH expectations. Only five EPT and one sensitive taxa were collected at this location. Dewatering from channelization and late summer low-flow conditions reduced this 20.7 mi^2 stream to interstitial conditions, with a reduced variety of habitat. Stream temperatures generally stayed cool (15.5° C) throughout the summer, but lentic conditions and predominantly glide/shallow habitats limited community quality. No baetid mayflies were collected, and only a few hydropsychid caddisflies were collected in shallows where a riffle had previously been under higher flow conditions. The bottom substrates were mostly sand, clay and silt sediments with some scattered gravel and occasional pieces of rubble. Midges were predominant along with fingernail clams (*Sphaerium* sp.), flathead mayflies (*Stenacron* sp.), and isopods. Six of the nine midge taxa were facultative and totaled about half of the midges collected. Most of the midges collected were either *Chironomus (C.) decorus gr*. (T) (which can inhabit reaches with elevated organic/nutrient inputs and low sediment s), *Dicrotendipes neomodestus* (F) or tanytarsini (F) midges as a group (Table 30).

Brinkman Ditch

Macroinvertebrate community performance from Brinkman Ditch at RM 2.35 (P09W17) was in the fair range and did not meet WWH expectations. There were only three EPT taxa and no sensitive taxa collected. Tolerant damselflies, planorbid snails and midges predominated. The macroinvertebrate community here has declined somewhat since sampling in 1997 when seven EPT and one sensitive taxa were collected at this location. Upstream at RM 2.80 (P09K11), nine EPT taxa were collected, with hydropsychid caddisflies and riffle beetles predominant; seven EPT taxa and a fair overall community were recorded at this location in 1997, indicating slight improvements. Well-documented nutrient over enrichment seem to be negatively impacting macroinvertebrate communities at RM 2.35.

Middle Fork Gordon Creek

Macroinvertebrate community performance from Middle Fork Gordon Creek RM 3.9 (P06S18) fell just short of HELP WWH expectations, with a fair evaluation. Attempts were made to collect a quantitative sample, but artificial substrates were removed from the stream prior to retrieval due to suspected disturbance or vandalism.

The macroinvertebrate community at RM 3.9 was dominated by tolerant *Chironomus (C.) decorus gr.* midges and moderately tolerant *Callibaetis* sp. Mayflies. These taxa can become common in reaches with excess nutrients, organic inputs, periodic low DOs and sedimentation. Taxa predominating the community at RM 3.9, overall, shifted more toward tolerant organisms, compared to predominantly facultative taxa in 1996 and 2000 (*Caenis sp.* mayflies and facultative midges, including tanytarsini midges).

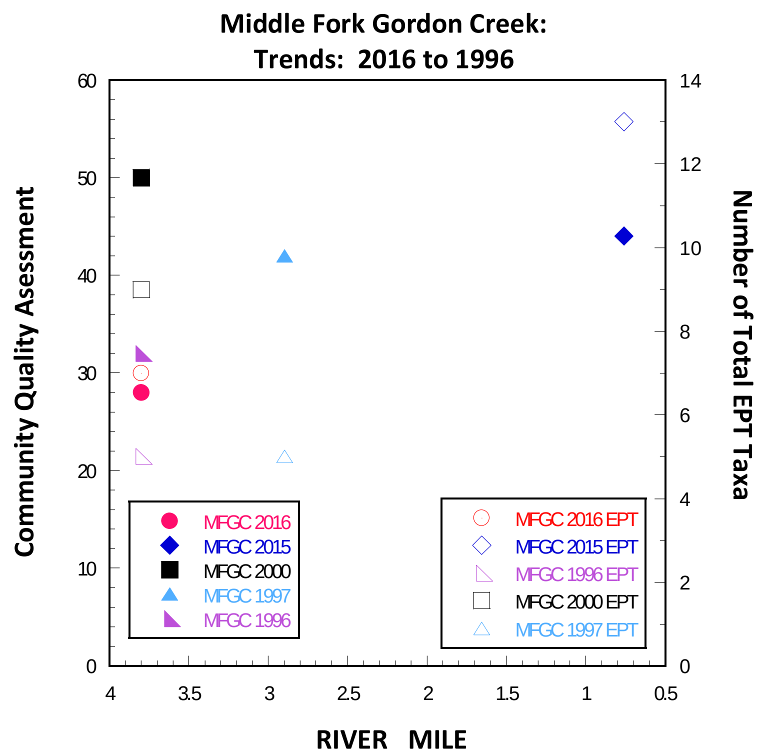

Figure 70 — Longitudinal display of community quality assessment and EPT totals from Middle Fork Gordon Creek, 1996 to 2017.

Cheumatopsyche sp. Caddisflies were also present in large numbers in 2000 when an ICI of 50 was recorded. Nine EPT were collected in 2000 at RM 3.9 compared to seven in 2016 (Table 30). Community performance has varied throughout the preceding decades somewhat, but communities consistent with WWH expectations were recorded in 1996 and 2000 (Figure 56). Community performance in Middle Fork Gordon Creek RM 0.76 (P06S16) exceeded HELP WWH expectations, where a very good macroinvertebrate community (ICI=44) was recorded (Table 30).

Pooled conditions and reduced overall flow/interstitial conditions in 2016 (a dry year compared to 2015) coupled with excessive siltation likely negatively impacted macroinvertebrate communities at RM 3.9.

Dry Creek

The fair macroinvertebrate assemblage at RM 8.8 (302848) fell just short of WWH expectations. Isopods and tolerant midges predominated. Assemblages were much higher at the lower location in Dry Creek (Table 30). It is likely that poor habitat and excessive siltation documented here are limiting assemblages.

Macroinvertebrate Community Trends

The following Maumee River tributaries have historical data not previously discussed: Zuber Cutoff Ditch; Gordon Creek; Sulphur Creek; Wade Creek; North Turkeyfoot Creek; South Turkeyfoot Creek; Konzen Ditch; Bad Creek; Beaver Creek; Yellow Creek; Little Yellow Creek; and Brush Creek.

Zuber Cutoff Ditch

Zuber Cutoff is "formed" by the confluence of North and South Creek just east of Antwerp. A narrative evaluation of the macroinvertebrate community at RM 1.1 (P06K13) fell in the good range in both 2016 and 1997. EPT taxa totals were similar between 2016 (nine) and 1997 (11), however a decrease in sensitive taxa coupled with an increase in highly tolerant taxa was observed over the same time period (Figure 71). The substantial decrease in sensitive taxa includes the absence of moderately intolerant mayflies and *Petrophila* sp. moth larvae, along with no new fresh dead or live mussels collected, compared to four mussel species collected in 1997 (two facultative and two MI mussel taxa). Similar to the fish community performance, macroinvertebrate communities still appeared to be recovering from the kill event in September 2015. Over-enriched conditions and generally degraded water quality in this sub-watershed may further slow the recovery of biological communities going forward.

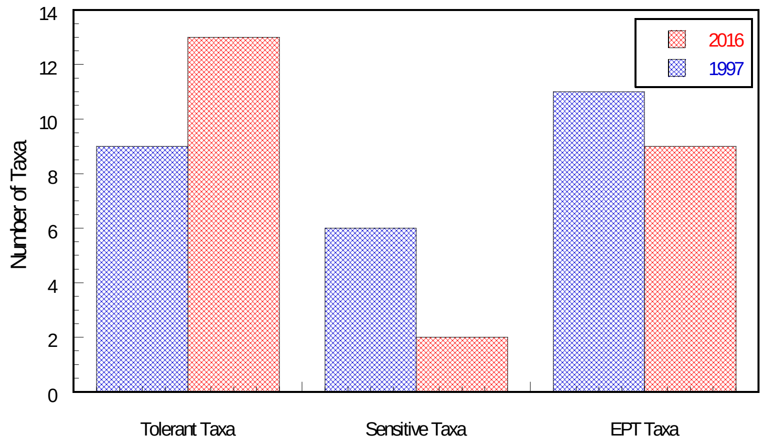

Figure 71 — Zuber Cutoff Ditch macroinvertebrate taxa summary totals, 1997 and 2016.

Gordon Creek mainstem

Macroinvertebrate communities from Gordon Creek had previously been sampled in 1984, 1996, 1997, and 2000. ICI scores or narrative quality assessments have generally been in the good to very good range since 1997; the 1996 ICI score was retrieved under inadequate flow conditions for quantitative sampling (Figure 72).

