



Biological and Water Quality Study of the Big Darby Creek Watershed 2014

Logan, Champaign, Union, Madison, Franklin, and Pickaway Counties, OH



Division of Surface Water
Ecological Assessment Section
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Biological and Water Quality Study
of the
Big Darby Creek Watershed, 2014-2015.

Logan, Champaign, Union, Madison, Franklin, and Pickaway Counties

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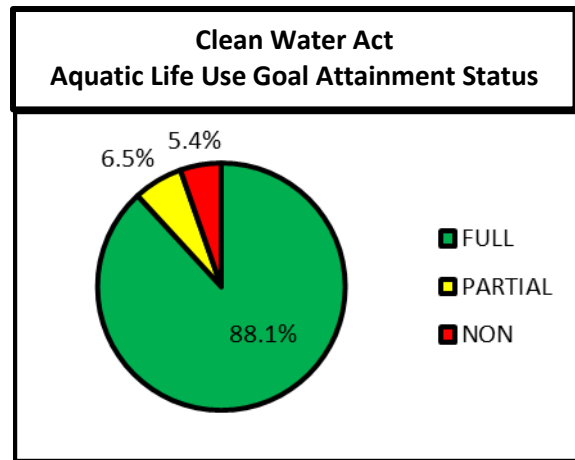
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Appendix L – Post-Mussel Mortality Inorganic Water Chemistry Data, October 2016

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 use designations, evaluate temporal trends, and also to determine if the use is meeting the goals of the federal Clean Water Act. In 2014 and 2015, 28 streams in the Big Darby Creek watershed, located in Logan, Champaign, Union, Madison, Franklin, and Pickaway counties, were evaluated for aquatic life, recreation, and human health use potential. The majority of data presented throughout this report were collected in 2014. Additional data were collected during the 2015 sampling season at or near locations displaying biological impairment in 2014. Sampling locations and corresponding narrative biological evaluations are displayed in Figure 1 and Table 1.



Biological samples were collected from 94 sampling locations. Of the 93 locations that could be assessed, 82 locations (88.1%) were fully meeting the designated or recommended aquatic life use (ALU), six locations (6.5%) were in partial attainment, and five locations (5.4%) were in non-attainment (Table 2).

All 34 (100%) of the locations evaluated on the Big Darby Creek mainstem were in full attainment of the existing aquatic life use designations. This is an improvement from the 2001 survey, when 26 of 35 (74.2%) sites were in full attainment of the designated aquatic life use. All but one of the 14 sampling locations (92.9%) on Little Darby Creek were in full attainment, which also was a slight improvement from the 2001 survey, when 13 of 16 (81.3%) sites achieved full attainment. Results for tributaries to Big and Little Darby creeks were more variable, but overall positive. Of the 45 locations situated on 26 tributaries to Big and Little Darby creeks, 35 locations (77.8%) were in full attainment, 5 locations (11.1%) were in partial attainment, and 5 locations (11.1%) were in non-attainment of the existing or recommended aquatic life use designations. The vast majority of these locations and/or stream reaches were sampled both in 2001 and 2014.

Results from the 2014 survey indicated substantial recovery from impairments documented during the 2001 survey in both Big and Little Darby creeks, and within many tributaries. Multiple and interrelated factors are likely responsible for this; these may include, but are not limited to, gradual natural rehabilitation of previously modified stream segments, reduced siltation, improved surface water quality, recovery from spills, and improved performance of NPDES permitted facilities. Negative impacts associated with channelization and direct habitat alterations such as excess siltation and sedimentation smothering natural substrates were the most common driver of biological impairment throughout the study area. Localized areas of nutrient and organic enrichment stemming from rowcrop agriculture, unrestricted livestock access, and other residential and commercial sources were likely driving biological impairment at several locations. Many of the negative impacts stemming from municipal point sources resulting in impairment to biological communities have effectively been abated since the 2001 survey. A complete list of sampling locations, attainment status, and associated causes and sources of impairment

from the 2014 survey are found in Table 2. More in depth discussion of impaired areas can be found throughout the body of this document.

Surface water chemistry grab samples from 121 locations within the Big Darby Creek watershed indicated multiple Water Quality Standards (WQS) exceedances of the minimum dissolved oxygen criterion throughout the watershed; the number of exceedances for each indicated waterbody is contained in parenthesis. Dissolved oxygen exceedances observed in the study area include Big Darby Creek (4), Robinson Run (1), Sugar Run (2), Treacle Creek (9), Barron Creek (1), Spring Fork (1), Trib. to Little Darby Creek (14.35) (1), and Hamilton Run (1) (Table 14). Additionally, automated water quality data loggers (*i.e.*, sondes) revealed minimum and 24-hour average D.O. exceedances indicative of both nutrient and organic enrichment in the upper reaches of Sugar Run, the lower reaches of Treacle Creek, and Wamp Ditch (Table 15). Total phosphorus and nitrate-nitrite concentrations were above target concentrations at multiple locations throughout the watershed (Table 16). Despite this, total phosphorus (TP), nitrate-nitrite, and total Kjeldahl nitrogen (TKN) concentrations appear to have decreased since 2001 (Figure 74). Iron (15), barium (2), and copper (1) exceedances were also recorded at locations throughout the watershed and were likely a result of high background soil concentrations from the underlying geology of the area. More substantial discussion can be found within the [Surface Water Chemistry](#) portion of this document.

Biological communities were evaluated at 94 locations throughout the watershed. Fish community performance in the Big Darby Creek mainstem has improved since 2001. Average IBI and MIwb scores, respectively, increased from 50.4/9.59 in 2001 to 54.8/10.63 in 2014. Macroinvertebrate community performance throughout the Big Darby Creek mainstem was very similar to slightly improved compared to the 2001 survey. Improvements to fish and macroinvertebrate community performance was most obvious throughout the middle and upper reaches of Big Darby Creek (Figure 10 and Figure 40). Improvements throughout these reaches can likely be attributed to improved municipal point source effluent quality (Plain City and Flat Branch WWTP), reduced non-point source impacts in both the mainstem and tributaries in these reaches, recovery from documented spills/kills, and habitat improvements in the uppermost headwaters reaches. Fish community performance has also improved in Little Darby Creek, with average IBI and MIwb scores, respectively, increasing from 49.6/9.35 in 2001 to 54.5/9.81 in 2014 (Figure 17). Macroinvertebrate community performance in Little Darby Creek was more variable and has improved in areas, while declines were observed through several reaches compared to 2001 (Figure 53).

Both fish and macroinvertebrate community performance, as a whole, improved substantially in tributaries to Big and Little Darby creeks that were sampled both in 2001 and 2014. The median IBI score for all tributaries sampled in both years increased 10 points and is now in the exceptional range (Figure 20). Improvements in macroinvertebrate community performance were also evident in numerous tributaries to Big and Little Darby creeks. Improvements in biological performance were especially pronounced within and downstream from both Flat Branch and Buck Run, Robinson Run, Hellbranch Run, the upper reaches of both Treacle Creek and Spring Fork, and within many of the other smaller tributaries draining to both Big and Little Darby creeks. Slight declines and/or continued underperformance relative to expectations occurred in the upper reaches of Sugar Run, the lower reaches of both Spain and Treacle creeks, Wamp Ditch, and in the headwater tributaries to Hellbranch Run. More substantial discussion related to biological communities can be found in the [Fish Community Overview and Trends](#) and [Macroinvertebrate Community Overview and Trends](#) sections of this document.

While macroinvertebrate communities in general have remained stable or improved in Big Darby Creek and its tributaries since the 2001 survey, trends in mussel populations have been more variable; some stream reaches maintained more stable or increased diversity, while other reaches seem to have declined in overall diversity (Table 13). In Big Darby Creek mainstem, increases in mussel community diversity or relatively stable conditions were evident in the upper reaches in the vicinity of Flat Branch and in the middle reaches extending from near Milford Center to upstream from Plain City (RMs 70-54) (Table 13). These reaches supported more stable or improving mussel populations compared to the rest of the mainstem. Water quality has generally improved throughout these reaches (Figure 70-Figure 74, Figure 81). Mussel diversity throughout the remainder of Big Darby Creek mainstem was more variable. Trends in mussel community diversity in Little Darby Creek were variable, with apparent increases in reaches, with declines in others. While mussels were collected from some of the smaller tributaries in 2014, their abundance and diversity were generally low and very similar to what was found during the earlier surveys. Discussion of specific sites and stream reaches is contained within the [Mussel Data Trends and Discussion](#) sub-section of this document.

The significant expansion in range of the state endangered spotted darter exemplifies the improved fish community performance observed throughout Big and Little Darby creeks (Figure 15). The spotted darter is one of the rarest and most intolerant darter species in Ohio and is sensitive to excess siltation and habitat degradation. Of the 48 instances statewide where the spotted darter has been collected by Ohio EPA since 1979, 40 (83%) have occurred in the Big Darby Creek basin. Historically, this species has been limited to only the very lowest reaches of Big Darby Creek, having been regularly recorded at RM 3.2 since 1979. The 2001 survey recorded the spotted darter as far up Big Darby Creek as RM 25.7; however, occurrences still appeared relatively sporadic on a site-by-site basis. In 2014, they were found as far upstream in Big Darby Creek as RM 34.2 and have even expanded their range as far as RM 8.2 into Little Darby Creek; these were the first Ohio EPA records of spotted darters in Little Darby Creek.

Improvements in biological community performance throughout the watershed, especially increases in abundance and biomass of simple lithophilic fish species like the spotted darter (*i.e.* sensitive to excessive siltation) are likely related, at least in part, to the adoption of modern tillage practices beginning in the early 1990s and subsequent diminution of clayey silts and other fine-grained particles to receiving streams. The eventual “coarsening” of the stream bed should, over time, stimulate a biological response in the form of recruitment of substrate-sensitive species. The cumulative effects from the full suite of modern tillage practices and related soil and water conservation practices have resulted in the significant reduction in gross erosion documented at national and regional scales since the late 1970s (NRCS 2010). Studies within the Maumee River watershed (and other watersheds) have demonstrated an association between agricultural best management practices, reduced soil loss and instream sedimentation, and a concurrent positive response of the ambient biology (Barton and Farmer 1997, Meyer and Metzker 2000, Yoder et al. 2004, Richards et al. 2009, and Tessler and Gottgens 2012, Miltner 2015). These findings parallel emerging phenomena Ohio EPA has observed state-wide regarding the reestablishment of not only formerly imperiled, substrate sensitive fish taxa (*i.e.*, spotted darter, eastern sand darter, bigeye chub), but large and positive community shifts towards lithophilic and specialist insectivorous species in general, with a corresponding decline in ecological generalists (*i.e.*, common carp).

Macrohabitat quality throughout both Big and Little Darby creeks as indicated by the Qualitative Habitat Evaluation Index (QHEI) was generally in the very good to exceptional range. Most QHEI scores fell within the “exceptional” range, while “good” habitat conditions persisted in the upper reaches of both Big and Little Darby creeks. Despite having a history of channelization in the upper reaches of both streams, the overwhelming presence of natural stream features (*e.g.*, good riffle quality, floodplain and riparian

quality, amounts and types of instream cover, best substrate types) throughout both Big and Little Darby creeks are necessary to support high quality aquatic communities found in this system. Macrohabitat quality in tributaries was variable, ranging from poor to excellent. Many tributaries that had generally deficient habitat have had a history of channelization activities and other types of direct habitat alterations. More substantial discussion can be found within the [Stream Physical Habitat](#) portion of this document.

A total of 41 National Pollutant Discharge Elimination System (NPDES) individual permitted facilities discharge sanitary wastewater, industrial process water and/or industrial storm water into streams within the Big Darby Creek watershed (Table 35). One major municipal discharger, Ohio Department of Rehabilitation and Corrections (ODRC) Pickaway Correctional Institute (PCI) Wastewater Treatment Plant (WWTP), is located in the watershed. Other municipal dischargers include West Jefferson, Plain City, Lake Darby Estates, Mechanicsburg, North Lewisburg and Flat Branch. Together with PCI, these dischargers account for 86% of the municipal NPDES individual permitted flow in the Big Darby watershed. Industrial NPDES discharge facilities include Honda of America, Ranco, Battelle Memorial Institute, and Tuffco Sand and Gravel. Permitted design flow for municipal dischargers is 6.36 MGD, while permitted industrial dischargers account for only 0.06 MGD design flow. No impairments to biological communities were documented downstream from or attributed to NPDES facilities during the 2014 survey. This denotes improvements since 2001, where aquatic life use impairment was documented downstream from and attributed to the Plain City WWTP, the Mechanicsburg WWTP, the Oakhurst Knolls WWTP, and the now decommissioned Timberlake WWTP. Generally speaking, many NPDES permitted facilities have improved operations through time since the 2001 survey. More substantial discussion pertaining to 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. Permit Violations from 2012-2014 for selected facilities can be found in Appendix I.

Thirty locations in the Big Darby Creek watershed were tested for bacteria indicators (*Escherichia coli*) to determine recreation use attainment status in 2014. Evaluation of *E. coli* bacteria results revealed that 26 locations failed to attain the applicable geometric mean criterion, and, thus, were in *non-attainment* of the designated Primary Contact Recreation use. Four locations, including three consecutive sites on the lower portion of Big Darby Creek were in full attainment of the recreation use criterion (Figure 96). Plausible sources of elevated bacteria concentrations were ubiquitous and most likely due to a variety of inputs and land use conditions within the watershed such as agricultural manure runoff, underperforming wastewater treatment plants, failing home sewage treatment systems (HSTS), or unsewered communities. More information is contained within the [Recreation Use](#) section of this document.

Sediment chemistry samples were collected from 17 sites in the Big Darby Creek watershed in late summer and early fall of 2014. Samples were analyzed for metals, organics, nutrients, total organic carbon (TOC) and particle size. Organic compounds were largely undetected in the majority of stream sediment samples collected from the Big Darby Creek watershed; organic compounds identified include dieldrin and pyrene (one detection each), flouranthene (two detections) and benzo(g,h,i)perylene (four detections). Detections were at or below concentrations expected to cause aquatic life impairment, with the exception of dieldrin (7 µg/kg) which was in excess of the 1.9 µg/kg threshold effect concentration (TEC) in Little Darby Creek at RM 38.78, downstream from Mechanicsburg at Wing Rd. The majority of sediment results were below Ohio Sediment Reference Values (SRVs) for metals. The majority of metal threshold exceedances were found at Big Darby Creek RM 51.1 downstream from Plain City. The highest sediment metal concentrations were located in the urbanized portion of the Hellbranch Run subwatershed, in both

Clover Groff and Hamilton Run, and downstream from Plain City. The sediment arsenic concentration (41 mg/kg) for Hamilton Run was the only tributary sampling location that exceeded the probable effect concentration (PEC) of 33 mg/kg. Sediment nutrient concentrations were elevated in many locations throughout the Big Darby Creek watershed. More detailed discussion can be found within the [Sediment Chemistry](#) section of this document.

Fish tissue data collection from 2014 were sufficient to support removal of the “one meal per month” PCB advisory in the lower reaches of Big Darby Creek for common carp. Smallmouth bass in Big Darby Creek will be added to the consumption advisory under the “one meal per month” limit due to mercury. Channel catfish and freshwater drum (20” and over) will remain on the advisory list for Big Darby Creek with elevated mercury levels. PCB concentrations for these two species have decreased; however, confirming samples will need to be collected before delisting this contaminant for these species. Little Darby Creek does not have any fish consumption advisories for PCBs or mercury and there will be no changes based on current data. All other species caught should follow the statewide advice of two meals per week for sunfish and yellow perch, one meal per month for flathead catfish 23” and over, and northern pike 23” and over, and one meal per week for all other species not otherwise listed. In addition to determining safe meal frequencies, fish contaminant data are also used to determine attainment with the human health Water Quality Standards criteria pursuant to OAC Rules 3745-1-33 and 3745-1-34. Within the Big Darby Creek watershed, fish tissue data were adequate to determine attainment status for several HUC-12 assessment units which incorporate Big Darby Creek or Little Darby Creek mainstem reaches. In general, most of the mainstem assessment units showed no impairment due to fish tissue contamination; however, the Big Darby mainstem included within two assessment units (Greenbrier Creek-Big Darby Creek and Lizard Run-Big Darby Creek) did show impairment for PCBs.

Table 1. Biological sampling locations within the Big Darby Creek watershed, 2014-15. 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**, **poor**, and **very poor**. Sites shaded blue (exceptional, very good) meet EWH and sites shaded green meet Warmwater Habitat (WWH). Typically, sites shaded yellow, orange, and red do not meet WWH goals, except in certain circumstances in the Huron-Erie Lake Plain (HELP) ecoregion with regard to fish biocriteria.

Site Number	STORET	Stream Name	River Mile	Drainage Area (mi ²)	Latitude	Longitude
1	V06K07	Big Darby Creek	83.20	1.50	40.315600	-83.591900
2	300621	Big Darby Creek	81.90	2.20	40.312403	-83.572964
3	V06K05	Big Darby Creek	81.60	3.00	40.308700	-83.570200
4	300620	Big Darby Creek	81.10	3.20	40.302858	-83.569058
5	V07P62	Big Darby Creek	80.75	4.50	40.298300	-83.570000
6	V07S57	Big Darby Creek	79.23	5.60	40.278600	-83.559700
7	V07P61	Big Darby Creek	78.44	19.40	40.269400	-83.551700
8	V07P59	Big Darby Creek	76.53	32.00	40.249700	-83.533100
9	V06K03	Big Darby Creek	69.34	71.70	40.194700	-83.474400
10	V07P54	Big Darby Creek	66.10	83.10	40.178300	-83.427800
11	V06W16	Big Darby Creek	64.38	85.00	40.163900	-83.404700
12	V07S12	Big Darby Creek	62.60	121.00	40.150300	-83.381900
13	V07P51	Big Darby Creek	58.80	131.00	40.135300	-83.320000
14	V06W04	Big Darby Creek	54.10	138.00	40.124000	-83.272500
15	V07S09	Big Darby Creek	51.10	157.00	40.091308	-83.255524
16	V06W08	Big Darby Creek	49.46	193.00	40.069400	-83.249200
17	603100	Big Darby Creek	41.75	239.00	39.981700	-83.249400
18	600830	Big Darby Creek	38.90	247.00	39.947389	-83.235925
19	V06W19	Big Darby Creek	38.33	248.00	39.941100	-83.230000
20	601140	Big Darby Creek	34.15	253.00	39.893600	-83.217500
21	V07S06	Big Darby Creek	30.17	448.00	39.845300	-83.193600
22	V07G70	Big Darby Creek	27.95	450.00	39.843300	-83.175100
23	V07S04	Big Darby Creek	26.80	454.00	39.836100	-83.170800
24	601110	Big Darby Creek	25.70	495.00	39.818200	-83.161948
25	V07S03	Big Darby Creek	23.75	501.00	39.802200	-83.169200
26	V07W56	Big Darby Creek	22.25	503.00	39.786400	-83.153100
27	V07P42	Big Darby Creek	21.35	506.00	39.777500	-83.144200
28	V07G19	Big Darby Creek	19.83	511.00	39.758500	-83.153800
29	V07P41	Big Darby Creek	19.10	513.00	39.753100	-83.147800
30	601300	Big Darby Creek	13.36	534.00	39.700800	-83.109700
31	V07P39	Big Darby Creek	11.30	537.00	39.677800	-83.096400
32	302740	Big Darby Creek	9.20	540.00	39.659760	-83.078970
33	203274	Big Darby Creek	7.40	545.00	39.656100	-83.060800
34	600970	Big Darby Creek	3.20	552.00	39.628600	-83.009700
35	V07P60	Flat Branch	0.90	12.70	40.277800	-83.540600
36	V06G33	Little Darby Creek (Logan Co.)	3.61	3.10	40.282375	-83.594150
37	V06W15	Little Darby Creek (Logan Co.)	0.34	7.20	40.267800	-83.557200
38	V06G31	Spain Creek	3.70	6.30	40.216800	-83.574600

Site Number	STORET	Stream Name	River Mile	Drainage Area (mi ²)	Latitude	Longitude
39	V07P58	Spain Creek	0.01	9.60	40.228799	-83.523092
40	V07P56	Pleasant Run	0.01	9.40	40.214300	-83.497700
41	V06G09	Buck Run	10.40	4.80	40.239900	-83.474900
42	V06P05	Buck Run	7.80	9.00	40.224200	-83.462600
43	V07P53	Buck Run	0.01	29.80	40.159921	-83.395189
44	V06G08	Robinson Run	2.10	9.70	40.134990	-83.286880
45	V06W05	Robinson Run	0.73	10.50	40.128819	-83.270422
46	V06G05	Sweeny Run	0.20	3.90	40.105800	-83.264700
47	V06K08	Sugar Run	5.40	11.40	40.142800	-83.248300
48	V07S13	Sugar Run	0.43	19.40	40.093900	-83.250300
49	V06G04	Worthington Ditch	0.24	4.60	40.084000	-83.253300
50	V06G64	Ballenger-Jones Ditch	0.18	7.30	40.071900	-83.252200
51	V06G02	Fitzgerald Ditch	0.55	5.90	40.017900	-83.261900
52	302733	Little Darby Creek	40.10	8.20	40.068900	-83.560930
53	V06Q07	Little Darby Creek	39.30	12.20	40.070231	-83.547763
54	V06S10	Little Darby Creek	38.78	12.70	40.075000	-83.541100
55	V06S05	Little Darby Creek	34.70	26.00	40.108300	-83.493300
56	V06S04	Little Darby Creek	29.46	70.00	40.115800	-83.425000
57	V06S03	Little Darby Creek	24.46	78.00	40.073361	-83.402720
58	V06Q01	Little Darby Creek	20.50	98.00	40.024761	-83.389119
59	V07S34	Little Darby Creek	17.25	142.00	39.986761	-83.375519
60	V07P67	Little Darby Creek	15.30	147.00	39.972261	-83.355718
61	302704	Little Darby Creek	13.35	149.00	39.966600	-83.331200
62	V07P65	Little Darby Creek	8.20	161.00	39.946162	-83.281316
63	V06G28	Little Darby Creek	7.35	162.00	39.951210	-83.269437
64	V07P64	Little Darby Creek	3.95	170.00	39.918162	-83.259315
65	601130	Little Darby Creek	0.07	178.00	39.893662	-83.218814
66	V06G27	Clover Run	0.60	1.90	40.063360	-83.564124
67	V06G25	Lake Run	0.95	5.70	40.092900	-83.523300
68	V06G26	Jumping Run	0.27	1.80	40.090959	-83.549525
69	V06G18	Treacle Creek	11.77	6.90	40.120136	-83.583051
70	V06G20	Treacle Creek	6.00	12.90	40.123859	-83.494024
71	V06S11	Treacle Creek	0.78	36.00	40.138160	-83.452423
72	V06G21	Proctor Run	4.90	8.80	40.166058	-83.553926
73	V06G23	Proctor Run	1.60	9.90	40.158959	-83.506525
74	V06G17	Barron Creek	0.20	8.20	40.072661	-83.406420
75	V06Q08	Wamp Ditch	0.10	5.50	40.057261	-83.393520
76	V06G13	Spring Fork	15.90	4.80	40.044182	-83.541933
77	V06G15	Spring Fork	10.08	15.00	40.066760	-83.473922
78	V06Q10	Spring Fork	7.80	19.50	40.047600	-83.441400
79	V07S36	Spring Fork	0.75	37.50	39.991961	-83.389619
80	V07K18	Smith Ditch	0.20	7.80	39.866300	-83.219100
81	203243	Hellbranch Run	9.40	23.10	39.921700	-83.177500
82	V07S50	Hellbranch Run	7.29	27.80	39.901100	-83.163100
83	V07G01	Hellbranch Run	5.80	32.00	39.879300	-83.154900

Site Number	STORET	Stream Name	River Mile	Drainage Area (mi ²)	Latitude	Longitude
84	V07P11	Hellbranch Run	0.98	37.40	39.828900	-83.160000
85	V07S47	Hellbranch Run	0.90	37.40	39.828100	-83.159700
86	V07G06	Hamilton Run	3.34	1.50	39.989810	-83.188080
87	203345	Hamilton Run	0.80	6.60	39.955300	-83.183300
88	V07P15	Hamilton Run	0.41	9.70	39.950000	-83.180800
89	203348	McCoy Run	0.10	3.10	39.951700	-83.183100
90	203358	Clover Groff Run	5.00	4.60	40.006900	-83.170000
91	300738	Clover Groff Run	3.60	5.70	39.987274	-83.170276
92	V07P14	Clover Groff Run	0.14	9.90	39.944400	-83.176400
93	203267	Springwater Run	0.80	1.80	39.808320	-83.172144
94	203269	Trib. to Big Darby Creek (23.61)	0.10	0.40	39.799700	-83.170300

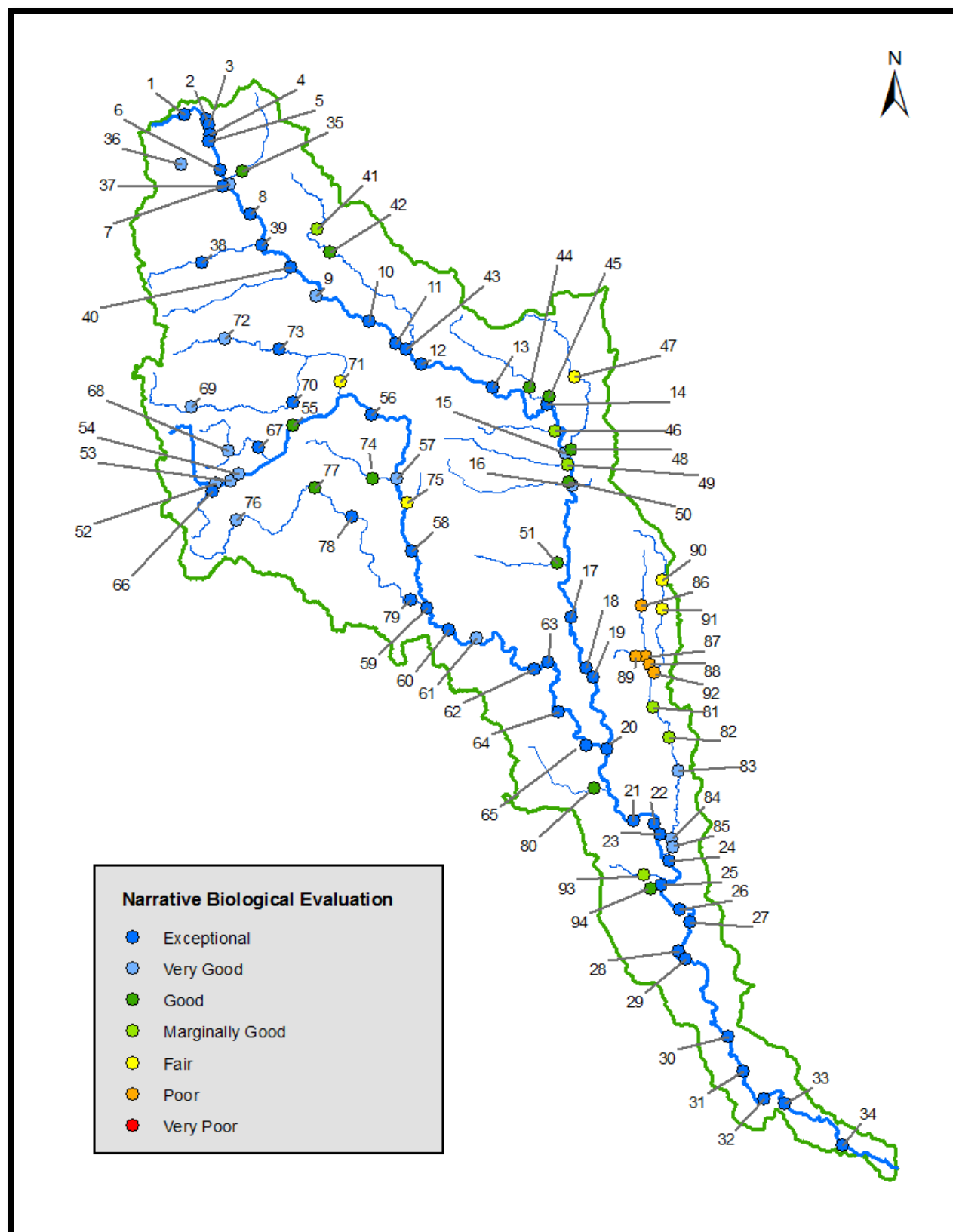


Figure 1. Biological and water quality sampling locations within the Big Darby Creek watershed, 2014-15. Site numbers correspond to Table 1.

Table 2. Aquatic life use attainment status for stations sampled in the Big Darby Creek study area based on data collected June-October 2014 and 2015. The Index of Biotic Integrity (IBI), Modified Index of well-being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biological communities. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat of the stream to support a biotic community. The Big Darby Creek watershed is located within the Eastern Corn Belt Plains (ECBP) 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. N/A = not applicable.

Location	STORET (RM) ^a	DRAIN. (MI ²)	IBI ^b	MIwb ^c	ICI ^d	QHEI	Status ^e	Causes	Sources
Big Darby Creek (02-200-000)	EWB & CWH Existing								
In headwaters at private residence	V06K07 (83.20)	1.5 ^H	54	N/A	50/52 ^b	77.25	FULL		
S. of East Liberty, upstream lane off Old US 33	300621 (81.90)	2.2 ^H	54	N/A	56	58.00	FULL		
At lane off Old US Route 33	V06K05 (81.60)	3.0 ^H	50	N/A	54	57.25	FULL		
N.E. of Middleburg, approximately 0.4 mi. upst. State Route 287	300620 (81.10)	3.2 ^H	54	N/A	56	67.50	FULL		
N.E. of Middleburg at State Route 287	V07P62 (80.75)	4.5 ^H	56	N/A	56	71.50	FULL		
S.E. of Middleburg at County Road 157	V07S57 (79.23)	5.6 ^H	50	N/A	58	55.25	FULL		
Big Darby Creek (02-200-000)	EWB Existing								
S.E. of Middleburg at County Rd. 153	V07P61 (78.3)	26.5 ^W	54	9.26 ^{NS}	48	68.25	FULL		
N.E. of North Lewisburg at North Lewisburg Rd.	V07P59 (76.54)	32.0 ^W	56	10.03	52/58 ^b	80.50	FULL		
N.W. of Milford Center at Collins Rd.	V06K03 (69.34)	71.0 ^W	55	9.90	VG ^{NS}	79.50	FULL		
At Milford Center Cemetery	V07P54 (66.10)	85.0 ^W	55	10.16	46	78.75	FULL		
Upst. Buck Run, adj. Middleburg-Plain City Rd.	V06W16 (64.38)	86.0 ^W	54	10.66	52	78.25	FULL		
S.E. of Bridgeport at State Route 38	V07S12 (62.60)	121.0 ^W	57	9.91	E	76.25	FULL		

Location	STORET (RM) ^a	DRAIN. (MI ²)	IBI ^b	MIwb ^c	ICI ^d	QHEI	Status ^e	Causes	Sources
S.E. of Unionville Center, adj. Robinson Rd.	V07P51 (58.80)	131.0 ^W	55	9.15 ^{NS}	E	70.00	FULL		
At Plain City, upst. US 42 and Ranco	V06W04 (54.10)	138.0 ^W	54	9.87	52	78.25	FULL		
S. of Plain City at Cemetery Pike	V07S09 (51.10)	157.0 ^W	54	9.76	44 ^{NS}	83.75	FULL		
Near Amity at Amity Pike	V06W08 (49.46)	193.0 ^W	55	9.76	E	81.50	FULL		
N. of West Jefferson at Hubbard Rd.	603100 (41.75)	239.0 ^W	57	9.87	54	85.75	FULL		
E. of West Jefferson at U.S. Route 40	600830 (38.90)	247.0 ^W	51	9.20 ^{NS}	E	87.50	FULL		
E. of West Jefferson, dst. Darbycrest	V06W19 (38.33)	248.0 ^W	55	9.67	E	87.75	FULL		
Near Georgesville at Alkire Rd., upst. BDC/LDC confluence	601140 (34.15)	253.0 ^W	59	10.74	48	93.25	FULL		
Upst. Darbydale dst. State Route 665	V07S06 (30.17)	448.0 ^B	60	11.32	50	86.25	FULL		
Dst. Darbydale	V07G70 (27.95)	450.0 ^B	55	11.21	52	86.00	FULL		
Upst. Gay Run, adj. Harrisburg-Georgesville Rd.	V07S04 (26.80)	454.0 ^B	55	10.70	E	86.00	FULL		
Approx. 0.5 mi. dst. Hellbranch Run and I-71	601110 (25.70)	495.0 ^B	54	10.41	54	82.25	FULL		
W. of Orient at State Route 762	V07S03 (23.75)	501.0 ^B	55	11.67	48	90.75	FULL		
Dst. PCI WWTP, upst. Snake Island	V07W56 (22.25)	503.0 ^B	54	11.66	48	90.25	FULL		
Dst. Snake Island	V07P42 (21.35)	506.0 ^B	56	11.79	56	88.50	FULL		

Location	STORET (RM) ^a	DRAIN. (MI ²)	IBI ^b	MIwb ^c	ICI ^d	QHEI	Status ^e	Causes	Sources
Ust. Scioto-Darby Rd.	V07G19 (19.8)	513.0	-	-	54	-	(FULL)		
S. of Orient at Darby Creek Rd.	V07P41 (19.10)	513.0 ^B	53	11.59	54	90.25	FULL		
Near Darbyville at State Route 316	601300 (13.36)	534.0 ^B	53	11.55	E	88.00	FULL		
S.E. of Darbyville at end of Darby Rd.	V07P39 (11.30)	537.0 ^W	58	10.74	56	85.75	FULL		
Ust. Westfall Aggregate	302740 (9.12)	544.0	-	-	54	-	(FULL)		
S.E. of Darbyville, dst. Westfall Aggregate	203274 (7.40)	545.0 ^B	52	12.44	48	88.50	FULL		
Near Fox at State Route 104	600970 (3.20)	552.0 ^B	55	12.10	54	86.25	FULL		
Flat Branch (02-223-000)	MWH-C Existing								
S.E. of Middleburg, dst. US Route 33	V07P60 (0.90)	12.7 ^H	45	N/A	44	53.75	FULL		
Little Darby Creek (02-200-020)	EWB & CWH Existing								
(Logan Co.) At State Route 287	V06G33 (3.61)	2.9 ^H	53	N/A	44 ^{NS}	57.50	FULL		
(Logan Co.) At Cratty Rd.	V06W15 (0.34)	7.2 ^H	54	N/A	54	81.50	FULL		
Spain Creek (02-222-000)	EWB & CWH Existing								
W. of North Lewisburg at Gilbert Rd.	V06G31 (3.70)	6.3 ^H	54	N/A	58	72.25	FULL		

Location	STORET (RM) ^a	DRAIN. (MI ²)	IBI ^b	MIwb ^c	ICI ^d	QHEI	Status ^e	Causes	Sources
E. of North Lewisburg at mouth	V07P58 (0.01)	9.6 ^H	58	N/A	52	73.25	PARTIAL^f	Alterations in stream-side/littoral vegetation cover, direct habitat alterations, Sedimentation/shifting bedload	Upstream channelization & loss of riparian habitat
Pleasant Run (02-221-000)		EWB Existing							
N.E. of Woodstock at mouth	V07P56 (0.01)	9.4 ^H	54	N/A	54	53.25	FULL		
Buck Run (02-209-000)		WWH Existing							
At Allen Center-Pottersburg Rd.	V06G09 (10.40)	4.8 ^H	36 ^{NS}	N/A	G	50.50	FULL		
W. of Marysville at State Route 245	V06P05 (7.80)	9.0 ^H	42	N/A	G	60.00	FULL		
Near Bridgeport at mouth	V07P53 (0.01)	29.8 ^W	53	9.78	48	80.00	FULL		
Robinson Run (02-207-000)		WWH Existing							
N. of Plain City at State Route 736 (middle crossing)	V06G08 (2.10)	9.7 ^H	42	N/A	G	67.75	FULL		
N. of Plain City at US Route 42	V06W05 (0.73)	10.5 ^H	50	N/A	G	86.25	FULL		
Sweeny Run (02-200-016)		WWH Existing							
At Plain City near mouth	V06G05 (0.2)	3.9 ^H	50	N/A	MG ^{NS}	57.00	FULL		

Location	STORET (RM) ^a	DRAIN. (MI ²)	IBI ^b	MIwb ^c	ICI ^d	QHEI	Status ^e	Causes	Sources
Sugar Run (02-206-000)	WWH Existing								
Near Arnold at US Route 42	V06K08 (5.40)	11.4 ^H	34 [*]	N/A	G	56.50	PARTIAL	Nutrient Enrichment Low/flashy flows, Sedimentation/siltation	Agriculture, Golf Courses, Manure Runoff, Unsewered areas, Upstream channelization, Post-development erosion and sedimentation
Near Plain City at Cemetery Pike	V07S13 (0.43)	19.4 ^H	44	N/A	42	75.25	FULL		
Worthington Ditch (02-200-015)	WWH Existing								
N. of Amity at Plain City-Georgesville Rd.	V06G04 (0.24)	4.6 ^H	50	N/A	MG ^{NS}	63.50	FULL		
Ballenger-Jones Ditch (02-200-013)	WWH Existing								
At Plain City-Georgesville Rd.	V06G64 (0.18)	7.3 ^H	52	N/A	G	67.00	FULL		
Fitzgerald Ditch (02-205-000)	WWH Existing								
At Plain City-Georgesville Rd.	V06G02 (0.55)	5.9 ^H	48	N/A	G	55.75	FULL		
Little Darby Creek (02-210-000)	EWH & CWH Existing								
Near Mechanicsburg at W. Sandusky St.	302733 (40.10)	8.2 ^H	54	N/A	VG ^{NS}	74.00	FULL		
Ust. Mechanicsburg WWTP	V06Q07 (39.30)	12.2 ^H	48 ^{NS}	N/A	[VG ^{NS}]	81.00	FULL		
Dst. Mechanicsburg WWTP at Wing Rd.	V06S10 (38.78)	12.7 ^H	46 ^{NS}	N/A	48	62.00	FULL		

Location	STORET (RM) ^a	DRAIN. (MI ²)	IBI ^b	MIwb ^c	ICI ^d	QHEI	Status ^e	Causes	Sources
Little Darby Creek (02-210-000)	EWB Existing								
N.E. of Mechanicsburg at Irwin Rd.	V06S05 (34.70)	26.0 ^W	46 ^{NS}	8.50*	50	72.00	PARTIAL	Direct Habitat Alterations, Sedimentation/Siltation	Channelization
W. of Chuckery at Axe Handle Rd.	V06S04 (29.46)	70.0 ^W	54	9.90	E	71.00	FULL		
E. of Rosedale at Rosedale-Plain City Rd.	V06S03 (24.46)	78.0 ^W	54	9.69	42 ^{NS}	65.25	FULL		
N.E. of Plumwood at Bradley Rd.	V06Q01 (20.50)	98.0 ^W	57	9.83	54	74.00	FULL		
S.E. of Plumwood at Little Darby Rd. ford	V07S34 (17.25)	142.0 ^W	58	10.05	E	86.75	FULL		
N.W. of West Jefferson at US Route 42	V07P67 (15.3)	147.0 ^W	60	10.12	E	78.25	FULL		
N.W. of West Jefferson at end of Snyder Lane	302704 (13.35)	149.0 ^W	59	10.13	44 ^{NS}	88.75	FULL		
Near West Jefferson at Taylor Blair Rd.	V07P65 (8.20)	161.0 ^W	58	9.86	46	91.00	FULL		
Near West Jefferson at Middle Pike	V06G28 (7.35)	162.0 ^W	58	10.31	50	87.00	FULL		
At end of Roberts Rd.	V07P64 (3.95)	170.0 ^W	56	10.21	52	92.50	FULL		
Near Georgesville at Alkire Rd.	601130 (0.07)	178.0 ^W	56	9.43	54	81.9	FULL		
Clover Run (02-218-000)	WWH Existing/CWH Recommended								
At road to Maple Grove Cemetery	V06G27 (0.60)	1.9 ^H	50	N/A	E	65.00	FULL		

Location	STORET (RM) ^a	DRAIN. (MI ²)	IBI ^b	MIwb ^c	ICI ^d	QHEI	Status ^e	Causes	Sources
Lake Run (02-216-000)	EWB Confirmed								
N.E. of Mechanicsburg at State Route 4	V06G25 (0.95)	5.7 ^H	56	N/A	E	77.00	FULL		
Jumping Run (02-217-000)	WWH Existing/EWB Recommended								
N. of Mechanicsburg at State Route 559	V06G26 (0.27)	1.8 ^H	48 ^{NS}	N/A	VG ^{NS}	70.25	FULL		
Treacle Creek (02-213-000)	EWB Existing								
N.W of Mechanicsburg at Parkview Rd	V06G18 (11.77)	6.9 ^H	48 ^{NS}	N/A	VG ^{NS}	71.25	FULL		
N.E. of Mechanicsburg at State Route 161	V06G20 (6.00)	12.9 ^H	54	N/A	56	62.50	FULL		
Upst. Winget Rd. covered bridge	V06S11 (0.78)	36.0 ^W	45*	8.55*	26*	40.50	NON	Sedimentation/Siltation, Direct Habitat Alterations, Organic Enrichment	Unrestricted livestock access, Channelization, Loss of riparian habitat, Grain spill
Proctor Run (02-214-000)	EWB Existing								
S.W. of Woodstock at Park Rd.	V06G21 (4.90)	8.8 ^H	48 ^{NS}	N/A	VG ^{NS}	64.00	FULL		
S.E. of Woodstock at mouth	V06G23 (1.60)	9.9 ^H	56	N/A	E	76.50	FULL		
Barron Creek (02-212-000)	WWH Existing								
E. of Rosedale at State Route 38	V06G17 (0.20)	8.2 ^H	48	N/A	G	65.25	FULL		
Wamp Ditch (02-210-001)	WWH Existing								
S. of Chuckery at Finley Guy Rd.	V06Q08 (0.10)	5.5 ^H	50	N/A	F*	54.50	PARTIAL	Sedimentation/Siltation, Nutrient Enrichment Direct habitat alteration	Channelization, Agriculture, Loss of riparian habitat

Location	STORET (RM) ^a	DRAIN. (MI ²)	IBI ^b	MIwb ^c	ICI ^d	QHEI	Status ^e	Causes	Sources
Spring Fork (02-211-000)	EWB Existing								
S. of Mechanicsburg at Wren Rd	V06G13 (15.90)	4.8 ^H	56	N/A	VG ^{NS}	75.00	FULL		
S.W. of Rosedale at Guy Cemetery Rd.	V06G15 (10.08)	15.0 ^H	56	N/A	G*	57.50	PARTIAL	Sedimentation/siltation Direct Habitat Alteration	Recent upstream channelization, Loss of riparian habitat
S.E. of Rosedale at Rosedale-Milford Center Rd	V06Q10 (7.8)	19.5 ^H	54	N/A	58	57.75	FULL		
Near mouth at Lafayette-Plain City Rd.	V07S36 (0.75)	37.5 ^W	-	-	E	-	-		
Smith Ditch (02-200-009)	EWB Existing								
N.W. of Darbydale at Biggert Rd.	V07K18 (0.20)	7.8 ^H	52	N/A	G*	77.00	PARTIAL	Natural Conditions (Flow or Habitat)	Natural Sources
Hellbranch Run (02-204-000)	WWH Existing								
N.W. of Galloway, approx. 0.6 mi. dst. Alton Rd	203243 (9.40)	23.1 ^W	38 ^{NS}	8.17 ^{NS}	46	70.00	FULL		
S. of Galloway at Kunz Rd.	V07S50 (7.29)	27.8 ^W	47	7.88 ^{NS}	44	72.75	FULL		
Dst. Oakhurst Knolls WWTP	V07G01 (5.8)	32.0 ^W	52	9.30	48	91.50	FULL		
Hellbranch Run (02-204-000)	EWB Existing								
N. of Harrisburg at Lambert Rd.	V07P11 (0.98)	37.4 ^W	[56]	[9.88]	44 ^{NS}	[75.5]	FULL		
Dst. Timberlake WWTP	V07S47 (0.90)	37.4 ^W	[56]	[9.50]	44 ^{NS}	[77.25]	FULL		

Location	STORET (RM) ^a	DRAIN. (MI ²)	IBI ^b	MIwb ^c	ICI ^d	QHEI	Status ^e	Causes	Sources
Hamilton Run (02-204-002)	MWH-C Existing								
S. of Hilliard at Walker Rd.	V07G06 (3.34)	3.6 ^H	26	N/A	F	43.50	FULL		
Hamilton Run (02-204-002)	WWH Existing								
Near Alton, upst. McCoy Ditch	203345 (0.80)	6.6 ^H	<u>24*</u>	N/A	MS ^{NS}	47.50	NON	Direct Habitat Alteration, Sedimentation/Siltation	Channelization
Near Alton at US Route 40	V07P15 (0.41)	9.7 ^H	<u>22*</u>	N/A	MG ^{NS}	58.25	NON	Direct Habitat Alteration, Sedimentation/Siltation	Channelization
McCoy Run (02-204-003)	Undesignated/WWH Recommended								
Near Alton at mouth	203348 (0.01)	3.1 ^H	<u>26*</u>	N/A	MG ^{NS}	44.00	NON	Direct Habitat Alteration, Sedimentation/Siltation	Channelization
Clover Groff Run (02-204-001)	MWH-C Existing								
At park adj. Frazell Rd.	203358 (5.00)	4.6 ^H	34	N/A	F	39.00	FULL		
At Timberbrook WTP near Hickory Hill Dr.	300738 (3.60)	5.7 ^H	34	N/A	MG	56.50	FULL		
Clover Groff Run (02-204-001)	WWH Existing								
Near Alton at Alton Rd.	V07P14 (0.14)	9.9 ^H	<u>26*</u>	N/A	MG ^{NS}	47.25	NON	Direct Habitat Alteration, Sedimentation/Siltation, Modified/flashy flow regime	Channelization, Urban runoff
Springwater Run (02-203-000)	WWH Existing/CWH Recommended								
At Harrisburg-Georgesville Rd.	203267 (0.80)	3.4 ^H	48	N/A	MG	50.25	FULL		

Location	STORET (RM) ^a	DRAIN. (MI ²)	IBI ^b	MIwb ^c	ICI ^d	QHEI	Status ^e	Causes	Sources
Trib. to Big Darby Creek (23.61) (02-200-024)	Undesignated/CWH Recommended								
S. of Harrisburg at mouth	203269 (0.10)	0.60 ^H	48	N/A	G	44.75	FULL		

- a - River Mile (RM) represents the Point of Record (POR) for the station, not the actual sampling RM.
- b - Biological scores denoted by [brackets] are based on data collected during the 2015 sampling index period. Scores separated by a "/" indicate replicate samples both collected in 2014.
- c - MIwb is not applicable to headwater streams with drainage areas < 20 mi².
- d - 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 were not collected; narratives in italics are over-rides of an ICI score which is suspect due to suboptimal artificial substrate retrieval factors. VP=Very Poor, P=Poor, LF=Low Fair, F=Fair, MG=Marginally Good, G=Good, VG=Very Good, E=Exceptional
- e - Attainment is given for the proposed use when a change is recommended.
- f - Partial attainment status resulted from insufficient cold-water macroinvertebrate taxa collected at this location
- ns - Non-significant 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.

Biological Criteria			
Eastern Corn Belt Plains			
Index – Site Type	EWB	WWH	MWH
IBI – Headwaters	50	40	24
IBI – Wading	50	40	24
IBI – Boat	48	42	24
MIwb – Wading	9.4	8.3	6.2
MIwb – Boat	9.6	8.5	5.8
ICI	46	36	22

Recommendations

Streams in the Big Darby Creek watershed currently listed in the [Ohio Water Quality Standards](#) (WQS) are assigned one or more of the following aquatic life use designations: Warmwater Habitat (WWH), Exceptional Warmwater Habitat (EWH), Modified Warmwater Habitat - Channelization (MWH-C), and Coldwater Habitat (CWH). The majority of streams are designated either WWH or EWH. Aquatic life use designations for the majority of streams in this survey have 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 or recommend aquatic life uses for streams in the Big Darby Creek study area.

Two streams, McCoy Run and an unnamed tributary to Big Darby Creek at RM 23.61, have not been previously assigned aquatic life, water supply, or recreation beneficial use designations. These streams will be recommended appropriate use designations based on 2014 sampling data.

Lake Run, a tributary to Little Darby Creek, has an EWH use designation that was not previously confirmed by standardized approaches to the collection of instream biological data or numerical biological criteria, despite being sampled during the 2001 watershed survey.

Twenty-nine streams in the Big Darby Creek study area were evaluated for aquatic life and recreational use potential in 2014-15 (Table 2). Significant findings include the following.

- Eight streams or stream segments with an existing EWH use designation should be retained. These include Big Darby Creek from RM 79.23 to the mouth, Pleasant Run, Little Darby Creek from RM 36.9 to the mouth, Proctor Run, Treacle Creek, Spring Fork, Smith Ditch, and Hellbranch Run from RM 5.04 to the mouth.
- Twelve streams or stream segments with an existing WWH use designation should be retained. These include Buck Run, Robinson Run, Sweeny Run, Sugar Run, Worthington Ditch, Ballenger-Jones Ditch, Fitzgerald Ditch, Barron Creek, Wamp Ditch, Hellbranch Run upstream RM 5.04, Hamilton Run from RM 2.1 to the mouth, and Clover Groff Run from RM 2.5 to the mouth.
- Four streams or stream segments with an existing dual EWH/CWH use designation should be retained. These include Big Darby Creek from the headwaters to RM 79.23, Little Darby Creek (Logan Co.), Spain Creek, and Little Darby Creek from the headwaters to RM 36.9.
- Three streams or stream segments with an MWH-C use designation should be retained. These include Flat Branch, Hamilton Run from the headwaters to RM 2.1, and Clover Groff Run from the headwaters to RM 2.5.
- Lake Run, a tributary that joins Little Darby Creek near Mechanicsburg, has an EWH use designation that was not previously verified by standardized approaches to the collection of instream biological data or numerical biological criteria, despite being sampled during the 2001

watershed survey. Sampling from 2014 indicated that the EWH use designation is consistent with observed biological conditions and thus, can be confirmed EWH.

- Jumping Run, a small tributary to Lake Run, currently has a verified WWH use designation. Biological sampling results from 2014 indicated that this stream is fully capable of supporting aquatic communities consistent with expectations for an EWH designated stream. The aquatic life use of Jumping Run is therefore being recommended changed from WWH to EWH.
- Clover Run, a small tributary to the headwaters of Little Darby Creek, currently has a verified WWH use designation. Biological sampling from 2014 indicated that this stream possesses an appropriate thermal regime and the requisite biology to be considered a CWH stream. Seven cold-water macroinvertebrate and one cold-water fish (mottled sculpin) taxa were collected. Cold-water fish taxa comprised approximately 20% of the overall fish community. Therefore, Clover Run is being recommended changed from WWH to CWH.
- Springwater Run, a small tributary to Big Darby Creek, currently has a verified WWH use designation. Biological sampling from 2014 indicated that this stream possesses an appropriate thermal regime and the requisite biology to be considered a CWH stream. Three cold-water macroinvertebrate and two cold-water fish taxa (mottled sculpin, southern redbelly dace) were collected. Cold-water fish taxa comprised approximately 28% of the overall fish community. Therefore, Springwater Run is being recommended changed from WWH to CWH.
- The unnamed tributary to Big Darby Creek at RM 23.61 currently is undesignated in the WQS and, therefore, does not have an assigned aquatic life use. Biological sampling from 2014 indicated that this stream possesses an appropriate thermal regime and the requisite biology to be considered a CWH stream. Five cold-water macroinvertebrate and one cold-water fish taxa (mottled sculpin) were collected. Cold-water fish taxa comprised approximately 10.5% of the overall fish community. Therefore, the unnamed tributary to Big Darby Creek at RM 23.66 is being recommended CWH.
- McCoy Run is currently undesignated in the WQS and, therefore, does not have an assigned aquatic life use. Biological sampling from 2014 indicated macroinvertebrate community performance in the marginally good range, while fish community performance was found to be in the poor range. Habitat quality as indicated by the QHEI can generally be considered fair. Many negative habitat attributes at this location can be attributed to historical channelization activities. McCoy Run also has characteristics of a wetland-type stream, such as the dominant substrate types and the ubiquitous presence of aquatic macrophytes, which can naturally limit biological performance, especially with regard to the fish community. Given more time to recover from historical channelization activities, a fish community consistent with expectations for a WWH stream should be achievable and therefore, the WWH use is recommended.

No streams in the Big Darby Creek study area evaluated in 2014-15 have public drinking water intakes and, therefore, do not have a Public Water Supply (PWS) use designation. Recreation uses for the Big Darby Creek watershed include PCR-A for the Big Darby Creek mainstem and PCR-B for all other streams assessed during this survey. All streams in the basin are designated Agricultural Water Supply (AWS), and Industrial Water Supply (IWS). All streams with existing Agricultural Water Supply (AWS), Industrial Water Supply (IWS), Primary Contact Recreation (PCR), or Secondary Contact Recreation (SCR) use designations should retain their respective designations. Two streams, McCoy Run and an unnamed tributary to Big Darby Creek at 23.61, were previously undesignated in the WQS and, therefore, were not previously assigned any of the aforementioned use designations. It is recommended that these two streams be assigned AWS, IWS, and PCR beneficial uses.

The entire lengths of Big and Little Darby creeks are listed as an Outstanding State Water (OSW) based on exceptional ecological values listed in the antidegradation rule (OAC 3745-1-05) of the Ohio Water Quality Standards. Hellbranch Run from RM 5.04 to the mouth, Little Darby Creek (Logan Co.), Proctor Run, Spain Creek, and Spring Fork are listed as Superior High Quality Waters based on their exceptional ecological values listed in the antidegradation rule (OAC 3745-1-05) of the Ohio Water Quality Standards. These streams were designated based on a high level of biological integrity. Included in evaluating exceptional biological value were determinations of presence of endangered, threatened, or rare aquatic species, declining fish species, high quality habitat to support exceptional aquatic faunas, and a display of biological integrity equivalent to or exceeding exceptional biological communities listed in rule 3745-1-07 of the Ohio Administrative Code.

General Watershed Recommendations

The Big Darby Creek watershed is one of the most biologically diverse and highest quality stream systems in Ohio. The current survey's effort documented many positive trends that have occurred throughout the watershed since the last intensive survey in 2001. However, there are still numerous and ever-present stressors within the watershed that can negatively impact water quality going forward. A truly multifaceted approach will be necessary to help lessen the impacts from water quality stressors and ensure the protection of one of Ohio's highest quality water resources.

Land use within the Big Darby Creek watershed consists of over 70% of row-crop agriculture, making this watershed inherently more prone to eutrophication and nutrient over-enrichment. Following prescribed courses of actions outlined in Ohio's Nutrient Reduction Strategy (Ohio EPA 2013c) will help to reduce the negative impacts that excess nutrients can have on this stream system. These can include, but are certainly not limited to, increasing the area of forested riparian buffers, improving manure and livestock management practices, proper fertilizer application practices, and advocacy for modern tillage and other conservation practices.

There are numerous areas along upper Little Darby creek and many tributaries that drain to both Big and Little Darby creeks that have substantially reduced or non-existent riparian buffers (Figure 7). It would be beneficial to establish some form of riparian buffer along areas that are deficient. Riparian buffers are an important component of a healthy stream system by helping to intercept sediment and other contaminants before they reach streams. Riparian buffers also offer shading to streams, which can help regulate water temperatures and also ameliorate impacts that may be present from excess nutrients in a stream.

Measures should also be taken to further buffer the Hellbranch Run sub-watershed and other areas throughout the Big Darby Creek watershed that are experiencing substantial development pressure from the effects of urbanization. The ultimate focus of these efforts should be centered around buffering these stream systems from human development and impacts, ultimately slowing down or intercepting overland runoff and filtering out pollutants before they reach receiving streams. Measures can include, but are certainly not limited to, increasing the coverage of riparian vegetation buffers and increasing the use of “green” storm water infrastructure.

There are areas throughout the Big Darby Creek watershed where cattle have free access to streams. Excessive cattle intrusion in streams can destabilize streambanks which will lead to increased erosion and excessive silts and sediment entering streams. Excess silt and sediment can smother natural substrates (i.e., gravels, cobbles) and have negative impacts on stream biology and water quality. It would be beneficial to establish exclusion fences for cattle where they are allowed free access to streams throughout the watershed.

The 2014 survey documented recovery in the upper reaches of Little Darby Creek (RMs 30-40) and all but one location was in full attainment. While improved since 2001, many locations in this reach of Little Darby Creek are only marginally meeting (non-significant departure) the applicable biological criteria. Stressors identified as causing biological impairment during the 2001 watershed survey include enrichment impacts from both point and non-point sources, open pasturage, sedimentation, and various spills; many of these appear to have lessened in severity, though are certainly still present. These upper reaches of Little Darby Creek also receive substantial groundwater inputs, which can help to ameliorate negative impacts associated with the aforementioned stressors. The upper reaches of Little Darby Creek needs careful attention going forward to ensure that biological performance in these reaches does not decline.

Table 3. Beneficial use designations for water bodies in the Big Darby Creek watershed.

Water Body Segment	Use Designations												Comments	
	S R W	Aquatic Life Habitat						Water Supply			Recreation			
		W W H	E W H	M W H	S S H	C W H	L R W	P W S	A W S	I W S	B W	P C R		S C R
Big Darby creek - twp. rd. 157 (RM 79.23) to the mouth			+						+	+		+		
- headwaters to twp. rd. 157			+			+			+	+		+		
Georges run (creek)		+							+	+			+	
Greenbrier creek		+							+	+		*		
Unnamed tributary (Big Darby creek RM 18.41)		+							+	+			+	
Unnamed tributary (Big Darby creek RM 20.2)		+							+	+		+		
Unnamed tributary (Big Darby creek RM 23.61)						▲			▲	▲		▲		
Unnamed tributary (Big Darby creek RM 23.77)		+							+	+			+	
Springwater run		+				▲			+	+		+		
Hellbranch run - Kropp rd. (RM 5.04) to the mouth			+						+	+		+		
- all other segments		+							+	+		+		
Clover Groff ditch - headwaters to Feder rd.				+					+	+		+		ECBP ecoregion - channel modification
- Feder rd. (RM 2.5) to the mouth		+							+	+		+		
Hamilton ditch - headwaters to Feder rd. (RM 2.1)				+					+	+		+		ECBP ecoregion - channel modification
- Feder rd. to the mouth		+							+	+		+		
McCoy run (Hamilton ditch RM 0.56)		▲							▲	▲		▲		ECBP ecoregion - channel modification
Gay run		+							+	+		+		
Smith ditch - unnamed tributary adjacent Lilly Chapel rd. at RM 3.7 to the mouth			+						+	+		+		

Water Body Segment	Use Designations												Comments	
	S R W	Aquatic Life Habitat						Water Supply			Recreation			
		W W H	E W H	M W H	S S H	C W H	L R W	P W S	A W S	I W S	B W	P C R		S C R
Unnamed tributary (Smith ditch RM 0.06) Little Darby creek - Lake run (RM 36.9) to the mouth - headwaters to Lake run Spring fork Bales ditch (Spring fork RM 3.64) - downstream st. rte. 29 (RM 1.3) to the mouth Wamp ditch - adjacent Finley-Guy rd. (RM 0.4) to the mouth Barron creek - Rosedale-Plain city rd. (RM 2.1) to the mouth - headwaters to Rosedale-Plain city rd. Treacle creek Proctor run Howard run Lake run Jumping run - adjacent Bullard-Rutan rd. (RM 1.5) to the mouth - headwaters to Bullard-Rutan rd. Clover run Fitzgerald ditch (Threemile run) - RM 1.65 (terminus of county maintenance) to the mouth - headwaters to RM 1.65														

Water Body Segment	Use Designations												Comments	
	S R W	Aquatic Life Habitat						Water Supply			Recreation			
		W W H	E W H	M W H	S S H	C W H	L R W	P W S	A W S	I W S	B W	P C R		S C R
 Yutzy ditch - adjacent Price-Hilliards rd. (RM 1.0) to the mouth Ballenger-Jones ditch - U.S. rte. 42 (RM 2.4) to the mouth Worthington ditch - upstream Plain city-Georgesville rd. (RM 1.0) to the mouth Sugar run - headwaters to Taylor rd. (RM 6.7) - all other segments Sweeney run - Lafayette-Plain city rd. (RM 1.8) to the mouth Robinson run Sugar run Buck run Prairie run Hay run - upstream Mechanicsburg-Plain city rd. (RM 0.5) to the mouth - headwaters to Mechanicsburg-Plain city rd. Unnamed tributary (Big Darby creek RM 69.4) Pleasant run Spain creek - headwaters to Erie-Lackawanna railroad crossing (RM 5.0) - all other segments Unnamed tributary (Big Darby creek RM 74.91)		+						+	+		+		ECBP ecoregion - channel modification	
	+							+	+		+			
	+							+	+		+			
				+				+	+		+			
	+							+	+		+			
	+							+	+		+			
	+							+	+		*			
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	+							+	+			+		
		+						+	+		+			
	+					+		+	+		+			
		+				+		+	+		+			
		+						+	+			+		

Water Body Segment	Use Designations												Comments	
	S R W	Aquatic Life Habitat						Water Supply			Recreation			
		W	E	M	S	C	L	P	A	I	B	P		S
		W H	W H	W H	S H	W H	R W	W S	W S	W S	W	C R		C R
			+			+			+	+		+		ECBP ecoregion - channel modification
Little Darby creek (Big Darby creek RM 78.34)														
Flat branch				+					+	+		+		

Introduction

Twenty-nine streams were evaluated at ninety-four stream sampling locations in the Big Darby Creek watershed in Logan, Champaign, Union, Madison, Franklin, and Pickaway counties in 2014 and 2015. In 2014 and 2015, thirty-four locations on the Big Darby Creek mainstem and 14 locations on Little Darby Creek were sampled along with 46 locations on tributaries including Flat Branch, Little Darby Creek (Logan Co.), Spain Creek, Pleasant Run, Buck Run, Robinson Run, Sweeny Run, Sugar Run, Worthington Ditch, Ballenger-Jones Ditch, Fitzgerald Ditch, Clover Run, Lake Run, Jumping Run, Treacle Creek, Proctor Run, Barron Creek, Wamp Ditch, Spring Fork, Smith Ditch, Hellbranch Run, Hamilton Run, McCoy Run, Clover Groff Run, Springwater Run, and an unnamed tributary to Big Darby Creek (23.61).



A total of 41 National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge sanitary wastewater, industrial process water, and/or industrial storm water into streams within the Big Darby Creek watershed. A complete list of NPDES permitted facilities can be found in Table 30.

From 2014-2015, Ohio EPA conducted a water resource assessment of 28 streams in the Big Darby Creek watershed (Figure 1, Table 1) using standard Ohio EPA protocols as described in *Notice to Users*. Included in this study were assessments of the biological, surface water and recreation (bacterial) condition. A total of 94 biological, 124 water chemistry, 35 water quality sonde, and 30 bacteriological stations were sampled in the Big Darby Creek watershed. Physical habitat was assessed at each biological sampling location. Fish tissue sampling was also conducted in Big Darby Creek and Little Darby Creek at selected sites 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 Big Darby Creek watershed in support of both the TMDL process and NPDES permits program;
- ascertain the present biological conditions in the Big Darby Creek watershed 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 (*i.e.*, 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 (e.g. NPDES permits, Director's Orders, or the Ohio Water Quality Standards [OAC 3745-1]), and may eventually be incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, Total Maximum Daily Loads (TMDLs) and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d] report).

Historical Sampling Efforts

The Big Darby Creek watershed has one of the largest collections of biological and physical habitat data compared to other watersheds its size in the state. Large, watershed-scale surveys occurred in 1992/1993, 2001, and 2014, encompassing both Big and Little Darby creeks and many of the major tributaries (Table 4). These large-scale watershed efforts will serve as the primary points of comparison when evaluating various trends on specific waterbodies. Other relatively minor sampling efforts have been conducted regularly in Big and Little Darby creeks throughout the period of record indicated in Table 4. Data from these years will be evaluated and presented where applicable. Similar to Big and Little Darby creeks, many of the major tributary streams were also sampled as part of the 1992/1993, 2001, and 2014 large-scale watershed sampling efforts. Other efforts have occurred regularly in many of these tributary streams and will be evaluated and displayed where applicable throughout the body of this document. Extensive, basin-wide water chemistry sampling occurred in both 2001 and 2014 and these two survey years will serve as primary points of comparison for water chemistry trends analysis.

As indicated above, the last intensive watershed survey of the Big Darby Creek watershed in 2001 identified areas of impairment throughout the watershed associated with both point and non-point sources of pollution.

The 2001 survey identified multiple areas of impairment in the Big Darby Creek mainstem, which were primarily located in the middle and upper reaches (RMs 50-80). Impairment was associated with multiple factors, including non-point source water chemistry, nutrient, and sedimentation impacts; impacts from point source dischargers; and various spills within these reaches. The 2014 survey documented substantial recovery throughout these reaches of Big Darby Creek and all sites on the Big Darby Creek mainstem fully met applicable biocriteria. Improved biological performance in the aforementioned reaches, and throughout the mainstem as a whole, indicate that the sources of stream impairment identified during the 2001 survey have been adequately attenuated.

The 2001 survey also indicated multiple areas of biological impairment in the upper reaches of Little Darby Creek (RMs 30-40) attributable to habitat modifications and siltation, enrichment impacts from point and non-point sources, and various spills. The 2014 survey documented substantial recovery throughout these reaches, with only one location displaying impairment associated with legacy habitat alterations. Despite the recovery of biological communities and adequate attenuation of stressors in the upper reaches of Little Darby Creek, these sources of stress have not gone away. Care should be taken to further minimize impacts from these stressors.

Numerous sites situation on tributaries to both Big and Little Darby creeks displayed biological impairment during the 2001 survey that were attributed to enrichment impacts stemming from both point and non-point sources, generally poor water chemistry conditions, siltation and habitat alterations, and impacts from unsewered areas. The 2014 survey indicated substantial recovery in many of these tributaries, especially the upper reaches of Hellbranch Run, Buck Run, Spring Run, and other small tributaries.

Table 4. Summary of historical macroinvertebrate (M), physical (H), and fish community (F) sampled collected from streams within the Big Darby Creek watershed, 1977-2015. Only historical information for streams that were sampled as part of 2014 watershed survey are displayed.

Stream	1977	1979	1981	1983	1984	1985	1986	1987	1988	1989
Big Darby Creek	M	M, H, F	H, F		F		M, H, F	H, F	M, H, F	F
Flat Branch		H, F							M, H, F	F
Little Darby Creek (Logan Co.)									M, H, F	F
Spain Creek			H, F						M, H, F	F
Pleasant Run									M, H, F	F
Buck Run			H, F						H,	
Robinson Run										
Sweeny Run										
Sugar Run			F						H	
Worthington Ditch										
Ballenger Jones Ditch										
Fitzgerald Ditch										
Little Darby Creek		M, F	H, F	M, F	H, F	F	F	M, H, F		
Clover Run										
Lake Run										
Jumping Run										
Treacle Creek										
Proctor Run										
Barron Creek										
Wamp Ditch										
Spring Fork										
Smith Ditch										
Hellbranch Run			H, F							
Hamilton Run										
McCoy Run										
Clover Groff Run										
Springwater Run										
Trib. to Big Darby Ck. (23.61)										

Stream	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Big Darby Creek	M, H, F	F	M, H, F	M, H, F	H, F	F		M, H, F	H	H, F
Flat Branch								M, H, F		
Little Darby Creek (Logan Co.)								M,		
Spain Creek										
Pleasant Run								M, H, F		
Buck Run	M, H, F									
Robinson Run			M, H, F							
Sweeny Run										
Sugar Run	M, H, F		M, H, F			M, H, F				
Worthington Ditch										
Ballenger Jones Ditch										
Fitzgerald Ditch					H, F					
Little Darby Creek	M, F	M, F	M, H, F	M, F	H, F	F	M, H, F	M, H, F	H, F	F
Clover Run										
Lake Run										
Jumping Run										
Treacle Creek			M, H, F		F			M, H, F		
Proctor Run			M, H, F							
Barron Creek										
Wamp Ditch										
Spring Fork			M, H, F		F					
Smith Ditch										
Hellbranch Run	M, H, F	M,	M, H, F	M, H, F				M, H, F		
Hamilton Run		M,	M, H, F	H, F				M, H, F		
McCoy Run										
Clover Groff Run		M,	M, H, F	H, F				M, H, F		
Springwater Run										
Trib. to Big Darby Ck. (23.61)										

Stream	2000	2001	2002	2003	2005	2006	2007	2008	2009	2011	2012	2013	2014	2015
Big Darby Creek	M, H, F	M, H, F	M, H, F			M, H, F	F	M, H, F			M, H, F		M, H, F	
Flat Branch		M, H, F											M, H, F	
Little Darby Creek (Logan Co.)		M, H, F	H										M, H, F	
Spain Creek		M, H, F											M, H, F	
Pleasant Run		M, H, F											M, H, F	
Buck Run		M, H, F											M, H, F	
Robinson Run		M, H, F											M, H, F	
Sweeny Run		M, H, F											M, H, F	
Sugar Run		M, H, F											M, H, F	
Worthington Ditch		M, H, F											M, H, F	
Ballenger Jones Ditch		M, H, F											M, H, F	
Fitzgerald Ditch		M, H, F											M, H, F	
Little Darby Creek		M, H, F	M, H, F				M, H, F						M, H, F	M
Clover Run		M, H, F											M, H, F	
Lake Run		M, H, F											M, H, F	
Jumping Run		M, H, F											M, H, F	
Treacle Creek		M, H, F											M, H, F	
Proctor Run		M, H, F											M, H, F	
Barron Creek		M, H, F											M, H, F	
Wamp Ditch		M, H, F											M, H, F	
Spring Fork		M, H, F	M, H, F				M, H, F						M, H, F	
Smith Ditch		M, H, F											M, H, F	
Hellbranch Run		M, H, F	M, H, F										M, H, F	H, F
Hamilton Run		M, H, F			H	M, H, F			M, H, F				M, H, F	
McCoy Run					H	M, H, F							M, H, F	
Clover Groff Run		M, H, F				H, F		M, H, F	M, H, F	M, H, F		M, H, F	M, H, F	
Springwater Run		M, H, F											M, H, F	
Trib. to Big Darby Ck. (23.61)													M, H, F	

Study Area Description

Location, Scope, and Demographics

Big Darby Creek and its tributaries drain approximately 555 mi² (355,200 acres) of predominantly agricultural landscapes across six counties including Champaign, Franklin, Logan, Madison, Pickaway, and Union. Big Darby Creek is one of the major tributaries to the Scioto River and comprises approximately 8.5% of the total Scioto River drainage. The headwaters of Big Darby Creek originate in Logan County, coursing through low hills, with the mainstem and Little Darby Creek draining areas of more gentle relief downstream to the confluence with the Scioto River.

From its headwaters to the mouth, the total length of Big Darby Creek is approximately 84 river miles in length. Principal tributaries include Little Darby Creek (178 mi²), Hellbranch Run (37.7 mi²), Buck Run (29.8 mi²), and Sugar Run (19.4 mi²). Little Darby Creek is approximately 44 river miles long and comprises about 32% of the total watershed area. Principal tributaries to Little Darby Creek include Treacle Creek (37.2 mi²) and Spring Fork (38 mi²).

The Big Darby Creek watershed encompasses seventeen 12-digit hydrologic unit code (HUC) assessment units. Assessment units and associated 12 digit HUC codes are depicted in Figure 2.

Population centers (population in parentheses) include portions of the western Columbus metropolitan region outside Interstate 270 including the majority of Hilliard (28,435), Lake Darby (4,592), Plain City (4,225), West Jefferson (4,222), Mechanicsburg (1,644), North Lewisburg (4,190), New California (1,411), Darbydale (793), and Milford Center (792) (US Census Bureau 2010).

Selected reaches of the watershed on the Franklin-Madison county border, as well as Hellbranch Run, drain landscapes that are under current or imminent development pressure from the expanding greater Columbus metropolitan region.

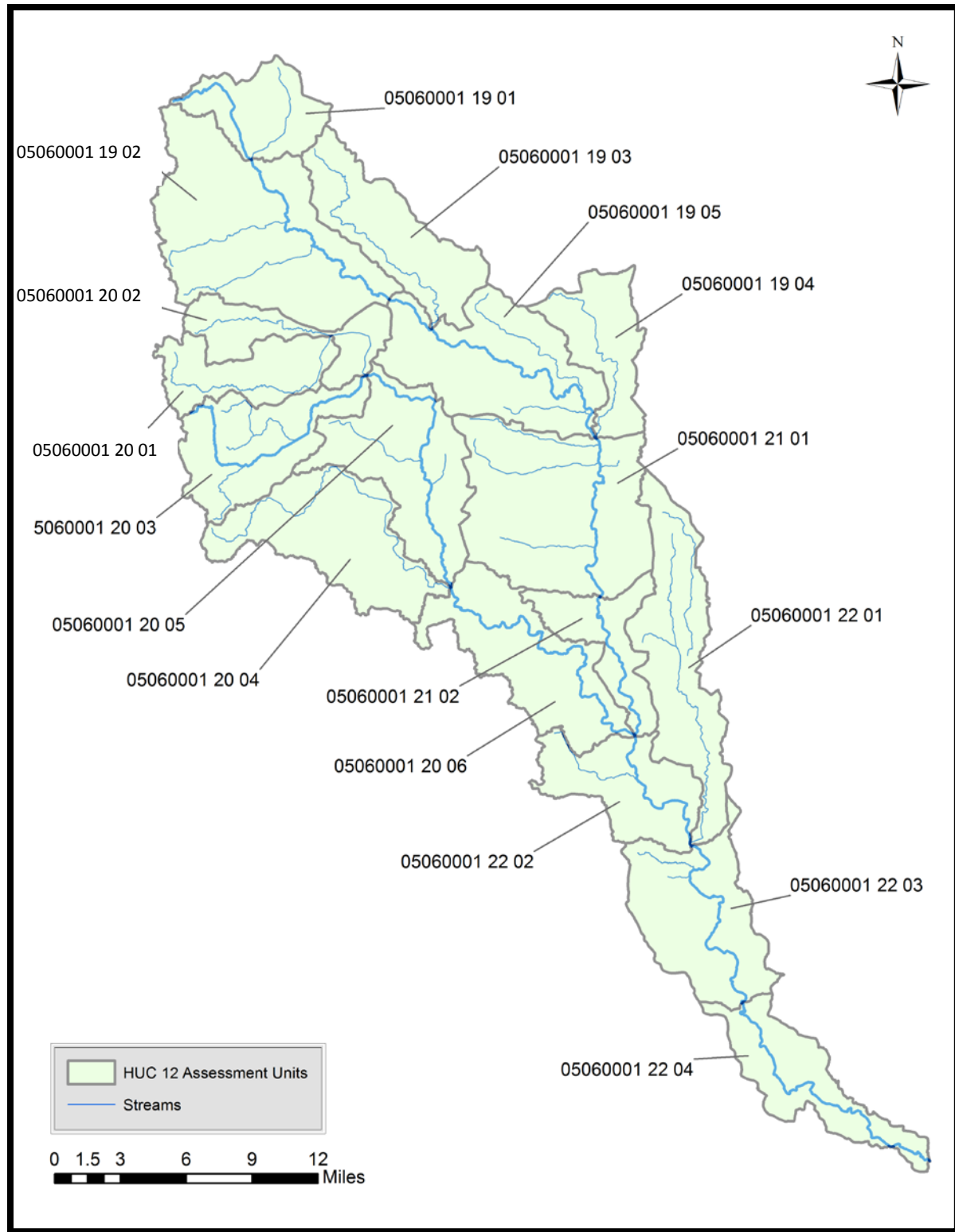


Figure 2. Twelve-digit hydrologic unit code (HUC) assessment units within the Big Darby Creek watershed.

Geology

All watersheds' drainage patterns, topography, soils, and water chemistry are influenced by their underlying geology. The geology of the Big Darby Creek watershed is, in large part, the result of interactions between four successive glacial periods and the Teays River, a fluvial system which drained most of the region for millions of years prior to the Pleistocene Epoch (Figure 3). Glacial ice dammed the Teays system, depositing poorly draining sediments which filled its valley and created new drainage patterns as the dammed water eventually flowed over older drainage divides.

The glacial ice itself deposited materials ranging from fine silts to boulders. Glacial meltwater carried fines to lakes where they accumulated, thus yielding highly impermeable beds. The retreating glacial front dropped materials, once icebound, which resulted in unconsolidated layers of till across the Central Ohio landscape. The meltwater carved valleys into the till, leaving behind the present mainstem course of Big Darby Creek (Ohio EPA 2004).

Substrates of the Big Darby Creek watershed reflect this geological history. Throughout the watershed, the substrates are derived of the calcareous-sedimentary parent materials seen in the region's bedrock. Igneous substrate constituents and glacial erratics also appear in the Darby system. They were carried to Ohio by the continental ice sheets.

A series of end moraines encompassing the Big Darby Creek watershed resulted from the advances and retreats of the glaciers which influence the stream system itself and the watershed landscape in multiple ways. Among these are watershed topography and cold, groundwater contribution to tributaries and the mainstem. Indirect indications of ground water influence include the presence of obligate cold-water and cool-water taxa. Direct indications of ground water flow were measurements of low temperatures in stream segments by field staff. Cold ground water contributions to streams have the potential to ameliorate negative effects on stream biota that may arise from water chemistry issues and/or deficient instream habitat (*e.g.*, channelization).

Portions of the Cable moraine complex extend from northeastern Champaign County south to London then southeast to Commercial Point (Figure 3). Streams proximate to this glacial landform with anecdotal field evidence of ground water inflow include upper Big Darby Creek, Little Darby Creek, Clover Run, Pleasant Run, Smith Ditch, Spain Creek and Springwater Run.

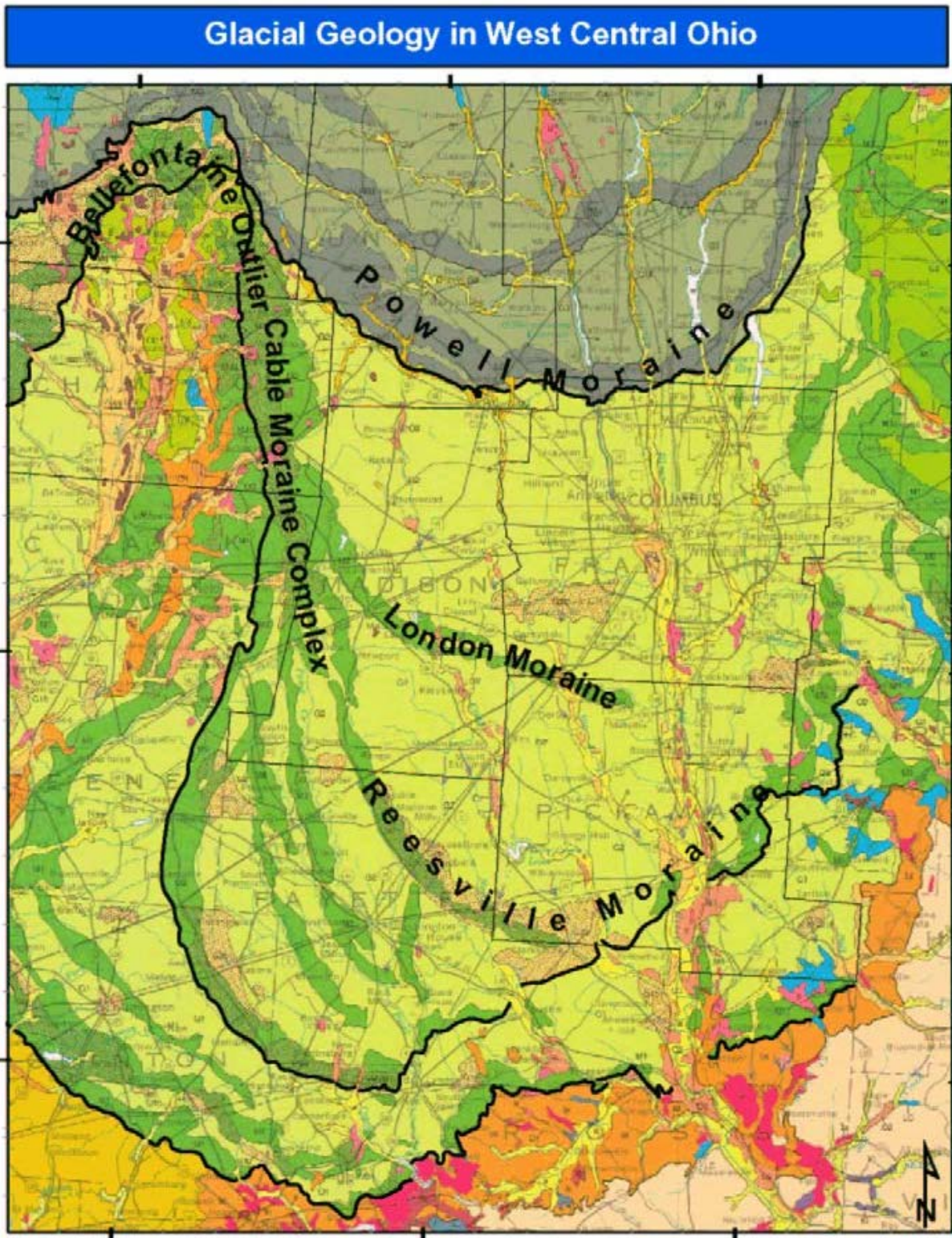


Figure 3. Glacial geology in west central Ohio. Map derived from ODNR Quaternary Geology of Ohio GIS layer, 1999.

Land Use

The 2011 USGS National Land Cover Dataset (NLCD) land cover types for the Big Darby Creek watershed are displayed in Figure 6, while percent area covered in the watershed is displayed in Figure 4. Also displayed in Figure 6 are the 2014 USDA Cropland data land cover types. Figure 5 and Figure 7 display NLCD land cover types within a 200-meter riparian buffer area (100 meters on each side of the National Hydrologic Dataset [NHD] stream GIS layer) and percent coverage within that buffer area.

Though residential, industrial, and commercial land uses are continuing to expand within the basin, cultivated crops are still the overwhelmingly dominant land use within the watershed, comprising approximately 72% of total watershed area (Homer et. al 2015). Comparisons between the 2001 and 2011 NLCD indicate that cultivated crops decreased in overall area by approximately 3.1 mi², a modest decrease of approximately 0.8% since 2001. Of the cultivated cropland in the watershed in 2014, soybeans comprised approximately 53%, corn approximately 41%, and all other crops approximately 6% (USDA 2014).

Developed land (all types) comprises approximately 8.9% of total watershed area, with open space/low intensity types comprising about 7.8% and medium/high intensity comprising approximately 1.1% of total watershed area (Figure 4 and Figure 6). The proportion of developed land has seen the largest percent change of all NLCD land cover types, an approximately 7.0% overall increase since 2001. The proportion of open space/low intensity areas has increased a modest 2.8%, from approximately 42.1 mi² in 2001 to 43.3 mi² in 2011. Though comprising a relatively small proportion (~1%) of the overall watershed area, medium/high intensity development saw the largest percent change of all land cover types. Medium/high intensity land cover types increased from 4.2 mi² in 2001 to 6.3 mi² in 2011, a nearly 50% increase. Most medium/high intensity development is congregated around the western Columbus metropolitan area, the areas surrounding Flat Branch near US 33, the West Jefferson area, the Plain City area, and the Harrisburg/Orient area. The remaining land cover types comprising the watershed include approximately 8.3% of all forest types (deciduous, mixed, evergreen), 9.3% hay/pasture, 0.9% herbaceous land, 0.6% other (barren land, open water), and 0.2% wetlands. The 2014 USDA cropland GIS layer estimates all forest types to comprise approximately 9.9% of total watershed area.

Dominant NLCD land use types within a 200m riparian buffer area for all streams in the Big Darby Creek watershed include approximately 57.6% cultivated crops, 17.7% forest, 12.5% hay/pasture, and 7.4% open space/low intensity development. When the riparian land use types for Big/Little Darby Creeks are separated from their tributaries distinct patterns emerge. Dominant riparian land use types for Big/Little Darby Creeks is comprised primarily by forest at 41.9%, with only 28.3% agriculture; however, tributaries are dominated by 62.7% cultivated crop and are only 13.6% forested (Figure 5 and Figure 7).

It would be beneficial to establish more substantial areas of riparian buffers throughout the watershed, especially in the upper reaches of both Big and Little Darby creek and their tributaries.

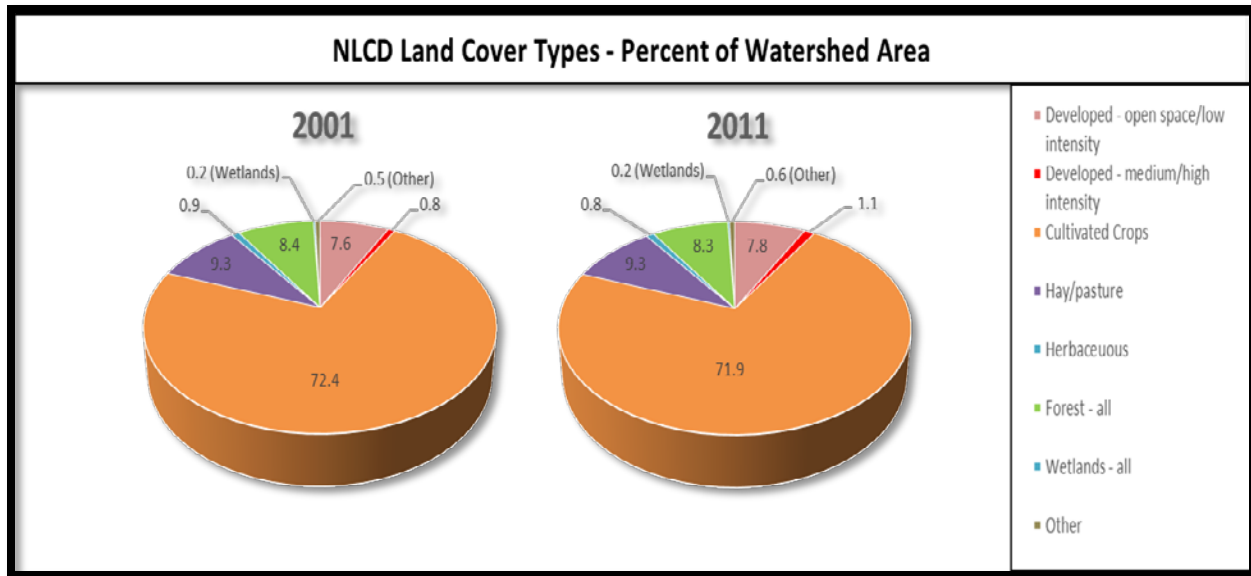


Figure 4. Percent of watershed area for various land cover types in the Big Darby Creek watershed, 2011. (USGS-NLCD 2011)

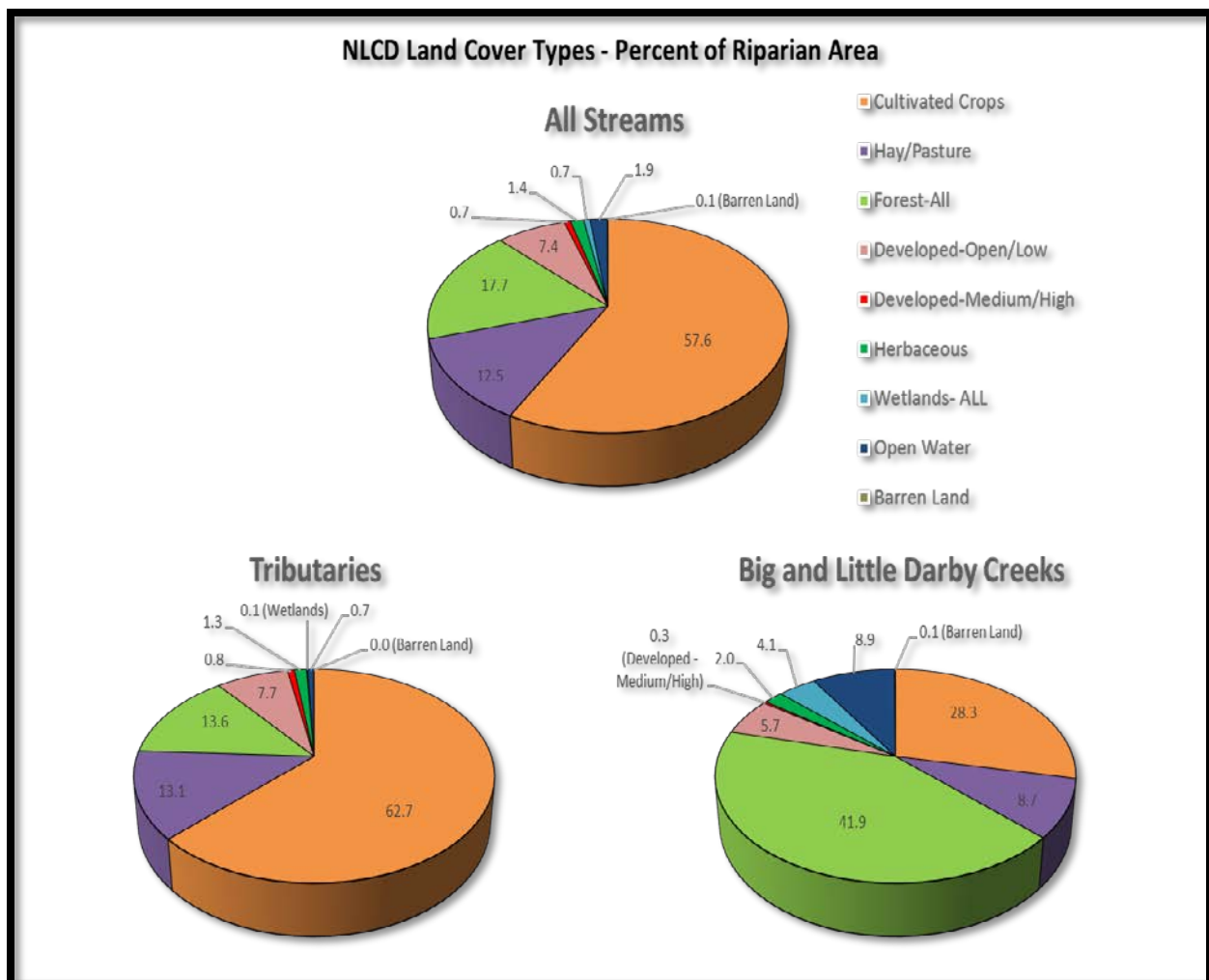


Figure 5. Percentage of area of NLCD land cover types within a 100m stream buffer (200m total) for indicated portions of the watershed.

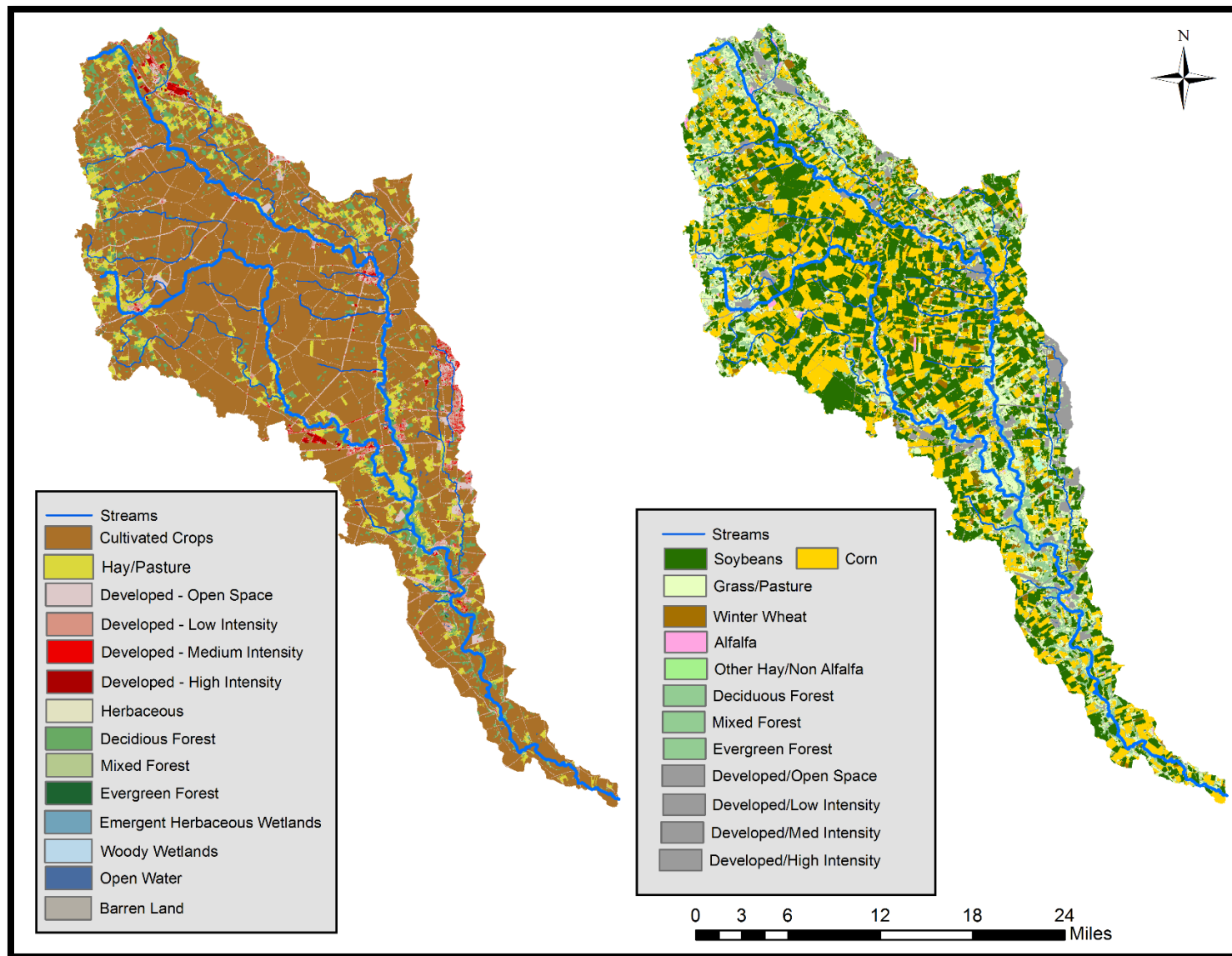


Figure 6. NLCD 2011 land cover types (left) and USDA Cropland Dataset 2014 crop and land cover types (right) for the Big Darby Creek watershed, 2011 and 2014.

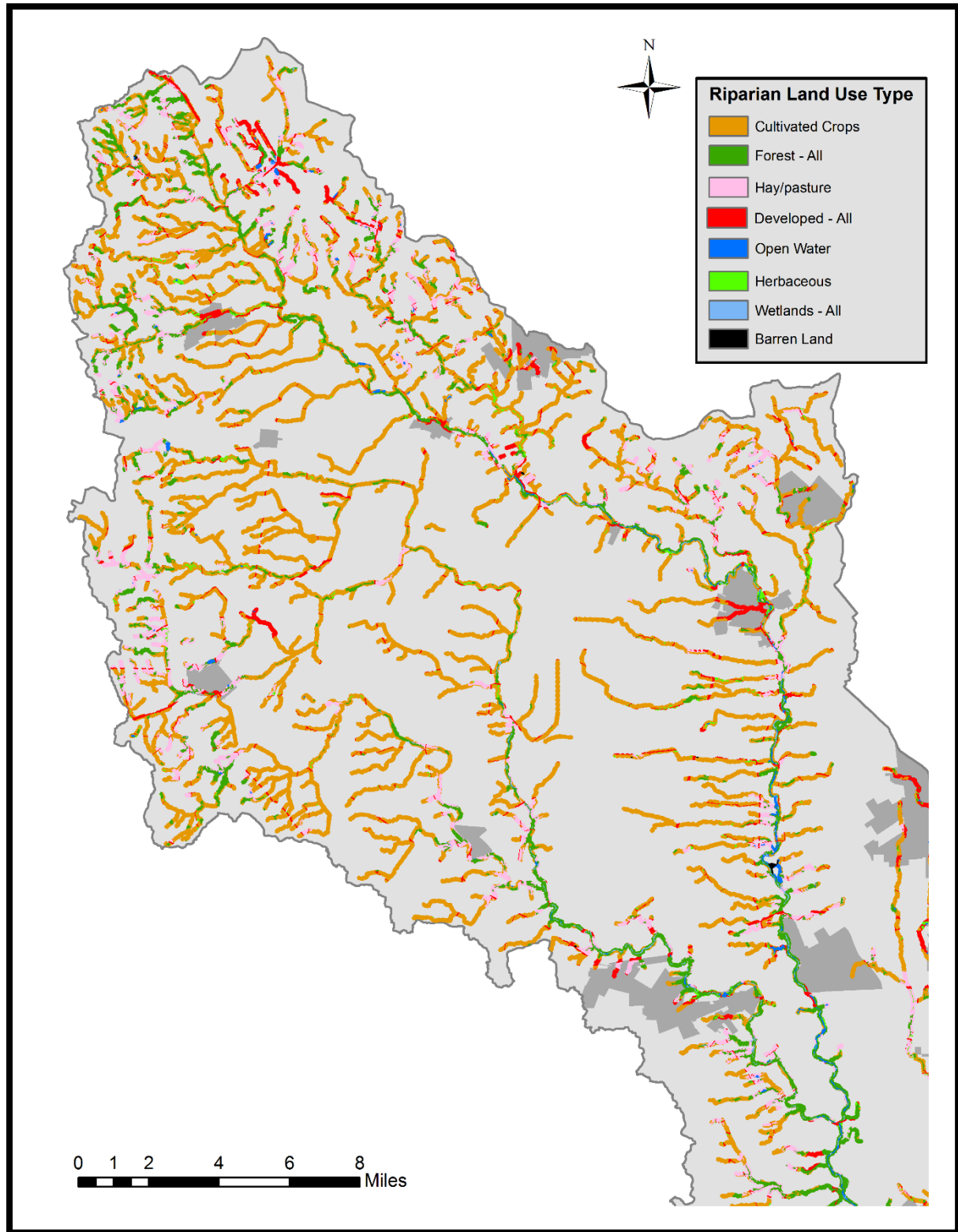


Figure 7a. NLCD 2011 land cover types within a 200-meter total buffer area (100 meters from center of stream line) for all streams within the upper reaches of the Big Darby Creek watershed.