The number of EPT taxa collected from locations near the mouth of Gordon Creek (RMs 1.1-2.2) were similar between 2015 (15) and 1997 (14), but have increased substantially since 1984 (four). The number of sensitive taxa collected was higher in 2015 (13) than both 1997 (six) and 1984 (three or less). Several species of freshwater mussels were also collected from the downstream reaches in 2015 (Figure 73). Similarly, the number of EPT and sensitive taxa present

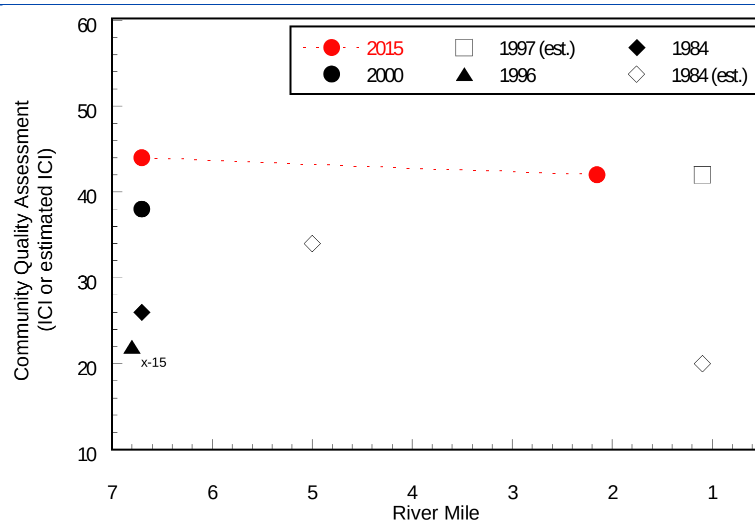

Figure 72 — Macroinvertebrate community assessments from Gordon Creek, 1984-2015.

throughout the upper sampling reaches in Gordon Creek (RMs 5.0-6.8) increased from the 1980s and 1990s compared to 2015 sampling results.

Figure 73 — Mapleleaf (Quadrula quadrula), Wabash Pigtoe (Fusconaia flava), and Pink Heelsplitter (Potamilus alatus) in Gordon Creek at RM 1.12 (2015).

Sulphur Creek

Macroinvertebrate community performance at both sampling locations on Sulphur Creek met WWH expectations. Community performance at RM 0.2 (P06W19) improved slightly from fair to marginally good from 1997 to 2015. Community performance at RM 0.2 did not meet WWH expectations in 1997. EPT taxa collected from both the upstream and downstream locations on Sulphur Creek increased since 1997; and hydropsychid caddisflies and baetids were among the predominant organisms in the 2015 survey (Table 30).

Despite multiple permit limit violations at the ***Sherwood WWTP*** recorded before and during 2015 (Table 12), no biological impairment was documented downstream from this facility. Sulphur Creek maintains good habitat quality where evaluated and the positive habitat attributes and riparian shading help attenuate impacts from water chemistry issues emanating from this facility. Both fish and macroinvertebrate community performance has improved since 1997. Evidence of acute stress is not readily apparent in the biological community in 2015. Harmful short-term episodes ranging from the onset of rapidly lethal conditions to a protracted chronic stress will generally be manifested in the response of resident biota. Thus, the biota can reveal the real-world effects of exceedances or violations and consequent harm more precisely than can be predicted or measured on a chemical or toxicity basis alone (Ohio EPA 1987).

Wade Creek

The macroinvertebrate community was sampled near the mouth of Wade Creek both in 1997 and 2015. Community performance improved from marginally good to good over this time period and both EPT and sensitive taxa present at the sampling locations increased as well.

Konzen Ditch

Figure 74 — Konzen Ditch at RM 4.15, upstream view (left) and downstream view (center). Algal mats present on Konzen Ditch at RM 1.55 (right).

Macroinvertebrate communities from Konzen Ditch were previously sampled in 1996 and 1984. The 1984 sample at RM 0.7 (P09K14) scored an ICI of 44 with nine total EPT collected. The 1996 ICI score at RM 0.7 (10) was invalidated because there was insufficient flow over the samplers at the time of artificial substrate retrieval. The 2015 survey sites scored an ICI of 34 at RM 4.15 (302987) and 42 at RM 1.55 (P09K14) (Table 30).

North Turkeyfoot Creek

Macroinvertebrate communities in North Turkeyfoot Creek were sampled at five locations both in 1997 and 2015 stretching from Wauseon downstream to RM 3.4. Macroinvertebrate community performance has improved immediately up and downstream from the Wauseon WRF. However, community performance from the lower 16 miles of North Turkeyfoot Creek has declined from 1997 to 2015 (Figure 75). The lower three sampling locations in 1997 scored ICIs of more than 50 – an average of 10 points higher compared to the 2015 results (Figure 75).

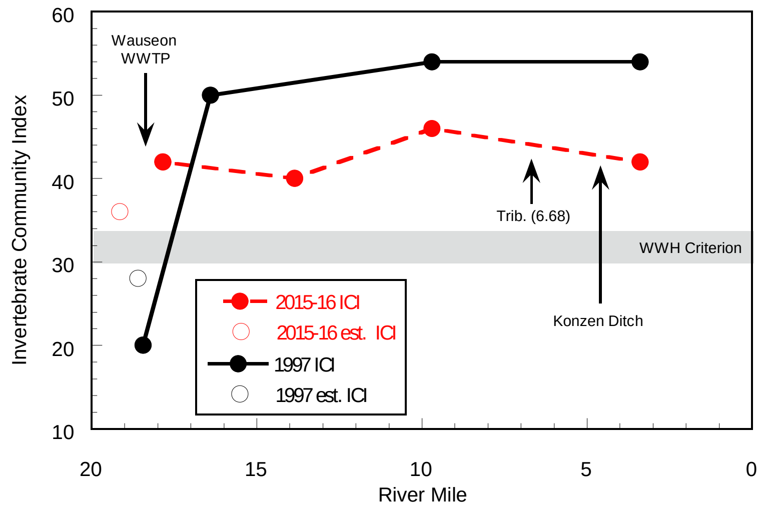

Figure 75 — Longitudinal ICI Trends from North Turkeyfoot Creek, 1997 and 2015.

The total number of EPT and sensitive taxa collected in 2015 at RM 9.7 (P09K12) decreased 20 to 30 percent compared to 1997 totals. At RM 3.4 (P09S01) the overall reduction in EPT and sensitive taxa collected in 2015 was less: 12 to 16 percent lower than in 1997.

Seemingly improved effluent quality from the Wauseon WRF since 1997 has facilitated the recovery of macroinvertebrate communities immediately downstream from this facility (Figure 75). A substantial decrease in the number of tolerant taxa and percentage of tolerant organisms immediately downstream from the Wauseon WRF was likely related to improved effluent quality since 1997 (Figure 76). Progressing downstream, most of the tolerant taxa from the lower reaches in 2015 were *Cricotopus bicinctus* at RM 9.7, and other midges tolerant of low DO and nutrient enriched conditions at RM 3.4. The percentage of sensitive organisms was higher just downstream from the Wauseon WRF in 2015 compared to 1997. However, the percentage of sensitive organisms was substantially (six to seven times) lower throughout the middle reaches of North Turkeyfoot Creek over the same period (Figure 76). Additionally, the facultative taxa in 2015 were almost exclusively filtering midges (>80 percent *Polypedilum* and tanytarsini midges) compared to a healthier combination of baetid mayflies, hydropsychid caddisflies, and tanytarsini midges collected throughout the middle and lower reaches in 1997 (Figure 77). The relative density of organisms was also substantially higher in 2015 compared to 1997 (Figure 78). Large increases in relative densities can occur under nutrient enriched conditions.