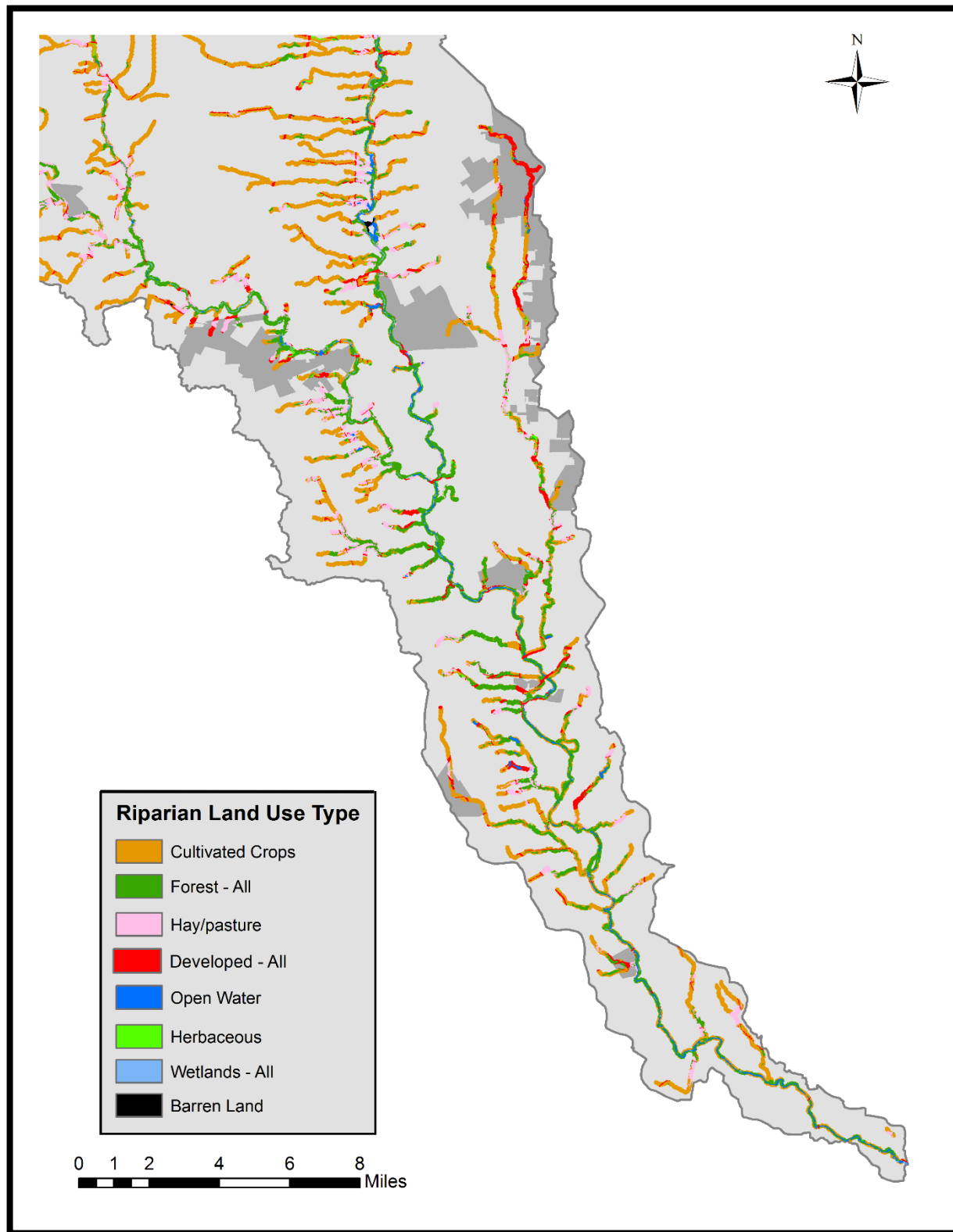


Figure 7b. NLCD 2011 land cover types within a 200-meter total buffer area (100 meters from center of stream line) for all streams within the lower reaches of the Big Darby Creek watershed.

Ecoregion

The Big Darby Creek watershed drains portions of the Eastern Corn Belt Plains (ECBP) Level 3 eco-region as defined by Omernik (1987). Common landscape features occurring in this ecoregion include rolling till plains and local end moraines characteristic of glaciation deposited over Devonian limestone. Wisconsin age glacial deposition is extensive and soils are better drained and loamier than most encountered in northwest Ohio.

Tributaries within the Big Darby Creek watershed drain four distinct level 4 sub-ecoregions; Figure 8 displays the level 4 sub-ecoregions that encompass the Big Darby Creek watershed. Tributaries in Union County drain two distinct sub-regions of the ECBP. Those that flow from the northeast to the mainstem (Flat Branch, Buck Run, Robinson Run, and Sugar Run) drain clayey, high lime till plains and have a higher requirement for artificial drainage than more southerly portions of the watershed. Tributaries that flow from the west and south of Union and Logan counties (Spain Creek, Little Darby Creek – Logan Co.) drain primarily the Darby Plains sub-ecoregion, an area of level to undulating landscapes characterized by productive crop and livestock farms (Omernik and Gallant 1988). Virtually all of the Big Darby system in Madison and Champaign counties (including Little Darby Creek) also drains the Darby Plains. Prior to the settlement of non-indigenous peoples, the Darby Plains were characterized by a distinct assemblage of oak forests, end moraine prairies, gravel filled pre-glacial valleys and seasonally wet areas. Most of the Darby system flowing across Pickaway County drains the more loamy, high lime till plains of the Eastern Corn Belt. This nearly level terrain is generally better drained than portions of the watershed upstream in northwestern Union County.

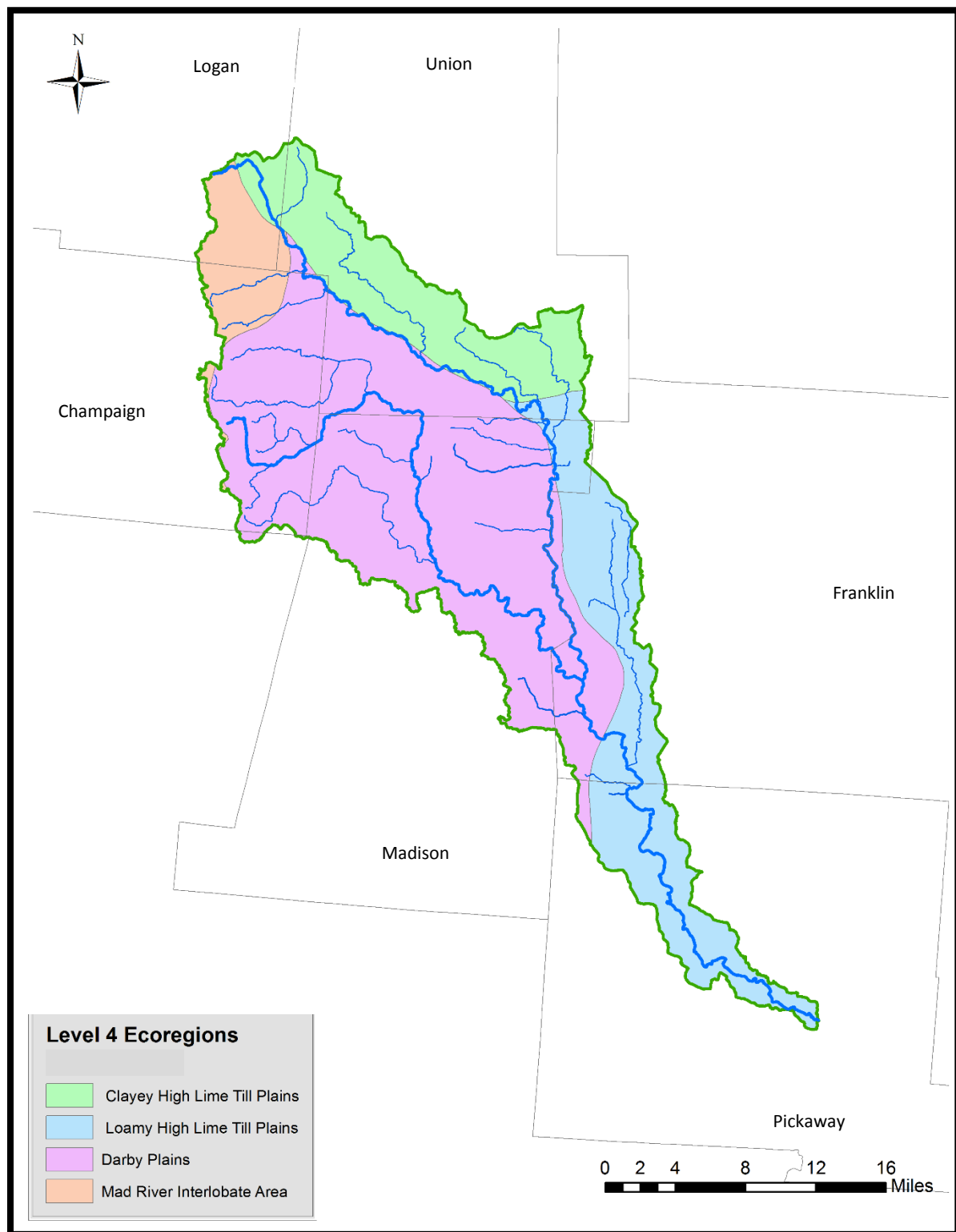


Figure 8. Level 4 ecoregion map for the Big Darby Creek watershed.

Protected Lands

The Big Darby Creek watershed includes approximately 11,360 acres of protected conservation and recreation lands, which account for approximately 3.2% of the total watershed area. Estimates were obtained from the USFWS Conservation and Recreation Lands (CARL) 2007 GIS dataset, coupled with other various sources (*e.g.*, websites) for larger areas in order to give the most up-to-date estimates of protected lands (Columbus and Franklin County Metro Park 2014, The Nature Conservancy 2016). Numerous other public and private lands (*e.g.* private riparian or other natural areas) are not included in these estimates, but can functionally serve as protected areas, though not necessarily recognized as such. The type and approximate acreage within the watershed are listed in Table 5.

Of all protected lands, the Battelle Darby Creek Metro Park (62.5%), Prairie Oaks Metro Park (18.7%), and Darby Headwaters Nature Preserve area (7.0%) are the largest in terms of overall area. These four areas account for approximately 88.2% of all protected land area and approximately 2.8% of the total watershed area.

Table 5. Estimated amounts of protected lands in the Big Darby Creek watershed. From the USFWS Conservation and Recreation Lands (CARL) GIS layer (2007). Other various sources (*e.g.*, websites) were used when available to create up-to-date estimates for larger areas. All sources are listed within this section. Created 2016.

Type	Acreage (approx.)
Metropark	9,226
Nature Preserve	1,355
Other Park	349
Natural Area	339
Open Space	92
Total	11,360

The Battelle Darby Creek Metro Park is located between Interstates 70 & 71 near the towns of Lake Darby and Darbydale. This Metro Park features approximately 7,100 acres of forest, prairies, and wetlands. It stretches along 13 miles of Big and Little Darby creeks. Also situated here are over 1,600 acres of restored wetlands and prairies. Bison have been reintroduced to the park and roam freely within two enclosed pastures (Columbus and Franklin County Metro Park 2014).

Prairie Oaks Metro Park is situated just north the town of Lake Darby and encompasses approximately 2,143 acres. Prairie Oaks features nearly 500 acres of lush flowering prairies and grasslands that were restored using seeds native to the Darby Plains (Columbus and Franklin County Metro-Park 2014).

Owned by The Nature Conservancy, the Big Darby Creek Headwaters Nature Preserve area covers approximately 800 acres and encompasses a mixture of wetlands and streamside forests. This area is located in the very upper reaches of Big Darby Creek and the area's streams are fed by numerous underground seeps that eventually convene to form Big Darby Creek and its many tributaries. In 2007, the conservancy launched a large project to restore the headwaters of Big Darby Creek to re-create its natural meandering flow in an effort to reverse negative impacts from channelization activities and highway construction; these efforts were completed in 2011. This area maintains many public access trails and interpretive signage (The Nature Conservancy 2016).

Soils

Soils result from the interaction of geological parent materials, flora, fauna, topography and climate over time. Climatic change and the resultant glaciation of what is now the Big Darby watershed have had a profound influence on the development of its soils. The five dominant soil associations in order of prevalence are 1) Kokomo-Crosby-Miamian, 2) Miamian-Celina-Crosby, 3) Brookston-Crosby-Celina, 4) Crosby-Miamian-Brookston, and 5) Blount-Glynwood-Morley (Table 6, Figure 9).

Reflective of the factors which led to their development, each soil and soil association type appears with varied frequency across different portions of the watershed (Figure 9). Each in turn exhibits varying physical characteristics (*e.g.*, erosion potential, permeability) which may affect chemistry of the water column, instream habitat quality, or water quality attributes. Major soil associations and soil hydrologic groups, their respective percentage of the Big Darby Creek watershed, and major characteristics of each group are listed in Table 6. Distributions of these soil types throughout the watershed are displayed in Figure 9.

Table 6. Dominant soil associations and hydrologic soil groups in the Big Darby Creek watershed including percent of watershed, general locations, and major characteristics.

Soil Associations	Percent of Watershed	Primary Location	Major Characteristics
Kokomo-Crosby-Miamian	27.9%	Between Big and Little Darby Creeks, from Logan and Champaign Counties to Marysville and south to I-70.	Very poorly drained on flats, high water tables, seasonal wetness, Crosby requires artificial drainage. Seen on ground moraines.
Miamian-Celina-Crosby	20.3%	Big and L. Darby source water areas in Logan and Champaign counties. Bordering the flood plain of Big Darby Creek and Little Darby Creek. in Franklin and Pickaway Counties.	Well drained to moderately well drained. (Crosby requires artificial drainage.) Seen on level to gentle slopes.
Brookston-Crosby-Celina	16.3%	Northern half of Hellbranch drainage in Franklin County. Southwestern drainage area of Little Darby Creek in Madison County.	Brookston, a naturally wet soil found on uplands – very poor drainage.
Crosby-Miamian-Brookston	11.9%	Big Darby Creek flood plain south of Plain City extending to I-70. Southern half of Little Darby Creek drainage in Madison County.	Somewhat poorly drained, prone to seasonal wetness. Miamian - well drained. Seen in the Darby Plains.
Blount-Glynwood-Morley	10.2%	North side of Big Darby Creek. drainage between Logan County and Plain City.	Found on hills and slopes. Somewhat poorly drained to moderately well drained.
Hydrologic Soil Group	Percent of Watershed	Major Characteristics (NRCS 2007)	
C	71.9%	Moderately high runoff potential when thoroughly wet. Water infiltration through soil is somewhat limited.	
B/D	16.3%	Characteristics of both class D and B. The first letter (B) is for drained areas and the second (D) is for undrained areas. These soils generally have a water table within 60 cm of the surface.	
D	6.0%	Very slow infiltration rate (highest runoff potential) when thoroughly wet. Primarily clays with a high shrink-swell potential. Generally have a high water table. Very slow rate of water transmission.	
B	5.8%	Moderately low runoff potential when thoroughly wet. Water infiltration through soil layers is generally unimpeded.	

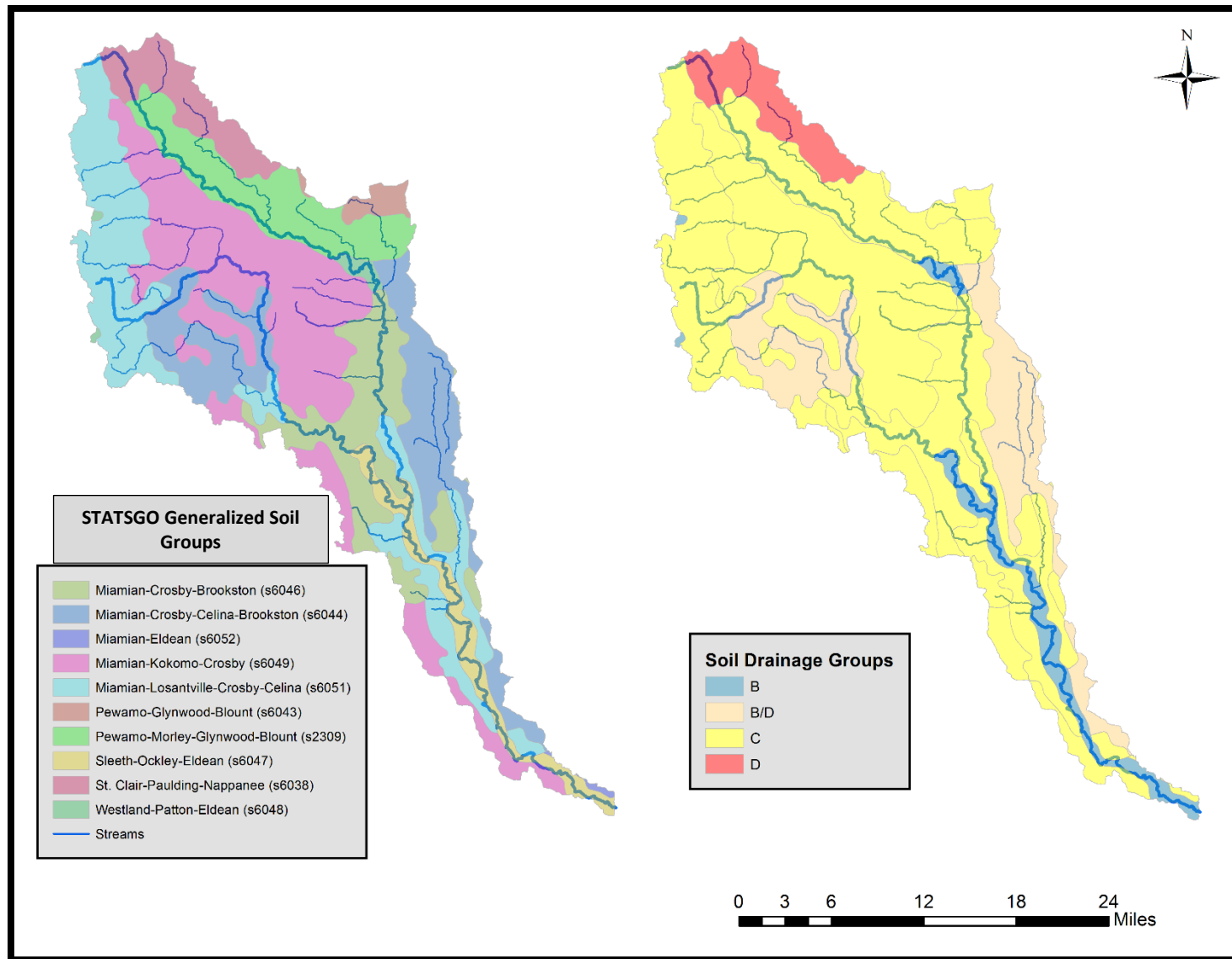


Figure 9. STATSGO generalized soil groups (left) and soil drainage class groups (right) in the Big Darby Creek watershed, 2014.

Nonpoint Source Issues

The most common nonpoint sources of pollution negatively affecting water quality throughout the basin include siltation and habitat alterations from agricultural and historical channelization activities, non-point urban runoff, and excess nutrients from agricultural, commercial, and/or municipal sources. Habitat degradation and siltation resulting from unrestricted livestock access was also present in areas throughout the basin.

NPDES Permitted Facilities

A total of 41 National Pollutant Discharge Elimination System (NPDES) individual permitted facilities discharge sanitary wastewater, industrial process water and/or industrial storm water into streams within the Big Darby Creek watershed study area. One major municipal discharger, Ohio Department of Rehabilitation and Corrections (ODRC) Pickaway Correctional Institute (PCI) WWTP, is located in the watershed. The West Jefferson WWTP has a design flow of 1.20 MGD but is not yet considered a “major” NPDES facility. Other municipal dischargers include West Jefferson, Plain City, Lake Darby Estates, Mechanicsburg, North Lewisburg and Flat Branch. There are also eight mobile home parks and five schools that operate small wastewater package plants and discharge treated effluent in the watershed. Industrial NPDES discharge facilities include Honda of America, Ranco, Battelle Memorial Institute, and Tuffco Sand and Gravel.

Fish Community Overview and Trends

A total of 96,471 fish representing 85 different species and 6 hybrids were collected at 93 sampling locations throughout the Big Darby Creek study area from June to October during the 2014 sampling season; additional sampling was conducted during the 2015 sampling season in the lower portion of Hellbranch Run. The current survey was preceded by several other large scale, basin-wide surveys conducted in 2001-02, 1997, and 1992-93 and was designed to investigate areas of impairment identified in previous surveys, identify potential areas of impairment not described by previous surveys, and identify any key trends or changes that have occurred in the watershed throughout this time period.



Only most recent data will be considered for aquatic life use attainment status. Relative numbers, biomass, and species collected per location are presented in Appendix C and IBI and MIwb scores are presented in Appendix D. Figures displaying the distribution of selected fish species throughout the Big Darby Creek watershed from 2001 to 2014 can be viewed in Appendix K. 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”. Sampling locations were evaluated using one or more of the following aquatic life use (ALU) designations: Warmwater Habitat (WWH), Exceptional Warmwater Habitat (EWH), Coldwater Habitat (CWH), or Modified Warmwater Habitat – Channelized (MWH-C). All streams in the Big Darby Creek study area were evaluated against Eastern Corn Belt Plains (ECBP) ecoregion biological criteria. A summary of the fish community data is presented in Table 9. Longitudinal graphs displaying fish community performance containing both current and historical data are contained within the trends portion of this section.

The Big Darby Creek watershed boasts one of the most diverse and highest quality stream fish communities in the state of Ohio. IBI and MIwb scores recorded throughout the basin are, collectively, among the highest observed statewide. Numerous state listed species were collected during the latest survey including the spotted darter (endangered), northern madtom (endangered), tippecanoe darter (threatened), river redhorse (species of concern), and least darter (species of concern).



Other intolerant, rare, or generally noteworthy taxa regularly collected included the bigeye chub, bluebreast darter, variegate darter, banded darter, black redhorse, brindled madtom, stonecat madtom, gravel chub, streamline chub, hornyhead chub, mimic shiner, rosyface shiner, silver shiner, smallmouth bass, and flathead catfish. Other relatively rare taxa that were collected in limited abundance included the black buffalo, creek chubsucker, dusky darter, silver lamprey, and trout-perch.

Big Darby Creek Mainstem: Overview and Trends

Thirty-two Big Darby Creek mainstem sites evaluating approximately 83 river miles were sampled intensively during the 2014 sampling index period. The six uppermost sites were previously designated both EWH and CWH, while the rest of the mainstem maintains an EWH use designation (Table 9). All thirty-two mainstem sites fully met applicable fish biocriteria. Longitudinal performance of fish biocriteria from selected years is displayed in Figure 10 and Figure 11.

The average IBI (54.8) and MIwb (10.63) scores for the Big Darby Creek mainstem correspond to an exceptional narrative evaluation. Overall, fish assemblage performance throughout the Big Darby Creek mainstem ranged from very good to exceptional, though the vast majority of fish scores fall within the exceptional range (Table 9).

Table 7. Average IBI and MIwb scores for sites located on the Big Darby Creek mainstem from selected years.

Year	IBI	MIwb
2014	54.8 n=32	10.63 n=25
2001	50.4 n=29	9.59 n=25
1992-93	52.4 n=25	9.74 n=24

Fish community performance throughout the Big Darby Creek mainstem has improved significantly in 2014 compared to historical values (Table 7, Figure 10, and Figure 11). Although readily apparent from a cursory examination of Figure 10 and Figure 11, non-parametric statistical treatment (Wilcoxon-Mann-Whitney rank sum test) indicated statistically significant differences between IBI and MIwb scores in 2014 compared to 2001 ($p < 0.0001$ [IBI], 0.0010 [MIwb]) and 1992-93 ($p = 0.0067$ [IBI], 0.0024 [MIwb]).

IBI scores from 2014 met or exceeded EWH expectations and were generally similar throughout the Big Darby Creek mainstem (Figure 10). The range of scores was substantially lower than has been observed historically and the median score is also higher throughout the mainstem, indicating improved fish community performance throughout with less overall variability between scores (Figure 11). A closer examination of IBI scores reveals that the greatest magnitude of improvement occurred in the middle and upper reaches (headwaters-RM 36) of Big Darby Creek (Figure 11). Improvements in these reaches can likely be attributed to improved municipal point source effluent quality (Plain City and Flat Branch WWTP), reduced non-point source impacts in both the mainstem and tributaries in these reaches, and recovery from documented spills/kills (Ohio EPA 2004). IBI scores in the lower mainstem (RM 36-mouth) were generally similar to historical values. Generally speaking, higher IBI scores indicate improvements pertaining primarily to functional aspects of the overall fish community (e.g. feeding/breeding characteristics, sensitivity/tolerance aspects).

MIwb scores from 2014 met, exceeded, or were in non-significant departure from EWH expectations throughout the mainstem and generally improved throughout the mainstem compared to historical values (Figure 10 and Figure 11). When separated into upper (headwaters-RM 36) and lower (RM 36-mouth) mainstem, several trends stand out. MIwb scores in both the upper and lower mainstem have improved substantially compared to historical values; the average MIwb score for the upper and lower reaches increased around 10% since 2001. The range of scores from the upper mainstem was substantially reduced since 2001 and trended closer to the median (Figure 11). Overall, aggregated MIwb scores from 2014 were higher in the lower stretches compared to the upper segments. Some of the variation in MIwb scores between the lower and upper segments is likely explained by differences in stream size; however, MIwb scores in the upper reaches are likely affected by the impoundment located at RM 37.2. This fish passage barrier is limiting the upstream movement of certain fish species that could reasonably be expected to thrive upstream from this impoundment, especially those rare and sensitive species found

just downstream from this impoundment. This will be discussed in greater detail later in the mainstem section.

Several locations in the Big Darby Creek mainstem have been sampled repeatedly since Ohio EPA began collecting fish community samples using a standardized approach. These sites afford the opportunity to view fish community performance at one location through time. Figure 12 displays IBI and MIwb scores at four locations through time where data exists. These series of graphs display a similar trend to that which was observed in Figure 10 and Figure 11. IBI scores from the lower reaches (RM 3.2, 13.36, 23.75) have improved since the early 1980s and have remained relatively stable through time, while MIwb scores have displayed consistent and gradual improvement through time. IBI scores from the upper reaches (RM 76.54) have been variable through time, but have improved noticeably since 2001; the MIwb displays a similar trend to the IBI in the upper reaches. These graphs further highlight the generally positive trajectory of fish community performance through time observed throughout streams in the basin.



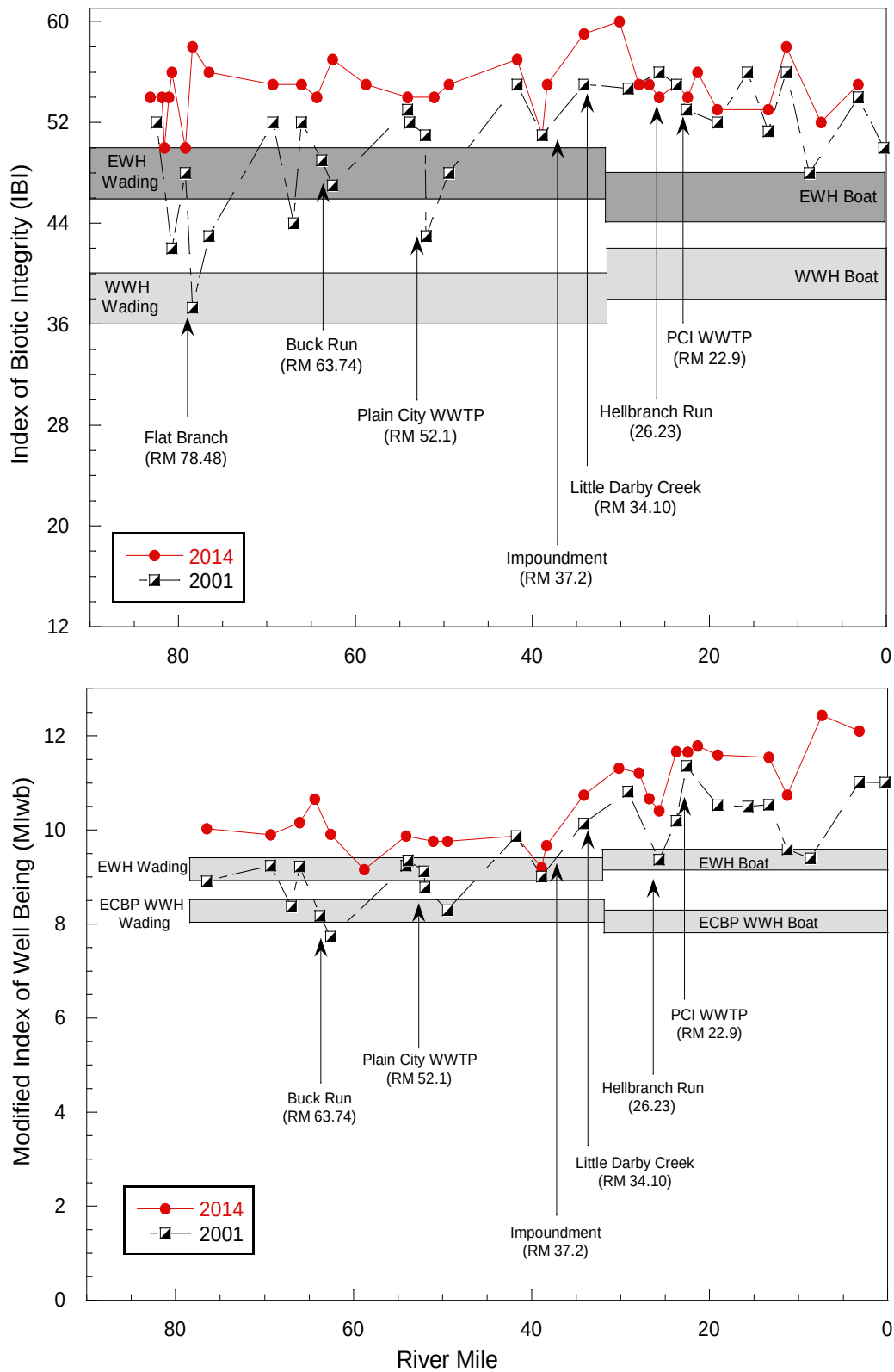


Figure 10. Longitudinal performance of IBI (top) and MIwb (bottom) scores for the Big Darby Creek mainstem from selected years. The shaded portions represent applicable biocriteria and areas of non-significant departure from said values.

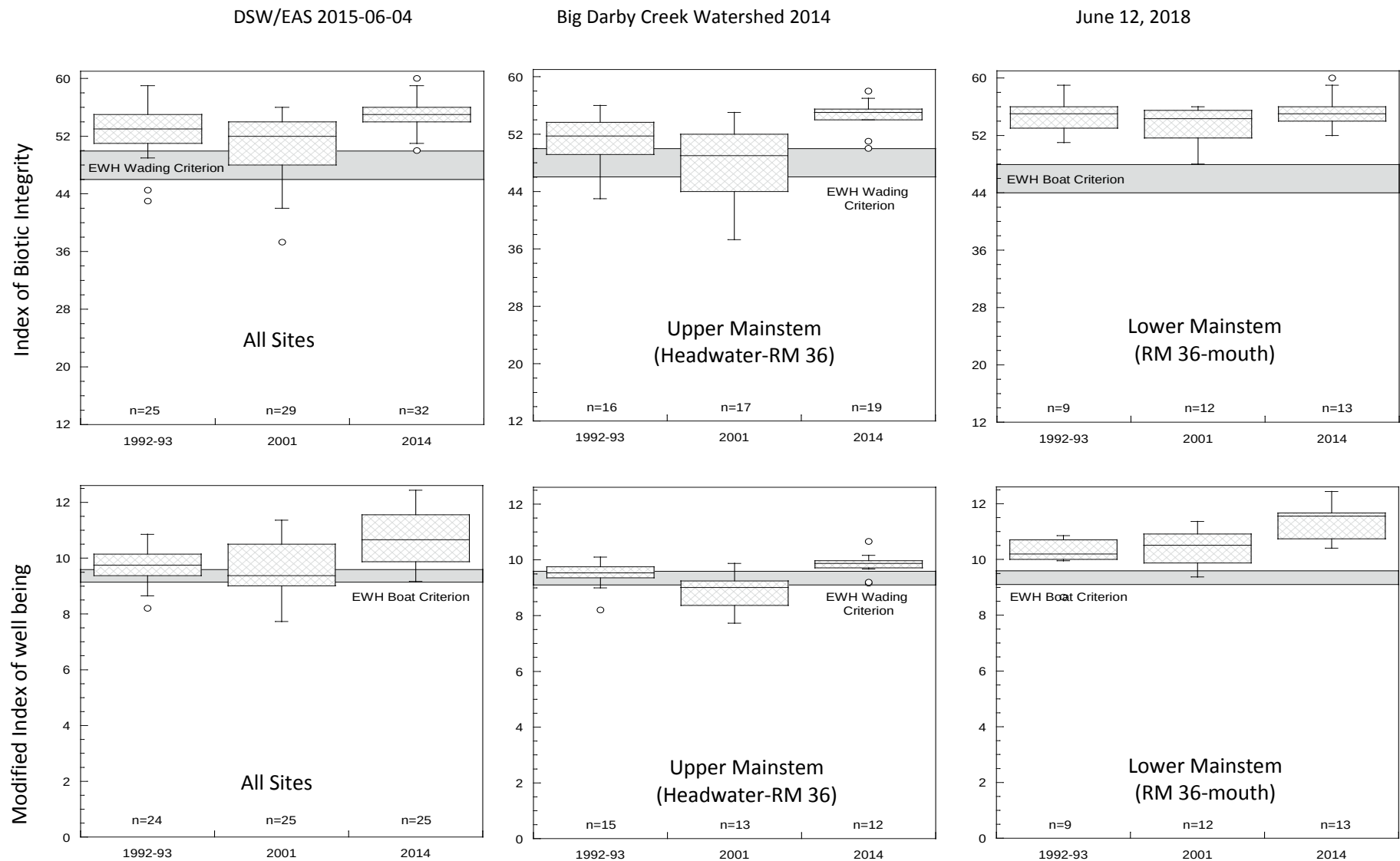


Figure 11. Aggregate performance by survey year of IBI (top row) and MIwb (bottom row) scores for the Big Darby Creek mainstem from selected years. Both IBI and MIwb scores are aggregated by all sites (left), lower mainstem sites (middle), and upper mainstem (right). The shaded portions represent applicable biocriteria and areas of non-significant departure from said values.

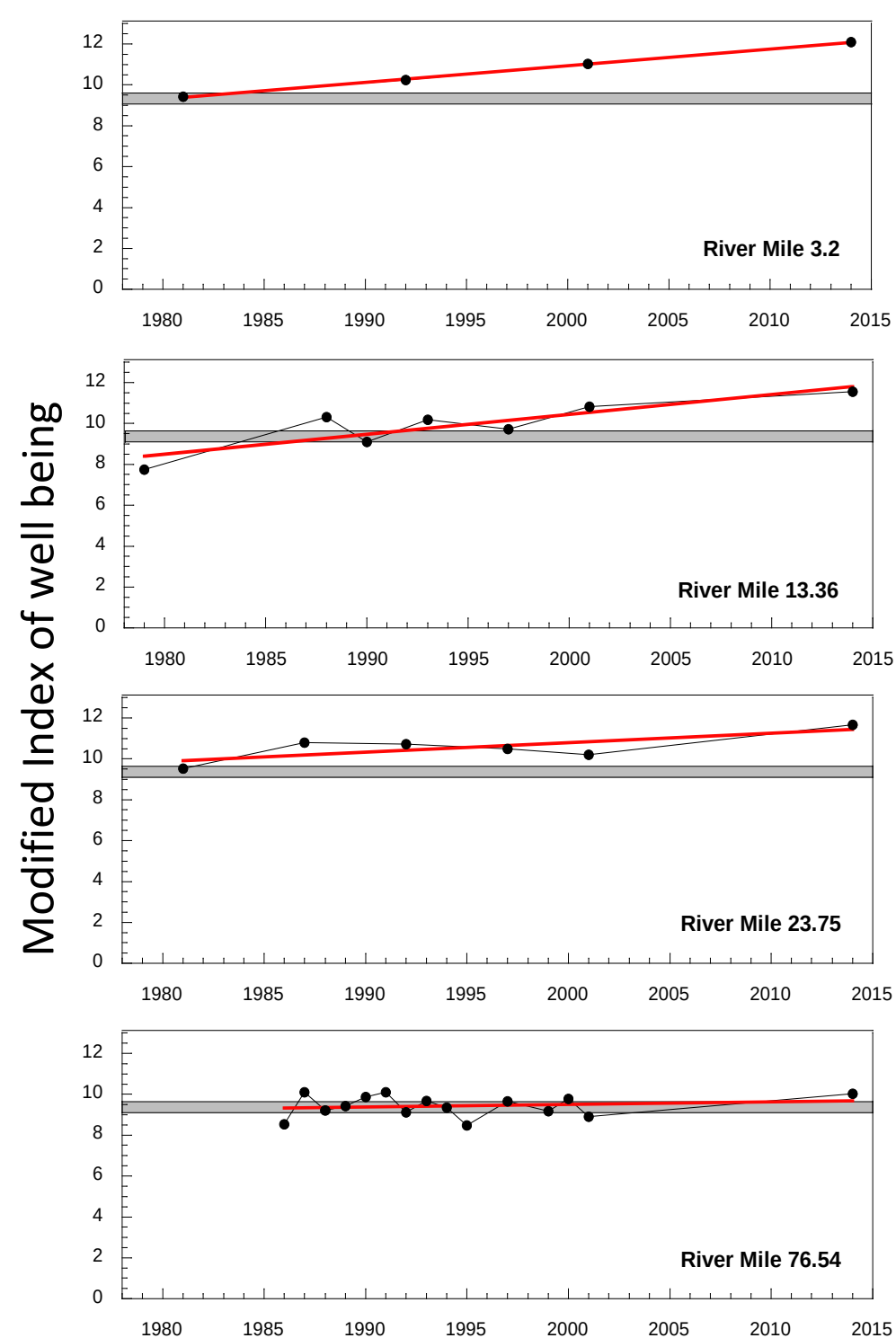
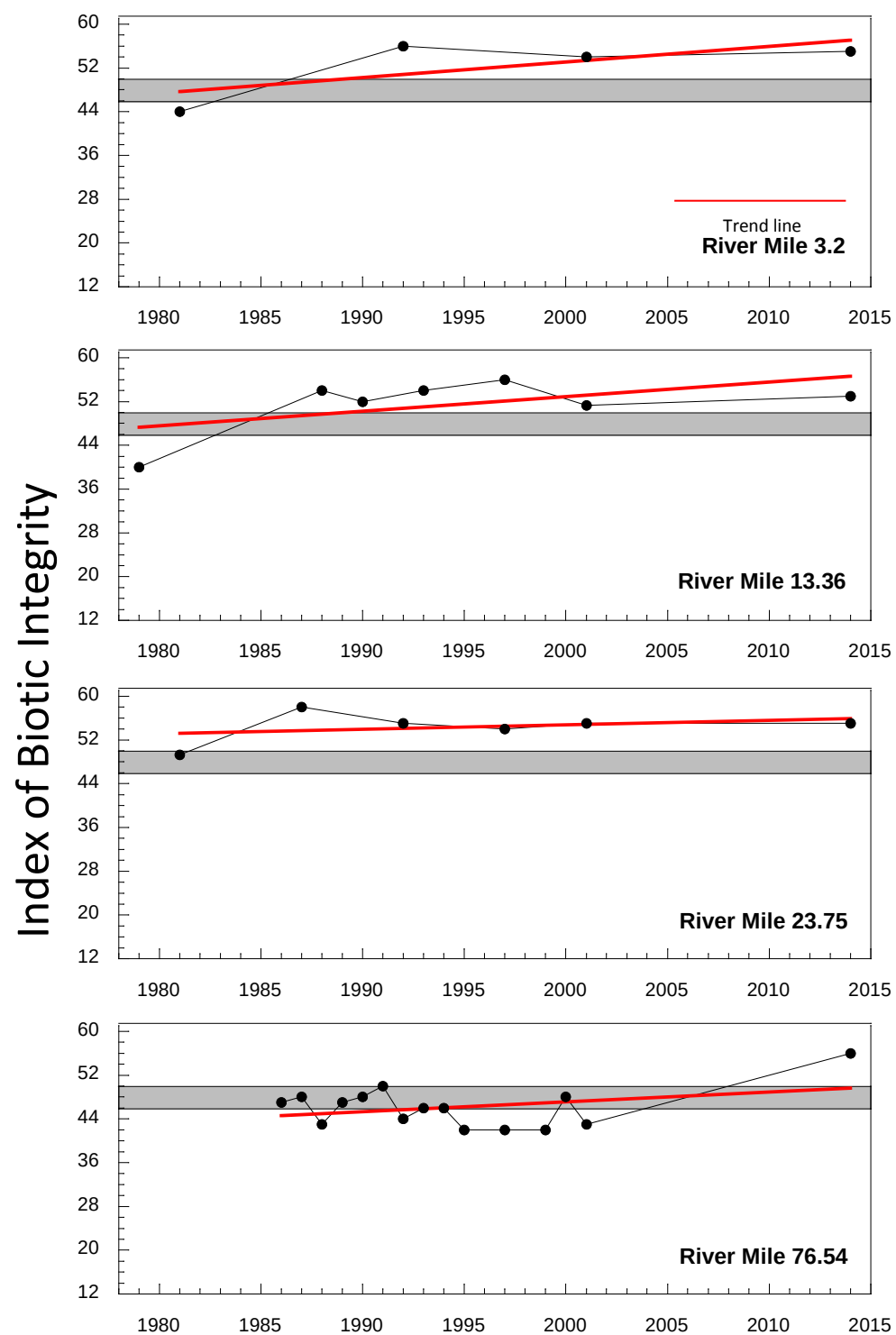


Figure 12. Performance of IBI scores through time from selected locations in Big Darby Creek. Shaded areas represent areas of non-significant departure from EWH criteria. The trend line is displayed in red.

Percent abundance and percent biomass that each species comprises of the overall fish community for boat, wading, and headwater locations from the Big Darby Creek mainstem are displayed in Table 8. Relative abundance and relative biomass for each species was averaged among all locations for each of the three portions of the mainstem; percentages were subsequently calculated from these averaged values.

Table 8. Percent abundance and percent of biomass for all fish species collected from boat, wading, and headwaters portions of the Big Darby Creek mainstem, 2014.

Lower Mainstem - Boat sites (RM 34-mouth)			
Species	Percent Abundance	Species	Percent Biomass
Golden Redhorse	17.28	Golden Redhorse	23.72
Central Stoneroller	11.03	Smallmouth Buffalo	8.22
Longear Sunfish	5.83	Common Carp	8.05
Northern Hog Sucker	5.54	Freshwater Drum	7.96
Greenside Darter	4.95	Silver Redhorse	7.31
Black Redhorse	3.86	Black Redhorse	6.40
Variegate Darter	3.79	River Carpsucker	6.03
Smallmouth Redhorse	3.71	River Redhorse	5.05
Silver Shiner	3.60	Smallmouth Redhorse	4.82
Streamline Chub	3.49	Flathead Catfish	4.45
Banded Darter	3.47	Channel Catfish	4.43
Smallmouth Bass	2.87	Smallmouth Bass	3.75
Bluntnose Minnow	2.51	Northern Hog Sucker	2.39
Rainbow Darter	2.38	Gizzard Shad	1.65
Tippecanoe Darter	2.27	Quillback Carpsucker	1.48
Bluebreast Darter	1.81	Longnose Gar	0.89
Sand Shiner	1.54	Sauger X Walleye	0.88
Mimic Shiner	1.49	Longear Sunfish	0.55
Spotfin Shiner	1.46	Rock Bass	0.38
Freshwater Drum	1.38	Central Stoneroller	0.30
Bluegill Sunfish	1.21	Sauger	0.21
Gizzard Shad	1.20	Streamline Chub	0.13
River Carpsucker	1.18	Spotted Bass	0.10
Rosyface Shiner	1.05	Bigmouth Buffalo	0.10
Silver Redhorse	0.97	Black Buffalo	0.07
Bigeye Chub	0.96	Largemouth Bass	0.06
Channel Catfish	0.87	Bluegill Sunfish	0.06
Rock Bass	0.86	Silver Shiner	0.05
Logperch	0.82	Greenside Darter	0.05

Smallmouth Buffalo	0.68	Logperch	0.05
Striped Shiner	0.59	White Crappie	0.04
Stonecat Madtom	0.58	Bluntnose Minnow	0.04
Johnny Darter	0.56	Spotted Sucker	0.04
River Redhorse	0.55	Variegate Darter	0.03
Common Carp	0.55	Stonecat Madtom	0.03
Longnose Gar	0.40	Spotfin Shiner	0.03
Quillback Carpsucker	0.36	Bluebreast Darter	0.02
Sauger X Walleye	0.34	Striped Shiner	0.02
Spotted Darter	0.26	Banded Darter	0.02
Flathead Catfish	0.23	Rainbow Darter	0.02
Green Sunfish	0.21	Sand Shiner	0.02
Emerald Shiner	0.18	Mimic Shiner	0.02
Steelcolor Shiner	0.14	Bigeye Chub	0.02
Species	Percent Abundance	Species	Percent Biomass
Gravel Chub	0.11	Rosyface Shiner	0.01
Orangespotted Sunfish	0.11	Tippecanoe Darter	0.01
Largemouth Bass	0.09	Redfin Pickerel	0.01
Spotted Bass	0.09	Green Sunfish	0.01
Sauger	0.09	Green Sf X Hybrid	0.01
Suckermouth Minnow	0.08	Orangespotted Sunfish	0.01
Spotted Sucker	0.05	White Sucker	0.01
Fantail Darter	0.05	Spotted Darter	0.00
Green Sf X Hybrid	0.05	Gravel Chub	0.00
Creek Chub	0.04	Steelcolor Shiner	0.00
Redfin Pickerel	0.04	Johnny Darter	0.00
Blackside Darter	0.04	Emerald Shiner	0.00
White Crappie	0.03	Silver Lamprey	0.00
White Sucker	0.02	Suckermouth Minnow	0.00
Dusky Darter	0.02	Bluegill SF x Orangespotted SF	0.00
Northern Madtom	0.01	Creek Chub	0.00
Silver Lamprey	0.01	Blackside Darter	0.00
Brindled Madtom	0.01	Dusky Darter	0.00
Fathead Minnow	0.01	Mottled Sculpin	0.00
Bigmouth Buffalo	0.01	Blackstripe Topminnow	0.00
Black Buffalo	0.01	Fathead Minnow	0.00
Blackstripe Topminnow	0.01	Northern Madtom	0.00
Mottled Sculpin	0.01	Tadpole Madtom	0.00
Scarlet Shiner	0.01	Brindled Madtom	0.00
Tadpole Madtom	0.01	Fantail Darter	0.00

Bluegill SF x Orangespotted SF	0.01	Scarlet Shiner	0.00
Middle Big Darby Creek - Wading sites (RM 34-76)			
Species	Percent Abundance	Species	Percent Biomass
Striped Shiner	13.79	Golden Redhorse	24.40
Rainbow Darter	12.04	Northern Hog Sucker	13.70
Greenside Darter	9.89	Smallmouth Bass	12.15
Bluntnose Minnow	8.47	Striped Shiner	7.66
Central Stoneroller	8.33	Rock Bass	6.75
Longear Sunfish	7.75	Longear Sunfish	5.43
Northern Hog Sucker	5.63	Black Redhorse	4.88
Fantail Darter	3.95	Common Carp	3.30
Golden Redhorse	3.29	White Sucker	2.88
Rosyface Shiner	2.73	Central Stoneroller	2.42
Silver Shiner	2.44	Silver Redhorse	1.75
Banded Darter	2.23	Largemouth Bass	1.40
Logperch	2.07	Bluntnose Minnow	1.24
Johnny Darter	2.05	Greenside Darter	1.11
Rock Bass	1.79	Redfin Pickerel	1.11
Green Sunfish	1.76	Green Sunfish	0.98
Hornyhead Chub	1.26	Logperch	0.90
Bluegill Sunfish	1.24	Yellow Bullhead	0.89
Smallmouth Bass	1.21	Hornyhead Chub	0.77
White Sucker	1.15	Stonecat Madtom	0.76
Scarlet Shiner	1.04	Creek Chub	0.71
Creek Chub	0.79	Spotted Sucker	0.67
Redfin Pickerel	0.72	Rainbow Darter	0.65
Species	Percent Abundance	Species	Percent Biomass
Blackside Darter	0.68	Bluegill Sunfish	0.53
Largemouth Bass	0.66	Rosyface Shiner	0.51
Orangespotted Sunfish	0.50	Green Sf X Hybrid	0.34
Black Redhorse	0.36	River Redhorse	0.32
Mottled Sculpin	0.34	Silver Shiner	0.26
Brindled Madtom	0.26	Orangespotted Sunfish	0.21
Spotted Sucker	0.25	Fantail Darter	0.19
Western Blacknose Dace	0.18	Scarlet Shiner	0.16
Green Sf X Hybrid	0.18	Blackside Darter	0.15
Spotfin Shiner	0.16	Banded Darter	0.12
Blackstripe Topminnow	0.14	Johnny Darter	0.11

Orangethroat Darter	0.13	Tadpole Madtom	0.11
Stonecat Madtom	0.11	Brindled Madtom	0.09
Yellow Bullhead	0.10	Green Sf X Bluegill Sf	0.06
Silverjaw Minnow	0.05	Spotfin Shiner	0.05
Silver Redhorse	0.04	White Crappie	0.04
Green Sf X Bluegill Sf	0.04	Mottled Sculpin	0.04
Common Carp	0.03	Blackstripe Topminnow	0.03
Redear Sunfish	0.02	Western Blacknose Dace	0.02
Tadpole Madtom	0.02	Pumpkinseed Sunfish	0.02
Fathead Minnow	0.01	Redear Sunfish	0.02
Hybrid X Sunfish	0.01	Orangethroat Darter	0.01
Striped Shiner x Rosyface Shiner	0.01	Longnose Gar	0.01
Trout-perch	0.01	Hybrid X Sunfish	0.01
White Crappie	0.01	Silverjaw Minnow	0.01
Brook Silverside	0.01	Yellow Perch	0.01
Longnose Gar	0.01	Striped Shiner x Rosyface Shiner	0.01
Golden Shiner	0.00	Trout-perch	0.01
Mimic Shiner	0.00	Goldfish	0.01
Redfin Shiner	0.00	Fathead Minnow	0.00
Striped Shiner x Silver Shiner	0.00	Redfin Shiner	0.00
Yellow Perch	0.00	Golden Shiner	0.00
River Redhorse	0.00	Mimic Shiner	0.00
Pumpkinseed Sunfish	0.00	Striped Shiner x Silver Shiner	0.00
Goldfish	0.00	Variegate Darter	0.00
Variegate Darter	0.00	Brook Silverside	0.00
Headwaters Big Darby Creek (RM 76-headwaters)			
Species		Percent Abundance	
Creek Chub		14.84	
Central Stoneroller		12.99	
Orangethroat Darter		12.17	
Mottled Sculpin		11.61	
Bluntnose Minnow		7.43	
Striped Shiner		6.91	
White Sucker		5.87	
Rainbow Darter		5.20	
Johnny Darter		5.12	
Western Blacknose Dace		4.71	
Green Sunfish		3.08	
Greenside Darter		2.57	
Fantail Darter		2.27	

Species	Percent Abundance
Redfin Pickerel	0.81
Northern Hog Sucker	0.79
South. Redbelly Dace	0.79
Banded Darter	0.53
Bluegill Sunfish	0.47
Silverjaw Minnow	0.39
Rosyface Shiner	0.36
Logperch	0.25
Longear Sunfish	0.22
Yellow Bullhead	0.19
Scarlet Shiner	0.08
Largemouth Bass	0.07
Least Brook Lamprey	0.07
Smallmouth Bass	0.06
Blackside Darter	0.03
Silver Shiner	0.03
Golden Redhorse	0.02
Rock Bass	0.02
Fathead Minnow	0.01
Hybrid x Minnow	0.01
Common Carp	0.01
Spotfin Shiner	0.01

Many of the fish species included in Table 8 fall into one or more groups based on similarities in sensitivity or tolerance to disturbance, feeding characteristics, or breeding characteristics. In addition to IBI and MIwb scores, these various groups can be further analyzed as a way to explain trends observed in IBI and MIwb scores. Analyzing specific indicator groups may also reveal specific trends regarding environmental quality that may not reveal themselves if only looking at IBI and MIwb scores. Several individual fish taxa or groups of taxa displayed trends in abundance and biomass through time and will be discussed below.

Many of the fish taxa listed in the above table are classified by Ohio EPA as “intolerant”. Intolerant fish are those that have been observed to respond negatively to a wide variety of disturbances, not just one or two specific types (Ohio EPA 1987). Some fish species are commonly observed and strongly associated with healthy fish communities, but may be recorded in areas that are slightly degraded; these fish species are referred to as “moderately intolerant”. “Intolerant” and “moderately intolerant” species are collectively referred to as “sensitive” species. The number and/or abundance of sensitive fish species present at a particular sampling location or through a stream reach is generally considered a good overall indicator of stream quality. The antithesis to sensitive species, highly tolerant species are those that increase proportionally to the overall fish community in degraded stream environments. Tolerance categories for individual fish taxa can be viewed in Appendix C.

Sensitive species comprise a greater percentage of the overall fish community abundance in Big Darby Creek than was observed in 2001 and a slightly greater percentage than was observed in 1992-93. Sensitive species also comprise a substantially greater proportion of fish biomass than has been observed historically (Figure 13). Large increases in the overall relative numbers of sensitive species were also observed. Following this positive trend, highly tolerant species comprised a substantially smaller proportion of overall fish abundance and biomass compared to historical values and the range of values among locations was also substantially reduced (Figure 13).

Simple lithophilic species (e.g. darters, redhorse suckers) are considered to be among the more environmentally sensitive of fish spawning guilds. These types of fish species broadcast their eggs in the water column, which then sink and come into contact with bottom substrates. Eggs then develop in the interstitial spaces between sand, gravel, and cobble sized substrate particles. Excessive amounts of silts or flocculent clays in streams can smother natural substrates and render eggs inviable (Ohio EPA 1987). Many species considered simple lithophilic are also considered sensitive. Simple lithophilic species were found to comprise a substantially greater proportion of the overall fish community and fish community biomass (Figure 13).

A reduced abundance of highly tolerant species and an increased abundance in sensitive species abundance indicated an improved environmental condition. This, coupled with a substantial increase in simple lithophilic species abundance, seems to indicate that the general basin-wide improvements have stemmed, at least partially, from improved instream sediment quality through the reduction of erosion and excessive sediment delivery to the receiving stream.

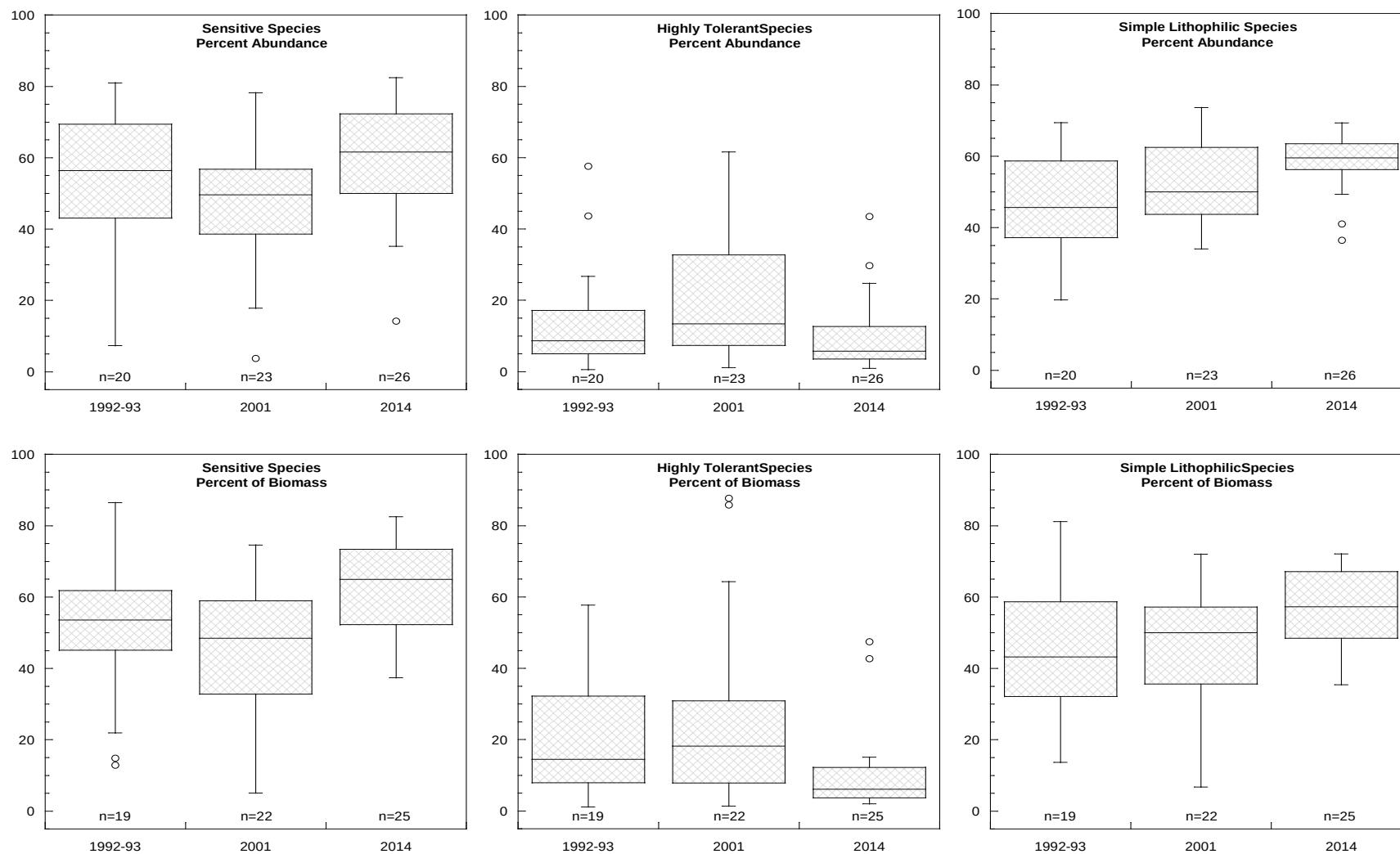


Figure 13. Percent abundance (top row) and percent of overall biomass (bottom row) of selected organism indicator groups from Big Darby Creek mainstem, 2014, 2001-02, and 1992-93. Only sites located within stream reaches generally common to all years (RM 79.2-mouth) and those using standard gear sampling types (e.g. boat in lower reaches, wading in mid-reaches) are displayed.

In addition to those taxa groups discussed above, other select species-specific trends were evaluated against historical data.

The state listed spotted darter (endangered) is highly intolerant to a wide range of disturbances and its presence is indicative of very high stream quality. Of the 48 instances statewide where the spotted darter has been collected by Ohio EPA since 1979, 40 (83%) have occurred in the Big Darby Creek basin. Historically, this species has been limited to only the very lowest reaches of Big Darby Creek, having been regularly recorded at State Route 104 (RM 3.2) since 1979. The 2001 survey recorded the spotted darter as far up Big Darby Creek as RM 25.7; however, occurrences still appeared relatively sporadic on a site-by-site basis (Figure 15). During the 2014 survey, the abundance of the spotted darter throughout the Big Darby Creek basin increased dramatically. They are now found as far upstream in Big Darby Creek as RM 34.2 and have even expanded their range as far as RM 8.2 into Little Darby Creek (Figure 15). These were the first spotted darter records by Ohio EPA in Little Darby Creek. In addition to the large adult individuals collected (above picture), other year classes were also recorded, with specimens as small as 3 cm collected. Figures displaying the distribution of other selected fish species throughout the Big Darby Creek watershed from 2001 to 2014 can be viewed in Appendix K.



The presence and absence of various species also displayed distinct patterns up and downstream from the impoundment located on Big Darby Creek at RM 37.2. Several species that have been recorded downstream from this impoundment have not been recorded upstream. The species which were found in appreciable abundance downstream from this impoundment and could reasonably be expected to flourish upstream include the streamline chub, bluebreast darter, variegate darter, tippecanoe darter, spotted darter, smallmouth redhorse, and bigeye chub. The four aforementioned darter species are among the most sensitive darters in the state of Ohio, especially the spotted and tippecanoe darter. Out of 2490 individuals of these species collected by Ohio EPA in Big Darby Creek since 1979, only one individual variegate darter was collected upstream from this impoundment and occurred in 2014. All taxa listed above, except the smallmouth redhorse (sensitive), are considered to be intolerant or rare-intolerant by Ohio EPA. All of the above listed species have also been commonly collected in Little Darby Creek. Other species in addition to those listed above (saugeye, sauger, freshwater drum, smallmouth buffalo, etc.) could likely be found above this impoundment; however, they would not likely comprise as dominant a component of the overall fish community.

Common carp are a classic generalist species that are highly tolerant of degraded environmental conditions and are often quite abundant in such conditions (Trautman 1981). The percent abundance and percent biomass of common carp decreased at sampling locations throughout the lower Big Darby Creek mainstem (Figure 14). Although not yet fully documented, reductions in common carp abundance and biomass through time may be an emerging trend in Ohio. Several large-scale, state sponsored water quality surveys across multiple ecoregions and including many of Ohio’s major drainages have revealed consistent declines in the numerical abundance and aggregate biomass of common carp over the past 20 plus years (Ohio EPA 2013a, Ohio EPA 2015a, b, c). On the contrary, native species such as buffalo (primarily smallmouth) and carpsuckers, which fill similar ecological niches as common carp, appear to have increased in the percent biomass of the overall fish community (Figure 14). The reduction of highly tolerant and exotic species, such as the common carp, coupled with increases in the abundance of native species that fulfill similar ecological niches may be a further indicator of improved water quality here and elsewhere, an observation supported by Kennard et al. (2005).

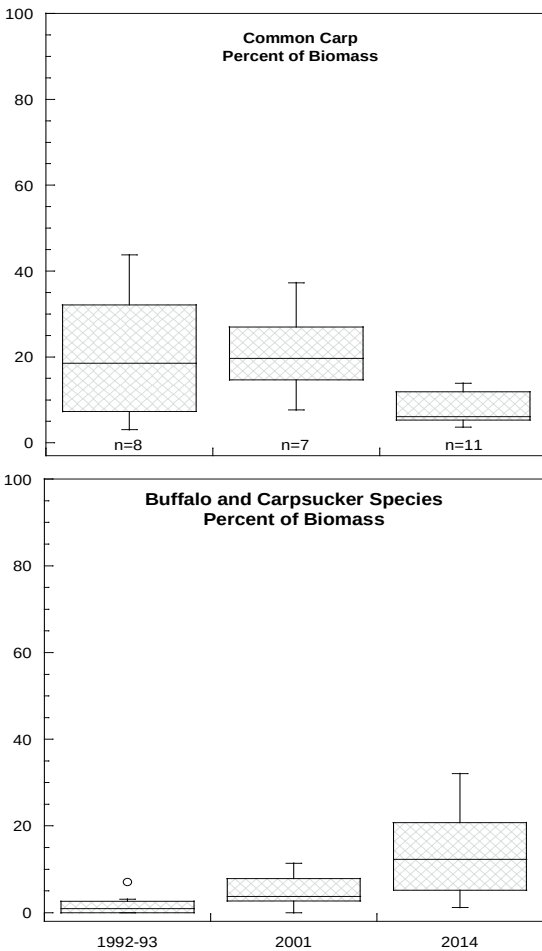


Figure 14. Percent biomass of common carp (top) and buffalo/carpsuckers (bottom) from the lower Big Darby Creek mainstem (RM 33.45-mouth), 2014, 2001, and 1992-93. Only samples collected using boat electrofishing methods are displayed.

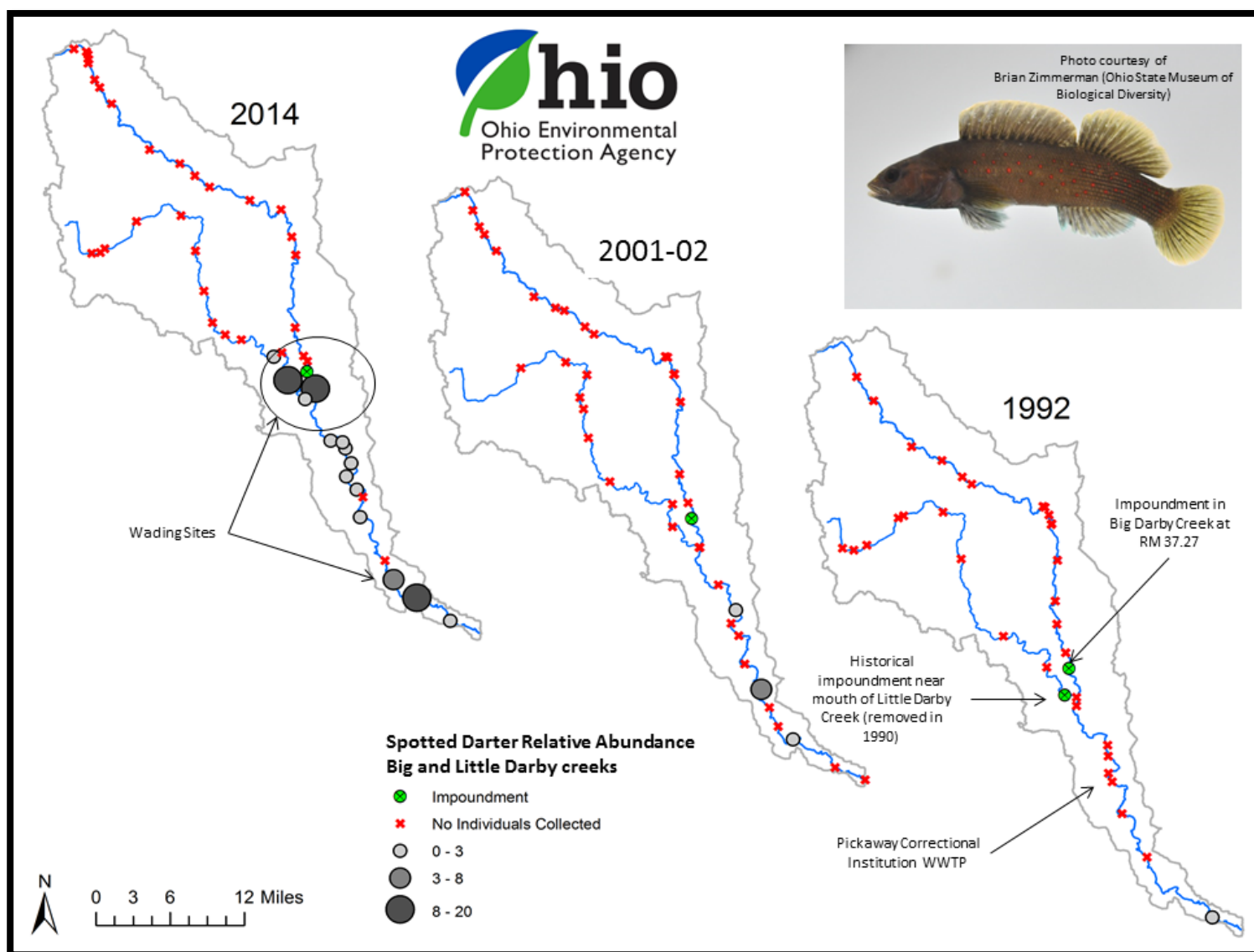


Figure 15. Spotted darter relative abundance (#/0.3km at wading sites, #/1km at boat sites) at sites within the Big Darby Creek basin, 2014, 2001-02, and 1992-93.

Little Darby Creek mainstem: Overview and Trends

Fourteen sampling sites evaluating approximately 41 river miles were evaluated during the 2014 sampling index period. The three uppermost sites were previously designated both EWH and CWH, while the rest of Little Darby Creek maintains an EWH use designation. Thirteen of fourteen sites fully met applicable fish biocriteria; one site (RM 34.70) only partially met applicable fish biocriteria, as the MIwb score at this location fell just short of EWH expectations (Figure 17). Longitudinal performance of fish biocriteria from selected years is displayed in Figure 16 and Figure 17.

The average IBI (54.5) and MIwb (9.81) scores for Little Darby Creek from 2014 correspond to an exceptional narrative evaluation. Overall, fish community performance throughout Little Darby Creek ranged from good to exceptional (Table 9). The IBI at RM 15.3, a regional reference site, scored the highest possible score of 60 for both fish sampling events during the summer of 2014, the first accomplishment of this type in the history of Ohio EPA's fish monitoring program dating back to 1979. IBI scores throughout Little Darby Creek are among the highest scores in Ohio.

The lower reaches of Little Darby Creek have higher gradient and have been relatively un-impacted by direct, systematic channelization activities that the upper reaches of Little Darby Creek have experienced. The majority of fish community samples from the middle and lower reaches of Little Darby Creek fall within the exceptional range. Fish community performance in the upper reaches of Little Darby Creek is more variable with narrative evaluations ranging from good to exceptional. In the very headwaters, Little Darby Creek is strongly influenced by groundwater contributions; the fish community at RM 40.1 reflected this, as mottled sculpin (obligate cold-water taxon) comprised approximately 69% of the overall fish community. Strong ground water contribution can effectively ameliorate potential stressors to the biological communities. Progressing downstream, fish community performance in the upper reaches of Little Darby Creek is likely influenced by negative stream habitat attributes resulting from historical channelization activities, such as monotonous channel development, less sinuosity, and excess siltation/embeddedness; a lower overall gradient compared to the rest of Little Darby Creek can exacerbate these issues by reducing stream power and slowing recovery of natural habitat attributes. The upper reaches of Little Darby Creek also have numerous areas of substantially reduced or complete removal of riparian vegetation and unrestricted cattle access is also present at areas throughout the upper reaches.

The MIwb at RM 34.7 fell just short of EWH expectations. Surface water grab samples from this location did not reveal any Ohio Water Quality Standards (WQS) criteria exceedances. Continuous water quality sonde monitoring results also did not reveal any minimum or average WQS criteria exceedances or D.O. swings/sags that would be indicative of nutrient or organic enrichment, though nitrate-nitrite concentrations were above target values at this location. Habitat conditions at this location were in the low range of excellent; however, this site did display several negative habitat attributes (low sinuosity, moderate amounts of embeddedness) which could have negatively influenced fish community performance. Additionally, the negative habitat attributes in the upper reaches of Little Darby Creek, in aggregate, have the potential to limit fish community performance. It is likely that fish community performance at RM 34.7 is limited primarily by excess sedimentation and direct habitat alterations associated with channelization activities that occurred historically in these reaches of Little Darby Creek.

Fish community performance throughout Little Darby Creek improved significantly in 2014 compared to previous years, as both aggregated IBI and MIwb scores are substantially higher compared to historical values (Figure 16 and Figure 17). Figure 18 displays IBI scores through time at several sites in Little Darby Creek and further highlights the gradual improvements in fish community performance.

Additionally, historical trends for various groups of indicator species and/or individual fish taxa were evaluated. Analyzing specific indicator groups may also identify specific trends regarding environmental quality that may not reveal themselves if only looking at IBI and MIwb scores.

The percent biomass of sensitive species increased substantially from 2001 to 2014 (Figure 19). This increase in percent biomass of sensitive species was driven primarily by increases in the percent biomass of several redhorse species at sampling locations throughout Little Darby Creek. Golden redhorse (+11.6%) and black redhorse (+6.1%) saw the greatest magnitude of increase; smallmouth redhorse also saw modest increases in percent abundance and became more common throughout Little Darby Creek compared to 2001. A decrease in the percent biomass of highly tolerant fish species also appeared to coincide with the increases observed in percent biomass of sensitive species between 2001 and 2014. The percent abundance of sensitive species has increased slightly since 2001, while the percent abundance of highly tolerant species has remained similar over the same time period.

Similar to the observed trend in Big Darby Creek, the percent abundance of simple lithophilic species also increased substantially throughout Little Darby Creek in 2014 compared to 2001-02, while percent biomass of simple lithophilic species modestly increased.

Reductions in the biomass of highly tolerant species, coinciding with an increase in biomass of sensitive species abundance, indicated an improved environmental condition. This, coupled with a substantial increase in simple lithophilic species abundance, seems to indicate that the general basin-wide improvements stemmed, at least partially, from improved instream sediment quality through the reduction of erosion and excess silt and sediment delivery to receiving streams. This trend generally follows that observed in the Big Darby Creek mainstem.

Other noteworthy trends regarding intolerant species observed in Little Darby Creek include the first ever Ohio EPA records of the state listed spotted darter (endangered), which were recorded from the mouth up to RM 8.2 (Figure 5). Bluebreast darters also increased in overall abundance since 2001 and were found as far upstream as RM 20.5, only having been previously recorded up to RM 6.5 in 2001. Streamline chubs were also found as far upstream as RM 13.35, having only been previously recorded at RM 6.5 in 1997.

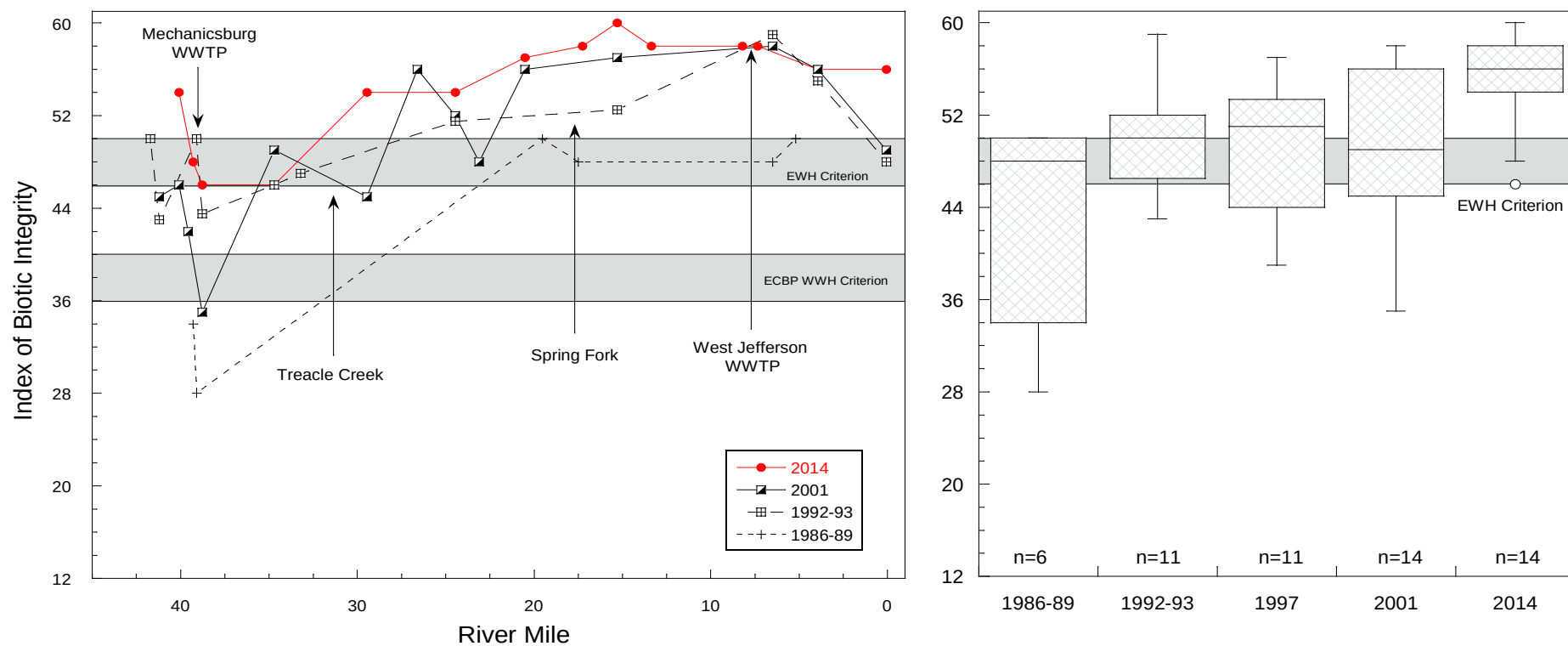


Figure 16. Longitudinal by river mile (left) and aggregate by survey year (right) performance of IBI scores for Little Darby Creek from selected years. The shaded portions represent applicable biocriteria and areas of non-significant departure from said values.

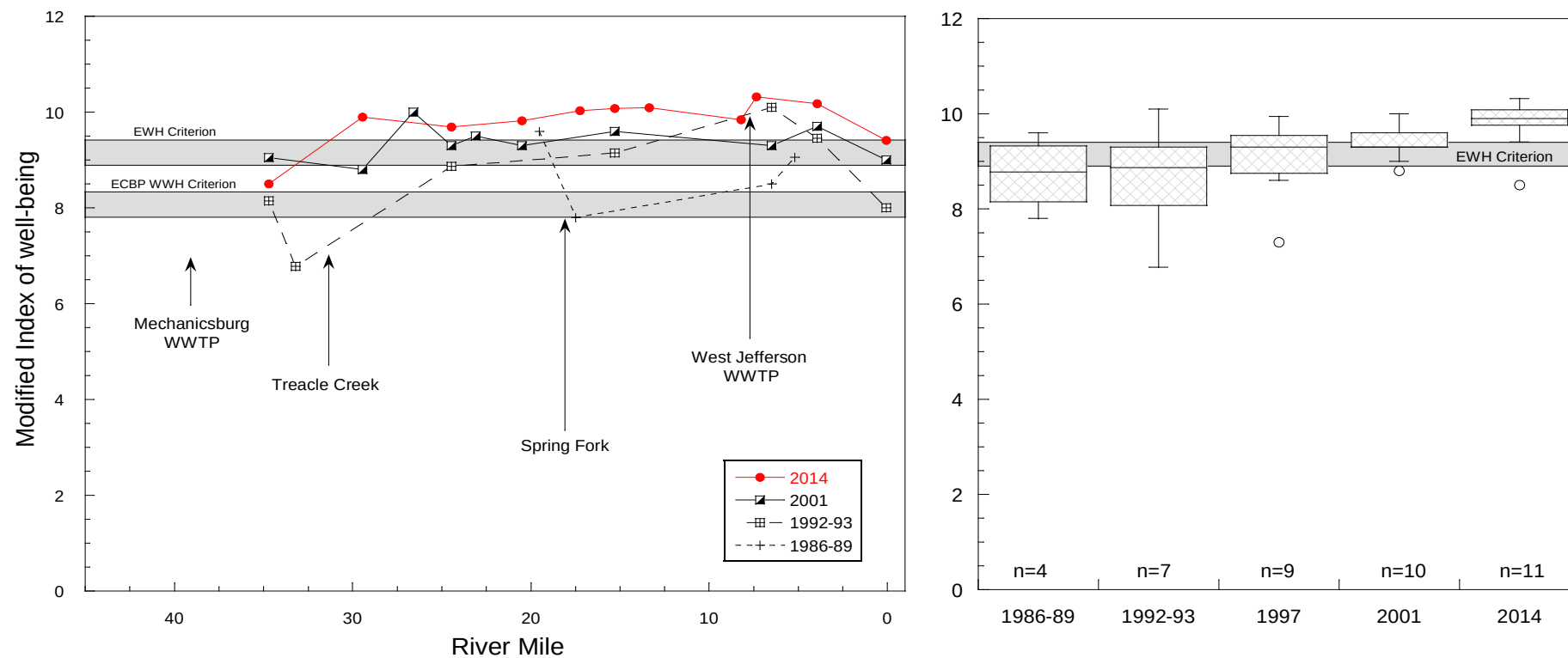


Figure 17. Longitudinal by river mile (left) and aggregate by survey year (right) performance of MIwb scores for Little Darby Creek from selected years. The shaded portions represent applicable biocriteria and areas of non-significant departure from said values.

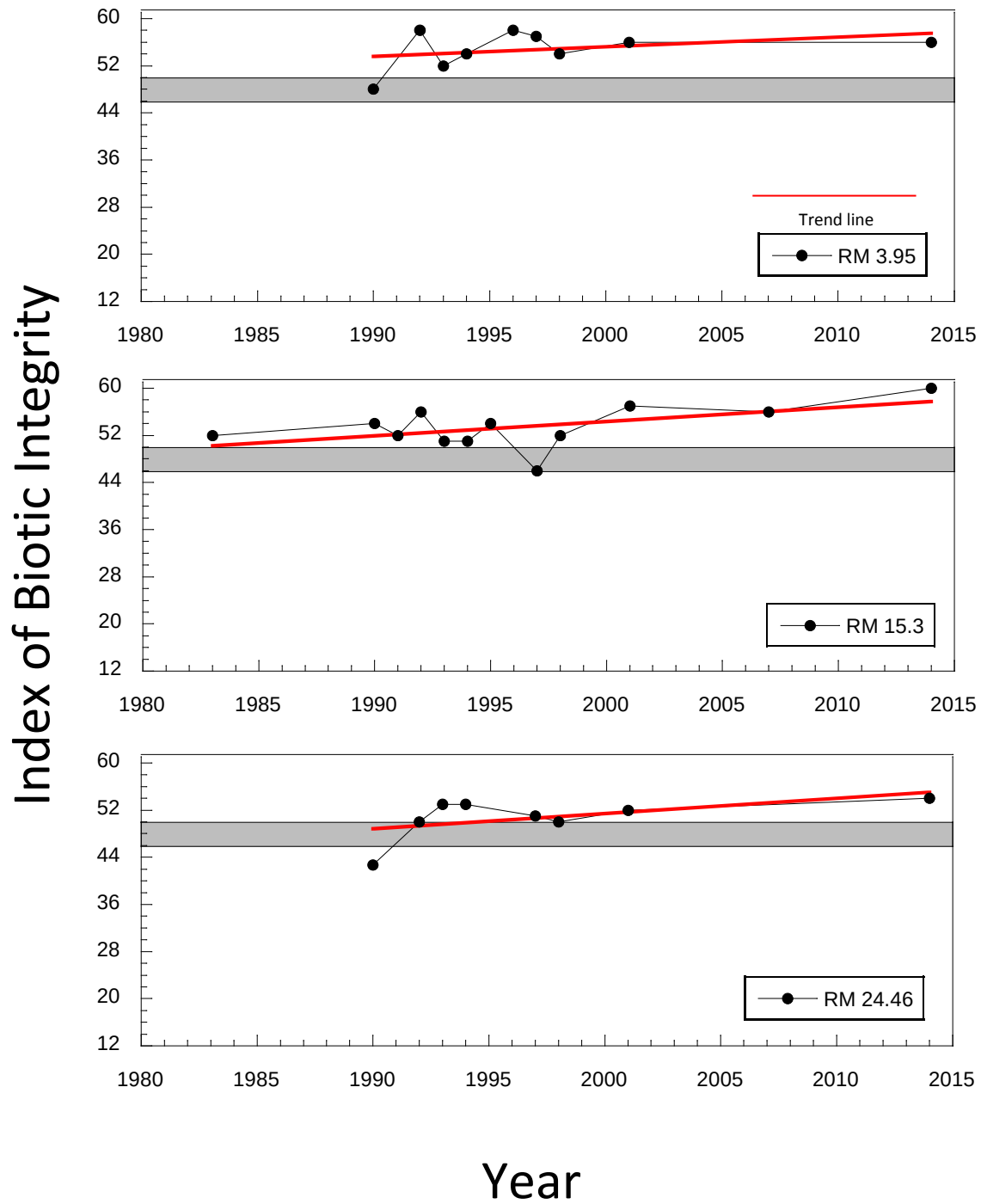


Figure 18. Performance of IBI scores through time from selected locations in Little Darby Creek. Shaded areas represent areas of non-significant departure from the indicated criterion. The trend line is displayed in red.

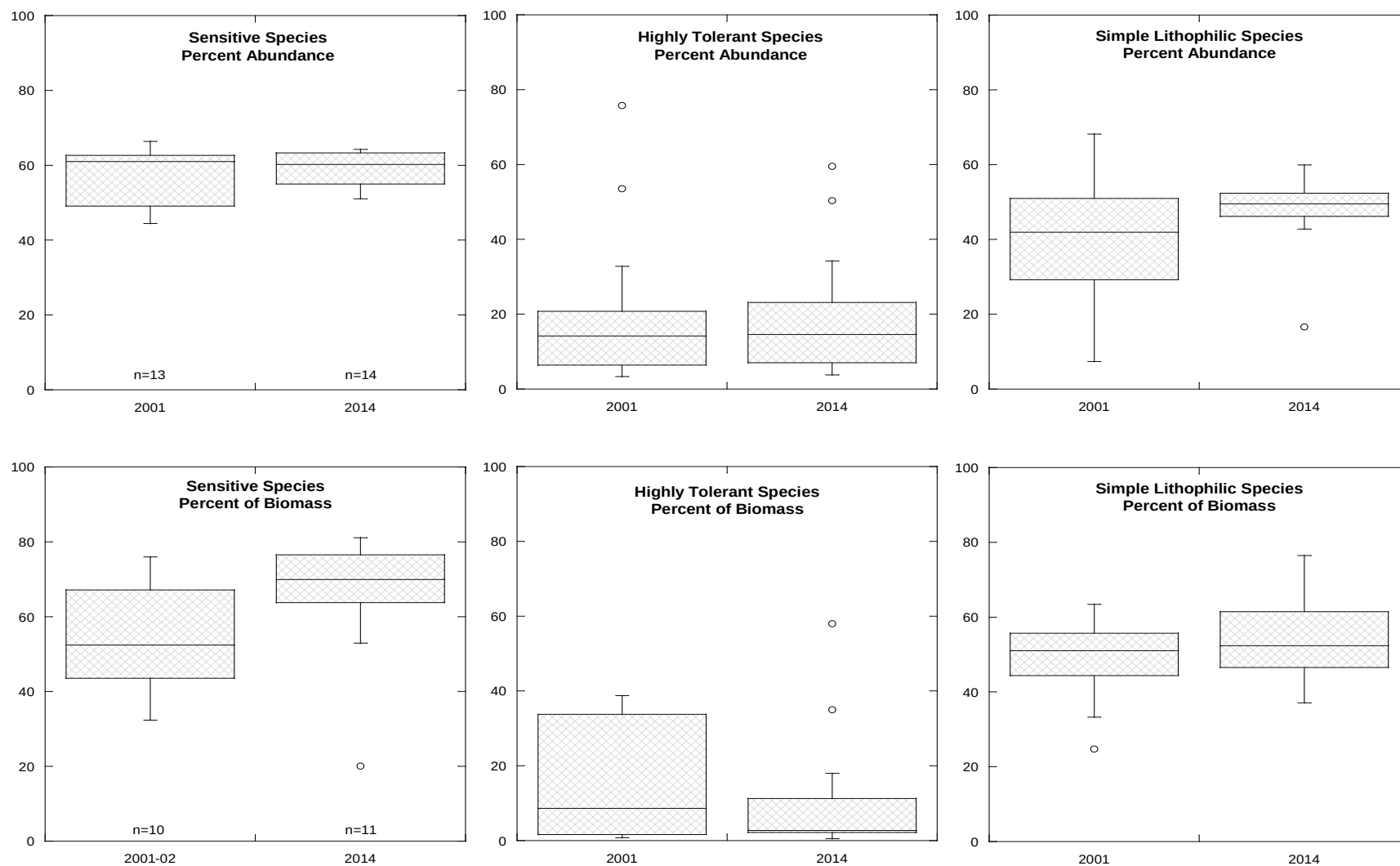


Figure 19. Percent abundance (top row) and percent of overall biomass (bottom row) of selected organism indicator groups from Little Darby Creek, 2014 and 2001-02.

Tributaries: Overview and Trends

Fish communities in 26 tributaries to Big Darby Creek and Little Darby Creek collected at 45 sites were fully assessed during the 2014 sampling index period; several samples were collected from lower Hellbranch Run in 2015. Of the 45 sites sampled, 39 (86.7%) sites fully achieved applicable fish biocriteria (IBI and MIwb), while six (13.3%) sites failed to achieve applicable fish biocriteria; narrative scores ranged from poor to exceptional (Table 9). More substantial discussion pertaining to individual tributaries is contained in the following paragraphs.

Fish community performance, as a whole, improved substantially in the tributaries to Big and Little Darby creeks that were sampled both in 2001 and 2014. The median IBI score for paired sampling locations or reaches sampled in both years increased 10 points; the range of IBI scores also trended more toward the mean than in 2001. The median IBI score for these tributaries improved from good to exceptional and would be meeting EWH criteria. Improvements in these tributaries highlight the general positive trajectory of fish community performance from 2001 to 2014.

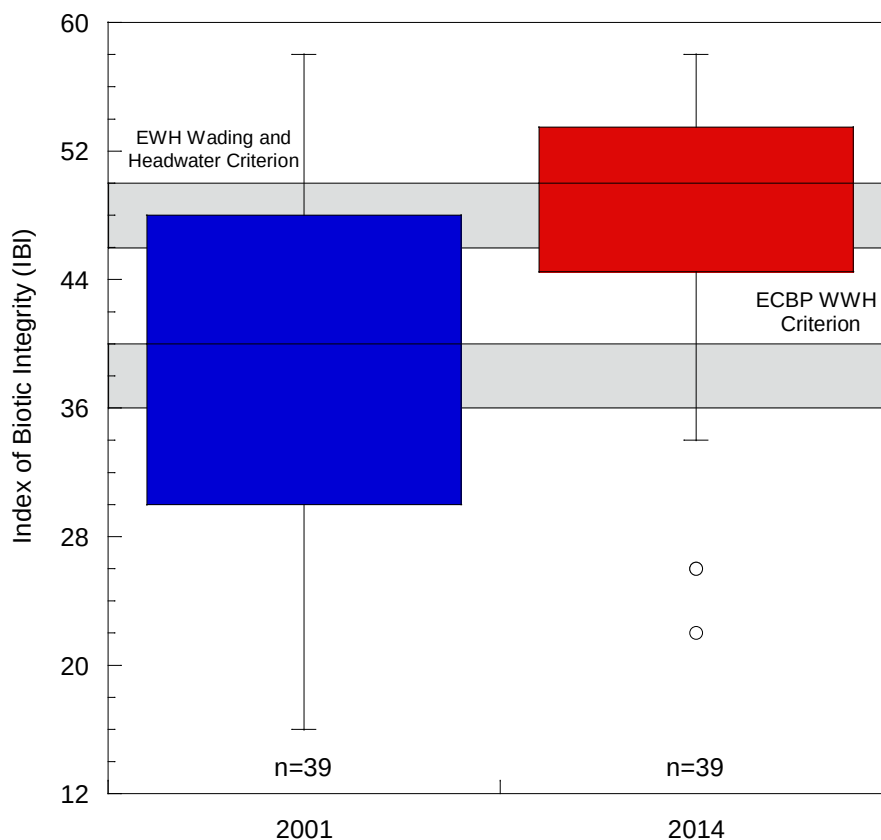


Figure 20. Aggregated performance of IBI scores for tributaries to Big Darby Creek and Little Darby Creek, 2014 and 2001. Only paired sampling locations or stream reaches (within 1 river mile) are displayed. Shaded areas represent areas of non-significant departure from indicated criteria.

Big Darby Creek Tributaries

Flat Branch

Flat Branch is a small tributary located in the headwaters of Big Darby Creek. The fish community was assessed at one location in 2014 and met applicable fish biocriteria; community performance was evaluated as good. Fish community performance has improved significantly compared to historical values at the one location sampled in 2014 (Figure 21). Highly tolerant fish species (e.g. carp, bluntnose minnow, green sunfish) comprised a much smaller proportion of the overall fish community in 2014 (55.0%) than they did in 2001 (75.6%) and 1997 (90.3%); not surprisingly, sensitive species comprised a greater proportion in 2014 (17%) than in 2001 (4.1%) and 1997 (0.2%). Four sensitive darter species (banded, greenside, logperch, and rainbow) comprised about 13.8% of the fish community; excluding logperch, these darter species have never been recorded in Flat Branch by Ohio EPA. The aforementioned darter species are simple lithophils and are especially sensitive to excess amounts of siltation and due to their life history requirements, generally will not inhabit areas plagued by excess siltation.

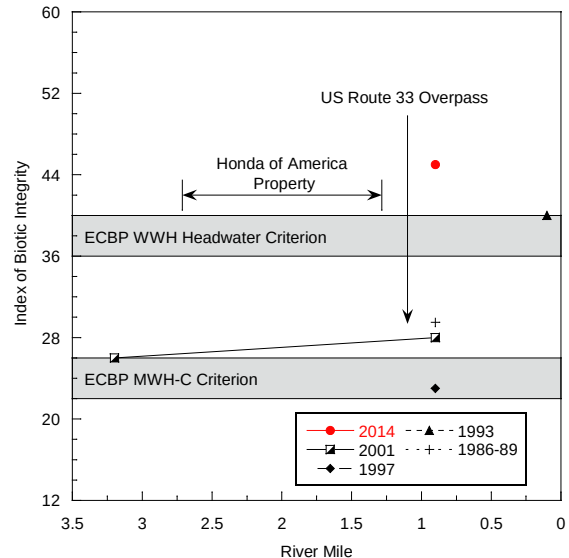


Figure 21. Longitudinal performance of IBI scores from Flat Branch for selected years. Shaded areas represent areas of non-significant departure from indicated criteria.

A significant portion of this stream's approximately 14.46 mi² drainage area lies within the Honda of America property. Efforts have been made by Honda of America in the past to widen vegetated buffers and install storm water retention ponds and wetlands; habitat quality improvements in Flat Branch, particularly improvements in sediment quality and reductions in excess siltation, are likely related to these efforts. These actions by Honda of America, along with other efforts in this small watershed, appear to be having a positive effect on instream habitat quality, and subsequent biological performance in Flat Branch proper and in the vicinity of its confluence with Big Darby Creek. As indicated by the biological performance, many of the historical issues identified in prior reports appear to have been attenuated. Flat Branch is currently designated MWH-C and is a regional reference site; if the positive trajectory of biological performance continues to improve, portions or the entirety of Flat Branch could be considered for the WWH use designation during the next survey cycle.

Little Darby Creek (Logan Co.)

Little Darby Creek (Logan Co.) joins Big Darby Creek just downstream from the Flat Branch confluence. The fish community was assessed at two locations in 2014 and a mean IBI score of 53.5 corresponds to exceptional community performance; both sites fully met existing EWH and CWH criteria. Fish community performance in this stream was found to be stable to slightly improved compared to scores from 2001 ($\bar{x}$ =52) and 1986-89 ($\bar{x}$ =50). Mottled sculpin, an obligate cold-water species, comprised an average of 34.6% of the fish community at both locations sampled, which is substantially greater than the historical

12%. Compared to historical values, sensitive species such as rainbow and greenside darters comprised a greater proportion of the fish community, while tolerant fishes such as the creek chub comprised a smaller proportion of the overall fish community.

Spain Creek

The fish community was evaluated at two locations and a mean IBI score of 56 corresponds to exceptional community performance. When compared to historical values, IBI scores from 2014 indicate a stable to improving fish community performance. Both sites fully met existing EWH criteria and CWH fish criteria, though the macroinvertebrates at the lower location deviated from expected CWH assemblages, resulting in an overall partial attainment status. Further examination of the fish community indicated that simple lithophils comprised a smaller proportion in 2014 compared to 2001 at both locations sampled, which can be an indication of excess siltation/sedimentation or a shifting substrate bedload. Mottled sculpin, an obligate cold-water species, comprised approximately 23.9% of the fish community at the upper location and 5.8% at the lower location, both of which are higher than what has been recorded historically.

Pleasant Run

The fish community was evaluated at one location and fully met the existing EWH criterion; narrative scores corresponded to exceptional community performance. Fish community performance as indicated by the IBI has remained relatively stable at the one location assessed, though slight declines have occurred through time (Figure 23). Sensitive species declined in abundance from 2001 (22.8%) to 2014 (13.0%), while the abundance of highly tolerant fishes increased from 28.2% to 33.1% over the same time period. The abundance of mottled sculpin, an obligate cold-water species, also decreased from 2001 (19.4%) to 2014 (5.0%). Habitat quality has declined at this location and examination of historical imagery has revealed substantial and complete channelization, and riparian vegetation removal immediately adjacent and upstream from the sampling location which occurred between 2007 and 2008. The channelization activity and riparian vegetation removal has very likely had a negative influence on fish community performance.

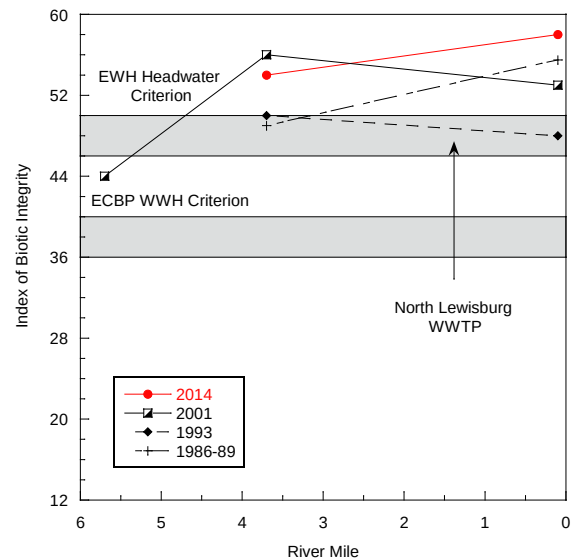


Figure 22. Longitudinal performance of IBI scores for Spain Creek from selected years. Shaded areas represent areas of non-significant departure from indicated criteria.

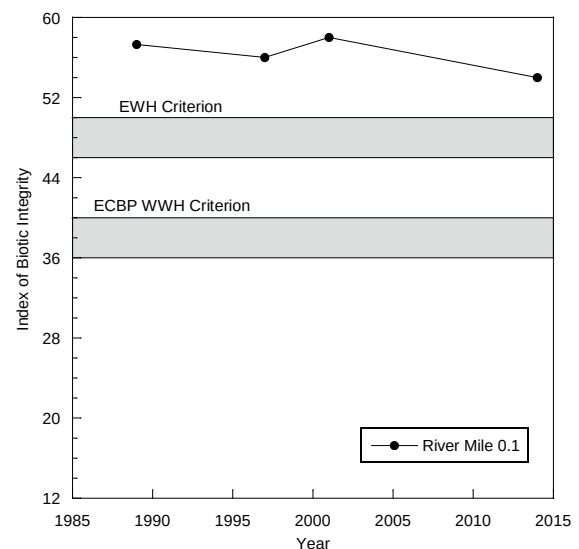


Figure 23. Performance of IBI scores through time in Pleasant Run at RM 0.1. Shaded areas represent areas of non-significant departure from indicated criteria.

Buck Run

Buck Run is a tributary that joins Big Darby Creek just southeast of Milford Center. The fish community in Buck Run was evaluated at three locations in 2014 and either fully met or was in non-significant departure from the existing WWH criteria. Fish community performance has improved substantially at all locations assessed when compared to historical values (Figure 24). Sensitive species comprised a greater proportion of the fish community in 2014 ($\bar{x}$ =19.5%) than in 2001 ($\bar{x}$ =4.0%) at the three locations assessed in both years, while highly tolerant fish species decreased in abundance from an average of 55.0% to 47.9% over the same time period. Additionally, simple lithophilic species comprised a larger proportion of the overall fish community in 2014 (30.1%) compared to 2001 (13.5%). The improvements in fish community performance in Buck Run are likely a result of improved instream habitat quality observed throughout Buck Run. Some of the issues related to water chemistry (elevated ammonia and nitrate-nitrite, low D.O. concentrations) appear to have been attenuated, as all concentrations were within target values.

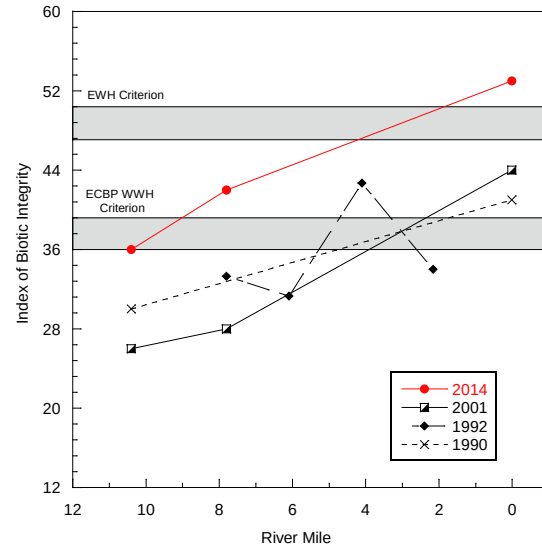


Figure 24. Longitudinal performance of IBI scores from Buck Run for selected years. Shaded areas represent areas of non-significant departure from indicated criteria.

Robinson Run

The fish community in Robinson Run was evaluated at two locations and was found to fully meet the existing WWH criterion. Fish community performance ranged from good at RM 2.1 to exceptional at RM 0.7. Substantial improvements in fish community performance occurred since the last survey, with the average IBI increasing from 30 in 2001 to 46 in 2014. The fish community in Robinson Run was comprised of a higher overall percentage of sensitive, insectivorous, and simple lithophilic species compared to 2001, while the proportion of highly tolerant, omnivorous, and pioneering species was substantially reduced. Robinson Run also accrued 11 additional fish species when compared to the 2001 collection. Many of the historical issues identified in the previous report appeared to have been attenuated.

Sweeny Run

Fish community performance was evaluated at one location in Sweeny Run and an IBI of 50 is indicative of an exceptional overall fish community. Slight improvements have occurred since 2001 when an IBI of 46 was recorded.

Sugar Run

Sugar Run is a direct tributary that joins Big Darby Creek just south of Plain City. The fish community was evaluated at two locations and fully met the existing WWH criterion at the most downstream site (RM 0.4). Fish community performance at the upstream site (RM 5.4) fell just short of ECBP WWH expectations, with an IBI of 34. The IBI scores from RM 0.4 have generally improved through time, while scores from RM 5.4, though improved since the early 1990s, have been more variable and have changed little since 2001 (Figure 25). The percentage of pioneering species at RM 5.4 increased substantially from 2001 (25.8%) to 2014 (80.3%). Tolerant and omnivorous fish taxa also comprised a larger proportion of the overall fish community in 2014 compared to 2001.