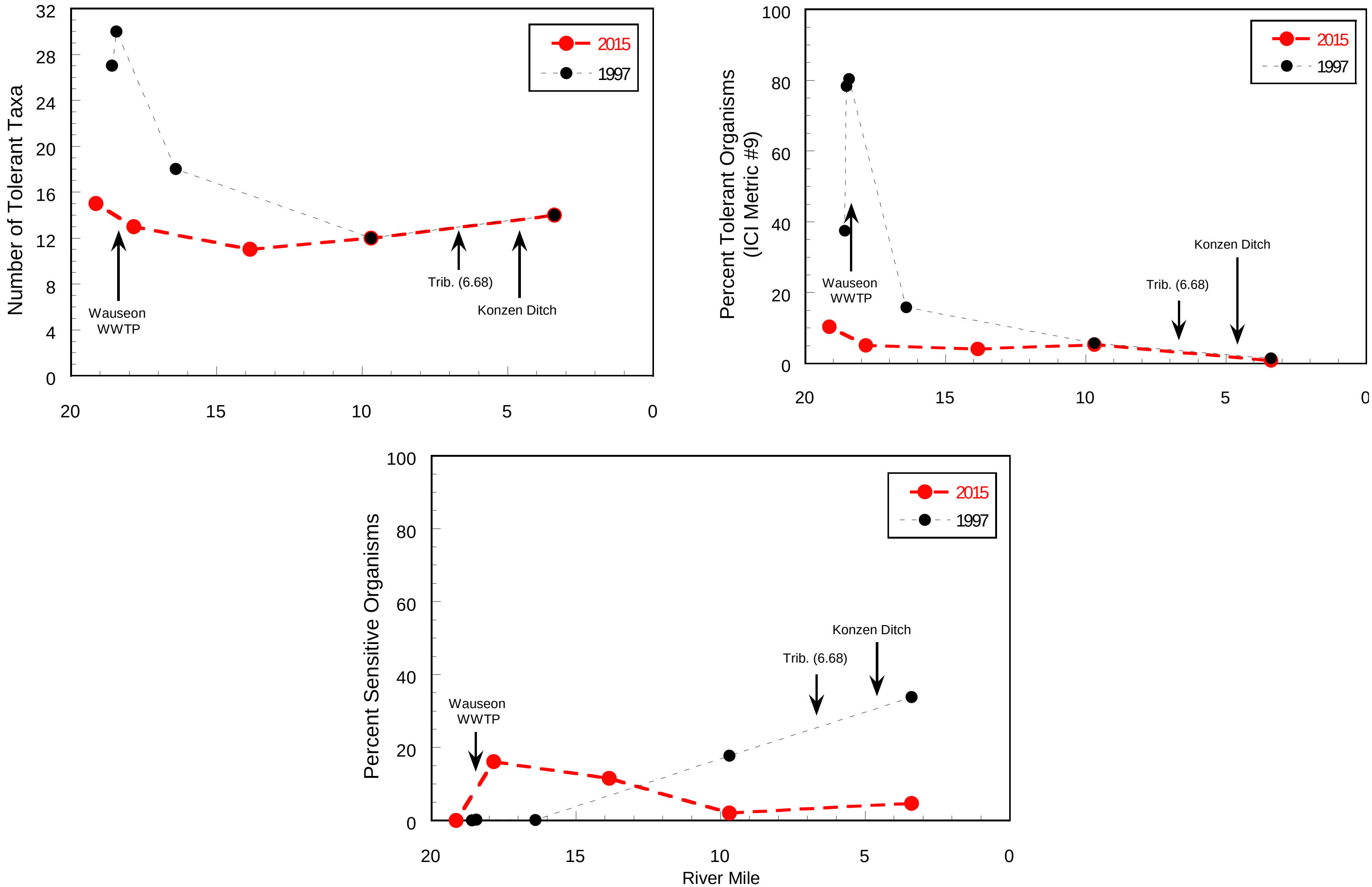

Figure 76 — Total number of tolerant taxa (top left), percentage of tolerant organisms (top right), and percentage of sensitive organisms (bottom) displayed by river mile from North Turkeyfoot Creek, 1997 and 2015.

Large diel DO swings (10.53 mg/l) and highly elevated benthic chlorophyll-*a* concentrations (593 mg/m²) were recorded immediately downstream from the Wauseon WRF at RM 17.85 (Table 21). These indicators suggest nutrient over-enrichment documented immediately downstream from the facility was not severe enough to cause localized biological impairment.

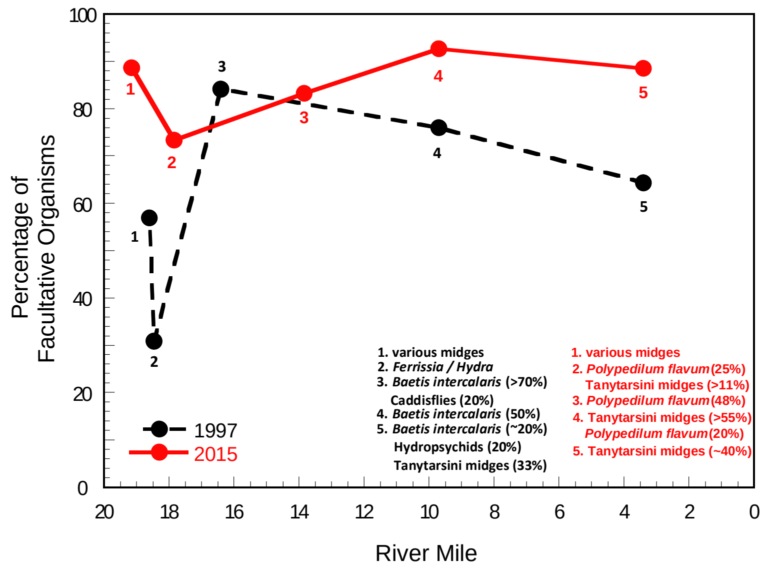

Figure 77 — Percentage facultative organisms comprising macroinvertebrate communities from North Turkeyfoot Creek by river mile, 1997 and 2015.

Localized improvements in macroinvertebrate community performance in the immediate vicinity of the Wauseon WRF was likely directly related to improved effluent quality from this facility since 1997.

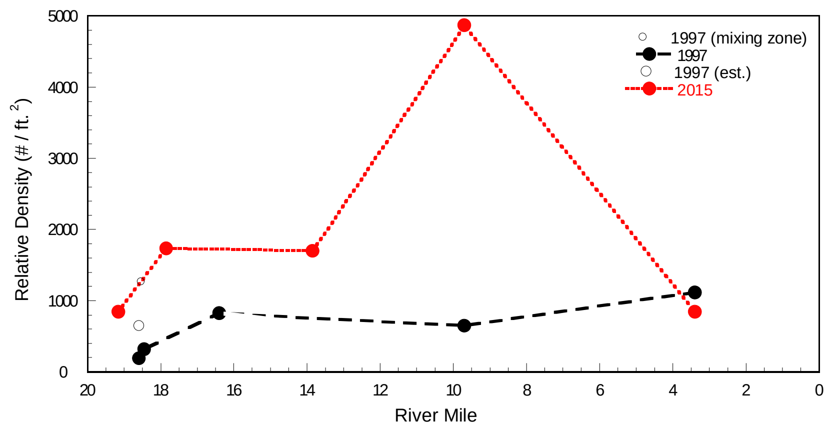

Figure 78 — Relative density of organisms from North Turkeyfoot Creek, 1997 and 2015.

However, declines in community quality structure and ICI performance throughout the middle reaches was likely related to more diffuse nutrient-enriched conditions fully manifesting themselves in a downstream progression from the Wauseon WRF. Though no diel sonde or chlorophyll data was collected from this reach, an altered DO regime (DO supersaturation, high DO concentrations) and nitrate-nitrite geometric mean concentrations well above 95th percentile for reference locations suggest nutrient enrichment impacts likely persisted throughout the middle reaches of North Turkeyfoot.

South Turkeyfoot Creek

Macroinvertebrate communities from South Turkeyfoot Creek were sampled at six locations both in 2015 and 1997 (Figure 79). Community performance has generally improved in the upper reaches both up and downstream from the Hamler WWTP (Figure 79), despite some enrichment in these upper reaches (Table 21). The EPT taxa totals in 2015 did show improvement in the upper reaches with similar totals near Malinta (Figure 80). There was still a decrease in sensitive taxa downstream from the Hamler WWTP similar to 1997; open canopy conditions here coupled with nutrient-rich wastewater allowed for excess algal production and lots of aquatic plants (Table 21, Figure 80). In 2015, the macroinvertebrate diversity and community quality improved downstream from the School Creek confluence with similar EPT and sensitive taxa totals despite some nutrient inputs (Figure 80). The slight decrease in sensitive taxa at RM 7.9 could be related to the infrequent low concentrations (3.03 mg/l) and increased relative density (1,428/ft.²) associated with excess nutrient inputs (Table 14, Figure 80). More mussel diversity was observed in 1997 from RM 13.1 downstream with four, two and five mussel species observed, respectively, compared to only two mussel taxa collected at the lower four 2015 sample sites (RMs 13.18 to 3.2).

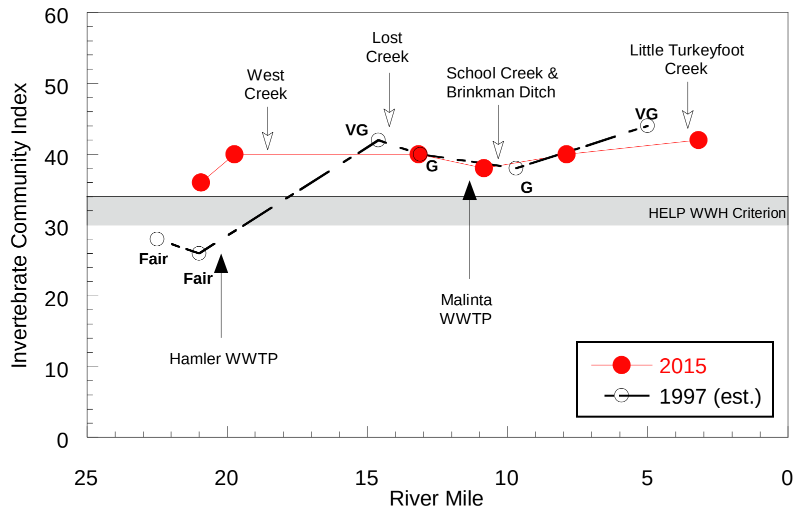

Figure 79 — Longitudinal ICI trends from South Turkeyfoot Creek, 1997 and 2015. ICI scores from 1997 are estimated based on qualitative sampling conducted. Corresponding narrative evaluations for these locations are also displayed.

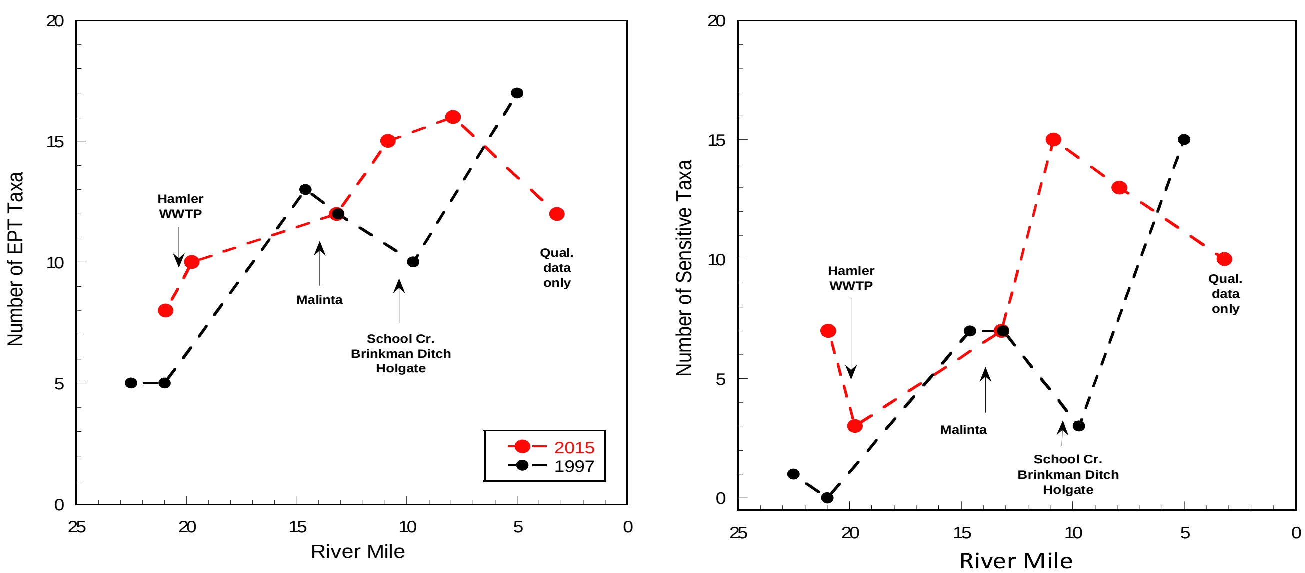

Figure 80 — Total EPT (left) and sensitive taxa (right) trends from South Turkeyfoot Creek, 2015 and 1997.

Bad Creek

Macroinvertebrate community samples were collected from Bad Creek in 1984, 1997 and 2015. Where sampled, macroinvertebrate community performance in Bad Creek has seemingly improved since the 1980s, though limited data exists from this time period. Generally stable conditions have persisted throughout the middle reaches and around the Delta WWTP since 1997, as indicated by the ICI performance (Figure 81). Similar EPT and sensitive taxa totals were also recorded throughout these middle reaches from 1997 to 2015 (Figure 82). Fairly substantial recovery was documented in the uppermost reaches of Bad Creek, with an increased ICI score and more EPT and sensitive taxa occurring at the most upstream location (RM 22.45, P11K48) (Figure 82).

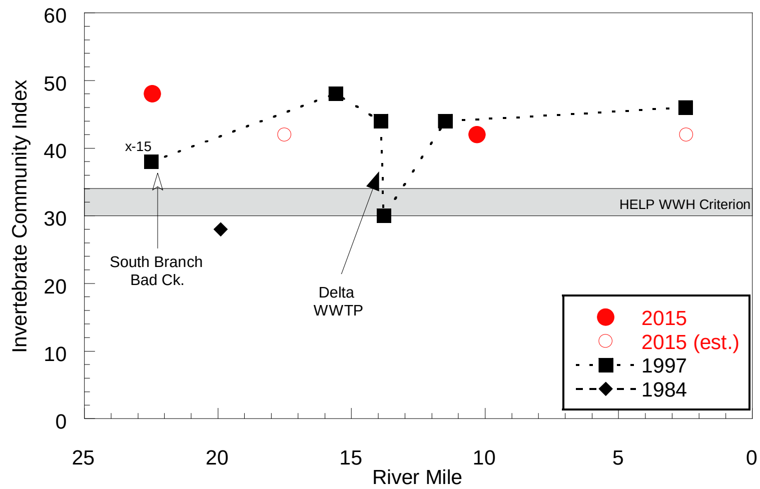

Figure 81 — Longitudinal ICI trends from Bad Creek, 1984, 1997 and 2015. X-15 denotes retrieval of artificial substrate coinciding with flow around substrate between 0.0 and 0.3 fps. Retrieval flows are typically greater than 0.3 fps.

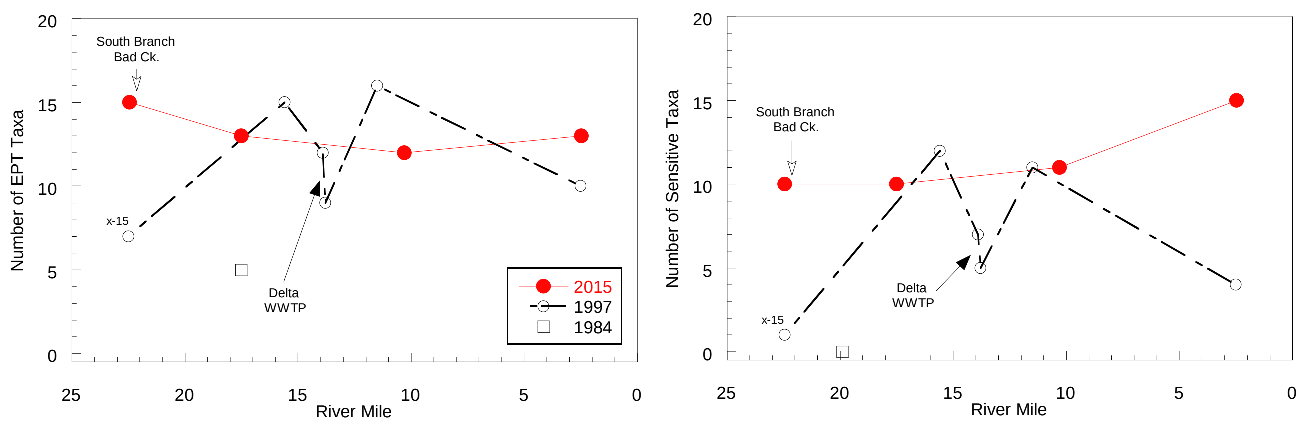

Figure 82 — Number of EPT taxa (left) and sensitive taxa (right) from Bad Creek displayed longitudinally, 1984, 1997 and 2015.

Beaver Creek

Prior to the current survey, Beaver Creek has only been sampled at two locations very near its confluence with the Maumee River.

The uppermost sampling site (RM 16.16, 302998) has historically been channelized and still maintained a relatively entrenched/incised channel with limited floodplain connectivity. Margin habitat types beneficial to an array of macroinvertebrates were generally lacking throughout the upper location. Some good root mats present yielded large burrowing mayflies (*Hexagenia bilineata*). Hydropsychid caddisflies, Steno mayflies and crayfish were the predominant organisms in a marginally good community (ICI = 30), which just met the WWH biocriterion.

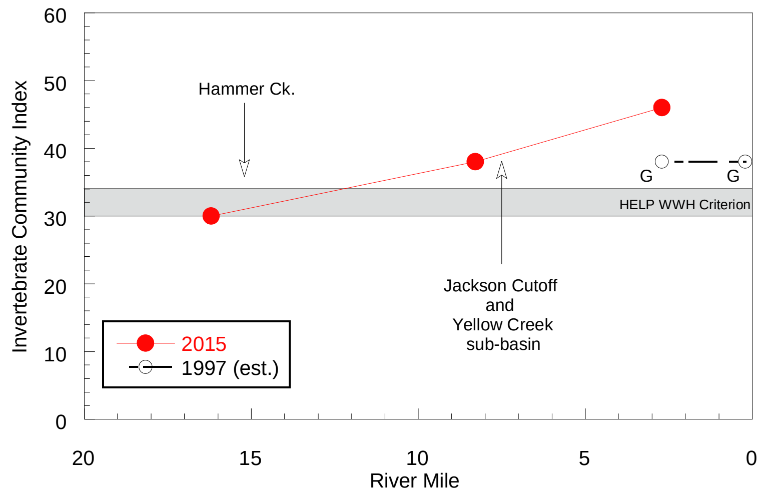

Figure 83 — Longitudinal ICI trends from Beaver Creek, 1997 and 2015. ICI scores from 1997 are estimated based on qualitative sampling conducted. Corresponding narrative evaluations for these locations are also displayed.