Pioneering fish taxa are tolerant of a wide range of environmental disturbance and can predominate in unstable environments impacted by temporal desiccation or other anthropogenic stresses. Pioneering fish taxa are often the first species to reinvade areas after temporal desiccation or other stressors are eliminated; such a high percentage of the overall fish community indicates that this portion of Sugar Creek likely experiences significant low and/or “flashy” flow events which can limit fish community performance. A “flashy” stream is one that receives excessive overland runoff during precipitation events which causes a rapid and pronounced rise in stream discharge followed by a similar rapid decrease. This situation typically occurs in streams that have altered drainage networks (*i.e.*, channelization, drainage tiles) or those that drain areas with a high density of impervious surfaces.

The significant expansion of the New California housing development adjacent to Sugar Run, a golf course constructed prior to the 2001 survey, and upstream agricultural activities (*i.e.*, channelization) have all likely played a contributing role to the overall modified flow regime in Sugar Run. Increased overland runoff can also result in significant erosion and sediment deposition in receiving streams, especially during periods of active construction activity. It is likely that the above sources have contributed excess sediment to the Sugar Run that has resulted in the extensive amounts of substrate embeddedness and siltation observed. The combination of low and flashy stream flows, pervasive substrate embeddedness, and excess siltation is likely negatively impacting the biology at this location.

In addition to the habitat stressors listed above, nutrient enrichment has been a well-documented issue throughout Sugar Run and still appears to be contributing to impairment in the fish community. The uptick in the percentage of omnivorous fishes, particularly the highly tolerant bluntnose minnow, coupled with large diel D.O. swings recorded in 2015, elevated benthic chlorophyll-*a* concentrations, and slightly elevated TP concentrations, likely indicate nutrient enrichment as an additional stressor at this location. Nutrient enrichment has historically been an issue at RM 5.4 and elsewhere throughout Sugar Run though, currently, the degree of nutrient enrichment does not appear to be as severe as in years past.

Historically, Sugar Run has been subjected to substantial stressors, impacts, and changes per unit area, rivaling any other subwatershed within the Big Darby Creek study area. Previous studies have documented severe water quality impacts and fish kills emanating from Sugar Creek’s very headwaters. In July of 1993, Ohio EPA staff measured toxic ammonia concentrations and severely depressed D.O. concentrations resulting from incorrect “fertilizer” applications to conservation reserve program (CRP) land prior to heavy rain. The fish kill extended downstream beyond the discharges of the now decommissioned New California and Kimberly Woods WWTPs. It was also discovered during the course of the investigation that this “fertilizer” had been applied repeatedly in the past and was later identified as wash water from two process lines at a local manufacturer of lawn chemicals that was collected into lagoons, pumped into containers, and then land applied based on measured NH₃ concentrations. During this same time period,

severe manure management issues were uncovered along Sugar Run; in one location, approximately five acre-feet of unincorporated manure was identified along the banks of Sugar Run. Multiple other fish kills were attributed to excess manure runoff during the early 1990s. Impacts associated with discharges from the New California and Kimberly Woods WWTPs were also a concern in the past before these plants ceased operation and likely exacerbated episodes of poor water quality spawned by these other upstream issues. All of these factors, along with generally deficient instream habitat in upper Sugar Creek, contributed to severe nutrient and organic enrichment issues identified during this time period.

During the 2000s, fish community performance generally improved throughout Sugar Run, though habitat quality and water chemistry issues still persisted. More substantial discussion regarding the history of Sugar Run is contained within the previous Big Darby Creek watershed technical report (Ohio EPA 2004).

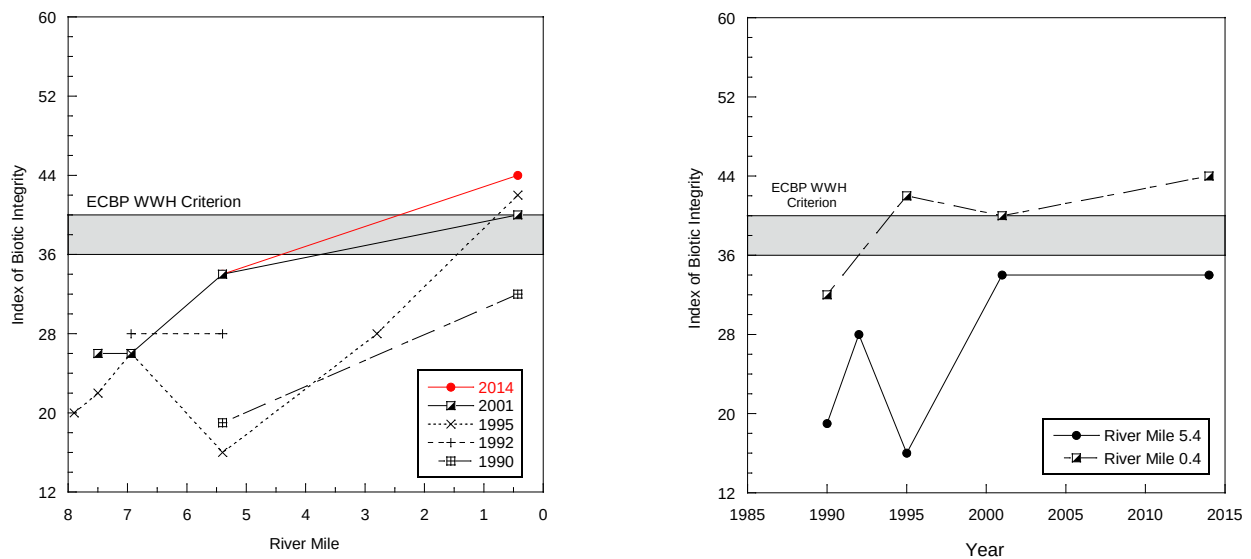


Figure 25. Longitudinal IBI performance from selected years (left) and performance of IBI at selected locations through time (right) for Sugar Run. Shaded areas represent areas of non-significant departure from indicated criterion.

Worthington Ditch

The fish community in Worthington Ditch was evaluated at one location and an IBI of 50 was indicative of an exceptional overall community. Substantial improvements have occurred here since 2001 when an IBI of 24 (poor) was recorded. This small stream has undergone a dramatic shift in fish community composition. In 2001, the community was dominated (60.6%) by the tolerant and omnivorous bluntnose minnow, whereas 2014 sampling indicated a predominance of the central stoneroller (34.9%) and rainbow darter (26.0%). The shift away from highly tolerant, omnivorous, and pioneering taxa toward more sensitive and simple lithophilic species signals conditions have improved here. Improvements in Worthington Ditch are likely a result of naturally directed recovery from historical channelization activities, coupled with improvements in fish community performance observed in the Big Darby Creek mainstem and generally basin-wide.

Ballenger-Jones Ditch

The fish community in Ballenger-Jones Ditch was evaluated at one location and an IBI of 52 was indicative of an exceptional overall community. Substantial improvements have occurred here since 2001 when an IBI of 40 was recorded. A total of 22 fish species were collected in 2014, five more than in 2001. The abundance of sensitive and insectivorous taxa was substantially higher in 2014 (48.9% and 76.5%, respectively) than in 2001 (14.1% and 28.9%, respectively), while the abundance of highly tolerant and generalist-feeding taxa decreased. This trend was driven largely by a 35.8% increase in darter abundance coupled with a 30.5% decrease in creek chub abundance.

Fitzgerald Ditch

The fish community in Fitzgerald Ditch was evaluated at one location and fully met the existing WWH criterion. An IBI of 48 suggested very good fish community performance, which is much improved since 2001 when an IBI of 32 was recorded at the same location. The overall number of species recorded at RM 0.55 increased from nine in 2001 to 17 in 2014. Additionally, the abundance of sensitive, simple lithophilic, and insectivorous fish taxa increased since 2001, while the abundance of highly tolerant, omnivorous/generalist feeding, and pioneering fish taxa decreased.

Smith Ditch

The fish community in Smith Ditch was evaluated at one location and fully met the existing EWH criterion. An IBI of 52 indicated exceptional overall fish community performance and was a substantial improvement from the 28 that was recorded in 2001. Sensitive, insectivorous, and headwater fish taxa comprised a larger proportion of the fish community, while highly tolerant and generalist/omnivorous feeding taxa decreased in abundance. Segments of this stream were observed to be dry late in the summer of 2014 and it is likely that this small stream goes interstitial on a regular basis, especially in late summer. Sampling in late September 2001 noted interstitial flow conditions and attributed impairment primarily to natural low flow conditions. It is likely that these natural low flow conditions are contributing to the impairments observed in the macroinvertebrate community.

Springwater Run

The fish community in Springwater Run was evaluated at one location in 2014. An IBI of 48 indicated very good fish community performance. Community performance has remained relatively stable since 2001 when an IBI of 50 was recorded. Mottled sculpin, an obligate cold-water species, was a predominant species in the catch and comprised nearly 22% of the overall fish community, a significant increase over what was observed in 2001; abundance of southern redbelly dace, another cold-water species, also increased substantially and comprised over 6% of the fish community. Springwater Run currently has an existing WWH designation; based on biological sampling from 2014, this stream is being recommended the CWH aquatic life use designation.

Tributary to Big Darby Creek (23.61)

This very small tributary to Big Darby Creek was evaluated at one location near the mouth. An IBI of 48 indicated very good fish community performance. Though highly tolerant species comprised the majority of the overall fish community (72%), the high percentage of headwater taxa (56%) coupled with the relatively low percentage of pioneering taxa (29%) indicated a relatively stable instream environment.

Mottled sculpin, an obligate cold-water species, comprised over 10% of the overall fish community. This small stream is currently undesignated and coupled with the results from macroinvertebrate and water chemistry results, this stream is being recommended the CWH aquatic life use designation.

Hellbranch Run

Hellbranch Run is one of the few significant tributaries that joins Big Darby Creek from the east; it is formed by the confluence of Hamilton and McCoy runs approximately 11 miles upstream from the confluence with Big Darby Creek. The fish community was evaluated at five locations; the lower two sites fully met existing EWH criteria, while the upper three locations were either fully meeting or in non-significant departure from existing WWH criteria (Figure 26). Community performance ranged from marginally good to very good in the upper reaches to exceptional in the lower reaches (Table 9).

Overall fish community performance in Hellbranch Run has improved over historical values. IBI scores have improved at all locations evaluated and the MIwb was also generally higher throughout (Figure 26). Improvements were especially pronounced in both the IBI and MIwb scores downstream from the Oakhurst Knolls WWTP (Figure 26). Improvements in IBI scores were also pronounced in the vicinity of the Timberlake WWTP which was decommissioned and abandoned in 2012; the MIwb at this location should improve slightly through time. It is often the case that the IBI is the first of the two fish indices to improve, followed by the MIwb. Across all locations sampled, 10 additional species were collected in 2014-15 compared to 2001, including intolerant species such as black rehorse, and brindled and stonecat madtom. The average abundance of sensitive (+14.8%), simple lithophilic (+7.4%), and insectivorous (+6.4%) fish taxa increased among all stations, while the abundance of highly tolerant (-8.8%) and generalist/omnivorous feeding taxa (-15.9%) decreased from 2001 to 2014-15 (Figure 27). Darters increased in abundance by approximately 10%, while the highly tolerant bluntnose minnow and creek chub decreased approximately 8% and 4%, respectively. Further highlighting observed improvements, the intolerant banded darter expanded its range and, in 2014, comprised 1-3% of the overall fish community in the lower six miles of the stream. Previously, this species had only reached these abundances in the lower one mile of Hellbranch Run.

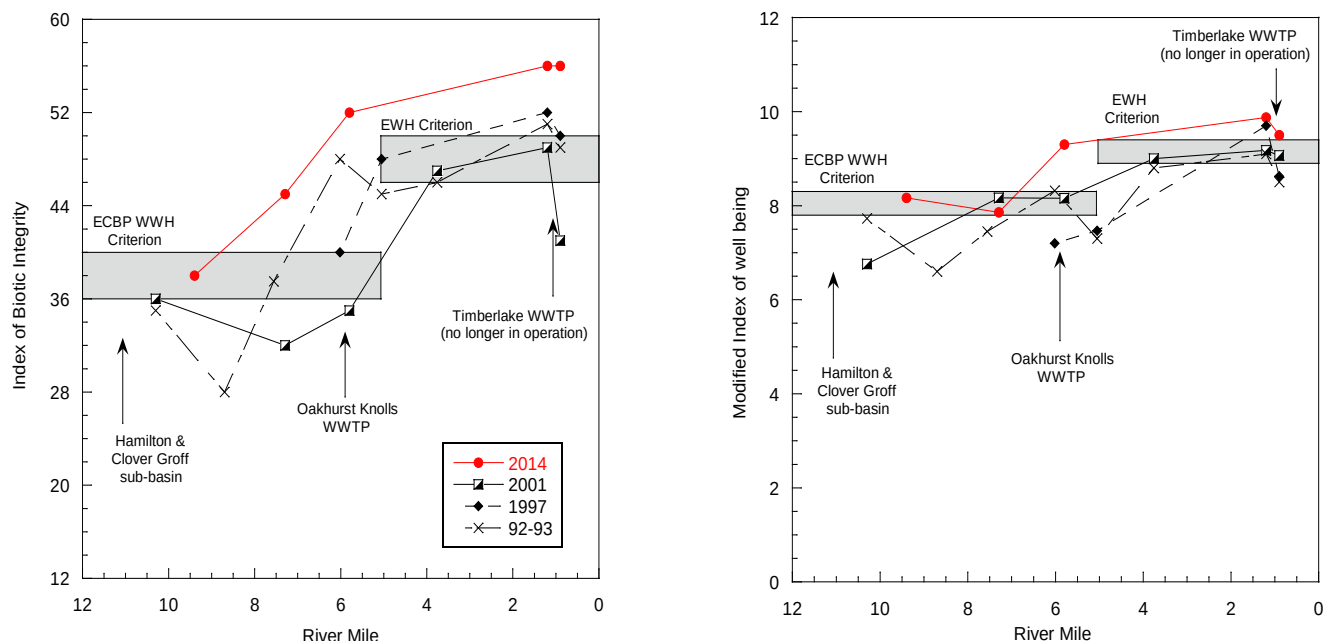


Figure 26. Longitudinal performance of IBI (left) and MIwb (right) from Hellbranch Run for selected years. Shaded regions represent areas of non-significant departure from indicated criteria.

Despite the readily apparent improvements observed in the fish community, the Hellbranch sub-watershed, particularly the eastern portion, still faces pressure from the rapid urban and suburban development of the western Columbus area. Increased urban runoff from impervious surfaces (*e.g.*, roads, parking lots, residential lawns), especially during precipitation events, is one of the major influences that urbanization is likely having on this sub-watershed. Increased urban runoff during precipitation events has likely increased the “flashy” aspect of this stream. A “flashy” stream is one that receives excessive overland runoff during precipitation events which causes a rapid and pronounced rise in stream discharge followed by a similar rapid decrease. This situation typically occurs in streams that have altered drainage networks or those that drain areas with a high density of impervious surfaces. A modified, “flashy” flow regime can negatively influence biological communities. Urban runoff can also convey undesired contaminants into receiving streams (*i.e.*, lawn pesticides and fertilizer, oil from impervious surfaces). Measures should be taken to further buffer the Hellbranch stream system from the effects of urbanization, especially in tributaries that drain into Hellbranch Run. The ultimate focus of these efforts should be centered around slowing down or intercepting overland runoff before it reaches receiving streams, effectively maintaining as natural a flow regime as possible.

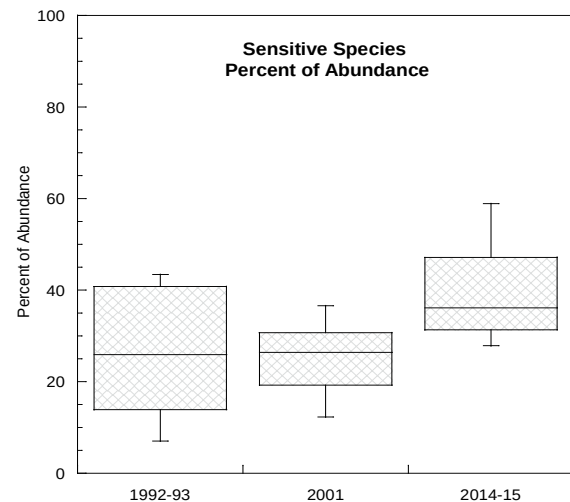


Figure 27. Percent abundance of sensitive species from all locations sampled in Hellbranch Run for selected years.

It is critically important to note that habitat restoration efforts in the headwaters region of this particular sub-watershed may not always immediately manifest themselves as site-specific improvements in the biological community given the modified nature of the system and overall basin characteristics (*i.e.*, low stream gradients), particularly in tributaries to Hellbranch Run. When evaluating the efficacy of these restoration projects through time, it is not only important to measure site-specific improvements in habitat and biology, but it is arguably just as important to use biological performance in the downstream reaches of Hellbranch Run as an overall indicator of the cumulative effects of habitat restoration efforts in the upper reaches of this system.

Hamilton, Clover Groff, and McCoy Runs

Hamilton and Clover Groff runs are two tributaries that join to form Hellbranch Run approximately 11 miles upstream from its confluence with Big Darby Creek. Fish community performance was evaluated at three locations within each stream. Sites situated within the existing MWH-C portions of these streams fully met the applicable IBI criterion, while sites situated in the existing WWH portions did not meet the WWH criterion (Figure 28). Narrative evaluations indicate poor fish community performance throughout Hamilton Run and fair to poor community performance in Clover Groff Run. No discernable historical trends are readily apparent and IBI scores in these small tributaries appear to be somewhat stochastic, but trending toward the poor-fair range. In 2014 and historically, fish in these streams were dominated by species that are highly tolerant (green sunfish, creek chub, bluntnose minnow) and ones that favor pooled, somewhat stagnant conditions (bluegill, green sunfish, bullhead catfish).

Fish community performance in these tributaries continues to be suppressed primarily by suboptimal habitat quality, which likely exacerbates any attendant water chemistry issues that may be present, especially in upstream reaches. Historically, un-ionized ammonia concentrations and nutrient enrichment contributed to low D.O. concentrations observed in these streams and subsequent biological impairment. It appears that some of these issues may have been reduced in severity since the last major survey in 2001, as only one D.O. exceedance was observed in the upper reaches of Hamilton Run; TP and nitrite-nitrate concentrations were above target concentrations at several locations in Hamilton Run and were largely below target concentrations in Clover Groff Run. These two streams also do not benefit from the same degree of groundwater input as observed in other streams within the basin; substantial groundwater inputs can buoy fish community performance despite the presence of anthropogenic stressors and habitat deficiencies, as has been demonstrated in other streams in the basin (Ohio EPA 2004).

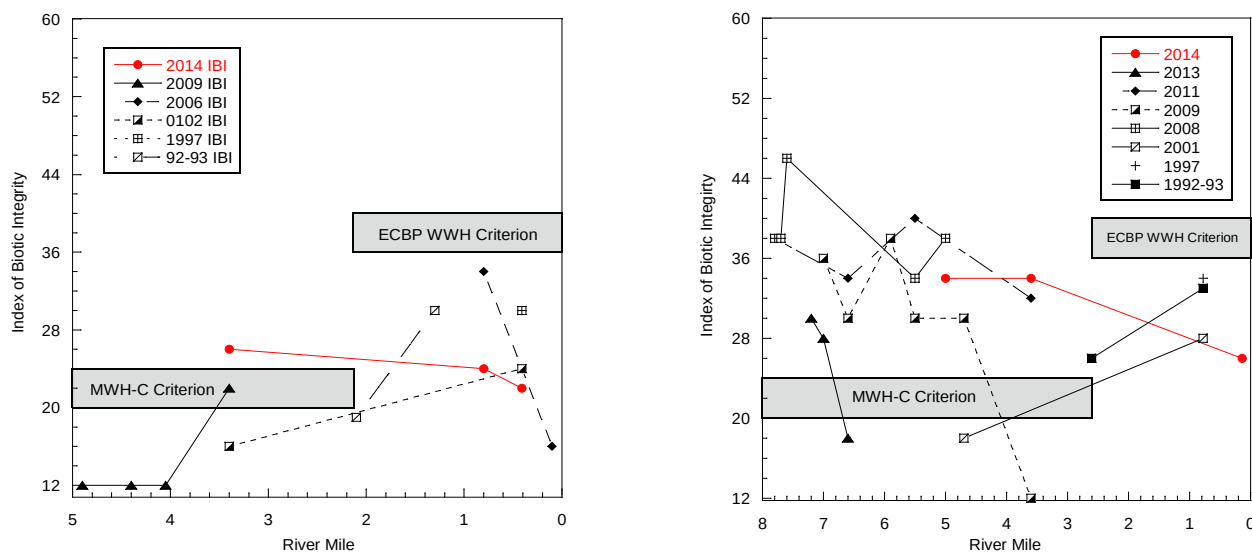


Figure 28. Longitudinal performance of IBI scores from Hamilton Run (left) and Clover Groff Run (right) from selected years. Shaded regions represent areas of non-significant departure from indicated criteria.

McCoy Run is a small tributary to Hamilton Run that joins just upstream from the confluence of Hellbranch Run. Fish community performance in McCoy Run was evaluated at one location near the mouth and an IBI of 26 was indicative of poor overall fish community performance. Slight declines have occurred since 2006, the only other evaluation of this stream, when an IBI of 34 was recorded. The fish community in this stream shared many attributes with those of Hamilton and McCoy runs. Very low overall numbers of fish collected in both years (<50 individuals) can disproportionately affect various IBI metrics and can cause certain metrics to increase/decrease with only nominal shifts in abundances of various fish taxa. An IBI can be “low-end” scored when the relative number of all individuals reaches a minimum threshold; the fish community in McCoy Run did not meet this threshold. Many negative habitat attributes at this location can be attributed to historical channelization activities and are likely precluding more significant recovery. McCoy Run also has characteristics of a wetland-type stream, such as the dominant substrate types and the ubiquitous presence of aquatic macrophytes, which can naturally limit biological performance, especially with regard to the fish community. Given more time to recover from historical channelization activities, a fish community consistent with expectations for a WWH stream should be achievable.

Little Darby Creek Tributaries

Clover Run

Clover Run is a small WWH-designated tributary that joins Little Darby Creek immediately south of Mechanicsburg. This stream originates in the boulder belt of the Cable moraine and drains some of the hilliest portions of the entire watershed. Because of this, Clover Run has sufficient stream gradient and substantial ground water input, both of which are desirable traits and benefit stream biology over the long term. An IBI of 50 indicated exceptional fish community performance, which was substantially improved since 2001 when an IBI of 36 was recorded. Mottled sculpin, an obligate cold-water species, comprised approximately 20% of the fish community; its presence reflected the cool ground water character of this stream. The abundance of darters increased nearly 9% from 2001 to 2014, while the abundance of the highly tolerant creek chub decreased by approximately 14% over the same time period. Based on the substantial presence of obligate cold-water fish, this stream is being recommended the CWH aquatic life use designation.

Lake Run

Lake Run is a small EWH-designated tributary that joins Little Darby Creek just north of Mechanicsburg. It flows through the Cable moraine and has several glacial kettle lakes situated on or draining into it, all of which influence the cool ground water character and sufficient gradient of this stream. The fish community was evaluated at one location and an IBI of 56 was indicative of excellent fish community performance, which achieved EWH expectations. Fish community performance improved substantially since 2001 when an IBI of 42 was recorded. Since 2001, the proportion of sensitive species increased approximately 31.8%, while the proportion of highly tolerant species decreased by 28.3%. Over the same time period, the proportion of simple lithophils (+22.2%) and headwater taxa (+11.9%) increased, while the proportion of pioneering taxa (-28.7%) decreased. Driving these trends were an increase in darter abundance (+38.7 %) and a decrease in the highly tolerant creek chub (-13.1%) and green sunfish (-13.6%) abundances. Biological performance here no longer appears limited by excess siltation or substrate embeddedness, which were identified as the primary stressors during the previous monitoring effort.

Of special note was the presence of the state listed least darter (species of concern) at this sampling location. The species has been found, currently and/or historically, at relatively low abundances in several small tributaries to Little Darby Creek. Current sampling results indicate that this species appears to be persisting in many of these tributaries, including Lake Run, Jumping Run, and Spring Fork. In Lake Run, one individual was collected in 2014 and three were collected in 2001.

Jumping Run

Jumping Run is a small WWH-designated tributary to Lake Run. An IBI of 48 at the one location assessed indicated very good fish community performance; community performance has improved substantially since 2001 when an IBI of 30 was recorded at the same location. The abundance of sensitive taxa increased 19.4% since 2001, while the abundance of highly tolerant taxa decreased 37.3% over the same time period. Additionally, the abundance of simple lithophilic (+26.2%), insectivorous (+32.4%), and headwater (+6.5%) taxa increased, while pioneering (-15.3%) and generalist/omnivorous feeding (-28.5%) taxa decreased. Driving these improvements was an increased darter abundance (+37.9%) with corresponding decreases in highly tolerant taxa such as creek chub (-15.5%), green sunfish (-12.4%), and white sucker (-15.8%). Eight individuals of the state listed species of concern least darter were collected from this

sampling location; this is the first Ohio EPA record of least darters in this small tributary, which had only been sampled one other time in 2001. Fish community performance in Jumping Run, as measured by the IBI score, exceeded the existing WWH criterion and is in non-significant departure from EWH criterion. Based on observed biological community performance, the entirety of Jumping Run is being recommended the EWH aquatic life use designation. All else being equal, fish community performance should continue on a stable to improving trajectory.

Treacle Creek

Treacle Creek is a direct tributary to Little Darby Creek. The fish community was evaluated at three locations and was fully meeting or in non-significant departure from the existing EWH IBI criterion at the two most upstream sites, while both IBI and MIwb scores deviated from EWH expectations at the most downstream location (Figure 29, Table 9). Fish community performance, as indicated by the IBI, has improved substantially through time at the two most upstream locations, while community performance at the most downstream location has remained relatively stable and consistently below EWH criteria (Figure 29). At the two upstream locations, the abundance of sensitive species (+13.1%), simple lithophils (+14.7%), insectivorous (+27.8%) and headwater (+6.2%) fish taxa increased, while the abundance of highly tolerant (-16.4%), generalist/omnivorous feeding (-16.4%), and pioneering (-8.3%) fish species decreased.

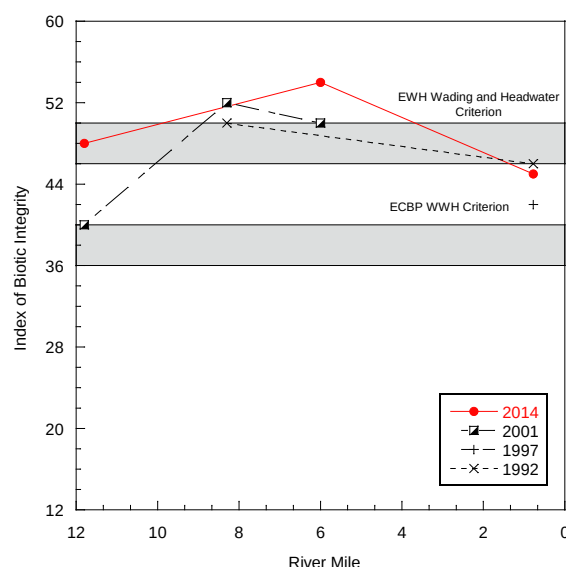


Figure 29. Longitudinal performance of IBI scores from Treacle Creek for selected years. Shaded areas represent areas of non-significant departure from indicated criteria.

Fish community performance at RM 0.78 has changed little since it was first evaluated in 1992. Habitat evaluations at this location have consistently yielded scores performing in the poor range, well below what would be expected for a stream segment capable of supporting a fish community consistent with EWH expectations (Figure 29). Thick silt deposits blanketed the natural substrates throughout much of the sampling location and were an obvious factor limiting overall biological performance. This lower location has been historically channelized and has consistently had issues with free cattle access to the stream (see [Stream Physical Habitat section](#)). The downstream reach also has a lower overall gradient than the rest of Treacle Creek, which reduces stream power and further limits the ability of the stream to flush excess silts/sediment and recover natural habitat features.

In addition to the obvious habitat limitations at this location, definitive signs of organic enrichment were observed. Multiple minimum D.O. concentration exceedances were observed and likely further limited biological performance. Continuous water quality sonde monitors revealed both minimum and 24-hour D.O. concentrations well below the EWH criteria in 2014, with minimum and 24-hour averages as low as 0.15 mg/L and 2.34 mg/L, respectively. Follow up sampling in 2015 still revealed minimum and 24-hour average D.O. exceedances, though not as severe as in 2014. Likely sources include excess organic waste from cattle intrusion into the stream and also potentially a grain spill observed by Ohio EPA staff that occurred in 2014. The persistence of D.O. concentration exceedances through multiple years may indicate a chronic condition driven primarily by excess organic enrichment; the grain spill in 2014 likely exacerbated existing conditions, resulting in the lower D.O. concentration observed in 2014. Establishing

cattle exclusion fences where necessary and establishing more substantial riparian buffers throughout the Treacle Creek sub-watershed will help to improve conditions here and elsewhere throughout this stream.

Proctor Run

Proctor Run is a small EWH-designated tributary to Little Darby Creek. The fish community was evaluated at two locations; IBI scores of 48 (RM 4.9) and 56 (RM 1.6) indicated very good to excellent fish community performance. Fish community performance either fully met or was in non-significant departure from the existing EWH criterion. Fish community performance has generally improved since 2001, when IBI scores of 42 and 52 were recorded at RM 4.9 and RM 1.6, respectively. Compared to 2001 collections, the abundance of sensitive species increased approximately 18.3% at both locations, while the abundance of highly tolerant species decreased approximately 13.6%. Additionally, the abundance of insectivorous fish taxa increased 6.7%, while the abundance of generalist/omnivorous feeding fish taxa decreased approximately 8.6%. Driving these trends was a substantial increase in darter abundance, specifically rainbow darters, coupled with decreases in abundance of the highly tolerant white sucker. These trends were even more pronounced in the upper reaches of Proctor Run.

Barron Creek

Barron Creek is a small WWH-designated tributary that drains directly to Little Darby Creek. The fish community was evaluated at one location and an IBI of 48 indicated very good community performance. Fish community performance fully met the existing WWH criterion. Fish community performance in Barron Creek remained relatively stable since it was first evaluated in 2001, when an IBI of 48 was recorded at RM 2.2. Fish taxa favoring rooted aquatic vegetation that would be expected in clear, cool water, vegetated prairie streams predominated (central mudminnow, grass pickerel, orangethroat darter, tadpole madtom), which is not surprising given the extensive amounts of overhanging grasses/vegetation and presence of aquatic macrophytes. Fish community performance in Barron Creek also benefits from substantial ground water connectivity, effectively ameliorating habitat deficiencies related to historical channelization activities.

Wamp Ditch

The fish community was evaluated at one location in this small WWH-designated tributary. An IBI of 50 indicated excellent community performance meeting the existing WWH criterion. This a significant improvement over the IBI score of 30 recorded in 2001. Performance of all major organism indicator groups improved substantially. For example, simple lithophilic taxa were completely absent in 2001, but comprised 41.6% of the overall community in 2014. Only four fish species were recorded in 2001, while 14 species were observed in 2014. Improved fish community performance has likely resulted from gradual, site-specific habitat improvements coupled with larger, basin-wide improvements in fish community performance. Similar to Barron Creek, fish community performance is likely buoyed to some extent by substantial ground water inputs to all streams in this geographic region. Despite considerable improvements in fish community performance, macroinvertebrate community performance still appeared limited by generally deficient habitat and nutrient enrichment.

Spring Fork

The fish community was evaluated at three locations in Spring Fork and fully met the existing EWH criterion at all three sites (Table 9). Fish community performance was solidly in the exceptional range where evaluated. Fish community performance improved in 2014 compared to historical values (Figure 30). Cumulative fish taxa increased from 24 in 2001 to 29 in 2014, several of which (e.g. banded darter, logperch darter) are considered sensitive species. At sites in the upper reaches evaluated both in 2014 and 2001, the abundance of sensitive (+22.1%), simple lithophilic (+15.2), and insectivorous (+22.2%) fish taxa were proportionately much higher in 2014 than in 2001, while the abundance of highly tolerant (-26.9%), pioneering (-27.1%), and generalist/omnivorous feeding (-26.8%) fish taxa decreased in abundance. Driving these trends was an approximately 21% increase in the abundance of rainbow and greenside darters and a 23% decrease in creek chub and bluntnose minnow abundance in 2014 compared to 2001. The majority of Spring Fork flows through glacial moraine which contributes to the strong ground water character of this stream and is beneficial to the stream biology. Of special note is the continued persistence of the state listed least darter (species of concern) in the headwaters region of Spring Fork, though it appears they are slightly reduced in overall abundance.

Attempts were made to collect an additional sample near the mouth at RM 0.75 to evaluate the downstream effects, if any, of the Green Meadows mobile-home park WWTP, but landowner permission was not granted. Fish community performance in Little Darby Creek downstream from Spring Fork did not appear affected by discharge from this tributary.

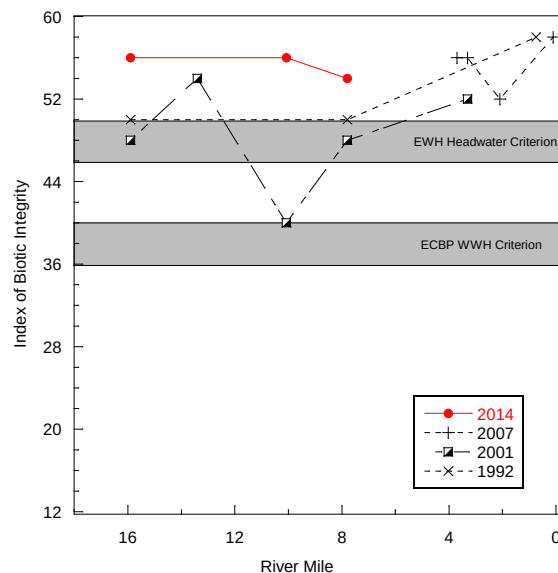


Figure 30. Longitudinal performance of IBI scores from Spring Fork for selected years. Shaded areas represent areas of non-significant departure from indicated criterion.

Table 9. Fish community summaries based on pulsed D.C. electrofishing sampling conducted by Ohio EPA in the Big Darby Creek watershed during the 2014 and 2015 sampling index periods. Data from two locations in Hellbranch Run was collected in 2015 and is denoted by [brackets]. Relative numbers and weights are per 0.3 km for wading and headwater sites, and per 1.0 km for boat sites.

River Mile	Drainage Area (Mi ²)	Cumulative No. All Species	Relative Number minus Tolerant Spp.	Relative Number (all)	QHEI (Habitat)	IBI	MIwb	Narrative Evaluation (IBI/MIwb)
Big Darby Creek 02-200-000 EWH & CWH Existing								
83.20	1.5 ^H	14	716.0	1252.0	77.25	54	N/A	Exceptional
81.90	2.2 ^H	14	1918.0	3100.0	58.00	54	N/A	Exceptional
81.60	3.0 ^H	21	2122.0	3634.0	57.25	50	N/A	Exceptional
81.10	3.2 ^H	19	840.0	1071.2	67.50	54	N/A	Exceptional
80.75	4.5 ^H	23	924.0	1212.0	71.50	56	N/A	Exceptional
79.23	5.6 ^H	19	550.6	974.3	55.25	50	N/A	Exceptional
Big Darby Creek 02-200-000 EWH Existing								
78.30	26.5 ^W	28	720.0	957.0	68.25	54	9.26^{NS}	Exceptional
76.54	32.0 ^W	39	1322.3	1882.5	80.50	56	10.03	Exceptional/Exceptional
69.34	71.0 ^W	32	1259.3	1558.6	79.50	55	9.90	Exceptional/Exceptional
66.10	85.0 ^W	33	1799.3	1847.3	78.75	55	10.16	Exceptional/Exceptional
64.38	86.0 ^W	36	2436.8	2639.3	78.25	54	10.66	Exceptional/Exceptional
62.60	121.0 ^W	35	867.0	925.5	76.25	57	9.91	Exceptional/Exceptional
58.80	131.0 ^W	29	711.8	861.8	70.00	55	9.15^{NS}	Exceptional/Very Good
54.10	138.0 ^W	31	999.5	1092.1	78.25	54	9.87	Exceptional/Exceptional

River Mile	Drainage Area (Mi ²)	Cumulative No. All Species	Relative Number minus Tolerant Spp.	Relative Number (all)	QHEI (Habitat)	IBI	MIwb	Narrative Evaluation (IBI/MIwb)
51.10	157.0 ^W	34	767.5	959.7	83.75	54	9.76	Exceptional/Exceptional
49.46	193.0 ^W	34	814.5	853.4	81.50	55	9.76	Exceptional/Exceptional
41.75	239.0 ^W	32	853.2	906.0	85.75	57	9.87	Exceptional/Exceptional
38.90	247.0 ^W	32	603.7	691.1	87.50	51	9.20^{NS}	Exceptional/Very Good
38.33	248.0 ^W	27	751.9	853.0	87.75	55	9.67	Exceptional/Exceptional
34.15	253.0 ^W	45	1289.2	1371.5	93.25	59	10.74	Exceptional/Exceptional
30.17	448.0 ^B	37	978.0	1012.0	86.25	60	11.32	Exceptional/Exceptional
27.95	450.0 ^B	44	1416.2	1486.6	86.00	55	11.21	Exceptional/Exceptional
26.80	454.0 ^B	39	1122.5	1188.8	86.00	55	10.70	Exceptional/Exceptional
25.70	495.0 ^W	35	888.6	898.6	82.25	56	9.99	Exceptional/Exceptional
25.70	495.0 ^B	34	1302.0	1314.0	82.25	52	10.82	Exceptional/Exceptional
23.75	501.0 ^B	51	1468.0	1501.0	90.75	55	11.67	Exceptional/Exceptional
22.25	503.0 ^B	47	1173.4	1233.6	90.25	54	11.66	Exceptional/Exceptional
21.35	506.0 ^B	41	828.0	860.0	88.50	56	11.79	Exceptional/Exceptional
19.10	513.0 ^B	44	1112.3	1153.3	90.25	53	11.59	Exceptional/Exceptional
13.36	534.0 ^B	47	1136.8	1179.3	88.00	53	11.55	Exceptional/Exceptional
11.30	537.0 ^W	44	769.8	805.5	85.75	58	10.74	Exceptional/Exceptional
7.40	545.0 ^B	49	1477.3	1506.6	88.50	52	12.44	Exceptional/Exceptional
3.20	552.0 ^B	51	924.4	950.5	86.25	55	12.10	Exceptional/Exceptional
Flat Branch								
02-223-000								
MWH-C Existing								
0.90	12.7 ^H	30	281.3	624.8	53.75	45	N/A	Good
Little Darby Creek (Logan Co.)								
02-200-020								
EWB & CWH Existing								
3.61	2.9 ^H	14	916.8	1372.8	57.50	44^{NS}	N/A	Exceptional

River Mile	Drainage Area (Mi ²)	Cumulative No. All Species	Relative Number minus Tolerant Spp.	Relative Number (all)	QHEI (Habitat)	IBI	MIwb	Narrative Evaluation (IBI/MIwb)
0.34	7.2 ^H	19	775.3	1064.0	81.50	54	N/A	Exceptional
Spain Creek 02-222-000 EWH & CWH Existing								
3.70	6.3 ^H	19	1074.0	1745.0	72.25	54	N/A	Exceptional
0.01	9.6 ^H	32	1352.8	1924.0	73.25	58	N/A	Exceptional
Pleasant Run 02-221-000 EWH Existing								
0.01	9.4 ^H	27	2681.0	4010.0	53.25	54	N/A	Exceptional
Buck Run 02-209-000 WWH Existing								
10.40	4.8 ^H	16	104.0	270.0	50.50	36^{NS}	N/A	Marginally Good
7.80	9.0 ^H	22	278.0	638.0	60.00	42	N/A	Good
0.60	29.7 ^W	32	991.0	1338.0	80.00	53	9.78	Exceptional/Exceptional
Robinson Run 02-207-000 WWH Existing								
2.10	9.7 ^H	18	282.0	448.0	67.75	42	N/A	Good
0.70	10.5 ^H	21	644.0	852.0	86.25	50	N/A	Exceptional
Sweeny Run 02-200-016 WWH Existing								
0.20	3.9 ^H	10	676.0	906.0	57.00	50	N/A	Exceptional
Sugar Run 02-206-000 WWH Existing								
5.40	11.4 ^H	14	456.0	842.0	56.50	34*	N/A	Fair
0.43	19.4 ^H	22	350.0	522.0	75.25	44	N/A	Good

River Mile	Drainage Area (Mi ²)	Cumulative No. All Species	Relative Number minus Tolerant Spp.	Relative Number (all)	QHEI (Habitat)	IBI	MIwb	Narrative Evaluation (IBI/MIwb)
Worthington Ditch								
02-200-015			WWH Existing					
0.24	4.6 ^H	12	858.0	1106.0	63.50	50	N/A	Exceptional
Ballenger-Jones Ditch								
02-200-013			WWH Existing					
0.18	7.3 ^H	21	734.0	920.0	67.00	52	N/A	Exceptional
Fitzgerald Ditch								
02-205-000			WWH Existing					
0.55	5.9 ^H	17	1932.0	3108.0	55.75	48	N/A	Very Good
Little Darby Creek								
02-210-000			EWH & CWH Existing					
40.10	8.2 ^H	16	1038.0	1340.0	74.00	54	N/A	Exceptional
39.30	12.2 ^H	13	864.0	1314.0	81.00	48^{NS}	N/A	Very Good
38.78	12.7 ^H	22	418.0	1034.0	62.00	46^{NS}	N/A	Very Good
Little Darby Creek								
02-210-000			EWH Existing					
34.70	26.0 ^W	30	430.6	867.3	72.00	46^{NS}	8.50*	Very Good/Good
29.46	70.0 ^W	40	524.5	682.5	71.00	54	9.90	Exceptional/Exceptional
24.46	78.0 ^W	37	721.5	878.3	65.25	54	9.69	Exceptional/Exceptional
20.50	98.0 ^W	36	873.6	1065.7	74.00	57	9.83	Exceptional/Exceptional
17.25	142.0 ^W	36	1097.3	1179.5	86.75	58	10.05	Exceptional/Exceptional
15.30	147.0 ^W	35	906.5	975.0	78.25	60	10.12	Exceptional/Exceptional
13.35	149.0 ^W	37	1107.0	1194.1	88.75	59	10.13	Exceptional/Exceptional
8.20	161.0 ^W	37	1000.2	1082.7	91.00	58	9.86	Exceptional/Exceptional
7.35	162.0 ^W	40	1434.0	1617.0	87.00	58	10.31	Exceptional/Exceptional
3.95	170.0 ^W	36	1174.2	1220.3	92.50	56	10.21	Exceptional/Exceptional
0.07	178.0 ^W	40	839.8	884.0	81.9	56	9.43	Exceptional/Exceptional

River Mile	Drainage Area (Mi ²)	Cumulative No. All Species	Relative Number minus Tolerant Spp.	Relative Number (all)	QHEI (Habitat)	IBI	MIwb	Narrative Evaluation (IBI/MIwb)
Clover Run 02-218-000 WWH Existing/CWH Recommended								
0.60	1.9 ^H	12	438.0	1312.0	65.00	50	N/A	Exceptional
Lake Run 02-216-000 EWH Confirmed								
0.95	5.7 ^H	21	966.0	1412.0	77.00	56	N/A	Exceptional
Jumping Run 02-217-000 WWH Existing/EWH Recommended								
0.27	1.8 ^H	14	353.8	641.4	70.25	48^{NS}	N/A	Very Good
Treacle Creek 02-213-000 EWH Existing								
11.80	6.9 ^H	17	705.0	1365.0	71.25	48^{NS}	N/A	Very Good
6.00	12.9 ^H	21	736.0	1088.0	62.50	54	N/A	Exceptional
0.78	36.0 ^W	25	315.8	465.0	40.50	45*	8.50*	Good/Good
Proctor Run 02-214-000 EWH Existing								
4.90	8.8 ^H	16	318.0	586.0	64.00	48^{NS}	N/A	Very Good
1.60	9.9 ^H	26	761.1	1095.4	76.50	56	N/A	Exceptional
Barron Creek 02-212-000 WWH Existing								
0.20	8.2 ^H	20	447.9	765.0	63.25	48	N/A	Very Good
Wamp Ditch 02-210-001 WWH Existing								
0.10	5.5 ^H	14	434.0	500.0	54.50	50	N/A	Exceptional
Spring Fork 02-211-000 EWH Existing								
15.90	4.8 ^H	21	614.0	754.0	75.00	56	N/A	Exceptional

River Mile	Drainage Area (Mi ²)	Cumulative No. All Species	Relative Number minus Tolerant Spp.	Relative Number (all)	QHEI (Habitat)	IBI	MIwb	Narrative Evaluation (IBI/MIwb)
10.08	15.0 ^H	22	1196.0	1648.0	57.50	56	N/A	Exceptional
7.80	19.5 ^H	25	1275.9	1694.1	57.75	54	N/A	Exceptional
Smith Ditch 02-200-009 EWH Existing								
0.20	7.8 ^H	15	261.0	385.5	77.00	52	N/A	Exceptional
Hellbranch Run 02-204-000 WWH Existing								
9.40	23.1 ^W	19	598.2	1205.5	70.00	38^{NS}	8.17^{NS}	Marginally Good/Marginally Good
7.29	27.8 ^W	21	251.3	414.0	72.75	47	7.88^{NS}	Very Good/Marginally Good
5.80	32.0 ^W	28	654.4	925.5	91.50	52	9.30	Exceptional/Very Good
Hellbranch Run 02-204-000 EWH Existing								
[1.20]	[37.4 ^W]	[35]	[1230.0]	[1338.3]	[75.50]	[56]	[9.88]	Exceptional/Exceptional
[0.70]	[37.4 ^W]	[32]	[1211.2]	[1449.8]	[77.25]	[56]	[9.50]	Exceptional/Exceptional
Hamilton Run 02-204-002 MWH-C Existing								
3.40	3.6 ^H	6	36.0	104.0	43.50	26	N/A	Poor
Hamilton Run 02-204-002 WWH Existing								
0.80	6.6 ^H	11	61.9	288.8	47.50	<u>24*</u>	N/A	Poor
0.41	9.7 ^H	6	42.0	176.0	58.25	<u>22*</u>	N/A	Poor
McCoy Run 02-204-003 Undesignated/WWH Recommended								
0.10	3.1 ^H	7	22.0	66.0	44.00	<u>26*</u>	N/A	Poor

River Mile	Drainage Area (Mi ²)	Cumulative No. All Species	Relative Number minus Tolerant Spp.	Relative Number (all)	QHEI (Habitat)	IBI	MIwb	Narrative Evaluation (IBI/MIwb)
Clover Groff Run 02-204-001 MWH-C Existing								
5.00	4.6 ^H	10	121.9	211.0	39.00	34	N/A	Fair
3.60	5.7 ^H	9	182.0	334.0	56.50	34	N/A	Fair
Clover Groff Run 02-204-001 WWH Existing								
0.10	9.9 ^H	8	35.6	125.6	47.25	<u>26*</u>	N/A	Poor
Springwater Run 02-203-000 WWH Existing/CWH Recommended								
0.80	3.4 ^H	8	688.0	1348.0	50.25	48	N/A	Very Good
Trib. to Big Darby Creek (23.61) 02-200-024 Undesignated/CWH Recommended								
0.10	0.60 ^H	8	166.0	606.0	44.75	48	N/A	Very Good

^{ns} - Non-significant departure from biocriterion (≤ 4 IBI units; ≤ 0.5 MIwb units).

H, W, or B - Denotes headwater (H), wading (W), or boat (B) site type.

* - Significant departure from biocriterion (> 4 IBI units; > 0.5 MIwb units). Poor and very poor results are underlined.

N/A - Not Applicable

Eastern Corn Belt Plains Biocriteria

INDEX - Site Type	WWH	EWB
IBI: Headwater/Wading/ Boat	40/ 40/ 42	50/ 50/ 48
MIwb: Wading/ Boat	8.3/ 8.5	9.4/ 9.6

Macroinvertebrate Community Overview and Trends

Macroinvertebrate communities were sampled in 28 streams at 94 sites, 93 of which were evaluated for attainment in 2014. (Table 2). In the aggregate, macroinvertebrates at 89 of 93 stations (95%) fully achieved existing or recommended aquatic life use expectations in the Big Darby Creek watershed during 2014. Included were 14 of 15 CWH designated sites which met community performance expectations for that use. Macroinvertebrate community quality was evaluated as exceptional at 54 stations, very good at 16, good at 11, marginally good at 8, and fair quality at 4 sites (Figure 31, Table 10).



Exceptional and highly diverse stream macroinvertebrate communities were documented during the 2014 survey. At least 100 different macroinvertebrate taxa were collected at ten sampling sites (range from 100 to 126 taxa), with highs of 126 taxa collected from the Big Darby Creek mainstem upstream from Scioto Darby Road (RM 19.5) and 121 taxa at Lewisburg Road (RM 76.6) (Table 10). In upper Little Darby Creek, a high total of 105 taxa were collected at Irwin Road (RM 34.70).

At eight sampling sites, at least 30 total Ephemeroptera/Plecoptera/Trichoptera (EPT) taxa (range from 30 to 36 taxa) were collected during the 2014 Big Darby Creek watershed survey (Table 10). A high of 36 EPT taxa was collected at two sites in the lower Big Darby Creek mainstem - at the end of Darby Road (RM 11.2) and near Fox at St. Rt. 104 (RM 3.1). There were also 35 EPT taxa collected upstream from and at Scioto Darby Road (RMs 19.5 and 19.1).

There were four Little Darby Creek sampling sites each with 29 total EPT taxa collected - ODNR property at Snyder Lane (RM 13.35), upstream Taylor-Blair Rd. (RM 8.95), near the Middle Pike Rd. bridge (RM 7.30), and in the Darby Creek Metropark off of Gardiner Road at RM 0.2 (Table 10).