The middle site (RM 8.3 P10K03) was upstream from Jackson Cutoff and contained substantial amounts of woody debris. Midges, *Stenacron* sp. mayflies, and *Cheumatopsyche* sp. caddisflies were the resident predominant organisms (Table 30). The wide and stable wooded riparian corridor allowed for continued presence of resident Giant Floater mussels (*Pyganodon grandis*).

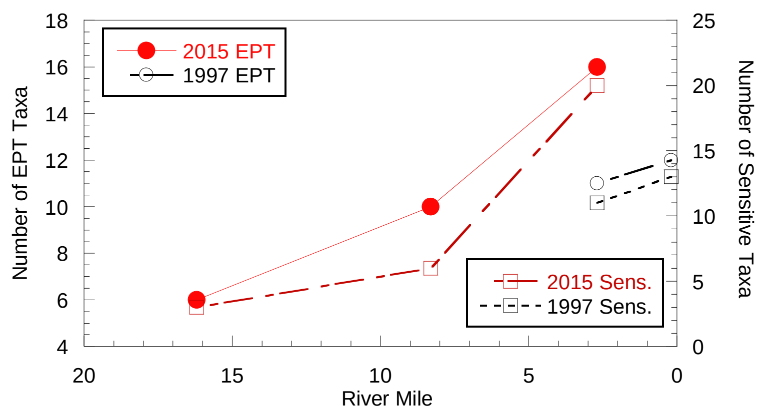

Figure 84 — Number of EPT taxa (left axis) and sensitive taxa (right axis) from Beaver Creek displayed longitudinally, 1997 and 2015.

Some instream habitat development downstream toward the mouth (RM 2.7, P10K02) and some related relative stability (increased larger rocky substrates and water willow) allowed for large increases in community macroinvertebrate diversity and continued large resident mussel populations with an increased number of both EPT and sensitive taxa present in 2015 (Figure 84, Figure 85). Overall, community quality increased from good in 1997 to exceptional (ICI = 46) in the lower reaches, while the upper reaches met the WWH biocriterion (Figure 83). Nine mussel species were collected in 2015 at RM 2.7 with two new species found compared to 1997 sample sites (combined): Mapleleaf (*Quadrula quadrula*) and Pimpleback mussels (*Quadrula pustulosa*).

Figure 85 — Beaver Creek at RM 16.16 (left), RM 8.3 (center) and RM 2.73 (right), 2015.

Brush Creek, a tributary to Yellow Creek, was previously sampled in 1981 between Leipsic and Deshler. Community quality was fair or worse then, but the 2015 samples upstream and downstream from Deshler were very good or better with ICI scores of 48 and 44 at RMs 8.99 (303002) and 0.58 (P10P06), respectively. Both sites had relative densities near or more than 2,000/ft.^{2} (Table 30).

Yellow Creek was sampled previously in 1981 from RMs 8.0, 6.0 and 3.1. Diversity ranged from highs of seven EPT and three or four sensitive taxa at RMs 8.0 and 6.0 to three to five EPT and four sensitive taxa downstream at RM 3.1. The 2015 samples at RM 4.5 and 3.18 indicated significant improvements with ICIs of 46 (exceptional) with ≥17 EPT and 14-16 sensitive taxa collected (Table 30).

Little Yellow Creek, which drains Leipsic and receives its WWTP inputs, is a tributary to Yellow Creek at RM 7.45. Previous biological samples were collected in 1981. A poor quality community evaluation was noted upstream at RM 5.5 (1.5 mi^2) and fair community quality was documented downstream at RM 0.90. In 2015 macroinvertebrate community quality demonstrated good quality (10 EPT/five sensitive taxa) at RM 0.9 (500700) and met the WWH biocriterion. In 2016 the sample of the macroinvertebrate community further upstream at RM 4.6 indicated only fair quality with five EPT.

Stream baseflow in the upper portions of Little Yellow Creek are significantly augmented by the Leipsic WWTP (1.5 MGD) relative to other streams draining three mi^2 or less in the HELP ecoregion. Other sites sampled in 2016 as part of the survey with drainages similar or larger to the upper reaches of Little Yellow Creek (upper South and Platter Creeks) were intermittent to nearly dry. Macroinvertebrate community performance in this nominally small stream, especially in the uppermost reaches, benefitted to an extent from the increased and somewhat stable baseflow.

Fish Tissue Contamination

Ohio has been sampling streams annually for sport fish contamination since 1993. Fish are analyzed for contaminants that bioaccumulate in fish and could pose a threat to human health if consumed in excessive amounts. Contaminants analyzed in Ohio sport fish include mercury, PCBs, DDT, Mirex, hexachlorobenzene, lead, selenium and several other metals and pesticides. Other contaminants are sometimes analyzed if indicated by site-specific current or historic sources. For more information about the chemicals analyzed, how fish are collected or the history of the fish contaminant program, see ***State Of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program, Ohio EPA, January 2010***

Fish contaminant data are primarily used for three purposes:

- to determine fish advisories;
- to determine attainment with the water quality standards; and
- to examine trends in fish contaminants over time.

Fish advisories

Fish contaminant data are used to determine a meal frequency that is safe for people to consume (for example, two meals a week, one meal a month, do not eat), and a fish advisory is issued for applicable species and locations. Because mercury mostly comes from nonpoint sources, primarily aerial deposition, Ohio has had a statewide one meal a week advisory for most fish since 2001. Most fish are assumed to be safe to eat once a week unless specified otherwise in the fish advisory, which can be viewed in the sportfish consumption advisory ***booklet***.

Seven water bodies had fish tissue sampled as part of the 2015 Maumee River tributaries survey: Bad Creek; Beaver Creek; Delta Reservoir #2; Jackson Cutoff Ditch; North and South Turkeyfoot creeks; and Yellow Creek.

Prior to the 2015 sampling, there were no consumption advisories in place for any species at any of these locations. The minimum data requirement for issuing a new fish advisory is three samples of a single species from within the past 10 years. Based on 2015 sampling results, four fish consumption advisories were issued in 2016, all of which were "good" advisories due to low levels of mercury in fish at these locations. These advisories are less restrictive than the statewide mercury advisory, which is detailed later in this section. The four new advisories in this study basin are:

- Bad Creek
  - Channel catfish, two meals per week due to low mercury
- North Turkeyfoot Creek
  - Channel catfish, two meals per week due to low mercury
  - Common carp, unrestricted consumption due to low mercury
- South Turkeyfoot Creek
  - Yellow bullhead, two meals per week due to low mercury

For all other species, the statewide advisories apply. These include: two meals a week for sunfish (bluegill) and yellow perch; one meal a week for most other fish; and one meal a month for flathead catfish 23" and over, northern pike 23" and over, and steelhead trout from Lake Erie and its tributaries.

A listing of fish tissue data collected from Maumee Basin in support of the advisory program and how the data compare to advisory thresholds is displayed in Table 31 and Table 32.

Table 31 — Select fish tissue mercury data from 2015 Maumee River tributaries sampling (mg/kg). The shading indicates the advisory category that each sample falls into. Blue = unrestricted; Green = two meals per week; yellow = one meal per week; orange = one meal per month.

Site	River Mile	Species	Result
Bad Creek S of Colton @ Co. Rd. T	2.47	Yellow Bullhead	0.026
Bad Creek S of Colton @ Co. Rd. T	2.47	Channel Catfish	0.062
Bad Creek S of Colton @ Co. Rd. T	2.47	Channel Catfish	0.072
Bad Creek S of Colton @ Co. Rd. T	2.47	Freshwater Drum	0.076
Bad Creek S of Colton @ Co. Rd. T	2.47	Channel Catfish	0.077
Bad Creek S of Colton @ Co. Rd. T	2.47	Rock Bass	0.13
Bad Creek S of Colton @ Co. Rd. T	2.47	Freshwater Drum	0.206
Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	2.73	Green Sunfish	0.058
Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	2.73	Channel Catfish	0.061
Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	2.73	Yellow Bullhead	0.064
Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	2.73	Rock Bass	0.078
Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	2.73	White Bass	0.078
Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	2.73	White Bass	0.101
Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	2.73	Freshwater Drum	0.26
Beaver Creek upst. Cutoff Ditch @ Wapakoneta Rd.	8.3	Green Sunfish	0.058
Beaver Creek upst. Cutoff Ditch @ Wapakoneta Rd.	8.3	Yellow Bullhead	0.067
Beaver Creek upst. Cutoff Ditch @ Wapakoneta Rd.	8.3	White Bass	0.151
Delta Reservoir #2, L-1	17.53	Bluegill Sunfish	<0.023
Delta Reservoir #2, L-1	17.53	Largemouth Bass	0.028
Delta Reservoir #2, L-1	17.53	Bluegill Sunfish	0.043
Delta Reservoir #2, L-1	17.53	Largemouth Bass	0.124
Jackson Cutoff Ditch near Weston @ Sand Ridge Rd.	1.15	Channel Catfish	0.039
Jackson Cutoff Ditch near Weston @ Sand Ridge Rd.	1.15	Yellow Bullhead	0.056
Jackson Cutoff Ditch near Weston @ Sand Ridge Rd.	1.15	Green Sunfish	0.06
Jackson Cutoff Ditch near Weston @ Sand Ridge Rd.	1.15	Freshwater Drum	0.166
Jackson Cutoff Ditch near Weston @ Sand Ridge Rd.	1.15	Freshwater Drum	0.206
Jackson Cutoff Ditch dst. Yellow Creek @ Bays Rd.		Green Sunfish	0.072
Jackson Cutoff Ditch dst. Yellow Creek @ Bays Rd.		Green Sunfish	0.074
Jackson Cutoff Ditch dst. Yellow Creek @ Bays Rd.		Yellow Bullhead	0.109
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Common Carp	0.035
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Common Carp	0.042
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Bluegill Sunfish	0.052
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Channel Catfish	0.052
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Common Carp	0.054
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Yellow Bullhead	0.066
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Freshwater Drum	0.067
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Channel Catfish	0.07
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Black Crappie	0.073
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Green Sunfish	0.074
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Largemouth Bass	0.101
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Freshwater Drum	0.136
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Freshwater Drum	0.143
S. Turkeyfoot Creek @ Twp. Rd. P-3	1.97	Yellow Bullhead	0.062
S. Turkeyfoot Creek @ Twp. Rd. P-3	1.97	Largemouth Bass	0.068
S. Turkeyfoot Creek @ Twp. Rd. P-3	1.97	Rock Bass	0.103
S. Turkeyfoot Creek near Shunk @ Co. Rd. N	7.9	Yellow Bullhead	0.064
S. Turkeyfoot Creek near Shunk @ Co. Rd. N	7.9	Rock Bass	0.131
S. Turkeyfoot Creek near Shunk @ Co. Rd. N	7.9	Rock Bass	0.149
S. Turkeyfoot Creek NW of Malinta @ Co. Rd. 11 (Upper Crossing)	10.8	Channel Catfish	0.033

Site	River Mile	Species	Result
S. Turkeyfoot Creek NW of Malinta @ Co. Rd. 11 (Upper Crossing)	10.8	Yellow Bullhead	0.054
S. Turkeyfoot Creek NW of Malinta @ Co. Rd. 11 (Upper Crossing)	10.8	Rock Bass	0.096
S. Turkeyfoot Creek @ Malinta @ Co. Rd. L	13.18	Green Sunfish	0.034
S. Turkeyfoot Creek @ Malinta @ Co. Rd. L	13.18	Yellow Bullhead	0.061
S. Turkeyfoot Creek @ Malinta @ Co. Rd. L	13.18	Green Sunfish	0.066
S. Turkeyfoot Creek @ Malinta @ Co. Rd. L	13.18	Rock Bass	0.18
Yellow Creek E of Deshler @ Roundhead Rd.	3.18	Green Sunfish	0.068
Yellow Creek E of Deshler @ Roundhead Rd.	3.18	Yellow Bullhead	0.085
Yellow Creek E of Deshler @ Roundhead Rd.	3.18	Yellow Bullhead	0.169

Table 32 — Select fish tissue PCB data from 2015 Maumee River tributary sampling (mg/kg). The shading indicates the advisory category that each sample falls into. Blue = unrestricted; yellow = one meal per week; orange = one meal per month.

Site	River Mile	Species	Result	Detected?
Bad Creek S of Colton @ Co. Rd. T	2.47	Freshwater Drum	0.0198	No
Bad Creek S of Colton @ Co. Rd. T	2.47	Rock Bass	0.0198	No
Bad Creek S of Colton @ Co. Rd. T	2.47	Channel Catfish	0.0199	No
Bad Creek S of Colton @ Co. Rd. T	2.47	Freshwater Drum	0.02	No
Bad Creek S of Colton @ Co. Rd. T	2.47	Yellow Bullhead	0.02	No
Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	2.73	Green Sunfish	0.0199	No
Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	2.73	Rock Bass	0.0199	No
Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	2.73	Yellow Bullhead	0.0199	No
Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	2.73	Freshwater Drum	0.0278	No
Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	2.73	White Bass	0.0842	Yes
Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	2.73	Channel Catfish	0.1451	Yes
Beaver Creek SE of Grand Rapids @ Wintergreen Rd.	2.73	White Bass	0.1691	Yes
Beaver Creek upst. Cutoff Ditch @ Wapakoneta Rd.	8.3	Yellow Bullhead	0.0199	No
Beaver Creek upst. Cutoff Ditch @ Wapakoneta Rd.	8.3	Green Sunfish	0.0798	Yes
Beaver Creek upst. Cutoff Ditch @ Wapakoneta Rd.	8.3	White Bass	0.1483	Yes
Delta Reservoir #2, L-1	17.53	Bluegill Sunfish	0.0199	No
Delta Reservoir #2, L-1	17.53	Largemouth Bass	0.0199	No
Delta Reservoir #2, L-1	17.53	Largemouth Bass	0.02	No
Jackson Cutoff Ditch near Weston @ Sand Ridge Rd.	1.15	Yellow Bullhead	0.0198	No
Jackson Cutoff Ditch near Weston @ Sand Ridge Rd.	1.15	Freshwater Drum	0.0199	No
Jackson Cutoff Ditch near Weston @ Sand Ridge Rd.	1.15	Green Sunfish	0.02	No
Jackson Cutoff Ditch near Weston @ Sand Ridge Rd.	1.15	Channel Catfish	0.048	Yes
Jackson Cutoff Ditch near Weston @ Sand Ridge Rd.	1.15	Freshwater Drum	0.27	Yes
Jackson Cutoff Ditch dst. Yellow Creek @ Bays Rd.		Green Sunfish	0.0199	No
Jackson Cutoff Ditch dst. Yellow Creek @ Bays Rd.		Yellow Bullhead	0.0199	No
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Black Crappie	0.0198	No
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Channel Catfish	0.0198	No
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Largemouth Bass	0.0198	No
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Common Carp	0.0199	No
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Freshwater Drum	0.0199	No
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Green Sunfish	0.0199	No
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Yellow Bullhead	0.0199	No
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Bluegill Sunfish	0.02	No
N. Turkeyfoot Creek S of Liberty Center @ Co. Rd. 8	3.4	Channel Catfish	0.02	No
S. Turkeyfoot Creek @ Twp. Rd. P-3	1.97	Largemouth Bass	0.0198	No
S. Turkeyfoot Creek @ Twp. Rd. P-3	1.97	Rock Bass	0.0199	No
S. Turkeyfoot Creek @ Twp. Rd. P-3	1.97	Yellow Bullhead	0.0199	No
S. Turkeyfoot Creek near Shunk @ Co. Rd. N	7.9	Rock Bass	0.0199	No

Site	River Mile	Species	Result	Detected?
S. Turkeyfoot Creek near Shunk @ Co. Rd. N	7.9	Yellow Bullhead	0.02	No
S. Turkeyfoot Creek NW of Malinta @ Co. Rd. 11 (Upper Crossing)	10.8	Channel Catfish	0.0199	No
S. Turkeyfoot Creek NW of Malinta @ Co. Rd. 11 (Upper Crossing)	10.8	Rock Bass	0.0199	No
S. Turkeyfoot Creek NW of Malinta @ Co. Rd. 11 (Upper Crossing)	10.8	Yellow Bullhead	0.0199	No
S. Turkeyfoot Creek @ Malinta @ Co. Rd. L	13.18	Rock Bass	0.0198	No
S. Turkeyfoot Creek @ Malinta @ Co. Rd. L	13.18	Green Sunfish	0.0199	No
S. Turkeyfoot Creek @ Malinta @ Co. Rd. L	13.18	Yellow Bullhead	0.0199	No
Yellow Creek E of Deshler @ Roundhead Rd.	3.18	Green Sunfish	0.0199	No
Yellow Creek E of Deshler @ Roundhead Rd.	3.18	Yellow Bullhead	0.0199	No

Fish tissue/human health use attainment

In addition to determining safe meal frequencies, fish contaminant data are also used to determine attainment with the human health water quality criteria pursuant to OAC Rules 3745-1-33 and 3745-1-34. The human health water quality criteria are presented in water column concentrations of μg/liter and are then translated into fish tissue concentrations in mg/kg. [See ***Ohio's 2016 Integrated Report, Section E*** (***epa.ohio.gov/Portals/35/tmdl/2016intreport/SectionE.pdf***) for further details of this conversion.]

To be considered in attainment of the water quality standards within the Lake Erie basin, sport fish caught within a HUC12 watershed must have a weighted average concentration of the geometric means for all species below 0.350 mg/kg for mercury and 0.023 mg/kg for PCBs.