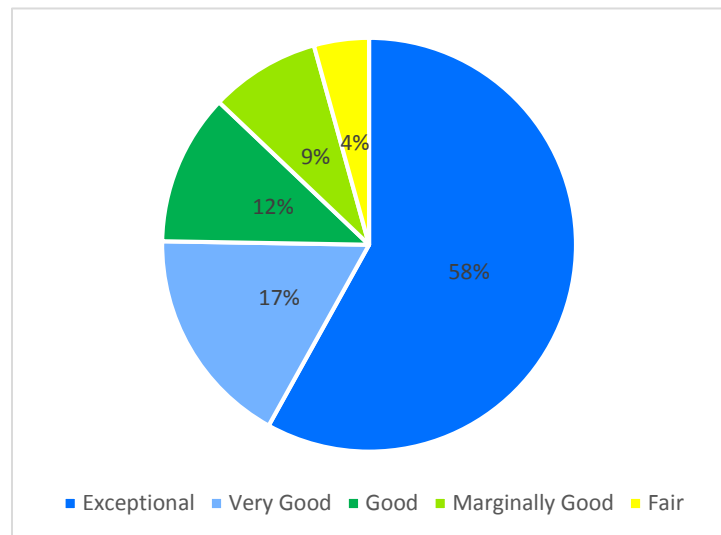


Figure 31. Percentages of macroinvertebrate community quality narrative evaluations for 93 sampled stream reaches in the Big Darby Creek Watershed 2014-15 survey.

Table 10. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Big Darby Creek watershed, 2014. ICI scores and narrative evaluations are color coded by quality: **Exceptional**, **very good**, **good**, **marginally good**, and **fair**.

Stream RM	Dr. Ar. (sq. mi.)	Total Taxa	Quant. Taxa	Qual. Taxa ^a	EPT Taxa Ql. / Total ^b	Sensitive Taxa Ql. / Total ^c	CW Taxa ^d	Ql. Tol. Taxa ^e	Relative Density Qual. / Quant. ^f	Predominant Organisms on the Natural Substrates with Tolerance Category(ies) ^g			ICI ^h	Narrative Evaluation ⁱ	
Big Darby Creek (02-200-000) EWH & CWH Existing															
83.2	1.5	81	50	57	17	20	19	25	9	7	Mod.	623/ ft. ²	Hydropsychid (F,MI,CW) & <i>Chimarra</i> caddisflies (MI), baetid mayflies (MI,F)	52	Exceptional
83.1	1.5	84	49	61	17	21	16	23	8	8	Mod. -Low	386/ ft. ²	<i>Macaffertium vicarium</i> mayflies (MI), hydropsychid caddisflies (F,MI,CW)	50	Exceptional
81.9	2.2	74	42	53	17	21	12	20	8	5	Mod.	490/ ft. ²	Hydropsychid (F,MI,CW) & <i>Helicopsyche</i> caddisflies (MI), <i>Macaff. vicarium</i> (MI) & baetid mayflies (F,MI), riffle beetles (F)	56	Exceptional
81.7	3.0	94	57	70	12	15	8	16	5	19	Mod. -High	802/ ft. ²	Fingernail clams (F), <i>Helicopsyche</i> (MI) & <i>Hydroptila</i> caddisflies (F)	54	Exceptional
81.0	3.2	92	51	74	21	24	16	21	1	14	Mod.	263/ ft. ²	Hydropsychid (F,MI) & <i>Helicopsyche</i> caddisflies (MI), mayflies (F,MI,I)	56	Exceptional
80.70	4.5	101	65	84	25	28	23	26	6	13	Mod.	344/ ft. ²	Hydropsychid caddisflies (F,MI), baetid mayflies (F,MI), & cased caddisflies – <i>Helicopsyche</i> , <i>Neophylax</i> , and <i>Nyctiophylax</i> spp. (F,MI)	56	Exceptional
79.2 _{RR}	5.6	91	57	63	24	26	22	29	4	5	Mod. -Low	198/ ft. ²	Baetid mayflies (F,MI), <i>Neophylax</i> (MI) and hydropsychid caddisflies (F,MI,CW)	58	Exceptional
Big Darby Creek (02-200-000) EWH Existing															
78.3	19.4	85	46	61	17	23	16	26	2	9	Mod. -Low	297/ ft. ²	Hydropsychid caddisflies (F,MI), baetid mayflies (F,MI), <i>Neophylax</i> caddisflies (MI), fingernail clams (F)	48	Exceptional
76.53	32	121	45	102	25	28	27	34	2	18	Low - High	617/ ft. ²	Hydropsychid caddisflies (F,MI,CW), baetid mayflies (F,MI), <i>Rheotanytarsus</i> midges (F)	52	Exceptional
76.53	32	115	41	102	25	28	27	34	3	18	Mod. -High	1055/ ft. ²	Replicate sample. Similar community to above.	58	Exceptional

Stream RM	Dr. Ar. (sq. mi.)	Total Taxa	Quant. Taxa	Qual. Taxa ^a	EPT Taxa Ql. / Total ^b		Sensitive Taxa Ql. / Total ^c		CW Taxa ^d	Ql. Tol. Taxa ^e	Relative Density Qual. / Quant. ^f		Predominant Organisms on the Natural Substrates with Tolerance Category(ies) ^g	ICI ^h	Narrative Evaluation ⁱ
68.35	71.7	59	-	59	18	18	19	19	0	4	Mod.	-	Hydropsychids (F,MI) and <i>Neophylax</i> (MI) caddisflies, mayflies (F,MI)	VG ^{ns}	Very Good
66.2	83.1	70	34	52	13	16	22	24	0	4	Mod. -High	699/ ft.2	<i>Neophylax</i> caddisflies (MI), baetid mayflies (F,MI), Hydropsychids (F,MI)	46	Exceptional
63.9	85	80	37	59	14	21	15	24	0	7	Mod. -High	1086/ ft.2	<i>Neophylax</i> (MI) and hydropsychid (F,MI) caddisflies, baetid mayflies (F,MI)	52	Exceptional
62.75	121	72	-	72	24	24	24	24	0	8	Mod.	-	<i>Neophylax</i> caddisflies (MI), baetid mayflies (F,MI)	E	Exceptional
59.9	131	70	-	70	22	22	26	26	0	8	Mod.	-	Hydropsychid (F,MI) and <i>Neophylax</i> (MI) caddisflies, heptageniid and baetid mayflies (F,MI), <i>Agneta flavescens</i> (I) stoneflies, water penny beetles (MI)	E	Exceptional
54.1	138	91	43	73	21	25	25	31	0	11	Mod.	508/ ft.2	Hydropsychid caddisflies (F,MI), riffle beetles (F,MI), baetid & burrowing mayflies (F,MI)	52	Exceptional
50.95	157	63	30	48	19	24	22	26	0	6	Mod.	343/ ft.2	<i>Neophylax</i> caddisflies (MI), baetid mayflies (F,MI), <i>Elimia</i> snails (MI)	44 ^{ns}	Very Good
49.4	193	79	-	61	19	20	17	19	0	9	Mod.	X13	Hydropsychids (F,MI) and <i>Neophylax</i> (MI) caddisflies, baetid mayflies (F,MI)	E	Exceptional
41.6	239	85	47	67	25	29	28	33	0	6	Mod.	304/ ft.2	Baetid mayflies (F,MI), hydropsychids (F,MI) and <i>Neophylax</i> caddisflies (MI)	54	Exceptional
38.9	247	80	-	66	20	21	23	25	1	10	Mod.	X13, X15	Riffle beetles (F), baetid and heptageniid mayflies (F,MI), <i>Elimia</i> snails (MI)	E	Exceptional
38.35	248	75	-	75	32	32	37	37	0	7	Mod.	-	Hydropsychids (F,MI), baetid, heptageniid, and <i>Ephemera</i> mayflies (F,MI), <i>Elimia</i> snails (MI), water penny beetles (MI)	E	Exceptional
34.20	253	101	42	83	25	28	32	37	0	12	Mod. -High	1032/ ft.2 (X13)	Hydropsychids (F,MI) caddisflies, heptageniid and baetid mayflies (F,MI), Bryozoa colonies	48	Exceptional

Stream RM	Dr. Ar. (sq. mi.)	Total Taxa	Quant. Taxa	Qual. Taxa ^a	EPT Taxa Ql. / Total ^b		Sensitive Taxa Ql. / Total ^c		CW Taxa ^d	Ql. Tol. Taxa ^e	Relative Density Qual. / Quant. ^f		Predominant Organisms on the Natural Substrates with Tolerance Category(ies) ^g	ICI ^h	Narrative Evaluation ⁱ
29.25	448	91	50	65	21	26	26	35	0	11	Mod. -High	620/ ft. ²	Hydropsychid caddisflies(F,MI), baetid mayflies (F,MI), <i>Elimia</i> snails (MI)	50	Exceptional
27.95	450	84	37	72	24	30	30	38	0	9	Mod.	1248/ ft. ²	Hydropsychid caddisflies (F,MI), baetid mayflies (F,MI)	52	Exceptional
26.7	454	67	-	67	22	22	24	24	0	7	Mod.	-	Baetid mayflies (F,MI), hydropsychid (F,MI) & <i>Protophila</i> (I) caddisflies	E	Exceptional
26.0	495	85	47	66	24	27	25	30	0	8	Mod.	478/ ft. ² (X15)	Baetid mayflies (F,MI), <i>Stenacron</i> sp. (F), <i>M. pulchellum</i> & <i>Leucrocuta</i> sp. mayflies (MI)	54	Exceptional
23.9	501	99	44	82	31	34	31	37	0	13	Mod.	584/ ft. ² (X15)	Hydropsychid caddisflies (F,MI), baetid mayflies (F,MI), Tanytarsini midges (F,MI)	48	Exceptional
22.25	503	100	57	68	17	29	15	29	0	13	Mod.	805/ ft. ²	Baetid mayflies (F,MI), Tanytarsini midges (F), <i>Macaffertium</i> (F,MI) and <i>Stenacron</i> (F) mayflies	48	Exceptional
22.0	506	90	48	70	22	29	37	38	0	9	Mod.	1044/ ft. ²	Baetid mayflies (F,MI), <i>Petrophila</i> moth larvae (MI), <i>Ceratopsyche morosa</i> gr. (MI) & other hydropsychid caddisflies (MI,F), <i>Macaffertium pulchellum</i> & other heptageniid mayflies (MI)	56	Exceptional
19.5	511	127	60	98	26	36	44	56	0	16	Mod. -High	1513/ ft. ²	Baetid mayflies (F,MI), <i>Protophila</i> sp. (I) & hydropsychids (F,MI) caddisflies, <i>Stenacron</i> sp. (F), <i>M. pulchellum</i> & other heptageniid mayflies (MI)	54	Exceptional
19.1	513	115	40	103	34	35	50	54	0	13	Mod.	1051/ ft. ²	<i>C. morosa</i> gr. & other hydropsychid caddisflies (MI,F), baetid mayflies (F,MI), <i>Chimarra</i> (MI) and <i>Protophila</i> caddisflies (I), <i>Elimia</i> snails , and riffle beetles (F,MI)	54	Exceptional
13.2	534	83	29	68	21	23	28	34	1	10	Mod.	X8, X15	Baetid mayflies (F,MI), <i>Elimia</i> snails (MI), Tanytarsini midges (F,MI)	E	Exceptional

Stream RM	Dr. Ar. (sq. mi.)	Total Taxa	Quant. Taxa	Qual. Taxa ^a	EPT Taxa Ql. / Total ^b		Sensitive Taxa Ql. / Total ^c		CW Taxa ^d	Ql. Tol. Taxa ^e	Relative Density Qual. / Quant. ^f		Predominant Organisms on the Natural Substrates with Tolerance Category(ies) ^g	ICI ^h	Narrative Evaluation ⁱ
11.2	537	106	50	86	33	36	41	46	0	7	Mod.	906/ft. ²	Baetid mayflies (F,MI,I), hydropsychid caddisflies (F,MI), <i>Stenelmis</i> riffle beetles (F), <i>M. pulchellum</i> and other heptageniid mayflies (MI,F)	56	Exceptional
9.15	540	81	37	74	23	25	30	34	0	10	Mod.-High	3611/ft. ²	<i>Cheumatopsyche</i> , <i>C. morosa</i> gr. (F,MI), <i>Protophila</i> (I), <i>Chimarra</i> (MI) and <i>Hydroptila</i> caddisflies (F); baetid mayflies (F,I,MI)	54	Exceptional
7.65	545	78	30	73	24	26	28	30	0	11	Mod.-High	1608/ft. ²	<i>C. morosa</i> gr. (MI) & others (MI,F), baetids (F,MI), <i>Chimarra</i> caddisflies (MI), and <i>Rheotanytarsus</i> midges (F)	48	Exceptional
3.1	552	106	40	92	33	36	38	46	0	11	High	2363/ft. ²	<i>Ceratopsyche morosa</i> gr. (MI), <i>Cheumatopsyche</i> (F) & other hydropsychid caddisflies (MI); baetid mayflies (F,I,MI), <i>Protophila</i> caddisflies (I), Tanytarsini midges (F,MI)	54	Exceptional
Flat Branch (02-223-000) MWH - C Existing															
0.8	13.0	63	31	47	10	12	6	12	0	9	Mod.	668/ft. ²	Baetid mayflies (F,MI), <i>Rheotanytarsus</i> midges (F,MI), Hydropsychid caddisflies (F,MI)	44 ^{ns}	Very Good
Little Darby Creek (Logan Co.) (02-200-020) EWH & CWH Existing															
3.6	3.1	109	79	83	24	30	26	31	10	13	Mod.-High	1433/ft. ²	Caddisflies [hydropsychids, hydroptilids, <i>Glossosoma</i> sp. (F,CW,MI)], Tanytarsini midges (F,MI,CW), baetid mayflies (MI,F,CW,I)	44 ^{ns}	Very Good
0.1	7.2	75	42	55	18	26	20	26	9	5	Mod.-Low	668/ft. ²	Tanytarsini midges (F,MI,CW), Hydropsychid caddisflies (F,CW,MI)	54	Exceptional

Stream RM	Dr. Ar. (sq. mi.)	Total Taxa	Quant. Taxa	Qual. Taxa ^a	EPT Taxa Ql. / Total ^b	Sensitive Taxa Ql. / Total ^c	CW Taxa ^d	Ql. Tol. Taxa ^e	Relative Density Qual. / Quant. ^f	Predominant Organisms on the Natural Substrates with Tolerance Category(ies) ^g			ICI ^h	Narrative Evaluation ⁱ	
Spain Creek (02-222-000) – EWH & CWH Existing															
3.6	6.3	73	40	56	17	19	20	22	6	2	Mod.	460/ft. ²	Hydropsychid (F,MI,CW) and <i>Neophylax</i> (MI) caddisflies, <i>Macaffertium</i> (MI) and <i>Stenacron</i> (F) heptageniid mayflies	58	Exceptional
0.1	9.6	94	54	71	17	17	13	20	2	17	Mod.	253/ft. ²	Hydropsychid caddisflies (F,MI), Tanytarsini midges (F,MI,CW) & other midges (F,CW)	52	Exceptional
Pleasant Run (02-221-000) EWH – Existing															
0.35	9.4	93	52	79	26	28	28	32	0	9	Mod.	360/ft. ²	Hydropsychid (F,MI) and <i>Neophylax</i> (MI) caddisflies, midges (F), heptageniid mayflies (MI,F)	54	Exceptional
Buck Run (0-209-000) WWH - Existing															
10.4	4.8	63	-	63	12	12	5	5	0	18	Mod.	-	<i>Rheotanytarsus</i> midges (F) and others, <i>Hydroptila</i> caddisflies(F), Bryozoa (F)	G	Good
7.8	9.0	63	-	63	13	13	6	6	0	14	Mod.	-	Hydropsychid caddisflies (F), midges (F), blackflies (F), heptageniid mayflies (F), <i>Helicopsyche</i> caddisflies (MI)	G	Good
0.8	29.5	77	54	56	10	12	7	9	0	15	Mod.	298/ft. ²	Hydropsychid caddisflies (F), <i>Elimia</i> snails (MI), midges (F), baetid mayflies (F,MI),	48	Exceptional
Robinson Run (02-207-000) WWH – Existing															
2.1	9.7	59	-	59	13	13	7	7	1	16	Mod.	-	<i>Caenis</i> mayflies (F), scuds (F), blackflies (F)	G	Good
0.73	10.5	64	31	50	14	14	9	9	0	9	Mod. -Low	X15	Hydropsychid caddisflies (F,MI), baetid mayflies (F,MI), <i>Elimia</i> snails (MI), <i>Helicopsyche</i> caddisflies (MI)	G	Good
Sweeny Run (02-200-216) WWH - Existing															
0.2	3.9	52	-	52	9	9	7	7	1	19	Low	-	Blackflies (F), baetid mayflies (F,MI), flatworms (F), <i>Hydracarina</i> (F)	MG ^{ns}	Marginally Good

Stream RM	Dr. Ar. (sq. mi.)	Total Taxa	Quant. Taxa	Qual. Taxa ^a	EPT Taxa Ql. / Total ^b	Sensitive Taxa Ql. / Total ^c	CW Taxa ^d	Ql. Tol. Taxa ^e	Relative Density Qual. / Quant. ^f	Predominant Organisms on the Natural Substrates with Tolerance Category(ies) ^g			ICI ^h	Narrative Evaluation ⁱ	
Sugar Run (02-206-000) WWH - Existing															
5.40	11.4	49	-	49	14	14	4	4	0	13	Mod.	-	Hydropsychid caddisflies (F), blackflies (F), red midges (F), <i>Stenonema femoratum</i> mayflies (F)	G	Good
0.43	19.4	67	36	50	13	14	8	11	0	14	Mod. -High	202/ft. ²	Baetid mayflies (F,MI), hydropsychid caddisflies (F)	42	Very Good
Worthington Ditch (02-200-015) WWH - Existing															
0.24	4.6	57	-	57	11	11	6	6	1	17	Mod.	-	Damselflies (F), flatworms (F), baetid mayflies (F,MI), hydropsychid caddisflies (F), midges (F)	MG ^{ns}	Marginally Good
Ballenger-Jones Ditch (02-200-013) WWH - Existing															
0.18	11.4	52	-	52	16	16	7	7	0	25	Mod.	-	Midges (F,MI,MT), baetid mayflies (F,MT,MI), <i>Dubiraphia</i> riffle beetles (F)	G	Good
Fitzgerald Ditch (02-205-000) WWH - Existing															
0.55	5.9	57	-	57	12	12	7	7	2	13	Mod.	-	Midges (F,CW,MI,MT), hydropsychid caddisflies (F), baetid mayflies (F,MI)	G	Good
Little Darby Creek (02-210-000) EWH & CWH - Existing															
40.1	8.2	62	-	62	17	17	17	17	7	10	Mod.	-	Hydropsychid caddisflies (CW,MI), baetid mayflies (CW,MI,F), midges (F,CW,MI)	VG ^{ns}	Very Good
39.3	12.2	83	50	67	18	18	18	23	9	15	Mod. -High	X12, X15	Baetid mayflies (mostly <i>B. brunneicolor</i>) (CW,MI,F), hydropsychid caddisflies (CW,MI), midges (F, MI,MT,CW)	VG ^{ns}	Very Good
38.78	12.7	82	42	66	14	17	13	20	9	11	Mod. -High	1144/ft. ²	Hydropsychids (CW,MI), midges (F,MI,CW)	48	Exceptional
Little Darby Creek (02-210-000) EWH - Existing															
34.7	26.0	105	53	80	20	21	18	24	4	17	Mod. -High	498/ft. ²	<i>Neophylax</i> caddisflies (MI), baetid mayflies (F,MI,I)	50	Exceptional

Stream RM	Dr. Ar. (sq. mi.)	Total Taxa	Quant. Taxa	Qual. Taxa ^a	EPT Taxa Ql. / Total ^b		Sensitive Taxa Ql. / Total ^c		CW Taxa ^d	Ql. Tol. Taxa ^e	Relative Density Qual. / Quant. ^f		Predominant Organisms on the Natural Substrates with Tolerance Category(ies) ^g	ICI ^h	Narrative Evaluation ⁱ
29.46	70.0	61	-	61	21	21	22	22	1	5	Mod.	-	Hydropsychid (CW,MI,F) and leptocerid caddisflies (F,MI,CW), baetid mayflies (F,MI)	E	Exceptional
24.46	78.0	80	49	60	17	21	20	24	0	10	Mod.	313/ft. ² (X15)	<i>Elimia</i> snails (MI), fingernail clams (F,MI); <i>Stenacron</i> , <i>Maccaffertium</i> (F,MI), and baetid mayflies (MI,F,I)	42 ^{ns}	Very Good
20.5	98.0	90	40	66	19	25	15	21	0	21	Mod.	1029/ft. ²	Baetid (F,MI,I), <i>Stenacron</i> , and <i>Maccaffertium</i> (F,MI) mayflies, hydropsychid caddisflies (MI,F)	54	Exceptional
17.25	142.0	90	35	72	19	23	27	32	0	10	Mod.	X12	Hydropsychid (F,MI) and <i>Neophylax</i> sp. (MI) caddisflies, <i>Isonychia</i> mayflies (MI)	E	Exceptional
15.30	147.0	65	-	65	25	25	23	23	1	9	Mod.	-	Hydropsychid caddisflies (MI,F), <i>Stenacron</i> and <i>Maccaffertium</i> (F,MI) mayflies, <i>Elimia</i> snails (MI)	E	Exceptional
13.35	149.0	80	31	64	25	29	25	31	1	9	Mod.	339/ft. ²	Hydropsychid caddisflies (MI,F); baetid, <i>Isonychia</i> , and <i>Maccaffertium</i> mayflies (F,MI); crayfish (F)	44 ^{ns}	Very Good
8.95	161.0	93	49	67	25	29	29	33	1	7	Mod. -Low	239/ft. ² (X15)	<i>Elimia</i> snails (MI); <i>Isonychia</i> , baetid & <i>Maccaffertium</i> mayflies (F,MI); <i>Orconectes</i> crayfish (F)	46	Exceptional
7.30	162	93	42	68	25	29	24	31	0	11	Mod.	458/ft. ²	Hydropsychid caddisflies (MI,F); baetid, <i>Isonychia</i> , and <i>Maccaffertium</i> mayflies (F,MI)	50	Exceptional
3.95	170	87	38	69	26	28	23	27	0	14	Mod. -High	531/ft. ² (X13)	Hydropsychid caddisflies (MI,F); baetid, <i>Stenacron</i> , and <i>Maccaffertium</i> (F,MI) mayflies; Tanytarsini midges (F,MI)	52	Exceptional
0.2	178	91	44	66	23	29	22	30	0	14	Mod.	565/ft. ²	<i>Isonychia</i> sp. (MI) and baetid mayflies (F), <i>Elimia</i> river snails (MI), fingernail clams (F,MI), <i>Neophylax</i> caddisflies (MI)	54	Exceptional

Stream RM	Dr. Ar. (sq. mi.)	Total Taxa	Quant. Taxa	Qual. Taxa ^a	EPT Taxa Ql. / Total ^b	Sensitive Taxa Ql. / Total ^c	CW Taxa ^d	Ql. Tol. Taxa ^e	Relative Density Qual. / Quant. ^f	Predominant Organisms on the Natural Substrates with Tolerance Category(ies) ^g			ICI ^h	Narrative Evaluation ⁱ	
Clover Run (02-218-000) WWH Existing/CWH Recommended															
0.6	1.9	61	-	61	24	24	23	23	7	7	Mod.	-	Mayflies (<i>Macaffertium vicarium</i> , <i>Baetis tricaudatus</i> , <i>Diphetor hageni</i>) (MI,CW), midges (F,MI)	E	Exceptional
Jumping Run (02-217-000) WWH Existing/EWH Recommended															
0.27	1.8	73	-	73	16	16	17	17	5	18	Mod.	-	Baetid mayflies (<i>Labiobaetis frondalis</i> , <i>Baetis</i> spp., & <i>Diphetor hageni</i>) (MI,F,CW), midges (F,MI,CW)	VG ^{ns}	Very Good
Lake Run (02-216-000) EWH Confirmed															
0.95	5.7	91	-	91	24	24	21	21	2	17	Mod.	-	Baetid mayflies (<i>Labiobaetis frondalis</i> , <i>Baetis</i> spp., & <i>Diphetor hageni</i>) (MI,F,CW), midges (F,MI,CW)	E	Exceptional
Proctor Run (02-214-000) EWH Existing															
4.9	8.8	58	-	58	16	16	12	12	1	11	Low.-Mod.	-	Hydropsychid caddisflies (F), riffle beetles (F,MI), midges (F)	VG ^{ns}	Very Good
1.6	9.9	70	-	70	23	23	24	24	3	11	Mod.	-	Hydropsychid caddisflies (F,MI), baetid mayflies (F,M), riffle beetles (F,MI), <i>Caenis</i> mayflies (F), midges (F,MI,CW)	E	Exceptional
Treacle Creek (02-213-000) EWH Existing															
11.75	6.9	63	-	63	16	16	16	16	4	8	Low.-Mod.	-	Hydropsychid and <i>Neophylax</i> (MI) caddisflies (F,MI), baetid mayflies (F,MI), Tanytarsini midges (MI,F)	VG ^{ns}	Very Good
6.7	12.9	77	39	59	19	22	19	25	4	7	Mod.	397/ft. ²	Hydropsychid and <i>Neophylax</i> sp. (MI) caddisflies (F,MI); <i>Isonychia</i> (MI), <i>Stenacron</i> , and <i>Macaffertium</i> spp. mayflies (F,MI)	56	Exceptional
0.75	36.0	56	42	30	3	8	4	6	0	13	Mod.-Low	670/ft. ²	Red midges & other midges(T,MT,F,MI)	26*	Fair*

Stream RM	Dr. Ar. (sq. mi.)	Total Taxa	Quant. Taxa	Qual. Taxa ^a	EPT Taxa Ql. / Total ^b		Sensitive Taxa Ql. / Total ^c		CW Taxa ^d	Ql. Tol. Taxa ^e	Relative Density Qual. / Quant. ^f		Predominant Organisms on the Natural Substrates with Tolerance Category(ies) ^g	ICI ^h	Narrative Evaluation ⁱ
Barron Creek (02-212-000) WWH Existing															
0.2	8.2	47	-	47	14	14	12	12	0	5	High	-	Neophylax caddisflies (MI), Elimia snails (MI)	G	Good
Wamp Ditch (02-210-001) WWH Existing															
0.10	5.5	46	-	46	6	6	3	3	1	24	High	-	Flatworms (F), Ceratopogonids – biting midges (F), midges (F,MT,T)	F*	Fair*
Spring Fork (02-211-000) EWH Existing															
15.9	4.8	66	-	66	15	15	11	11	3	19	Mod.	-	Hydropsychid caddisflies (F), baetid mayflies (F,MI), midges (F,CW,MI, scuds (F)	VG ^{ns}	Very Good
10.0	15.0	68	-	68	14	14	11	11	1	16	Mod.	-	Hydropsychid caddisflies (F,MI), baetids (F,MI)	G*	Good*
7.7	19.5	76	39	60	16	18	12	16	1	9	Mod.	516/ft. ²	Sphaerium finger nail clams (F), Hydropsychid caddisflies (F,MI), baetid mayflies (F,MI,I), Tanytarsini midges (F,MI)	58	Exceptional
0.65	37.5	57	-	57	20	20	16	16	0	10	Mod.	-	Baetid mayflies (F,MI), Neophylax caddisflies (MI), Elimia snails (MI)	E	Exceptional
Smith (Run) Ditch (02-200-009) EWH Existing															
0.30	7.8	44	-	44	13	13	10	10	2	8	Mod.	-	Hydropsychid caddisflies (F,MI), baetid mayflies (F,MI), (MI), midges (F,CW,MI), riffle beetles (Stenelmis sp.) (F)	G*	Good*
Hellbranch Run (02-204-000) WWH Existing															
9.4	23.1	70	43	50	11	13	5	8	1	15	Low.-Mod.	225/ft. ²	Baetid & Stenacron sp. mayflies (F,MI)	46	Exceptional
7.29	27.8	67	39	45	10	12	6	8	1	7	Mod.	223/ft. ²	Baetid & heptageniid mayflies (F,MI)	44	Very Good

Stream RM	Dr. Ar. (sq. mi.)	Total Taxa	Quant. Taxa	Qual. Taxa ^a	EPT Taxa Ql. / Total ^b		Sensitive Taxa Ql. / Total ^c		CW Taxa ^d	Ql. Tol. Taxa ^e	Relative Density Qual. / Quant. ^f		Predominant Organisms on the Natural Substrates with Tolerance Category(ies) ^g	ICI ^h	Narrative Evaluation ⁱ
5.75	32.6	68	-	68	14	14	11	11	1	16	Mod. -Low	340/ft. ²	Heptageniid and baetid (F,MI), mayflies (F), hydropsychid caddisflies (F,MI), midges (F,MI), riffle beetles (F,MI)	48	Exceptional
Hellbranch Run (02-204-000) EWH Existing															
1.0	37.4	76	38	55	14	15	13	16	1	10	Mod.	96/ft. ² X15	Baetids (F,MI), <i>Chimarra</i> caddisflies (MI), hydropsychid caddisflies (F,MI)	44 ^{ns}	Very Good
0.7	37.5	74	38	53	13	16	11	18	0	7	Mod.	293/ft. ² X15	Hydropsychids (F,MI), baetids (F,MI), riffle and elmids beetles (F,MI), Psephenus (MI)	44 ^{ns}	Very Good
Hamilton Run (02-204-002) MWH-C Existing															
3.34	1.5	36	-	36	5	5	0	0	0	12	Mod.	-	<i>Rheotanytarsus</i> midges (F), hydroptilid caddisflies (F)	F	Fair
Hamilton Run (02-204-002) WWH Existing															
0.80	6.6	33	-	33	11	11	3	3	0	9	Mod.	-	Hydropsychid and leptocerid caddisflies (F), baetid mayflies (F,MI)	MG ^{ns}	Marg. Good
0.41	10.3	56	-	56	11	11	4	4	0	19	Mod. -High	-	Hydropsychids caddisflies (F), baetid mayflies (F,MI)	MG ^{ns}	Marg. Good
McCoy Run (02-204-003) Undesignated/WWH Recommended															
0.1	3.1	44	-	44	8	8	3	3	2	16	Mod.	-	Hydropsychid caddisflies (F), baetid mayflies (F)	MG	Marg. Good
Clover Groff Run (02-204-001) MWH-C Existing															
5.00	4.6	40	-	40	3	3	0	0	0	25	Mod. -High	-	Sponge (F), fingernail clams (F)	F	Fair
3.4	5.7	54	-	54	9	9	4	4	0	15	Mod. -High	-	Fingernail clams (F), <i>Oecetis</i> caddisflies (F,MI), <i>Elimia</i> snails (MI)	MG	Marg. Good
Clover Groff Run (02-204-001) WWH Existing															
0.14	9.9	40	-	40	8	8	3	3	0	11	Mod.	-	Baetid & heptageniid mayflies (F), hydropsychid caddisflies (F)	MG ^{ns}	Marg. Good

Stream RM	Dr. Ar. (sq. mi.)	Total Taxa	Quant. Taxa	Qual. Taxa ^a	EPT Taxa Ql. / Total ^b	Sensitive Taxa Ql. / Total ^c	CW Taxa ^d	Ql. Tol. Taxa ^e	Relative Density Qual. / Quant. ^f	Predominant Organisms on the Natural Substrates with Tolerance Category(ies) ^g	ICI ^h	Narrative Evaluation ⁱ			
Springwater Run (02-203-000) WWH Existing/CWH Recommended															
0.80	1.8	65	-	65	7	7	8	8	3	16	Mod.	-	Midges (F,MI,MT,CW), baetid and heptageniid mayflies (F), hydropsychid caddisflies (F), blackflies (F)	MG	Marg. Good
Trib. to Big Darby Creek @ RM 23.61 (02-200-024) Undesignated/CWH recommended															
0.1	0.4	39	-	39	9	9	3	3	5	10	Mod. -Low	-	Baetid mayflies (F), <i>Diplectrona</i> (CW) and other hydropsychid caddisflies (F), Hydroptila caddisflies (F)	G	Good

a - Qual. or Ql. = Qualitative

b - EPT taxa are the total taxa collected from the mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera) insect orders combined.

c - Sensitive Taxa: Taxa listed by Ohio EPA as MI (moderately intolerant) or I (intolerant).

d - CW = Cold-water taxa. Includes total on artificial and natural substrates.

e -Tol. = Tolerant

f - Quant. Relative Density: Quantitative sample collected on Hester-Dendy artificial substrates, density is expressed in organisms per square foot. Qual. Relative Density: Qualitative sample relative density (Low, Mod.=Moderate, High). -X8=ND or Non-detectable current; X12=Suspected High Water Influence; X13=Suspected HD Disturbance/Vandalism; X15=Insufficient Current - Current > 0.0 feet/second (fps) and < 0.3 fps

g - Tolerance Categories: VT=Very Tolerant, T=Tolerant, MT=Moderately Tolerant, F=Facultative, MI=Moderately Intolerant, I=Intolerant

h - ICI = Invertebrate Community Index. Narrative evaluations of the community of the natural substrates are presented in lieu on a numerical ICI where artificial substrate data are not available.

i - Narrative evaluations reflect the condition of the benthic community collected qualitatively from the natural substrates in lieu of an ICI. Narrative evaluations that are paired with an ICI score reflect the narrative associated with that ICI and is not an independent evaluation of the qualitative benthic sample.

There were 22 sampling sites with at least 30 sensitive macroinvertebrate taxa, ten of which supported at least 35 sensitive taxa (Table 10). The highest total was 56 taxa, collected from the Big Darby Creek mainstem near Scioto Darby Road (RM 19.5) (Figure 32, Figure 33). There were also 46 sensitive taxa collected in lower Big Darby Creek at the end of Darby Road (RM 11.2) and near Fox at St. Rt. 104 (RM 3.1). The Little Darby Creek sites supported a maximum of 30 to 32 sensitive taxa at five different sampling sites from RM 17.25 downstream to RM 0.2 (Table 10). In addition, 24 sampling sites supported sensitive taxa that comprised at least 35 percent of the total individual taxa collected. Sensitive taxa exceeding 40% of the faunal diversity were collected at ten sites. Downstream from Darby Crest Estates south of U.S. Rt. 40 at RM 38.35, sensitive taxa comprised nearly 50% of the faunal diversity (Figure 33).



Figure 32. Big Darby Creek downstream (top) from Scioto Darby Rd. (RM 19.5, V07G19), July 21, 2014.

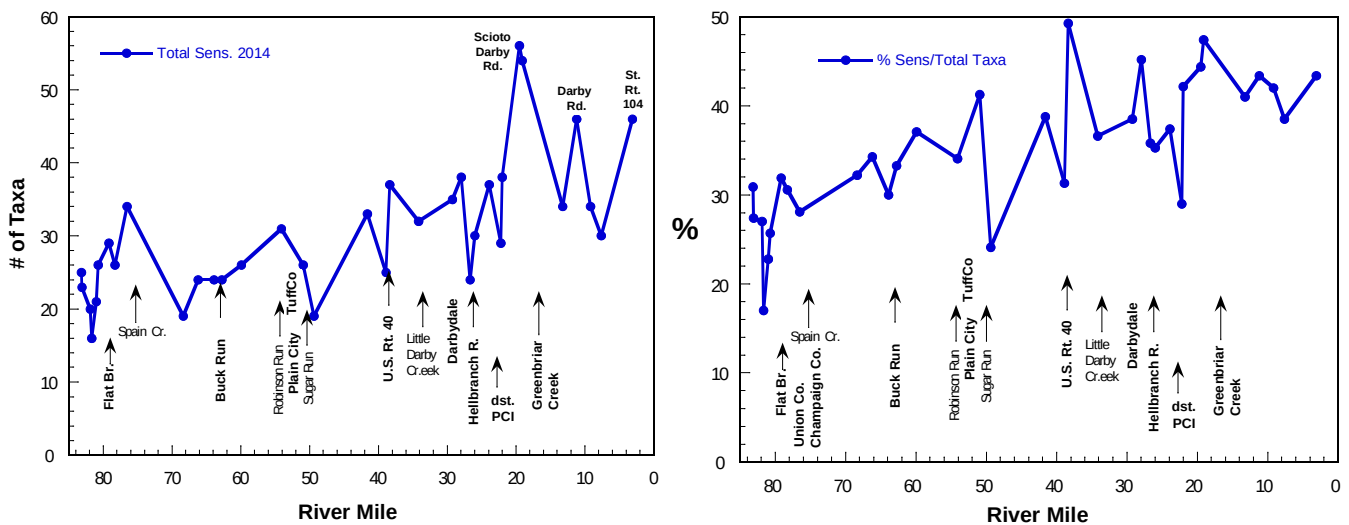


Figure 33. Longitudinal distribution of total sensitive taxa (quantitative + qualitative) (left) and percentage of sensitive taxa of the total faunal diversity collected (right) in Big Darby Creek, 2014/2015.

The highest ICI scores in the watershed (58) occurred at four sampling sites – two in the upper Big Darby Creek mainstem and in Spain Creek and Spring Fork (Table 10). Both Big Darby Creek mainstem sites were regional reference sites, one near Middleburg by State Route 157 (RM 79.2) with a drainage area of 5.6 mi² and the other downstream at the North Lewisburg bridge (RM 76.54) draining 32.0 mi² (Figure 34). Spain Creek at Gilbert Road (RM 3.6, Figure 35), also a regional reference site, scored a 58, including 6 cold-water taxa, despite some habitat disturbances that had occurred prior to the survey a couple of miles upstream. Most of upper Spain Creek is protected by wide riparian corridors. Regarding Spring Fork, the 2004 Big Darby Creek basin report stated that “Spring Fork... can recover in time from habitat impacts...but success will require protection of the riparian buffer” (Ohio EPA 2004). The high biological performance at RM 7.7 in 2014 was documented despite some upstream riparian removal and subsequent sediment transport downstream, as evidenced by total suspended solids concentrations of 254 and 197 mg/l on 5/15/14 and 6/25/14, respectively. The Spring Fork macroinvertebrate community at RM 7.7 was protected due to its consistently intact and wide treed riparian buffer (Figure 36).



Figure 34. Big Darby Creek upstream from North-Lewisburg Rd (RM 76.54, V07P59), 2 July 2014.



Figure 35. Spain Creek upstream from Gilbert Rd. (RM 3.6, V06G31), July 2014.

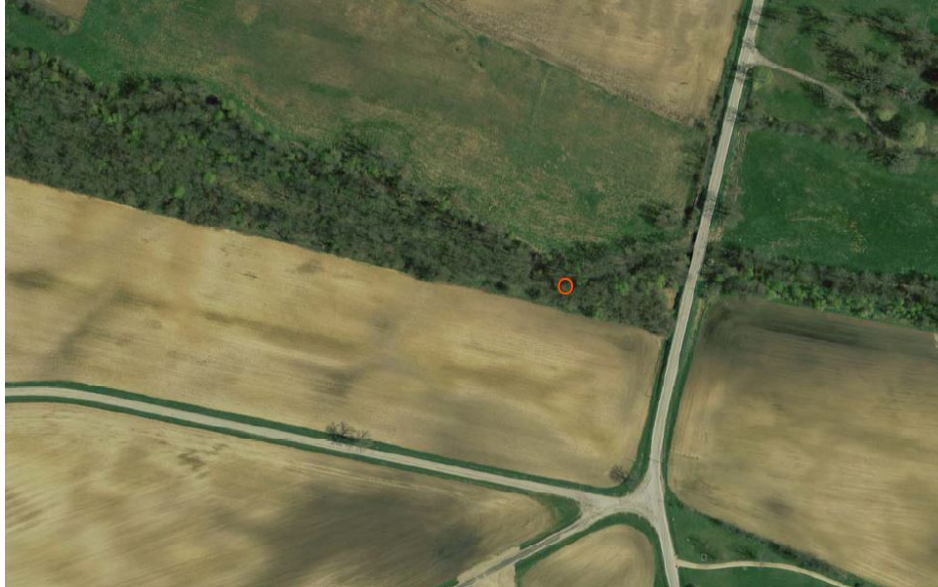


Figure 36. Wide wooded riparian corridor and buffer adjacent Spring Fork upstream from Rosedale–Milford Center Rd. (RM 7.7) ameliorated upstream habitat impacts (aerial view).

Only four macroinvertebrate communities fell short of aquatic life use expectations - Spain Creek (CWH) near the mouth, Spring Fork (EWH) near Guy Cemetery Rd at RM 10.1, Wamp Ditch (WWH) and Smith Ditch (EWH) (Table 10).

Big Darby Creek and Tributaries

The survey area was comprised of two main watershed components: the Big Darby Creek mainstem with its direct tributaries and the Little Darby Creek sub-watershed with its tributaries. Tributaries to Big Darby Creek sampled included Flat Branch, Little Darby Creek (Logan Co.), Spain Creek, Pleasant Creek, Buck Run, Robinson Run, Sweeny Run, Sugar Run, Worthington Ditch, Ballenger-Jones Ditch, Fitzgerald Ditch, Smith Ditch, Hellbranch Run, Hamilton Run, McCoy Run, Clover Groff Run, Springwater Run, and an unnamed tributary to Big Darby Creek at RM 23.61. Little Darby Creek tributaries included Clover Run, Lake Run, Jumping Run, Treacle Creek, Proctor Run, Barron Creek, Wamp Ditch, and Spring Fork.

Big Darby Creek Mainstem 2014

The EWH aquatic life use designation was met at all 34 locations sampled on Big Darby Creek. The mean ICI was 52.1 (STD. Dev. $\pm$ 3.58) with a median of 54. The Big Darby mainstem ICIs ranged from 44 to 58 (Table 10, Figure 37). Only two sites were marginally meeting the EWH biocriterion

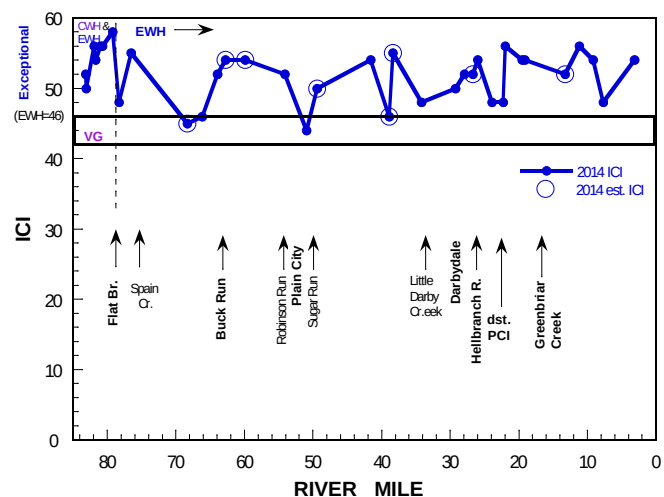


Figure 37. Longitudinal macroinvertebrate ICI at sampling sites in Big Darby Creek, June–October, 2014. The ICI is estimated based on a qualitative evaluation where quantitative data are not available.

with very good narrative evaluations (Figure 37); however, both communities were close to exceptional quality. In particular, the ICI of 44 garnered downstream from Cemetery Pike (and Plain City) and upstream from Sugar Run at RM 50.95 (V07S09) was demonstrably close to a fully exceptional score. The addition of one more caddisfly taxon or two more dipteran taxa on the artificial substrate sampler would have scored two points higher on each corresponding metric, placing the ICI at or slightly above the biocriterion of 46. Increased nutrient loads from the Plain City WWTP and sporadic low D.O. concentrations (3.09 mg/l), along with periodic high total suspended solids from Plain City and TuffCo discharges also could have suppressed benthic community quality slightly (Table 14, Appendix I).

Six of the seven most upstream headwater Big Darby Creek sites clearly achieved CWH community performance expectations in addition to the designated EWH use. The other site, Big Darby Creek in the new meadow channel at RM 81.0, only marginally met CWH expectations, with only one cold-water taxon collected. Prior to the current survey, the Big Darby Creek mainstem was diverted out of an entrenched reach near RM 81.7 and was released back into a restored open, grassy, mixed-shrub prairie valley at The Nature Conservancy's Big Darby Headwaters Nature Preserve. As the sampling site at RM 81.0 was toward the downstream end of the newly-formed natural channel (Figure 38), some of the woody debris near the stream is still small so there is more open canopy and likely higher stream temperatures. While cold-water fish have repopulated well, more cold-water macroinvertebrate taxa should in time repopulate the new channel reaches via drift or aerial repopulation.



Figure 38. View of Big Darby Creek toward the end of the new meadow channel on the TNC property (upstream and downstream views), June 23, 2014.

Despite macroinvertebrates meeting EWH expectations at all sites, there were several reaches of Big Darby Creek where relative organism density was elevated. Six reaches were sampled where the relative density exceeded 1200 organisms/ft² – the Big Darby Creek mainstem at RMs 27.95 (V07G70), 19.5 (V07G19), 9.15 (V07G17), 7.65 (203274), and 3.1 (600970) (Table 10). The peaks in organism density may be reflective of nutrient inputs from the PCI WWTP, as well as from agricultural and suburban nonpoint sources. The reach of Big Darby Creek from RM ~21.5 - 19.5 was where nutrient inputs from PCI appeared to show the greatest possible instream enrichment effects. Total phosphorus permit violations were the primary issue for PCI from 2012 to mid-2014 (Appendix I). On 8/7/2014, PCI effluent discharge contained elevated total phosphorus (1.61 mg/l), TKN (2.75 mg/l), and ammonia (1.94 mg/l) concentrations. On the previous day (8/6/2014), low concentrations of ammonia were present (0.051-0.70 mg/l) downstream from Snake Island (RM 22.0) – likely remnants of larger ammonia inputs from upstream. Five total phosphorus samples were above the 0.1 mg/l EWH target at RM 19.1 (Scioto Darby Road) in 2014– more than any other sampled site. Also, ten of thirteen nitrate/nitrite concentrations were above the nutrient EWH target of 1.0 mg/l, with a mean of 2.0 mg/l, with the highest concentrations of 4.74 and 5.31 mg/l occurring on 4/30/2014 and 6/5/2014, respectively. However, no large diel dissolved oxygen swings, a key indicator of instream nutrient enrichment, were recorded throughout this stretch of Big Darby Creek during the 2014 survey (Table 15).

The highest relative density of 3611 organisms/ft² was documented at RM 9.15. There were areas of open canopy at RM 9.15, as well as at RM 7.4, where relative density decreased down to 1608 organisms/ft². However, chemical nutrient parameters and chlorophyll concentrations were unremarkable in the reach between RMs 11.2 and 7.4, and there were no large diel dissolved oxygen swings (Table 15).

Big Darby Creek Mainstem – Trends

Overall, the macroinvertebrate community improved slightly from the last survey in 2001-2002, as the ICI scores increased modestly. The median ICI score increased to 54 from 52 in 2001-2002 which was also the 75th percentile. The 95th percentile ICI also increased to 58 from 56, while the 25th percentile scores were similar (Figure 39).

The Big Darby Creek mainstem longitudinal trend graph displays improved ICI performance in several reaches (Figure 40). The upper reaches of Big Darby Creek have recovered from channel relocation and restoration efforts. Improvements have occurred throughout the middle reaches in Union County, including recovery from various spills/kills in late 1990s and improvements in tributary quality in Buck Run and Robinson Run (Ohio EPA 2004). There also were mixed improvements downstream from Darbydale that may be the result of consolidation of mobile home park (MHP) discharges. However, this reach still receives stress from continuing issues with Oaks Hills and Pleasant View MHPs (violations and/or raw sewage spills/ammonia) and nutrients, particularly nitrates, above EWH targets that may be associated with higher macroinvertebrate community relative density. Macroinvertebrate performance improved slightly downstream from Hellbranch Run compared to 2001-2002.

Big Darby Creek Mainstem Tributaries 2014

Upper Big Darby Creek Tributaries (Headwaters to Plain City)

Flat Branch, Little Darby Creek (Logan Co.), Spain Creek, Pleasant Creek, and Buck Run were tributaries sampled in the upper reaches of Big Darby Creek (Table 10). Eight of nine survey sites, many of which are designated regional reference

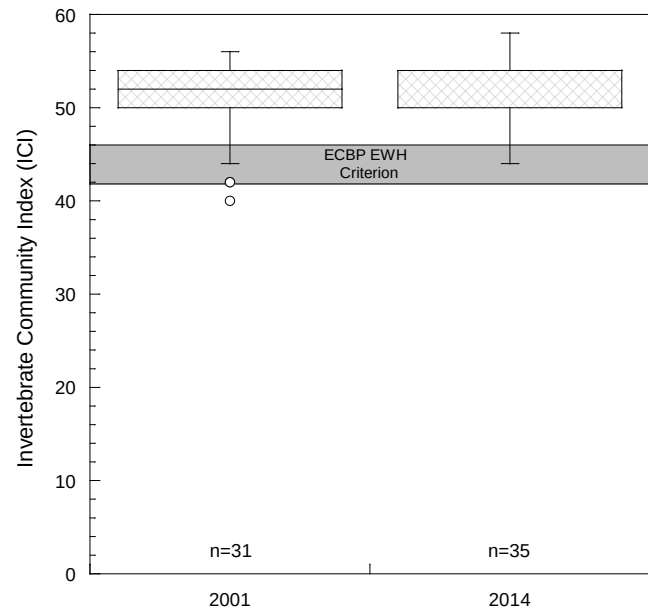


Figure 39. Aggregated performance of ICI scores from the Big Darby Creek mainstem, 2001 and 2014. The shaded box represents the area of non-significant departure from the EWH biocriterion.

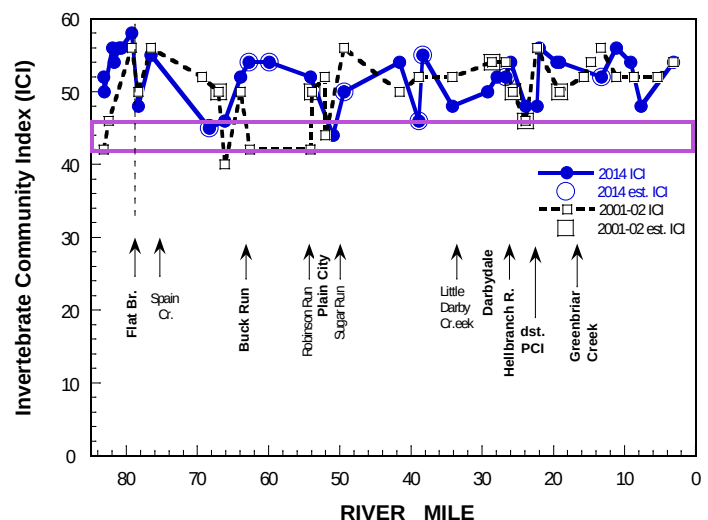


Figure 40. Longitudinal ICI performance from the Big Darby Creek mainstem, 2001 and 2014. The purple box indicates areas of non-significant departure from the ECBP EWH criterion.

sites, met their designated aquatic life use(s). The 2014 assessments will be reviewed and compared to previous data from the 2001-2002 survey to assess trends.

Flat Branch, which comprises a low gradient agricultural area and wetlands draining much of Honda's properties, scored an ICI of 44, which corresponded to a very good macroinvertebrate community evaluation (Table 10). Community quality improvements included an increase in sensitive taxa from six to 12. Enhancements in riparian habitat and storm water retention in upstream wetlands, and subsequent decreased siltation seemed to have improved the overall macroinvertebrate community.

The smaller **Little Darby Creek** in Logan County met its EWH and CWH use designations despite some agricultural nonpoint source inputs throughout the small sub-watershed. Sensitive and EPT taxa increased by 50% compared to the 2001 survey, and the number of cold-water taxa also increased (mean of 9.5 in 2014 compared to 5 taxa in 2001), with *Glossosoma* saddle-case making caddisflies among the predominant organisms collected (Table 10). The 13° C water temperature also contributed to community quality improvements.

Spain Creek scored an ICI of 58 at the upstream site (RM 3.7, V06G31), which was much higher than the ICI of 44 in 2001. Community structure was much improved with more sensitive organisms such as *Neophylax* sp. caddisflies and the sensitive flathead mayfly *Maccaffertium vicarium* being predominant. However, the site downstream from North Lewisburg (RM 0.1, V07P58) did not meet the CWH performance expectations as a result of general declines in the presence and abundance of cold-water taxa/organisms, coupled with increases in the number of tolerant taxa. The lack of consistent wooded riparian corridor, channel modifications, and accompanying unstable sand bedload downstream near the mouth prevented cold-water macroinvertebrate organisms from colonizing. There were three cold-water taxa collected in 2001 and two collected in 2014. The stream temperature was still a cool 14.5° C on 9/8/2014. The EPT and sensitive taxa totals were stable between the 2001 and the 2014 surveys, but the number of tolerant taxa organisms (particularly beetles, dragonflies, and a couple of tolerant midges) increased from six in 2001 (9% of taxa collected) to 17 in 2014 (18% of the total collected). The North Lewisburg WWTP documented summer total phosphorus, total suspended solids, dissolved oxygen, ammonia-N, and fecal coliform violations 2012 to 2014 with an elevated diel dissolved oxygen range (5.0 mg/l) and elevated nitrates downstream (Table 14-Table 16, Appendix I).

Despite the presence of various permit violations at the North Lewisburg WWTP, performance of this plant's operations has improved since the 2001 survey (Figure 116 and Figure 117); the number of permit violations has also decreased substantially since the 2001 survey (235 from 1999-2001, 88 from 2012-2014). The type of violations has also "improved", shifting away from ammonia, total suspended solids, and BOD₅ (1999-2001) to relatively minor dissolved oxygen (many above EWH expectations, but below requisite CWH permit limits) and total phosphorus permit violations; several ammonia and other types of violations were recorded (Appendix I). There was also no evidence of flocculent biosolids downstream from the WWTP discharge that was observed during the 2001 survey (Ohio EPA 2004). Interaction between Ohio EPA and the facility continues in efforts to address the ongoing noncompliance; more information on this facility and their efforts to improve effluent quality can be found within the [NPDES Permitted Facilities](#) portion of this document.

Macroinvertebrate community performance in the lower reaches of Spain Creek is undoubtedly influenced by the North Lewisburg WWTP. However, this stretch of Spain Creek has been shown to fully attain EWH criteria (IBI, ICI) and CWH expectations despite the relatively poor operating performance of the WWTP documented historically (Ohio EPA 2004). The 2014 survey revealed substantial woody riparian

removal, channel diversion/creation, and bank armoring near the mouth of Spain Creek, and extensive land clearing in the upper reaches, which ultimately resulted in excess sedimentation and a shifting stream bedload. The additional stress of sedimentation/shifting bedload, coupled with the background inputs from the North Lewisburg WWTP, seems to have added enough additional stress to cause slight declines in macroinvertebrate community performance. Substrate sensitive fish species (simple lithophils) also comprised a smaller proportion of the fish community, while obligate cold-water species (mottled sculpin) comprised a larger proportion of the fish community compared to the 2001 survey; this suggested substrate quality, rather than temperature, affected impacts. See the [Water Chemistry](#) section for additional information.

Pleasant Run, despite some recent channelization activities, scored similarly to 2001 with an ICI of 54 (Table 10). EPT and sensitive taxa totals were similar between sampling years.

Buck Run met the WWH biocriterion at all three sampling sites. Buck Run drains lower gradient agricultural areas in its upper reaches and transitions to a higher gradient in the lower reaches. The two upstream sites supported good quality communities and an ICI of 48 was scored near the mouth (RM 0.8, V07P53) in a reach with better habitat development. Compared to the 2001 survey, all Buck Run sampled reaches improved significantly in 2014. Total EPT and sensitive taxa numbers increased at all duplicated sites between surveys (Figure 41). Improvements are likely the result of improved stream habitat with decreased nonpoint source nutrient influences.

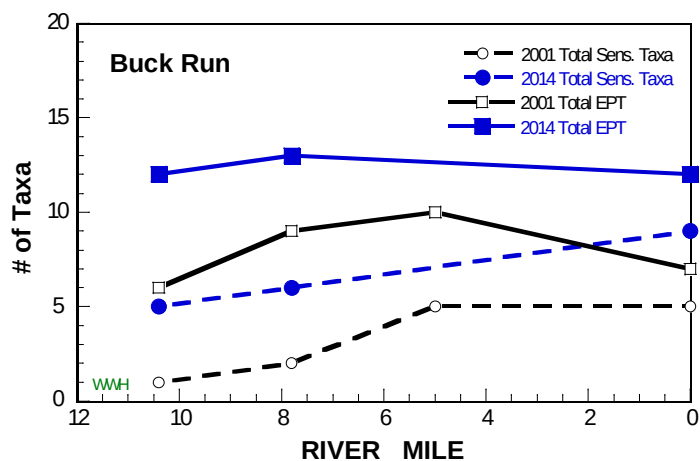


Figure 41. Longitudinal trends for both total EPA taxa and total sensitive taxa from Buck Run, 2001 and 2014.

Middle Big Darby Creek Tributaries (Plain City to Little Darby Creek Confluence)

Robinson Run, Sweeny Run, Sugar Run, Worthington Ditch, Ballenger-Jones Ditch, and Fitzgerald Ditch were sampled in the middle reaches of Big Darby Creek during the 2014 survey. All eight sampling locations within these streams achieved aquatic life use expectations.

Both **Robinson Run** sites indicated good community quality performance in 2014 (Table 10). In the years between the 2001 and 2014 surveys, remediation work has continued on the former Ranco site adjacent to Robinson Run, which likely has reduced surface or subsurface inputs. Upstream at RM 2.1, a dramatic increase in EPT and sensitive taxa (Figure 42) indicated increased stability along the stream, particularly margin habitat, even though nonpoint source inputs contributed to high tolerant taxa numbers. Robinson Run stream quality is on a definite improving trajectory.

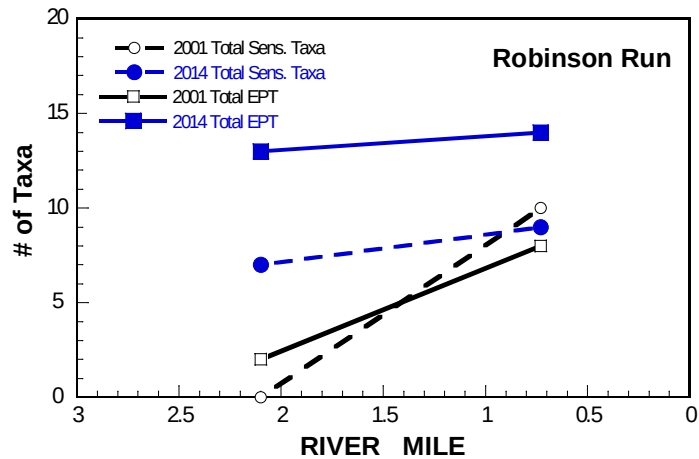


Figure 42. Longitudinal trends for both total EPA taxa and total sensitive taxa from Robinson Run, 2001 and 2014.

Macroinvertebrate community performance in **Sweeny Run** was assessed as fair quality in 2001. Community quality in 2014 improved to marginally good and minimally achieved WWH expectations. There were nine EPT and seven sensitive taxa collected at RM 0.2 (V06G05), which was double and quadruple the numbers collected in 2001, respectively (Table 10). Improvements in inflow/infiltration issues affecting sewage delivery to the Plain City WWTP has likely improved instream water quality.

Sugar Run is an agriculturally dominated stream to the east and north of Plain City that flows through urbanized areas in its lower reaches and also is channelized in many upper reaches. Some stability over time has occurred after upstream riparian improvements. At St. Rt. 42 (RM 5.4), the number of EPT taxa doubled to 14 in 2014, and the stream reach quality was assessed as good, which met the WWH use. Sensitive taxa increased to four from one in 2001 but is still somewhat lower than expected due to some intermittent flashiness with episodic sediment and nutrient inputs. The mouth site at Cemetery Pike (RM 0.43) improved with 11 sensitive taxa collected, including moderately intolerant *Acerpenna* and *Labiobaetis* (baetid) and *Leucrocuta* (heptageneid) mayflies (Table 10). The ICI score of 42 (very good) at this site indicated that Sugar Run quality has improved in the lower reaches with slightly less negative influences from upstream sources.

Worthington Ditch, Ballenger-Jones Ditch, and Fitzgerald Ditch, three small agricultural tributaries between 4.6 and 7.3 mi², join Big Darby Creek from the west between RMs 50.62 and 44.96. They were reassessed at St. Rt. 142 (Plain City – Georgesville Rd.) in 2014 (Table 10, Figure 43).

Worthington Ditch demonstrated marginally good community quality. There were more new mayfly taxa with a more diverse midge community compared to 2001. **Ballenger-Jones Ditch** now receives the Jonathon Alder High School effluent since the last survey, discharging near St. Rt. 42 a few miles upstream. There was only a slight decrease in EPT taxa collected in 2014 compared to 2001, with a noticeable decrease in sensitive taxa.

Ballenger-Jones Ditch still supported a solidly good macroinvertebrate community, with 16 EPT taxa collected during the 2014 survey, despite the added high school effluents, as well as being under county drainage maintenance. **Fitzgerald Ditch** has improved since a plant upgrade at Canaan MHP that occurred between the two surveys. In the 2014 survey, there was an increase in EPT taxa, including the presence of the sensitive stonefly *Neoperla*.

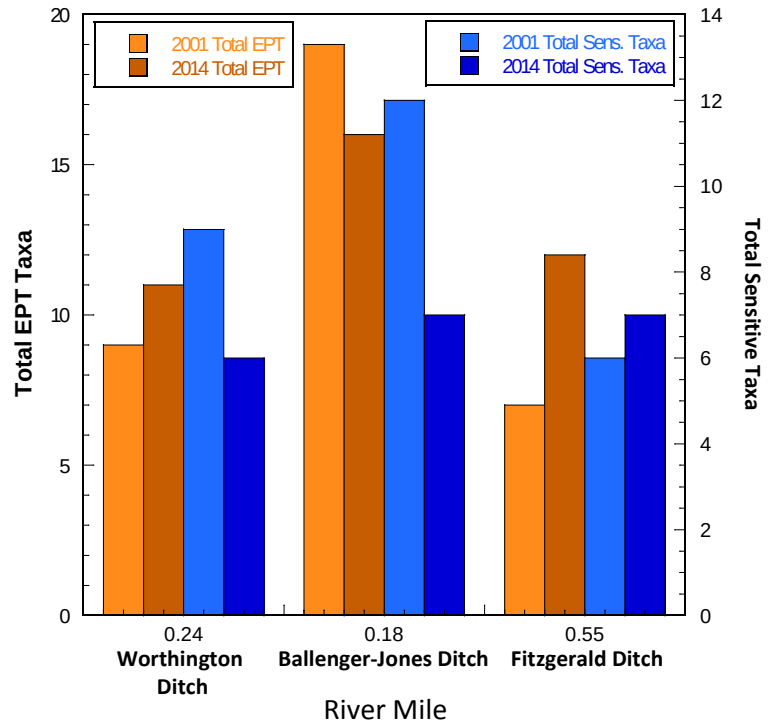


Figure 43. Total EPT and sensitive taxa in Worthington, Ballenger-Jones, and Fitzgerald ditches, 2001 and 2014.

Lower Big Darby Creek Tributaries (Little Darby Creek Confluence to Mouth)

Tributaries sampled in this stretch of Big Darby Creek during the 2014 survey included Smith Ditch, Hellbranch Run, Hamilton Run, McCoy Run, Clover Groff Run, Springwater Run, and an unnamed tributary to Big Darby Creek at RM 23.61. Macroinvertebrate community performance at 14 of 15 sampling locations within these streams met the assigned aquatic life use. While some sites have multiple years of data available, primary trends analysis focused on the 2001 and 2014 datasets.

Smith Run, a small EWH tributary in the Darby Creek Metropark upstream from Darbydale, was assessed at Biggert Rd. (RM 0.2, V07K18) during the 2014 survey. The macroinvertebrate community collected at RM 0.2 was evaluated as good, which was not meeting the designated EWH use. Flow was limited, as well as habitat (likely a “losing” stream), and the cause of impairment was listed as natural low flow conditions. EPT and sensitive taxa totals were similar between the 2001 and 2014 surveys.

Hellbranch Run is a larger tributary to Big Darby Creek, formed from the confluence of Clover Groff and Hamilton runs, that drains portions of the western Franklin County metropolitan area (city of Hilliard, Norwich, Brown, and Prairie townships). Five sites were sampled in Hellbranch Run in 2014. ICI scores ranged from 44 to 48 and all sites met existing WWH expectations in the upstream reaches and marginally met the EWH use in the lower reaches (Figure 44, Table 10). Compared to the 2001 survey, all sites performed similarly, while substantially improved performance was documented downstream from the Oakhurst Knolls WWTP in 2014. An issue with total suspended solids was resolved, and, in the future, the Oakhurst Knolls WWTP will be connected to Darbydale WWTP and will cease discharging. Timberbrook WWTP has been abandoned and, thus, no longer discharges since the last survey.

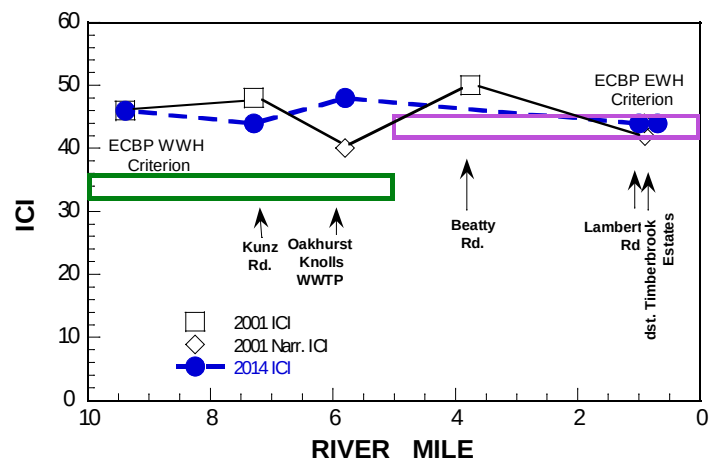


Figure 44. Longitudinal ICI performance from Hellbranch Run, 2001 and 2014.

The total EPT and sensitive taxa numbers in the lower reach from RM 1.0 to the mouth were very similar between survey years. Efforts to slow down or retain storm water upstream in urban tributaries, particularly in Hamilton and Clover Groff runs, to reduce flashiness, erosional siltation, embeddedness, and/or instability should be continued to counteract watershed hardening via continued growth and increased impervious surfaces. Pool and riffle/run habitat appeared more developed and stable in Hellbranch Run during the 2014 survey as compared to 2001. As trees become more mature, the constructed meandering channel at the mouth of Hellbranch Run will be opened to further utilize floodplain retention in order to temper flashiness and decrease erosion and sediment delivery to Big Darby Creek (Figure 45).



Figure 45. Constructed meandering channel near the mouth of Hellbranch Run with its confluence with Big Darby Creek (left). View on right shows older straightened and entrenched channel with sand/gravel bar covered in grass that blocks flow into new constructed channel at ~ RM 0.7-0.65. 2014.

Hamilton Run was assessed at three sites in 2014. Macroinvertebrate performance has improved as documented in the 2014 survey. The upper MWH-designated site at Walker Rd. (RM 3.34) indicated fair quality and met the MWH-C performance expectations with five EPT taxa, as compared to two taxa in 2001 (Figure 46). The downstream channel was open with room to develop, though there was still some entrenchment; the upstream reach was still an entrenched and narrow run/glide channel locked in by mature trees in the straight diked banks. In an effort to improve stream connectivity to the flood plain and water retention, another reach of Hamilton Run at Roberts Rd. was opened up with braided channels. Beavers constructed dams soon after stream channel restoration/modification, which benefitted resource quality by reducing flashiness and increasing local water retention. Downstream near the confluence with Clover Groff Run, Hamilton Run was sampled upstream near U.S. Rt. 40 at two sites - upstream and downstream from McCoy Run (RMs 0.8 and 0.41). Marginally good community performance was demonstrated at both sites with increased EPT and slightly higher sensitive taxa totals (Figure 46). In 2014, hydropsychid caddisflies and mayflies were predominant compared to midges in 2001.

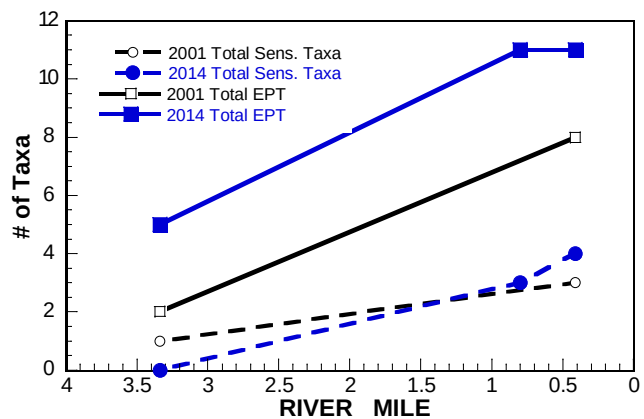


Figure 46. Longitudinal trends for both EPT and sensitive taxa from Hamilton Run, 2001 and 2014.

McCoy Run is a small, groundwater-fed tributary that flows from the west and joins Hamilton Run upstream from U.S. Rt. 40. The cool ground water inputs (10° C temperature) allowed eight EPT taxa and a few sensitive and cold-water taxa to inhabit this modified and entrenched stream. The resulting marginally good evaluation met expectations for the existing WWH aquatic life use.

The **Clover Groff Run** macroinvertebrate community structure indicated a slight improvement in quality in the upstream reach adjacent to Frazell Rd. at RM 5.0. Clover Groff Run supported a fair quality macroinvertebrate community at this location which met designated MWH-C performance expectations. Total taxa doubled to 40 with three EPT taxa, compared to zero EPT and only 19 total taxa in 2001-2002. Just upstream from Renner Rd. (RM 3.4), improved habitat, such as narrowed channels with rocky riffle/runs, increased macroinvertebrate diversity and quality, as nine EPT and 54 total taxa were collected, resulting in a marginally good evaluation. The lower site at Alton Rd., RM 0.14, was partially limited by the entrenched channel and remnants of beaver dam impoundments that inhibited the development of normal riffle/run/pool complexes (Figure 47). Regardless, the macroinvertebrate community still indicated marginally good quality with hydropsychid caddisflies and baetid and heptageniid mayflies predominant, which met WWH expectations. This attainment in the lower reach was an improvement compared to the fair range ICI of 20 at RM 0.8 (upstream U.S. Rt. 40) in 2001. Continued instream habitat improvement and storm water attenuation efforts upstream will improve the quality of lower Clover Groff Run and, in turn, Hellbranch Run and Big Darby Creek.



Figure 47. Clover Groff Run downstream from Alton Rd. (RM 0.14, V07P14), 2014.

Springwater Run, a largely ground water-fed tributary (19.5°C) which drains the area around Harrisburg, was sampled at one location in 2014. The sample was assessed as marginally good with baetid mayflies, hydropsychid caddisflies, blackflies and midges predominant (Table 10). There were seven EPT and three cold-water midge taxa collected, compared to 3 EPT and zero cold-water taxa in 2001 when nonpoint source industrial runoff in Harrisburg had affected the community quality and diversity.

Another small ground water-fed stream south of Harrisburg, the **Tributary to Big Darby Creek at RM 23.61**, was sampled in 2014. The 9° C temperature helped support five cold-water taxa, including the caddisfly *Diplectrona modesta* plus four cold-water midges, as well as nine EPT taxa. Predominant taxa included *Diplectrona* and other hydropsychid caddisflies, hydroptilid caddisflies, and baetid mayflies. This stream was recommended for the CWH aquatic life use designation due to the resident populations of cold-water fish and macroinvertebrate taxa and cool stream temperatures.

Little Darby Creek and Tributaries

Little Darby Creek Mainstem 2014

Fourteen sites evaluating 41 river miles were sampled along the Little Darby Creek mainstem in 2014, with one site, RM 39.3, resampled in 2015. The three uppermost sites are included in the reach that is designated both EWH and CWH; the rest of Little Darby Creek maintains an EWH use designation. The longitudinal performance of the benthic communities in Little Darby Creek indicated full achievement of EWH expectations at all 14 sites (Table 10, Figure 48).

The two most upstream sites sampled on Little Darby Creek were marginally meeting EWH expectations with narrative evaluations of very good, and were also achieving CWH expectations with the collection of numerous cold-water taxa. This headwater reach of Little Darby Creek is challenged by potential impacts from nutrients due to open pasturage, fertilizer inputs via storm water, and/or other agricultural nonpoint runoff sources. (Figure 49). A water chemistry sample collected on 8/21/2014 from a storm water outlet at RM 39.5 revealed extremely elevated levels of ammonia (0.208 mg/l), nitrate (7.58 mg/l), and phosphorus (0.492 mg/l). Instream concentrations of nitrate averaged 2.40 mg/l from July–September 2014, with the single highest value of 3.56 mg/l also collected on 8/21/2014. The site downstream from this discharge at RM 39.3 documented high abundances of the pollution tolerant midges *Chironomus decorus* gr., *Polypedilum illinoense*, and *Cricotopus bicinctus*. Large numbers of aquatic worms were also observed on instream algal mats. Currently, ground water inputs prevent these and other pollution tolerant organisms from predominating the benthic community at this location. However, continued and additional inputs of excess nutrients into this reach could affect achievement of biological goals in the future, especially considering that communities at both of these headwater sites were within non-significant departure of the EWH biocriterion.

Downstream from the Mechanicsburg WWTP at RM 38.78, the ICI rose to just above the EWH biocriterion with a score of 48. This was in spite of inconsistent plant performance from the Mechanicsburg WWTP. The plant has documented historical violations for total phosphorus, total suspended solids, cBOD, ammonia and bacteria (see facilities comments in Appendix I). More information regarding compliance history and efforts to improve effluent quality are detailed within the [NPDES Permitted Facility](#) portion of this document. Nitrates were above the EWH target concentrations at sampling locations in the Mechanicsburg reach, and persisted downstream past Lake and Jumping runs. The community collected from the artificial substrates indicated a peak in relative density in excess of 1000 organisms/ft², which is comparatively higher than most other sites on the Little Darby Creek mainstem. This increased biomass is likely associated with increased nutrient inputs.

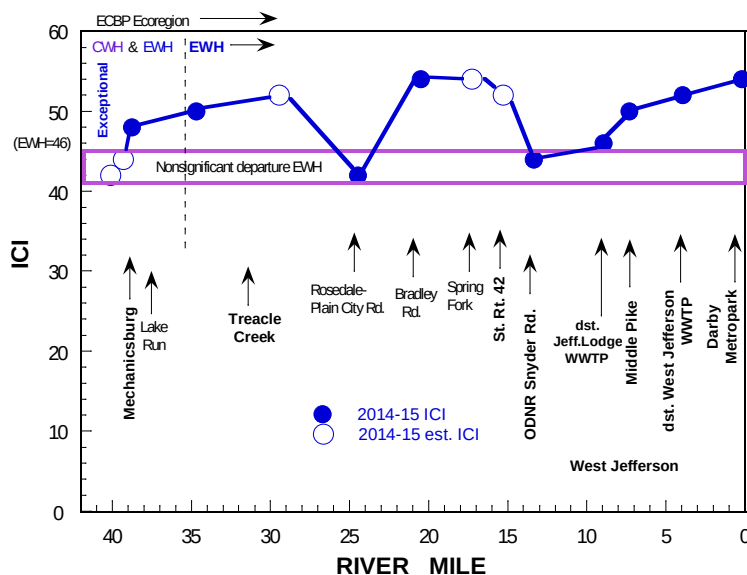


Figure 48. Longitudinal macroinvertebrate performance of the ICI in Little Darby Creek, 2014/2015. The ICI is estimated via qualitative evaluation where quantitative data are not available.



Figure 49. Little Darby Creek through open pasture area upstream and downstream from the Mechanicsburg WWTP (RMs 39.2-39.3), 2014.

Further downstream from Mechanicsburg, the highest total taxa richness in Little Darby Creek occurred at the Irwin Road site at RM 34.7, with 80 qualitative taxa and 105 total taxa (Figure 50, upper). From this site downstream to the mouth, taxa richness (total, EPT, and sensitive) generally increased with increasing streamside forest cover, in concert with decreased agricultural nonpoint source runoff and direct discharges. Riparian forest density and width remained thinned in the predominantly agricultural middle reaches. Slow current speeds over the artificial substrates depressed the ICI somewhat at RM 24.46, as low densities of caddisflies and mayflies were captured as a consequence of the reduced current velocity. In spite of this, the ICI still scored within non-significant departure of the EWH biocriterion (Figure 48). Nutrient signatures were evident within the benthic community at Bradley Rd. (RM 20.5) via both a modest spike (>1000 organisms/ft²) in relative density when compared to other sites on Little Darby Creek, as well as a large proportion of blackflies collected from the artificial substrates. Qualitative sensitive taxa also declined noticeably at this location (Figure 50, lower). This site receives nutrient inputs from nonpoint source runoff, which may in turn be exacerbated by decreased riparian buffers and channelization. However, a massive instream emergent macrophyte growth of water willow helped assimilate these inputs, and, thus, in spite of the nutrient signatures within the community, the ICI at this location scored well within EWH expectations.

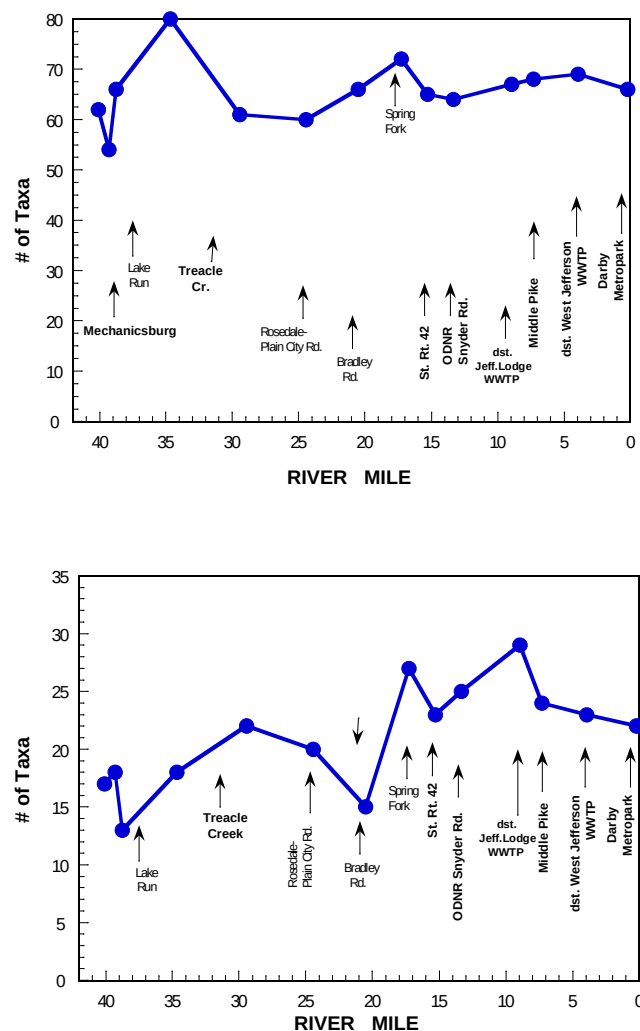


Figure 50. Longitudinal trend of total qualitative taxa (upper) and total qualitative sensitive taxa (lower) in Little Darby Creek, 2014/2015.

In the lower 20 miles of Little Darby Creek, a more consistently dense and wide riparian corridor was maintained. This was reflected in the high and consistent numbers of both EPT and sensitive taxa (Table 10). Qualitative EPT taxa richness ranged from 19-26 taxa, with the lower 15 miles in particular supporting EPT taxa numbers consistently in the mid-20s. Qualitative sensitive taxa ranged from 22-29 taxa. This lower reach also supported populations of freshwater mussels at most sampling locations (Table 13). These findings are discussed in more detail in the [freshwater mussel discussion](#) at the end of this section.

Caveats to the high performance of the benthic communities of lower Little Darby Creek begin with the assessment of several small unnamed tributaries (UTs) that discharge into the reach from RMs 17.25-8.85, draining the area around West Jefferson Industrial Park (Figure 51). Elevated total dissolved solids (TDS) and conductivity concentrations were recorded in the UT #1 @ RM 14.35 (max of 1490 mg/l and 2520 umhos/cm, respectively, with a low dissolved oxygen reading of 3.06 mg/l) and in UT #4 @ RM 12.88 (max of 724 mg/l and 1250 umhos/cm, respectively, with some high nitrate values). In the 2014 data, there were no real changes or losses in mayfly diversity through this reach. Mayflies as a group are particularly susceptible to the effects of elevated TDS/conductivity (Pond et al. 2008, Pond 2010), and as such, one may expect to observe declines in mayflies with increasing TDS/conductivity concentrations. However, impacts to channel stability due to the changing hydrological regimes from these tributary storm water inputs, as well as agricultural runoff from fields adjacent to St. Rt. 29 are of concern. Visual inspections of the Little Darby Creek channel downstream from UT #2 @ RM 13.70, UT #3 @ RM 13.35, UT #4 @ RM 12.88, at Forest Lake (RMs 9.2-9.1) and at Jefferson Lodge (RM 8.95) were recorded in October 2015. Loose substrates, substantial erosive activity, and bottom substrate instability were noted (Figure 52); however, adequate floodplain width preserved much of the channel, as evidenced via high flow channels. Erosion and substrate instability may impact benthic communities by contributing excess silt and sediments to the bottom substrates, which in turn limit interstitial space available to benthic invertebrates for colonization. Unstable substrates can also impact stationary mussel beds found in this reach.



Figure 51. Small tributaries draining West Jefferson Industrial Park area adjacent U.S. Rt. 29 into Little Darby Creek at utility crossing at the end of Snyder Rd. (RM 13.35).

In addition to the unnamed West Jefferson Industrial Park tributaries listed above, another concern regards discharges from the Jefferson Lodge MHP WWTP (RM 9.0). There were reported sewage spills from this facility in 2011 (2) and 2013 (7); from 2010 to 2015, there were 42 listed permit violations, with daily average flow consistently exceeding the design flow. However, as of March 2016, the Jefferson Lodge

MHP WWTP is currently in compliance with permit limits. Elevated total suspended solids values were recorded from an UT @ RM 9.10 in July and August of 2014 (16 and 15 mg/l, respectively), with even higher values downstream from Jefferson Lodge WWTP at RM 8.95 on the same dates (24 and 19 mg/l, respectively). A low level ammonia concentration was also detected from the UT @ RM 9.10 with sustained presence of ammonia downstream at RM 8.95 (Table 26 and Appendix F).

This stream reach should be included in any future monitoring efforts to assure that additional flows and associated chemical inputs do not further erode either the instream habitat stability or the high biological integrity of this section of Little Darby Creek. Additional sampling during winter and spring might better illuminate the magnitude of any negative consequences of the storm water inputs from the tributaries draining the West Jefferson Industrial Park. Considerations to possibly decrease urban storm water to this sensitive reach of Little Darby Creek may include increased capacity of storm water catchment ponds, installation of a storm water holding/treatment facility adjacent to St. Rt. 29, and redirection of the storm water to the Deer Creek watershed via a Gladly Run tributary.



Figure 52. Mostly loose sand/gravel/small cobble substrates along Little Darby Creek river left from RMs 8.84 - 8.6, 2015. Note that some areas of the creek on the river right of these photos were more embedded.

Little Darby Creek Mainstem Trends

Trends were examined between the 2014/2015 and 2001/2002 surveys in Little Darby Creek. ICI comparisons indicated some minor changes in community quality (Figure 53).

Similar communities were collected from the natural substrates during both surveys upstream from the Mechanicsburg WWTP. Relative density on the artificial substrates was demonstrably higher at RM 39.6 in 2001 than any site sampled in either the 2001/2002 or the 2014/2015 surveys (3914 organisms/ft²). Inadequate current speeds over the artificial substrates at the RM 39.3 location in 2015 were not sufficient to provide a numerical comparison of benthic productivity between survey years, but organism density on the natural substrates was appraised as moderate/high, suggesting continued inputs of nutrients into the stream in both surveys. In addition to the fertilizers, open pasture, and agricultural nonpoint source runoff discussed in the preceding paragraphs, there have been a number of spills recorded in the Mechanicsburg area that could also have contributed nutrients, as well as toxics, into the headwater reach of Little Darby Creek. According to Ohio EPA Division of Environmental Response and Revitalization records, there were multiple oil spills in 2006, a sewage release from the Spring Street lift station in Mechanicsburg in 2008, automobile fluid spills (including oil and antifreeze) twice in 2009, an aqueous nitrogen fertilizer spill on Parkview Road in 2010, a spill of the herbicide Paraquat near Catawba and Loveless roads in 2011, a sewage spill along Spring Street in 2012, and a spill of the herbicide Clethodin in 2015. The benthic communities in the headwaters of Little Darby Creek only marginally met the EWH biocriterion in 2014/2015, so it important to manage or eliminate potential inputs of nutrients and toxics in order to sustain achievement of biological goals.

Less than optimal artificial substrate colonization parameters were likely responsible for the six-point decline in the ICI at RM 34.7, as less caddisflies and more dipteran/non-insect taxa were captured on the artificial substrates. However, the resulting ICI score still easily exceeded EWH expectations. A more noticeable decline in ICI was documented at RM 24.5 (Rosedale-Plain City Road). An ICI of 42 was scored in 2014, which was on the low end of the range of non-significant departure of the EWH biocriterion, and a represented a 16-point decline from the ICI of 58 that was garnered in 2001. In the year or years preceding the 2014 survey, trees in the area adjacent to St. Rt. 38 upstream at RM 26.5 were cut down, and much of that wood was left in Little Darby Creek, which in turn decreased current velocity and created pooled conditions (Figure 54). In the previous survey in 2001, the substrates at RM 24.5 were well-aerated, with small pea gravel, sand, logs, and other assorted larger substrates with very little silt. In 2014, the rocky substrates were much more silt-laden and less suitable for colonization, which decreased community diversity as qualitative total taxa declined from 85 to 60 (Figure 55). Sensitive and EPT taxa

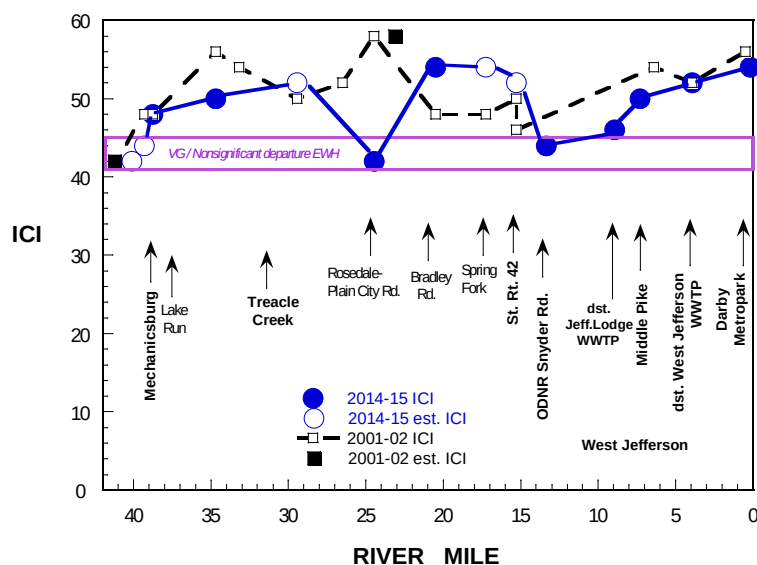


Figure 53. Longitudinal trends of ICI scores for Little Darby Creek mainstem sites, 2001-2002 and 2014-2015. The ICI is estimated via qualitative evaluation where quantitative data are not available.

richness also declined between survey years. The temporary pools created by damming from the downed trees decreased flow velocity in the upstream reach, and the increased silt/sediment deposition may have affected the macroinvertebrate community at RM 26.5, particularly the clubshell mussel population that inhabited this reach in 2001.

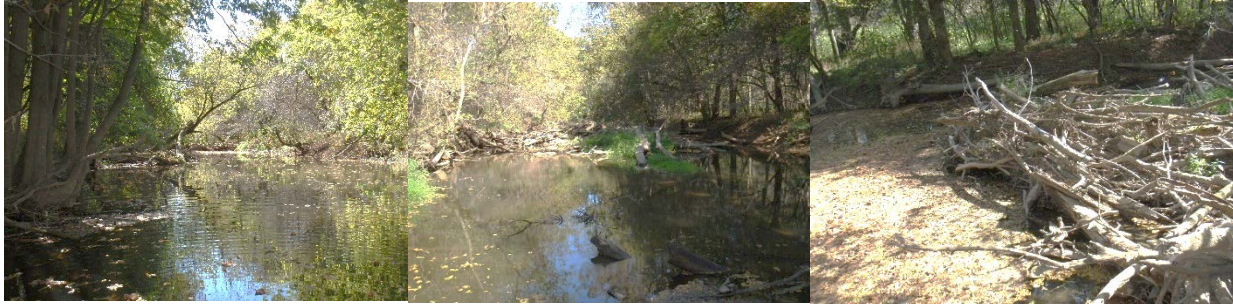


Figure 54. Logjam/pile in Little Darby Creek at RM 24.71 in 2014 - pool upstream logjam & in pool downstream logjam (foreground).

The ICI score at Bradley Rd. (RM 20.5) rose to a 54 in 2014 from a 48 in 2002. In general, increases were realized in key community attributes such as total and EPT taxa richness in 2014 from 2002 (Figure 55 and Figure 56). However, as discussed previously, nutrient signatures were present in the 2014 community via increased relative density, of which a significant proportion were facultative blackflies. Similar benthic performances were documented between both surveys in the lowest reach of Little Darby Creek from RM 17.25 to the mouth. Qualitative EPT taxa richness, in particular, was noticeably higher in this reach in 2014/15 as compared to 2001/02 (Figure 56). There was less calcium build-up observed in the cobble and rubble at RM 17.25 in 2014 as compared to 2001, and pH values were lower, ranging between 7.9-8.05. ICI scores remained consistent downstream from the West Jefferson WWTP at RM 3.95, but a decline in relative density, and a reduced predominance of the midge species *Rheotanytarsus* on the artificial substrates were reflective of reduced nutrient inputs from the West Jefferson WWTP. There were some declines observed in the freshwater mussel communities at RMs 17.25, 15.30, and 7.30, which are discussed in the [Mussel Evaluation](#) at the end of this section.

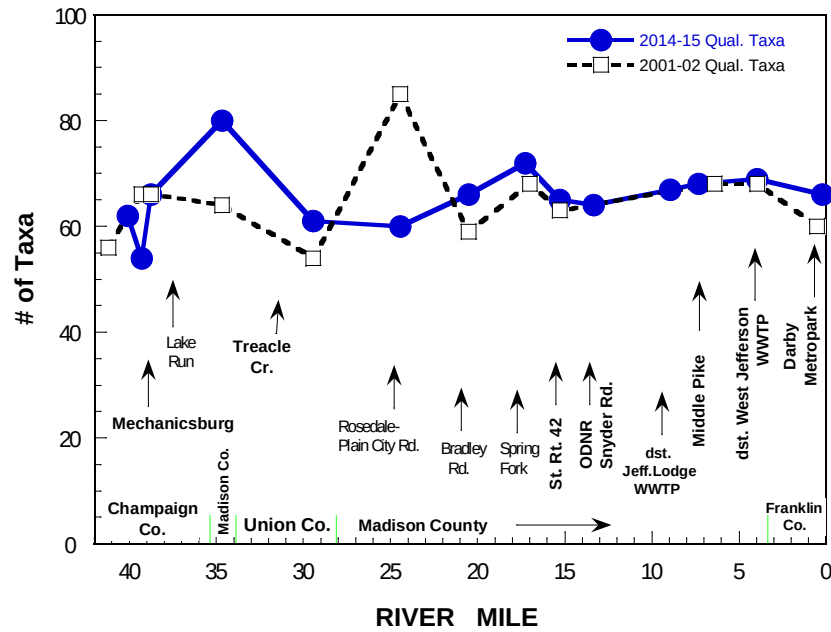


Figure 55. Qualitative total taxa from Little Darby Creek collected from Little Darby Creek, 2001/2002 and 2014/2015.

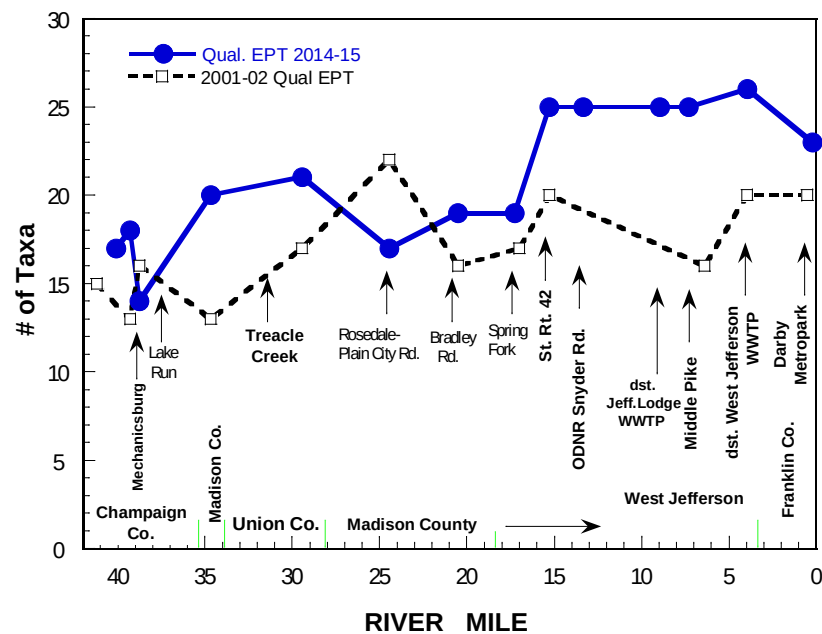


Figure 56. Qualitative EPT taxa collected from Little Darby Creek, 2001/2002 and 2014/2015.

Little Darby Creek Tributaries

Tributaries sampled in the Little Darby Creek watershed included Clover Run, Lake Run, Jumping Run, Treacle Creek, Proctor Run, Barron Creek, Wamp Ditch, and Spring Fork.

Clover Run is augmented by cool ground water from the boulder belt of the Cable moraine and a robust riparian corridor (Figure 3). The one sampling location on Clover Run (RM 0.60, V06G27) supported an improved macroinvertebrate community that met EWH expectations in 2014. There were large increases in EPT and sensitive taxa since 2001; 24 EPT and 23 total sensitive taxa were collected in 2014 compared to 14 EPT and 13 sensitive taxa in 2001. Seven cold-water taxa were present, and the cold-water mayfly *Baetis tricaudatus* and caddisflies *Ceratopsyche slossonae* and *Glossosoma* sp. were among the predominant organisms present or very common (Table 10). These taxa, along with an abundant population of mottled sculpins, supported the recommendation to re-designate Clover Run to the CWH aquatic life use designation.

Lake Run met EWH expectations with an exceptional quality community. There were 91 taxa collected in 2014, including 24 EPT and 21 sensitive taxa. There was still some dark brown silt in pools (inputs from kettle lakes or from Jumping Run), but it did not affect quality to any large degree. Some vegetation stabilization and channel improvements allowed incremental recovery and increased diversity compared to 2001, as baetid mayflies became predominant in the macroinvertebrate community. In 2014, the 90 total taxa were nearly three times higher than the 38 collected in 2001, and the 2014 EPT and sensitive taxa totals were substantially higher as well (Figure 57), further substantiating improvements in stream quality.

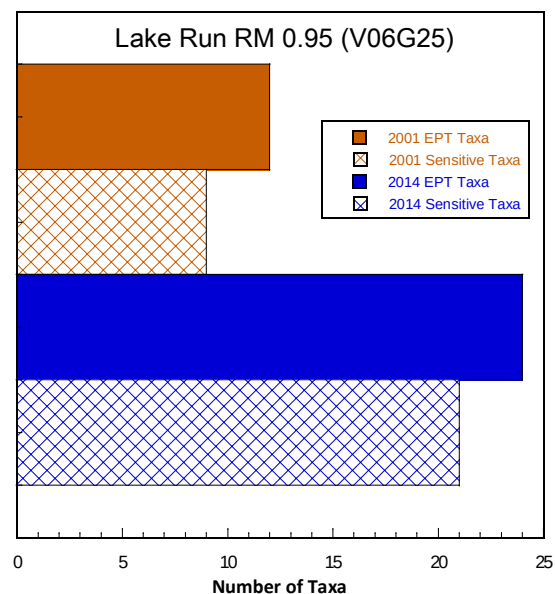


Figure 57. Number of qualitative EPT and sensitive taxa Lake Run RM 0.95, 2001 and 2014.

The macroinvertebrate community of **Jumping Run**, a WWH tributary to Lake Run, reflected improvement since 2001. Despite some elevated nutrient inputs, a very good community was present with 16 EPT and 17 sensitive taxa, along with a total of 73 total taxa (Table 10). The 17°C stream temperature, driven by ground water inputs, helped ameliorate some of the issues from excess algal production. Five cold-water taxa were collected, including the sensitive mayfly taxon *Baetis brunneicolor*, as compared to two taxa in 2001. Jumping Run, recommended to be upgraded to the EWH aquatic life use, is on a positive trajectory; there were only eight EPT taxa and five sensitive taxa collected in 2001.

Treacle Creek was sampled at three locations in 2014 and met EWH expectations at the upper and middle sites with a very good evaluation at RM 11.77 and an exceptional ICI score of 56 at RM 6.7. Treacle Creek, augmented by cool ground water from the moraines in the upper and middle reaches, supported high instream habitat quality with ambient water temperatures of 15–20°C; four CW taxa were collected at both upstream sampling sites (Figure 58). The sensitive caddisfly *Neophylax* and mayflies *Isonychia* and various heptageniids were among the predominant organisms. Compared to 2001, there has been an improvement in diversity and quality (Figure 59, Figure 60). Quantitative totals were even higher at RM 6.7 – 22 total EPT and 25 total sensitive taxa (Table 10).

A grain spill occurred in **Treacle Creek** in July of 2014 at the Winget Rd. bridge (RM 0.78, V06S11) during the artificial substrate colonization period. Also, removal of a mature wooded riparian reach along Treacle Creek downstream from the Winget Rd. covered bridge had occurred (Figure 58). Dissolved oxygen exceedances as low as 0.15 and 1.59 mg/l were documented after the spill. At the time of artificial substrate sample retrieval and qualitative sampling, there were only three EPT and four sensitive taxa documented in the samples downstream at RM 0.75 (Table 10). An elevated number of tolerant aquatic worms (928 = ~28% of the total sample) and tolerant midges (18% of quantitative sample), including *Chironomus (C.) decorus group* and *Tribelos jucundum*, dominated the community totals on the artificial substrates collected. The abundance of these organisms illustrated the negative change and impact to the macroinvertebrate community. The fair quality ICI score of 26 in **Treacle Creek** at Winget Rd. (RM 0.77, V06S11) did not meet the EWH biocriterion. This lower reach of Treacle Creek has had a history of sedimentation from previous removal of the wooded riparian corridor and unrestricted livestock access in this lower reach, as first noted in 2001. Both activities affected stream resource quality in the earlier survey (Ohio EPA 2004) and are still affecting this reach of Treacle Creek currently.



Figure 58. Treacle Creek at Parkview Rd. RM 11.8 (V06G18) - left, RM 6.7 (V06G20) – middle, and RM 0.78 (V06S11) – right. Note lack of riparian corridor and lack of natural habitat features at RM 0.78.

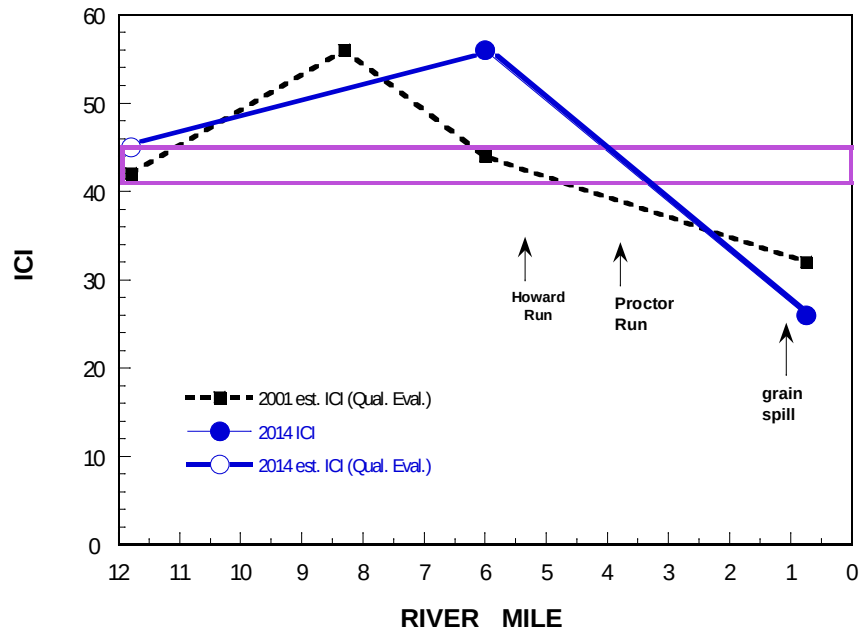


Figure 59. ICI and estimated ICI scores from narrative evaluations at Treacle Creek sampling sites, 2001 and 2014.