Within the Maumee River basin study area, fish tissue data were adequate to determine attainment status for four of the eight watershed assessment units (WAUs) sampled. At least two samples from each trophic level 3 and 4 were needed for each WAU. Of the WAUs with sufficient information for assessment, two units were deemed to be in attainment (status of 1), and two units were deemed impaired due to PCBs in fish tissue (status of 5). The remaining WAUs were granted a status of 3i indicating that insufficient information was available for assessment. Prior to this assessment, all WAUs had a status of 3 (no data) or 1h (in attainment based on historic data). Table 33 below shows these details.

Table 33 — Tentative updates to attainment status for the Maumee River tributaries study area in Ohio's 2018 Integrated Report. Attainment status will be finalized with the approval of the 2018 Integrated Report.

WAU	Previous Status (2016)	New Status (2018)	Cause of Impairment	Assessment Unit Name
41000090104	3	3i		Middle South Turkeyfoot Creek
41000090106	3	3i		Lower South Turkeyfoot Creek
41000090302	1h	1		Lower Bad Creek
41000090402	3	1		North Turkeyfoot Creek
41000090506	3	3i		Lower Yellow Creek
41000090507	3	5	PCBs	Cutoff Ditch
41000090508	3	3i		Middle Beaver Creek
41000090509	3	5	PCBs	Lower Beaver Creek

Fish Tissue Contaminant Trends

Fish tissue contaminant levels can be used as an indicator of pollution in the water column at levels lower than laboratory reporting limits for water concentrations but high enough to pose a threat to human health from eating fish. Most bioaccumulative contaminant concentrations are decreasing in the environment because of bans on certain types of chemicals like PCBs, and because of stricter permitting limits on dischargers for other chemicals. However, contaminants like PCBs and mercury continue to pose a risk to humans who consume fish.

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

Of the seven water bodies sampled in 2015 as part of the Maumee River tributaries survey, six did not have previous fish tissue data available. Trends for these waterbodies could not be assessed. Delta Reservoir #2 previously had tissue data collected in 2005, but a different assemblage of species was collected and analyzed that year, making any trends analysis difficult.

Generally speaking, mercury concentrations in fish tissue collected from these waterbodies in 2015 were low. Averages for most species were below the 0.22 mg/kg threshold, the level below which species may be consumed at the one meal per week advisory level (Figure 86). This data suggests that fish tissue from various species collected from the Maumee River tributary water bodies are generally clean in terms of tissue contamination from mercury. The only water body with two years of available data—Delta Reservoir #2—showed similar levels of mercury in 2005 and 2015.

The other major fish tissue contaminant of concern is PCBs. PCBs were not detected in most sample and, where detected, were at generally low concentrations (Figure 87). Most water bodies had PCBs below the limit of laboratory detection for all samples, except Beaver Creek, Delta Reservoir #2, and Jackson Cutoff Ditch which had low levels of PCBs detected, with all species averages in the one meal per week consumption advisory range (below 0.22 mg/kg) or better. The only water body with two years of data available for trends analysis was Delta Reservoir #2. All results were below the detection limit for all species in both years (2005 and 2015).

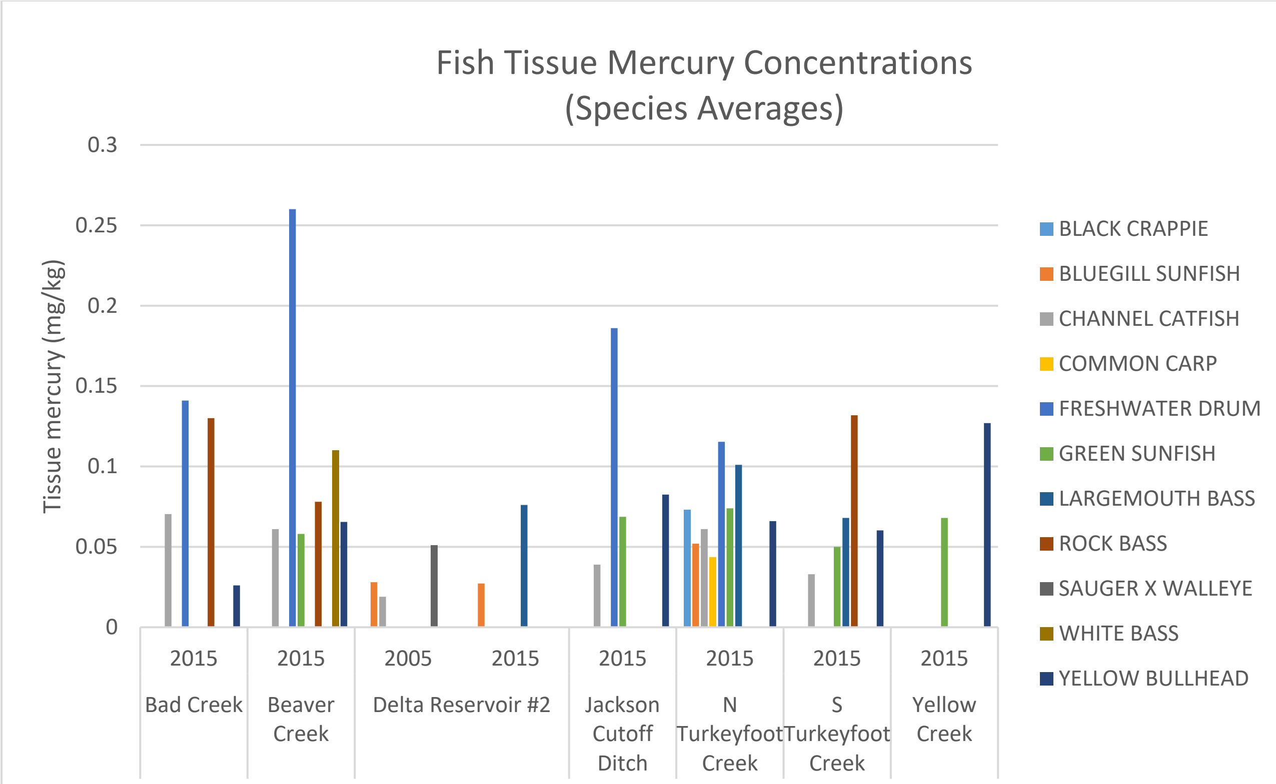

Figure 86 — Mercury concentrations in the Maumee River tributary survey.

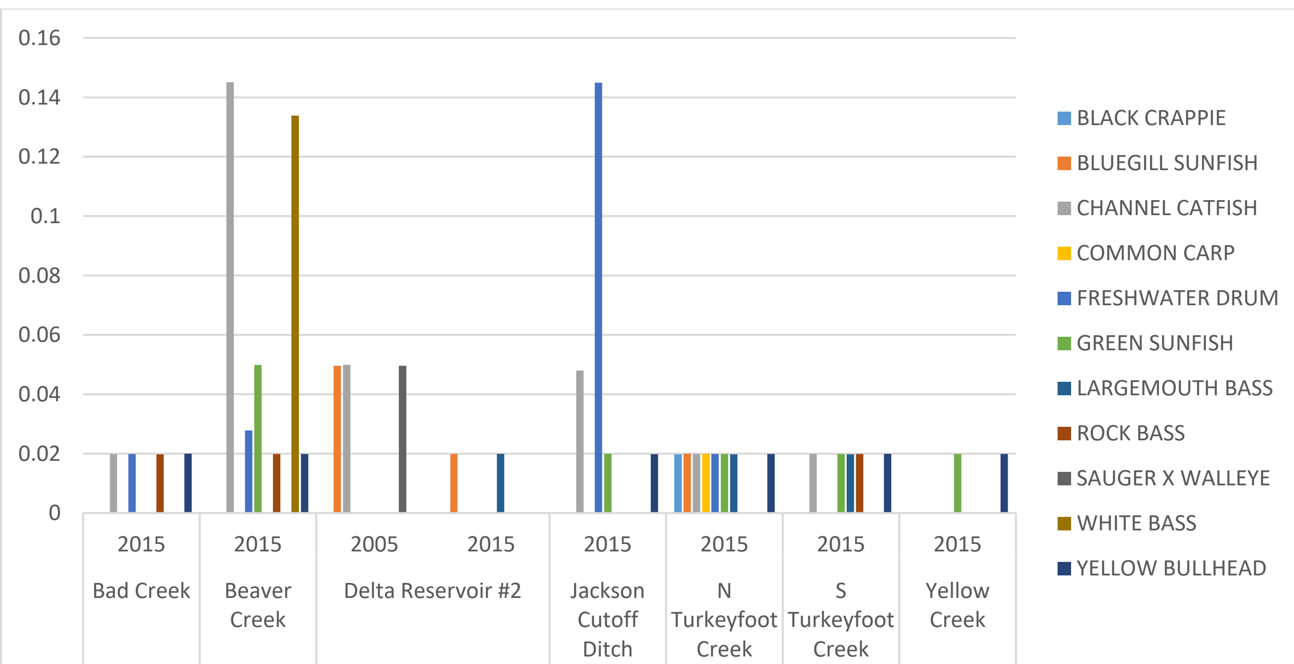

Figure 87 — Total PCB concentrations in fish tissue in the Maumee River basin survey area. Values of 0.02 mg/kg represent non-detects in 2015, while non-detects for Delta Reservoir #2 in 2005 are represented as 0.05 mg/kg (with non-detects represented as 100 percent of the sample's laboratory reporting limit).

Public Drinking Water Supplies

The public water supply beneficial use in the WQS (OAC 3745-1-33) currently applies within 500 yards of drinking water intakes and for all publicly owned lakes. Ohio EPA has developed an assessment methodology for this beneficial use which focuses on source water contaminants not effectively removed through conventional treatment methods. The *2016 Integrated Water Quality Monitoring and Assessment Report* (2016 Ohio IR) describes this methodology and is available on Ohio EPA's ***website***.

Impaired source waters may contribute to increased human health risk or treatment costs. For the case when stream water is pumped to a reservoir, the stream and reservoir will be evaluated separately. 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. For those cases when the treatment plant processes do not specifically remove a source water contaminant, the finished water quality data may be considered representative of the raw source water directly feeding into the treatment plant.

There are two public water systems (Delta and Wauseon) served by surface water sources within the study area. Delta has an intake on Lower Bad Creek (RM 17.0) and Wauseon has intakes on Big Ditch and Stucky Ditch. Table 34 provides a summary of exceedances for the PWS beneficial use, while Appendices F and H contain surface water quality analytical results. All cyanotoxin (microcystins, saxitoxins, and cylindrospermopsin) results are available on Ohio EPA's website:
http://wwwapp.epa.ohio.gov/dsw/hab/HAB_Sampling_Results.xlsx

Village of Delta

The village of Delta operates a community public water system that serves a population of approximately 3500 people through 1500 service connections. A community public water system is a system that regularly supplies drinking water from its own sources to at least 15 service connections used by year-round residents of the area or regularly serves 25 or more people throughout the entire year. The Delta water treatment system obtains its water from Bad Creek. The system's treatment capacity is 1.2 MGD. Water is pumped from Bad Creek into two upground reservoirs for storage prior to treatment. The village operates a reverse osmosis membrane filtration plant with fluoridation and chorine disinfection.

Ohio EPA collected water quality samples from Bad Creek and both of Delta's Reservoirs (L-1) during 2015. To assess the PWS beneficial use, samples were analyzed for nitrate and atrazine. Cyanotoxins (microcystins, saxitoxins, and cylindrospermopsin) were also analyzed from samples collected at Delta Reservoir #2. The PWS assessment unit is HUC 04100007 03 02 (Lower Bad Creek). Nitrate-nitrite concentrations near the intake on Bad Creek ranged from 2.2 to 20 mg/l and in the reservoirs ranged from below detection to 2.3 mg/l (reservoir #1) and 1.1 to 6.3 mg/l (reservoir #2). All reservoir results were below the water quality criterion for nitrate (10.0 mg/l), but two stream samples exceeded the water quality criterion. Atrazine sampled near the intake on Bad Creek ranged from below detection to 0.63 ug/l and was below detection in all reservoir samples. All annual averages for atrazine were below the water quality criterion and instantaneous detections were all > 12 ug/l. All results for cyanotoxins (microcystins, saxitoxins, and cylindrospermopsin) in Delta Reservoir #2 were below detection. All results were below the water quality criterion for microcystin (1.0 ug/l), saxitoxin (0.2 ug/l), and cylindrospermopsin (1.0 ug/l) (Table 34).

Routine compliance raw-water monitoring for microcystins and cyanobacteria screening began in June 2016. A trace microcystins-production gene (mcyE) detection occurred in 2017, but microcystins were not detected. Saxitoxin and cylindrospermopsin production genes were not detected. There were no finished water nitrate or atrazine MCL violations within the last five years.

In the 2016 Ohio integrated report, Lower Bad Creek (04100007 03 02) is listed as impaired for the PWS beneficial use due to elevated nitrates near Delta's intake on Bad Creek. Nitrates were detected at concentrations of 20 mg/l and 13 mg/l in June and July of 2015, exceeding the water quality criterion for nitrate (10 mg/l). There was insufficient data to assess the pesticide or algal indicators, but recent data shows the algal indicator in full support.

Village of Wauseon

The village of Wauseon operates a community public water system that serves a population of approximately 7,300 people through 1,780 service connections. The water treatment system obtains its water chiefly from the Maumee River (note: the Maumee River source is not covered in this assessment); intakes on Big Ditch and Stucky Ditch are used primarily as back-ups to the Maumee River intake. The system's treatment capacity is 3 MGD, but current average production is 833,000 gallons per day. Water is pumped into two upground reservoirs (combined 340 million-gallon capacity) for storage prior to treatment. The village of Wauseon's water treatment system consists of powdered activated carbon addition, coagulation, lime softening, sedimentation, filtration, and chlorine disinfection.

Ohio EPA collected water quality samples from Wauseon Reservoir #2 (L-1) during 2015. Water quality samples were not collected near the Big or Stuckey Ditch intakes, as the reservoirs source their water primarily from the Maumee River. To assess the PWS beneficial use, samples were analyzed for nitrate-nitrite and atrazine. Cyanotoxins (microcystin, saxitoxin and cylindrospermopsin) were also analyzed from samples collected at Wauseon Reservoir #2. The PWS assessment unit is HUC 04100009 04 02 (North Turkeyfoot Creek) for Wauseon Reservoir #2. Nitrate ranged from below detect to 1.2 mg/l. All results were below the water quality criterion for nitrate (10.0 mg/l). Atrazine ranged from below detect to 1.3 ug/l. There were no exceedances of the maximum instantaneous value >12 ug/l. All annual averages of atrazine were below the water quality criteria (3.0 ug/l). All results for cyanotoxins (microcystin, saxitoxin and cylindrospermopsin) in Wauseon Reservoir #2 were below detection. All results were below the water quality criterion for microcystin (1.0 ug/l), saxitoxin (0.2 ug/l) and cylindrospermopsin (1.0 ug/l).

Routine compliance raw water monitoring for microcystins and cyanobacteria screening began in June 2016. All results for microcystins were below detection. All results for cyanotoxin-producing genes were below detection. There were no finished water nitrate or atrazine MCL violations within the last five years.

In the 2016 Ohio integrated report, Konzen Ditch (04100009 03 02-Big Ditch intake) and North Turkeyfoot Creek (04100009 04 02-Stucky Ditch and reservoirs) the drinking water use support is listed as unknown due to insufficient data for nitrates, pesticides and algae. North Turkeyfoot Creek was put on a watch list due to nitrates. At this time, these assessment units would be considered in full attainment of the PWS beneficial use, but North Turkeyfoot Creek would remain on a watch list for nitrate-nitrite concentrations.

Table 34 — Summary of available Ohio EPA water quality data for parameters of interest at sampling sites near/at PWS intakes. This table does not include finished water sample results.

	Public Drinking Water Supply - Parameters of Interest				
	Nitrate-Nitrite WQC = 10 mg/l[1]		Atrazine WQC = 3.0 ug/l[2]		
Location(s)	Average (sample count)	Maximum (# samples >WQC)	Average (sample count)	Annual Average (2015)[3]	Maximum Single Detect.
HUC 04100007 03 02 Lower Bad Creek/Delta PWS					
Bad Creek Upstream Delta at County Road H (P11W22)	8.0 mg/l (n=8)	20 mg/l (2)	Below Detect (<0.2 ug/l) (n=6)	Below Detect (<0.2 ug/l)	0.63 ug/l
HUC 04100007 03 02 Lower Bad Creek/Delta PWS					
Delta Reservoir #1 L-1 (204637)	1.5 mg/l (n=20)	2.7 mg/l (0)	N/A	N/A	N/A
HUC 04100007 03 02 Lower Bad Creek/Delta PWS					
Delta Reservoir #2 L-1 (203749)	4.1 mg/l (n=13)	6.3 mg/l (0)	Below Detect <0.2 ug/l) (n=5)	Below Detect (<0.2 ug/l)	Below Detect (<0.2 ug/l)
HUC 04100009 04 02 North Turkeyfoot Creek/Wauseon PWS					
Wauseon Reservoir #2 L-1 (203751)	0.30 mg/l (n=6)	1.2 mg/l (0)	0.87 ug/l (n=6)	0.87 ug/l (n=6)	1.3 ug/l

1 Nitrate Water Quality Criteria (WQC) evaluated as maximum value not to be exceeded, impaired waters defined as having two or more excursions about the criteria.
2 Atrazine WQC evaluated as annual average based on quarterly averages. Watch List conditions include maximum instantaneous value > 12.0 ug/l.
3 *Annual averages assume zero for quarters without data.*

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