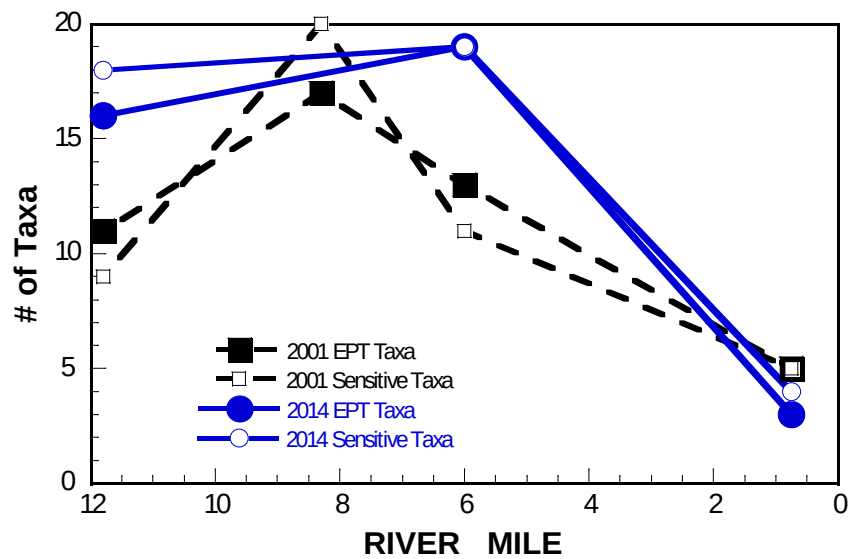


Figure 60. Number of qualitative EPT and sensitive taxa at Treacle Creek sampling sites, 2001 and 2014.

Proctor Run met EWH expectations at both sampling locations in 2014. The narrative evaluations of very good at RM 4.9 (V06G21) and exceptional at RM 1.6 (V06G23) were similar to the 2001 survey. Good riparian corridor shading kept algal production low. There were increased EPT and sensitive taxa collected in 2014, with hydropsychid caddisflies and baetid mayflies predominant, which indicated some improvement in community quality. There were 16 EPT taxa collected in 2014 compared to 12 EPT taxa collected in 2001 at RM 4.9, and a total of 24 sensitive taxa in 2014 versus 18 sensitive taxa in 2001 at RM 1.6. There was no evidence of either raw sewage inputs or an HSTS issue that was documented during the 2001 survey (Ohio EPA 2004).

Barron Creek was sampled at RM 0.2 (V06G17) near the mouth at St. Rt. 38 in 2014. A good quality community was confirmed and met WWH expectations. There were 14 EPT taxa and 12 sensitive taxa collected, with the sensitive cased caddisfly *Neophylax* sp. and the river snail *Elimia* sp. predominant in the 2014 macroinvertebrate community. This was a large improvement in quality from 2001, when six EPT and five sensitive taxa were collected at RM 0.2. Improvements can be attributed to riparian habitat improvements and cooler instream temperatures (10°C). The fields adjacent to this lower reach of Barron Creek were removed from crop production (formerly denuded with open canopy) and were in secondary succession with trees, shrubs, and grass (Figure 61).



Figure 61. Barron Creek upstream from St. Rt. 38 at RM 0.2 (V06G17). Note succession after stream corridor removed from crop/pastoral production (upstream view above left and downstream view above right), 2014.

Wamp Ditch, a ground water-fed modified and ditched watercourse (tributary to Little Darby Creek @ RM 23.0), was sampled in 2014 upstream from Finley-Guy Rd. at RM 0.1 (V06Q08). There was a short, more natural, 5-meter reach downstream from the road where Wamp Ditch emptied into Little Darby Creek that was sampled in 2001, but not in 2014. A tolerant and impaired macroinvertebrate community was documented in Wamp Ditch in the sampled reach in 2014. Flatworms and midges predominated, with only one mayfly taxon collected among the six total EPT and three sensitive taxa collected (Table 10). The 2014 narrative assessment of fair did not meet WWH expectations which was in contrast to 2001. A marginally good community was present in 2001 with nine EPT and six sensitive taxa, including the snail-cased caddisfly *Helicopsyche borealis*, river snail *Elimia*, and water penny beetle *Psephenus herricki*.

Spring Fork, which drains an area of almost 38 mi² and joins Little Darby Creek at RM 17.46, was sampled at four locations in 2014. The EWH biocriterion was met at three of four sampling sites in 2014 (Table 10). The most upstream site, Wren Rd. at RM 15.8, drains through the boulder belt of the Cable Moraine which provides good ground water recharge. The cooler 18.5°C water temperature through this grassy, historically channelized, gravel stream reach ameliorated some erosional and nutrient inputs from adjacent cropland. Riparian corridor widths were roughly 40 feet with mostly small trees. The QHEI score improved to >75 from the 60 scored in 2001 (Ohio EPA 2004). The improvement in habitat/riparian height, along with a related 3°C decrease in stream temperature, helped contribute to a large improvement in stream community quality (Figure 62). The macroinvertebrate community, assessed as very good, supported 15 EPT and 11 sensitive taxa, with hydropsychid caddisflies and baetid mayflies (*Baetis* spp. and *Labiobaetis* spp.) predominant (Table 10). These EPT and sensitive taxa totals were two to three times higher than those generated in the 2001 survey (eight EPT and three sensitive taxa) (Figure 63).

At RM 10.0 downstream from Guy Cemetery Rd., the macroinvertebrate community was impacted by silt and sand bedload from recent riparian removal and channelization upstream from the bridge. As a consequence of riparian removal, the instream temperature rose to 25°C with open canopy conditions and the narrative assessment of good failed to meet EWH expectations. The 14 EPT and 11 sensitive taxa collected in 2014 were less than those collected in the 2001-2002 survey, which included 20 EPT and 18 sensitive taxa that corresponded to an exceptional ICI score of 56 (Figure 62, Figure 63). The QHEI decreased to 57.5 in 2014 compared to the 69.5 scored during the earlier survey.

Wider and better riparian shading at RM 7.7 (upstream from Rosedale-Plain City Rd.), and the resulting lower ambient stream temperature (17.8°C), contributed to the very high ICI score of 58 at this location. This was despite a low dissolved oxygen measurement, elevated iron, and two high total suspended solids measurements (254 mg/l and 197 mg/l) recorded on 5/15/14 and 6/25/14, respectively; these were attributed to the riparian removal and channelization activities about 2.5 miles upstream near Guy Cemetery Rd. There was good habitat development upstream from Rosedale-Plain City Rd. inside the diked channel where diverse taxa were collected from the larger stable substrates in the riffles, runs, and root wads/rocks in flowing margin areas. The ICI score of 58 greatly improved upon the good quality macroinvertebrate community collected in 2001 (Figure 62 and Figure 63). Sediment bedload was also problematic in 2001, and the EPT and sensitive taxa totals collected then were much lower at this site compared to the 2014 survey (18 EPT and 16 sensitive taxa in 2014 versus 11 EPT and 8 sensitive taxa in 2001).

The lowest **Spring Fork** sampling site downstream from Lafayette-Plain City Rd. at RM 0.65 (V07S36) was sampled to evaluate Plumwood and the Green Meadows MHP, the latter which had a wastewater spill in 2011. The macroinvertebrate community was assessed as exceptional, with 20 EPT and 16 sensitive taxa collected (Table 10). Spring Fork in this lowest reach was characterized by rocky substrates with water willow islands/bars and varied macrohabitat. The exceptional community at RM 0.65 was similar to the community quality near Plumwood in 2001-2002.

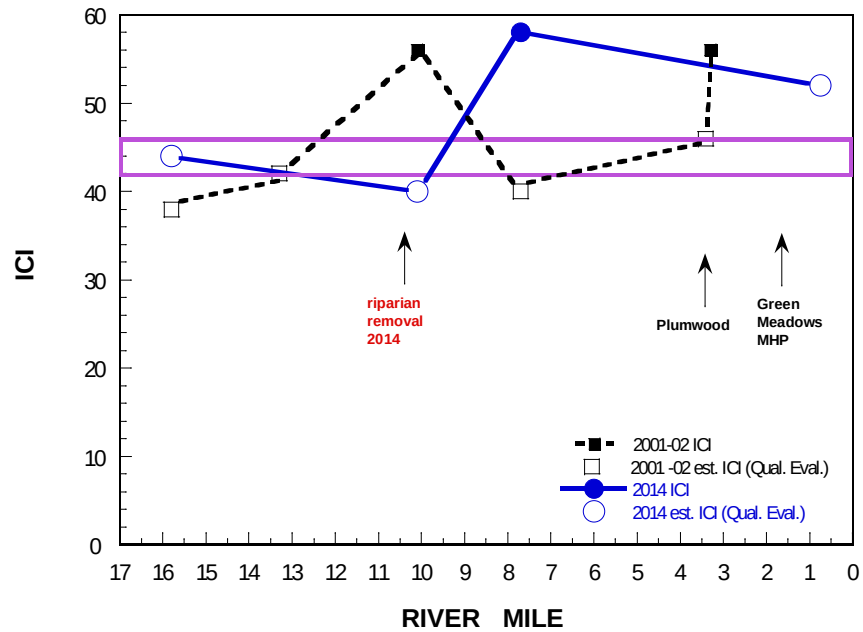


Figure 62. ICI and estimated ICI scores from narrative evaluations at Spring Fork sampling sites, 2001-2002 and 2014

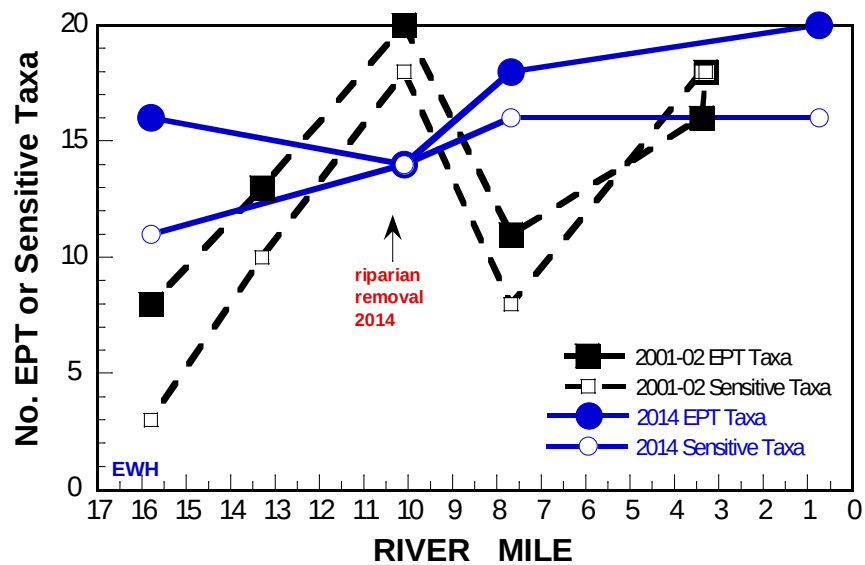


Figure 63. Number of qualitative EPT and sensitive taxa collected from Spring Fork sampling sites, 2001-2002 and 2014.

Mussel Data Trends and Discussion

Ohio EPA collected mussel data from locations within the Big Darby watershed during both the 2001/2002 and 2014 watershed surveys and during various other intervening years in response to events (*e.g.*, spills) which occurred. The methods used to collect the data were low intensity (*i.e.*, visual surveys of sites to locate and identify either live specimens or collect fresh dead shells) and did not include more robust procedures that would involve vigorous excavating substrates or transect searches for counts and population estimates. As such, there are some limitations as to the depth and detail of the ensuing mussel assessment, which for the most part, focused on changes in the presence or absence of mussel species observed at co-located sites during both surveys or other intervening years with available data. However, this approach effectively provides an “apples to apples” comparison of Ohio EPA mussel collections from the Big Darby Creek watershed. As vibrant and robust populations of mussels in the Big Darby watershed are mainly confined to the mainstems of Little Darby Creek and Big Darby Creek, the focus of the ensuing discussions center on those two water bodies. While mussels were collected from some of the smaller tributaries in 2014, their abundance and diversity were generally low and very similar to what was found during the earlier survey. Table 13 is a comprehensive listing of live animal and fresh dead shell mussel species identified or collected by the Ohio EPA at Big Darby basin sites from roughly 2000 to 2014.

While the primary focus of the ensuing *trends* discussion in this report focused on qualitative, species presence/absence information collection efforts in the Big Darby Creek watershed by Ohio EPA from 2001 to 2014, other entities conducted a more extensive survey focused solely on fully describing mussel assemblages in Big and Little Darby creeks. The Ohio Department of Natural Resources funded a more intensive mussel survey conducted by Enviroscience from September 2014 through May 2015 in an effort to document trends relative to past mussel surveys in the basin conducted in 1986, 1990, and 1996 (Enviroscience 2015, Watters 1998). Although these two recent survey efforts differed substantially in objectives and methodology, these two independent efforts effectively complement each other and information from each would be useful to help describe recent trends in unionid communities and fill in different pieces of the puzzle.

The Big Darby Creek watershed has been widely acclaimed for its diverse unionid mussel fauna (Watters 1994) and still supports 30 or more different mussel species, including both state and federally listed mussel species (Enviroscience 2015, Table 13). Surveys from 1986 through the early 2000s have shown a general decline in species richness within the watershed (Ohio EPA 2004, Watters 1998). However, these long-term, systematic declines in species richness are not a phenomenon specific to the Big Darby Creek watershed and largely mirror declines observed in other mussel rich areas throughout North America (Haag 2012).

Despite the generally downward trend through time, it appears as if the systematic declines in species richness have curtailed somewhat in the recent decade compared to historical declines. A similar number of species was found between the 2001 Ohio EPA efforts and the more recent mussel surveys (Enviroscience 2015). Though some species may seem harder to find (*i.e.* northern riffleshell, snuffbox), it is unclear whether this is because of these rare species are experiencing further declines or whether it is due simply to the fact that the common species, with seemingly more advantageous reproduction strategies, are becoming more common (T. Watters in Arenschield 2016). State listed species such as the kidneyshell (species of concern) has remained a substantial component of the mussel community, while the state listed wavyrayed lampmussel (species of concern) has also apparently become a larger component of the overall mussel community.

Generally speaking, Ohio EPA data from the current survey suggests that the upper to middle reaches of Big Darby Creek from the vicinity Flat Branch downstream through the Plain City seemed to support more stable mussel populations than other areas in the watershed, and some limited recolonization of species (such as the creeper – *Strophitus undulatus*) in these areas has likely been facilitated by clearly improved water quality throughout these reaches. Using traditional measures, water quality in this system is better than it has ever been. Water quality or other habitat stressors have not precluded the apparent persistence of state listed species such as the kidneyshell or wavyrayed lampmussel.

Ohio EPA (2004) identified water quality issues in the watershed that could be negatively impacting mussel communities throughout specific stream reaches (Tables B.7.4.2 & B.7.4.3). Many of the issues identified in Ohio EPA (2004), particularly instream enrichment indicators (i.e. DO swings and supersaturation) and water chemistry issues stemming from point sources have been effectively addressed since 2001. Given the high proportion of agricultural land in the watershed, efforts to combat nutrient enrichment should continue. Sedimentation and unstable substrates, especially in more developed areas such as downstream from Hellbranch Run, will also likely need constant and on-going attention to further buffer this stream system from anthropogenic development and ensure as natural flow regime as possible. The impoundment at RM 37.2 continues to present an obstacle for both fish and mussel species that might otherwise move upstream; removing this barrier to passage would undoubtedly allow for some of the species only found downstream to begin working their way upstream into Big Darby Creek.

Looking forward, there has been much interest in forming an interdisciplinary workgroup of interested stakeholder groups, including state and local partners, to help inform and guide future mussel monitoring and conservation efforts in this watershed.

Mussel Reproductive Strategy Observations

A mussels' life history and reproductive strategy is often quite complex and species-specific information has not always been readily available or well understood. Though more information exists today than historically, reproductive strategies and host inter-relationships for some species are still not fully understood (Watters et. al 2009). Along with well-documented sensitivities to water chemistry and other physical habitat perturbations (Haag 2012, MBI 2010), generally convoluted life history strategies can only add to the sensitivity of these organisms (Haag 2012).

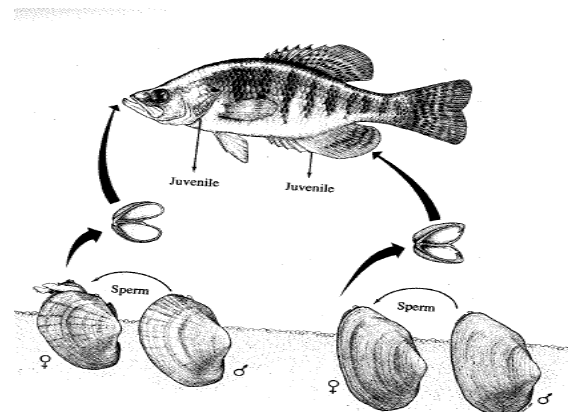


Figure 64. General freshwater mussel life cycle. Used with permission from Ohio DNR.

The life cycle of a mussel often involves a larval mussel, or glochidia, becoming attached to an appropriate host fish to mature, before falling off to complete its life cycle into adulthood (Figure 64). However, within this general life cycle, there are a myriad of different strategies different mussel species use to achieve this (Watters et. al 2009). The mechanism in which an adult mussel uses to “infect” a suitable host fish, the timing of spawning, the amount of time glochidia reside on a host fish, and the number of broods per year can all vary among species. Additionally, suitable fish host species can vary

widely among mussel species; some mussels may be generalists and can use many different fish species, while others can only use very specific fish species.

Though not all encompassing, an effort was made to present select reproductive characteristics for noteworthy mussel species currently or historically found within the Big Darby Creek watershed in succinct and summarized fashion (Table 11). Lack of documented reproduction from translocated species like the northern riffleshell despite its continued persistence (albeit at low concentrations), coupled with the apparent success of other mussel species in the watershed like spike and kidneyshell suggests the possibility that reproductive strategies may play a role in explaining why some mussels have apparently been more successful and increased in abundance compared to other species.

The three most commonly mussel species collected in the Big Darby Creek watershed were fatmucket, spike, and kidneyshell (species of concern) (Table 13). The rainbow darter (*Etheostoma caeruleum*) is one of the more abundant fish hosts for both the spike and kidneyshell mussels and has expanded somewhat throughout the watershed since 2001 (Appendix K, Watters et al. 2005, 2009ab). The kidneyshell mussel (*Ptychobranhus fasciolaris*) uses four other darter host species in addition to the rainbow darter, including greenside, fantail, johnny, and banded darters; similar to the rainbow darter, all of the aforementioned fish host species maintained robust populations or have increased in abundance throughout the Big Darby Creek watershed since 2001 (Appendix K, Watters et. al 2009ab). Relatively common and ubiquitous fish host species are an obvious benefit to these and other species that are hosts generalists. Comparatively, those mussel species who may use fish hosts that are rarer (i.e. rare darters) or fish hosts that are only limited to certain portions of the watershed, either naturally because of stream size preferences or because of dams (i.e. freshwater drum, river redhorse, sauger) likely don't realize these same benefits. Species that rely solely on large river species such as freshwater drum (i.e. deertoe, washboard, pink papershell), may have natural spatial limitations (Table 11).

The kidneyshell mussel (species of concern) utilizes parental glochidial overwintering in the female marsupium after fertilization in August (Watters et al. 2009b). In the spring (April and May) glochidial release, metaconglutinates (mimic "lure" structures expelled by the female mussel with glochidia within) are released and adhere to rocks or sticks after release (Watters 1999). These metaconglutinates mimic insect or larval fish and "are avidly consumed by fish resulting in glochidial attachment" to the gills, parasitizing fish hosts (Figure 65, Figure 64, Waters et al. 2009b). This particular reproductive strategy, coupled with a widespread abundance of their host fish species, has seemed to benefit the kidneyshell mussel. Its presence was noted at nine sampling sites along the Big Darby Creek mainstem in 2014, often in locally high abundance (third highest in Ohio EPA totals).

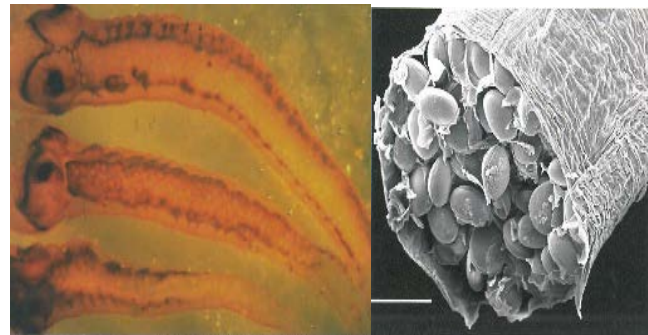


Figure 65. Metaconglutinates mimicking fish fry (left) and cross-section through metaconglutinate with central core of glochidia (right). Images from Watters et al. 2009b, p252 (used with permission).

The spike mussel (*Elliptio dilatata*) is tachytictic (fertilization in the females from March to July) and releases glochidia in two distinct periods: August- September at 19° C. ± 2° C. and in November when temperatures reached 5° C. (Jirka and Neves 1992, and Watters and O' Dee 1998). Female spike mussels have multiple broods, or a staggered glochidial release with glochidia discharged in narrow and tapered white conglutinates (Utterback 1915 in Watters et al. 2009b). The asynchronous glochidial releases allows for potential host overwintering on a number of possible common host species, including the rainbow darter, rock bass, white and black crappie, gizzard shad, flathead catfish, and sauger (Watters and O' Dee 1999, O'Dee and Watters 1998). Effective reproductive strategies and very common host fish species have kept the spike mussel among the most abundant species throughout the watershed; it was collected at 14 sampling stations along the Big Darby Creek mainstem in 2014 (Table 13, Figure 66).



Figure 66. Spike mussel (*Elliptio dilatata*)

The fatmucket (*Lampsilis radiata luteola*) is the most common mussel collected at Ohio EPA sampling sites in 2014, with live or fresh dead specimens found at 16 locations (Table 13). The fatmucket has multiple broods and releases large numbers of glochidia from May to December with some glochidia in the water column almost year-round; fatmuckets are also capable of utilizing both host fish species or parental care for overwintering (Watters and O' Dee 1999, 1998, Watters et. al 2009b). With common and ubiquitous species such as smallmouth and largemouth bass, sand shiners, bluntnose minnows, and centrarchids (bluegill and many others) as hosts for glochidia, this generalist mussel species was the most common collected throughout the watershed in 2014. The aforementioned suite of traits obviously benefits the fatmucket.

Two other lampsiline mussels, (*Lampsilis cardium* and *L. fasciola*), the plain pocketbook (9 sites) and wavy-rayed lampmussel (5 sites), were other commonly collected species at Ohio EPA sampling locations in 2014 (Table 13). Both utilize common fish species as hosts, including sunfishes and smallmouth bass, whose range extension and abundance have increased both upstream and downstream from the impoundment located on Big Darby Creek (Appendix K). Both species use a mantle lure mimicking a juvenile fish, which when struck by a predator fish releases a cloud of glochidia into the fish's mouth to attach on gills (Watters et al. 2009b, Watters 1995). Plain pocketbooks can effectively overwinter on hosts, while wavy-rayed lampmussels can have multiple broods which are released to metamorphose in the fall or overwinter in marsupia of females (Watters and O'Dee 1999, Watters et al. 2009).

The Wabash pigtoe (*Fusconaia flava*) and creeper (*Strophitus undulatus*) were also somewhat common during the 2014 watershed survey and were collected at five and six mainstem sampling sites, respectively (Table 13). Similar to the above listed abundant mussel species, both the Wabash pigtoe and creeper use common fish species as hosts with conglutinates for glochidial infestation (Watters et al. 2009). Both are also versatile and can inhabit a variety of water bodies from small headwater streams to larger rivers (Watters 1995).

A combination of traits, including common and widespread fish hosts, multiple or continuous glochidial releases per breeding season, the use of conglutinate or conglutinate like structures, and the the ability of glochidia to overwinter seem to be comparatively advantageous reproductive strategies. Ultimately, effective reproductive strategies and very common host fish species seemed to have benefitted the aforementioned mussel species, as they remain among the more abundant species throughout the watershed.

Table 11. Selected reproductive characteristics of select mussel species currently or formerly found in the Big Darby Creek watershed, Ohio. Mussel reproductive information was displayed for Ohio, though some these traits may differ within a species from state to state. Fish host abundance and distribution information is tailored to the Big Darby Creek watershed. Unless otherwise noted, information within the table was derived from Watters et. al 2009. FE = federally endangered, OE = Ohio endangered, OSC = Ohio species of concern

Species		Bradytictic /Tachytictic	Spawning & Egg/glochidial development period	Glochidial Release months	Glochidial Delivery Strategy	Glochidia ability to overwinter?	Potential Host Species & notes	Other Notes
<i>Villosa fabalis</i>	Rayed bean (FE,OE)	bradytictic	Gravid females found in May	Folllowing spring.**	Lure display. Flickering white marsupia behind dark mantle tissue.	Y	Tippecanoe darter - limited range (Watters et. al 2009b). Greenside darter, mottled sculpin, rainbow darter, and largemouth bass are also reported as potential hosts in Canada.**	Mantle-lure not as "flashy" as other species using this dispersion strategy. Relatively small mussel.
<i>Epioblasma torulosa</i>	Snuffbox (FE,OE)	bradytictic	September (YR1)	April-May (YR2)	Female traps snout of host fish; no lure display.	Y	Logperch, mottled sculpin, blackside darter.	
<i>Epioblasma torulosa</i>	Northern Riffleshell (FE, OE)	bradytictic	Summer	September (YR1) through June (YR2)	Lure display. Female traps head of host. No conglutinate	Y	Possibly sculpin, bluebreast, rainbow, & banded darter. Latter 3 common and widespread.	Protracted glochidial release period can occur from September through winter, until to the next June. Description seemingly indicates later, drawn out release of glochidia; long term breeder. Females move to substrate surface during brooding in winter/spring. (Watters et. al 2009b)
<i>Pleurobema clava</i>	Clubshell (FE, OE)	tachytictic	May-June	By end of June	Fragile, white, non-elastic conglutinate	N	Central stoneroller, striped shiner, logperch, blackside darter. Common and widespread.	Slow growth throughout entirety of life.
<i>Quadrula cylindrica cylindrica</i>	Rabbitsfoot (FT, OE)	Tachytictic	May-August	August	Tan to orang, lanceolate conglutinates.	N(?)	Rainbow darter, striped shiner. Possibly spotfin shiner and bigeye chub.	Prefers creeks and small rivers (Watters et. al 2009b). Still presend throughout Little Darby Creek (Enviroscience 2015).
<i>Truncilla truncata</i>	Deertoe (OSC)	tachytictic	April-May*	May-June*	No durable conglutinate is formed.	Y	Freshwater drum only	Glochidial ability to either develop quickly or overwinter on host (Haag 2012). Spawning period seems to match host spawning run upstream and seems largely governed by minimum temperature (Loyd 2017). Given host specificity, species only found in larger rivers and lakes. Fast growing and fairly short lived.
<i>Lampsilis fasciola</i>	Wavyrayed Lampmussel (OSC)	bradytictic	August (YR1)	October (YR1) & April (YR2)	Lure display	Y	Black bass and longear. Widespread and abundant.	Literature suggests 2 potential glochidial release periods per year. Mantle-lure display more "flashy" compared to snuffbox or northern riffleshell. Several distinct mantle lure types, even in populations living side-by-side. (Haag 2012)

Species		Bradytictic /Tachytictic	Spawning & Egg/glochial development period	Glochial Release months	Glochial Delivery Strategy	Glochidia ability to overwinter?	Potential Host Species & notes	Other Notes
<i>Ptychobranchnus fasciolaris</i>	Kidneyshell (OSC)	bradytictic	August-September (YR1)	April-May (YR2)	Metaconglutinate	Y	Common & widespread darters	Unique conglutinate structure, termed metaconglutinate. 2 types of conglutinates observed in this species. One apparently mimics fish fry and the other insect larvae. Both types have adhesive tail. Conglutinates released individually by mussel and may travel 6+ inches before attaching to substrates and being consumed by fish. Glochidia overwinter in female before being released. (Watters et. al 2009b)
<i>Fusconaia flava</i>	Wabash Pigtoe	tachytictic	May-August (YR1)	July-August (YR1)	Conglutinates	N	Metamorphosis only documented in white crappie, striped shiner, & creek chub. All are common, but striped shiner is most common.	Conglutinates observed to be orange-red in Little Darby Creek, but have also been observed as pink or white in other systems in Ohio. Widespread throughout Ohio drainages and western Lake Erie.
<i>Lampsilis cardium</i>	Plain pocketbook	bradytictic	May-July (YR1) & July-October (YR1)	July-August (YR1) & April-May (YR2)	2 types observed: white, leaf shape conglutinate & free glochidia.	Y	Centrarchids. Common and widespread throughout watershed.	Glochidia can overwinter on host species for at least 6 months at 10°C. (Watters et. al 2009b)
<i>Elliptio dilatata</i>	Spike	tachytictic	March-May & July-August	Aug/Sept & November	White, lanceolet conglutinate	N	Common and widespread	Two glochial release periods in Ohio. Rare in large rivers (Ohio & Muskingum), but found in Lake Erie. (Watters et. al 2009b)
<i>Strophitus undulatus</i>	Creeper	bradytictic	Summer (YR1)	April (YR2)	Mesoconglutinate	Y	Numerous. Common and widespread. Generalist.	Unique conglutinate strategy, termed mesoconglutinate. When released, each conglutinate is comprised of relatively few, but large glochidia. Each glochidium is associated with a respective pore in the conglutinate, where it eventually moves to surface of conglutinate after expulsion from mussel while waiting for a fish host. Can either be ingested by more "pelagic" species or attach anywhere on "benthic" species as they pass over the conglutinate, not necessarily just the fins. Host generalist. (Watters et. al 2009b).
<i>Lampsilis radiata luteola</i>	Fatmucket	bradytictic	Summer	Year round once temps reach 15 °C.	Mantle-lure display	Y	Numerous, but most centrarchids. Common and widespread. Generalist.	

*Loyd (2017)

**Fisheries and Oceans Canada (2016)

Big DarbyCreek mainstem – Longitudinal Discussion

In the upper headwaters reaches of Big Darby Creek (RMs 83 to 79), there have been improvements in biological community and habitat quality after stream restoration activities were completed in the early 2000s. *Strophitus undulatus* (creeper), a common headwater mussel, was collected at RM 81.0 during the 2014 survey; this species had only been previously recorded as far upstream as RM 69.4, well downstream from Flat Branch (Table 13). Ammonia and numerous other violations documented during the 2001 watershed survey emanating from the Flat Branch WWTP that could have been negatively impacting mussel communities throughout this reach have largely been resolved (see [NPDES Permitted Facilities](#)). Additionally, there have been a large number of known spills recorded in the Flat Branch subwatershed which could have negatively impacted mussel communities in this vicinity since the 2001 watershed survey. Two diesel fuel spills occurred in 2003 and 2006 with the possible receiving stream being Flat Branch in Logan County. The majority of the spills in this area have occurred in Union County. During 2003 and 2004, five spills were documented (a glycol and four wastewater spills) with possible entry into Flat Branch or its tributaries. Truck oils and an unknown material were spilled near Flat Branch between 2006 and 2008. Diesel fuels and/or sewage/wastewater were spilled five times between 2009 and 2012 with possible entry into Flat Branch. Lube oil was spilled at the CSX railyard in 2013 and 2014, and diesel fuel was spilled near Flat Branch in November 2014. Extreme care is needed to limit spills and possible kills in Big Darby Creek from this very busy manufacturing area. Pending continued good and improving water quality and notwithstanding any future toxic events from any other possible source(s) occurring in the upper Big Darby watershed, upstream range extensions of other mussel species could be expected in the future. At least four other species were present within two miles of this location at RM 76.5 or in Flat Branch. Lower temperature regimes in the upper headwaters could slow colonization upstream for some mussel species (Watters & O'Dee 1999, 1998a).

Five mussel species were collected in 2014 at North Lewisburg Rd. (RM 76.5). The fatmucket, the most common mussel collected from the Big Darby mainstem, was found both in 2014 and 2001. The four other mussels collected were new taxa in 2014. Two were headwater species (cylindrical papershell and creeper), and the other two were the giant floater and paper pondshell, both common pool species (Table 13). While there has been an increase in mussel diversity in this reach when compared to 2001 results, two of the more common sensitive taxa (spike and kidneyshell mussels) were collected in 2001, but not in 2014. They may still be present but, if not, a ready source for return of these two species exists at Collins Rd. (RMs 68-69) where they have been consistently abundant (Table 13). Trophic evaluations at RM 76.5 did note modest nutrient enrichment with elevated diel D.O. swings and somewhat elevated benthic chlorophyll-*a*. Some water quality issues have occurred in the vicinity as a chicken manure spill occurred in February, 2004 just upstream from North Lewisburg Rd into an unnamed tributary to Big Darby Creek. The same area had a "sediment" spill and a horse manure spill reported within 20 minutes of each other in November, 2014. Additionally, stream bank and channel maintenance has occurred on agricultural land immediately upstream from North Lewisburg Rd.

In 2000 and 2001, the Collins Rd. reach (RM 69.4) was sampled to assess mussel diversity and relative abundance upstream from Milford Center, a reach affected by a 2000 grain/molasses spill. There were abundant live mussels with eight taxa present in 2000. In 2001, the same site was sampled but only four mussel taxa were collected (fatmucket, kidneyshell, spike, and fluted shell). A reason for the decline was unclear, although 2001 flow and turbidity conditions made mussel sampling difficult (Figure 67). The 2014 mussel taxa totals were similar to the 2001 sample with three species collected (Table 13). However, the taxa not collected in 2014 at RM 69.3, but observed in 2000 (threeridge, Wabash pigtoe, creeper, and

rainbow mussels), were collected from downstream reaches between Milford Center and Plain City (Table 13). Thus, the potential exists for upstream recolonization of these species into reaches previously occupied.



Figure 67. Big Darby Creek upstream from Collins Rd. (8/15/2001) and adjacent to Collins Rd. (8/14/2014).

All comparisons of 2014 with 2001/2002 mussel data from the Big Darby mainstem reach between Milford Center and Plain City are somewhat relative since 2001/2002 data collections continued to reflect the impacts from the 2000 grain/molasses spill which seriously affected mussel diversity and abundance throughout this reach. Comparisons of the 2014 and 2001/2002 mussel data indicated some relative improvements in the mainstem upstream from Buck Run (RMs 63.9/64.4) where three species were observed in 2014 and zero in 2001. Other improvements in mussel species diversity occurred in 2014 downstream from Buck Run (RMs 62.75/62.9 – four species vs. two in 2001) and near U.S. Rt. 42 (RMs 54.1/54.2-53.9 - six species vs. two in 2001) (Table 13). This reach of Big Darby Creek, from near Milford Center to upstream from Plain City (RMs 70 - 54) has supported more stable or improving mussel populations compared to the rest of the mainstem (Table 13). These relative improvements have occurred in spite of numerous spills which occurred between 2003 and 2013 including fire runoff chemicals, sewage, ammonia fertilizer (multiple), latex paint and oil stain, hydraulic and engine oil, gasoline/diesel fuel (multiple), and transformer oil (PCB source).

There were more mussel species collected downstream from Plain City in 2014, but the sampling location was further downstream from the Plain City WWTP discharge (just upstream from Sugar Run confluence at RM 50.95) compared to the 2001 sampling location (RM 52.0). In 2014, a sediment sample was collected at RM 51.1 between these two locations at a site upstream from Cemetery Pike. Habitat consisted of a slow, deep, and wide run with depositional areas where elevated sediment phosphorus, metals, and ammonia concentrations were measured. While these measured values could be capable of impacting mussels directly exposed to sediments (Ohio EPA 2004, Table 32; Newton et al 2003; Bartsch et al. 2003; Frazier et al. 1996), four species of mussels were collected at the 2014 sampling location at RM 50.95 which reflected better diversity and abundance than observed farther upstream at RM 52.0 in 2001 where no mussels were collected.

From RMs 50.0 to 37.27 (downstream from Sugar Run to the Big Darby low-head dam), there were declines in mussel diversity at three co-located sampling sites when comparing 2014 with 2001/2002 collections. In 2001 upstream from Amity Pike at RM 49.7, eight mussel species were found at the site upstream from Ballenger Jones Ditch. This sampling site was upstream from Plain City School and Suburban MHP inputs. A little farther downstream at RM 49.4 in 2014, only old shells were found, and there were heavy algal blooms in the pools upstream and downstream from the Amity Pike bridge observed during all three visits in 2014. Nutrient sources have accumulated (Robinson Run, Sugar Run,

Plain City, and smaller discharges on smaller tributaries), and nitrates and sometimes total phosphorus concentrations on Big Darby Creek in this reach were, with a few exceptions, above nutrient targets. The other sampling locations with slight species richness declines in 2014 were near Hubbard Rd (two species observed in 2014 and four in 2001 and 2006) and at U.S. Rt. 40 (RM 38.9) downstream from Lake Darby Estates and Green Tree MHP discharges (one species observed in 2014 and three in 2002) (Table 13). While no comparable sampling occurred in 2001/2002, the sampling site downstream from U.S. Rt. 40 at RM 38.35 reflected improved mussel diversity as five fresh dead species were collected in 2014, including kidneyshell, spike, plain pocketbook, and Wabash pigtoe.

The only low-head dam in the Big Darby Creek basin is located on the Big Darby mainstem at RM 37.27. As this dam is an effective barrier to upstream migration of several fish species (see Fish Community section above), there are distinct possibilities that distributions of certain mussel species can be affected as well. Looking at the distinct site aggregations of Ohio EPA data across all sampling years (2000-2014, 39 sites), there are a few species that were common below the dam which were not found above. However, for the most part, the common species collected from the mainstem, including, spikes, kidneyshells, plain pocketbooks, Wabash pigtoes, creepers, and wavy-rayed lampmussels, were as likely to be collected at sites upstream from the dam as downstream (Table 13).

Two mussel species which were not collected upstream from the low-head dam but were common downstream were the fragile papershell (*Leptodea fragilis*) and pink heelsplitter (*Potamilus alatus*) (Table 13); both can be affected by dams as barriers to upstream migration (Ohio EPA 2004, Watters 1995b, Haag 2012). Two situations can exist – 1) certain fish host(s) susceptible to glochidia infestation are either no longer present or are prevented by the barrier from reaching upstream locations and 2) fish hosts exist upstream from the low-head dam but the mussels do not, and the barrier has kept the mussel population and any fish hosts from below it from expanding upstream (Watters 1996). Listed below are some species (and fish hosts) that could further expand their effective range upstream into the Big Darby watershed without the low-head dam impediment.

- Fragile papershell (*Leptodea fragilis*) – freshwater drum, only fish host and presently not above the low-head dam
- Pink heelsplitter (*Potamilus alatus*) - freshwater drum, only fish host and presently not above the low-head dam
- Deertoe (*Truncilla truncata*) – freshwater drum and sauger
- Elktote (*Alasmidonta marginata*) - logperch, one of its hosts, has greatly expanded downstream and even farther upstream in middle and upper Big Darby Creek
- Clubshell (*Pleurobema clava*) – ranges and abundance of hosts striped shiners, logperch, blackside darters, stonerollers and possible host fantail darters have generally expanded (Appendix K)
- Rabbitsfoot (*Quadrula cylindrica cylindrica*) – ranges and abundance of host rainbow darters, striped shiners and bigeye chubs have expanded
- Mapleleaf (*Quadrula quadrula*) & pistolgrip (*Tritogonia verrucosa*) – host channel catfish, have been collected up to the middle reaches of Big Darby Creek and in lower Little Darby Creek

The first sampling site downstream from the low-head dam on Big Darby Creek, just upstream from the Little Darby Creek confluence at RM 34.2, reflected a slight increase in mussel diversity in 2014 compared to 2001 (three species, including spike and kidneyshell collected in 2014 and one species in 2001, fragile papershell) (Table 13). Downstream near Darbydale, the 2014 sampling site was immediately upstream from the St. Rt. 762 (McKinley) bridge (RM 29.25) while in 2002 the sample was collected about 0.6 miles farther downstream (RM 28.6). The mussel species totals were fairly similar with six species collected in

2014 and nine species in 2002 (Table 13). However, the Oak Hills MHP WWTP discharge, problematic due to permit violations for ammonia, affects the Big Darby mainstem between these two sites. This discharge will be eliminated and eventually tied to the Darbydale WWTP after its upgrades are completed. Downstream from Darbydale at RM 27.95, two mussel species were collected in 2014; while no sampling was conducted at this site in 2001/2002, the decline in mussel diversity was evident compared to the collections upstream in the Darbydale area both in 2014 and 2002. At RMs 26.9/26.7 adjacent to Georgesville-Harrisburg Rd., mussels were not found either in 2014 or 2001. At both locations the stream bottom substrates were more embedded than at other sampling locations and this may have inhibited the occurrence of mussels at these sites.

Downstream from Hellbranch Run and upstream from St. Rt. 762 (RMs 26.1-23.8), there were declines in mussel diversity in the Big Darby mainstem between 2014 and 2001/2002 (zero species in 2014 and five in 2001/2002) (Table 13). In 2001/2002, field observations noted substrates consisting of broken slab bedrock and gravel but with increased embedding sediment and sand; the source of the fines likely emanated from Hellbranch Run, the most urbanized Big Darby Creek sub-watershed and the one most affected by storm water and other urban influences. In 2014, the reach upstream from St. Rt. 762 was even more embedded with sand and it was noted that larger riffle substrates were encrusted with travertine. This reach just downstream from the Hellbranch Run confluence does have good overall habitat diversity and the potential for mussel recolonization exists, assuming successful restoration projects and WWTP improvements/eliminations in the Hellbranch subwatershed result in improved water quality and reduction of storm water related water quality and sediment delivery issues.

Immediately downstream from the Pickaway Correctional Institution (PCI) (RMs 22.5-22.0), Ohio EPA data indicated little change in mussel taxa diversity between the two sampling events (three species collected in 2014 and two in 2001) (Table 13). Live plain pocketbooks were collected both years and live fatmuckets and pink heelsplitters were found in 2014 and giant floaters in 2001. Downstream from PCI and the "Clarks Lake" tributary (@ RM 20.20) to Scioto Darby Rd. bridge (RM 19.0), there was some nutrient enrichment as measured by Ohio EPA water quality sampling in 2014. Good, variable mussel habitat exists downstream in this reach with high species diversity. In 2014 at two sites, 11-14 mussel species were collected live or as fresh dead shells but 20 species were collected in 2001 which indicated a decline (Table 13). Between the two sites sampled in 2014, six of 14 mussel species were collected with live specimens, but only one of eleven mussel species collected at RM 19.1 was represented by live animals. Sediment ammonia (230 mg/kg), sediment arsenic (10.8 mg/kg) and sediment phosphorus (913 mg/kg) at this site were the second highest total concentrations measured at Big Darby Creek sites. Sediment phosphorus was greater than the Lowest Effect Level (LEL) (Table 32). The sediment ammonia concentration in 2014 (230 mg/kg) was five to seven times the concentration found in 2001 in this reach (34-42 mg/kg) (Ohio EPA 2004). At these concentrations, there is potential for impacts to mussels where sediment has accumulated (USEPA 2013; Augspurger et al. 2003; Newton et al. 2003; Bartsch et al. 2003; Frazier et al. 1996).

From RMs 15.8 to 13.2 (near Gulick Rd. to Darbyville), mussel totals were similar (two species in 2014 and 0-2 in 2001/2002) (Table 13). As documented in the 2001/2002 survey, this reach of Big Darby Creek has had water quality issues with nutrient enrichment (diel D.O. swings ≥ 6 in areas with open canopy) and physical habitat issues with erosion, unstable substrates (moving bedloads), and other areas of embeddedness; these all jeopardize and put at risk stable mussel habitat, especially during peak flows (Ohio EPA 2004). Nutrients were still elevated in 2014, with the highest nitrate geomean for the Big Darby mainstem at RM 13.36 (Figure 71, Table 16). In 2014, more stable habitat was developing downstream from St. Rt. 316 with multiple channels and islands.

Near the end of Darby Rd. at RM 11.2, a relatively stable stream reach with a complete and mature riparian corridor appeared physically similar in 2014 compared to 2002. Nitrates were still elevated above the EWH nutrient target in 2014 (Table 16). Phosphorus geomean concentrations were the lowest in the lower 22 river miles (Figure 70). There was a possible decline in mussel taxa in 2014 (four species in 2014 and 14 in 2002 (Table 13). However, some of the difference was likely due to collection effort and collector inconsistencies between the years.

From RMs 9.15 to 5.3, there were no co-located 2014 and 2001/2002 sampling sites, but the more stable habitat with some riparian shading and a very stable riffle at RM 8.4 in 2002 supported seven mussel species. This site contrasted noticeably with the other 2014 and 2002 sites in this reach where narrow or nonexistent riparian corridors resulted in open canopies and instream habitat exacerbated by eroded banks from scour and embeddedness and/or soft, unstable bedload movement. Few or no mussel species were observed at these sites (RMs 9.15 and 7.65 in 2014 and RM 5.3 in 2002).

At St. Rt. 104 (RM 3.2), the 2014 and 2001 Ohio EPA mussel collections were similar with zero or one mussel species collected. In 2012, five Ohio EPA biologists collectively noted five mussel species at RM 3.2 as part of a QA/QC event (Table 13). The 2012 field notes indicated there was a lot of silt accumulation on rocks in slow runs with algal growths on riffle/run substrates. While this more intensive data collection effort suggested the mussel diversity could be slightly better than seen during the 2014 and 2001 surveys, this site on Big Darby Creek near the mouth was still nutrient enriched, and sedimentation and/or unstable bedload movement was still an issue (Ohio EPA 2004).

Little Darby Creek Longitudinal Discussion

Little Darby Creek mussel diversity reflected mixed trending conditions. Downstream from Mechanicsburg near Irwin Rd. (RM 34.7/34.6), one mussel species (fatmucket or giant floater) was collected during both Ohio EPA survey years (Table 13). Upstream near RM 38.78, periodically inconsistent Mechanicsburg WWTP effluent, spills, open pasturage, non-point source nutrient inputs, and high sediment nutrient concentrations could be limiting mussels in this reach (Table 32, Ohio EPA 2004). Sediment ammonia concentrations downstream from the aforementioned stressors at RM 38.78 (V06S10) in 2014 was found to be 130 mg/kg; sediment ammonia in 2001 at RM 41.2 (upstream from listed stressors) was found to be 57 mg/kg. Elevated nutrient concentrations were also present throughout this reach of Little Darby Creek (Table 16) and enrichment signatures (e.g. D.O. swings) may be more prevalent throughout these reaches if not for the substantial ground water inputs. Just 1.5 miles further downstream from Irwin Rd. (RM 33.2 near Bates Rd.,) two different mussel species were collected (Wabash pigtoe and threeridge) in 2002, but 2014 status was not determined as this site was not sampled (Table 13).

Increased siltation/sedimentation occurred in Little Darby Creek near RM 24.5 (V06S03) likely resulting from the removal of riparian trees a few miles upstream in the years immediately preceding the 2014 survey (Figure 54). In spite of this, the total number of mussel species observed at RM 24.5 in 2014 remained similar to diversity totals collected at a sampling site a few miles upstream at RM 26.5 in 2002 (Table 13). If mussel populations were affected by erosion, sedimentation, and substrate smothering in the vicinity of the riparian removal, 2014 data suggested diverse mussel populations at Rosedale-Plain City Rd. were available for repopulating the upstream reach if habitat and substrate conditions have stabilized.

From Finley Guy Rd (RM 23.2) to Bradley Rd. (RM 20.5) there were 3-4 mussel taxa collected in 2002. In 2014 at Bradley Rd., where community changes were evident from agriculture-related nutrient enrichment (increased relative density, increased facultative and tolerant taxa with decreased sensitive taxa totals), no living or fresh dead shell mussels were collected (Table 13, Figure 55, Figure 56). Some substrate embeddedness, siltation in depositional areas, and travertine encrusting riffles were still present as noted in the 2001 survey (Ohio EPA 2004). An increased wooded riparian corridor throughout this reach upstream would likely help ameliorate impacts from excessive sedimentation/siltation and nutrient enrichment influences and would help improve mussel habitat conditions and promote the recovery of mussel diversity.

From Grewell Rd. (RM 19.8) to Little Darby Rd. (RM 17.0), five to ten mussel species were present at Ohio EPA sites collected in 2001 and 2007 (Table 13). In 2014 at Little Darby Rd., excellent mussel habitat was still present. There were ten mussel species collected which indicated similar diversity totals between each sampling year (Table 13). However, 2014 field observations noted a large number of fresh dead spike shells (and some kidneyshells) with much lower totals of live mussels observed than in 2007 or 2001. Discussion above regarding macroinvertebrates at this site listed possible inputs from Plumwood, excess agricultural inputs from Spring Fork, and/or negative Green Meadows STP inputs (e.g., wastewater spill in 2011) just upstream on Spring Fork could have possibly affected the mussel population at Little Darby Rd. Mussel sampling in Little Darby Creek upstream from St. Rt. 42 (RM 15.3/15.4) in 2014 revealed a large decline in diversity since 2007, and a similar, but not as substantial change, to what was observed in 2001 (one to three species in 2001/2002, six in 2007, and 0 in 2014) (Table 13). Field observations during the 2014 sampling at the site noted sand and silt on rocks in margins and pools with slimy growth in riffles and runs (Figure 68). However, based on a visual assessment made during a fall 2015 site visit, stream habitat had become more stable upstream with good development and with less unstable, moving, gravel bedload than observed in 2001-02.



Figure 68. Little Darby Creek (2001) upst. St. Rt. 42 (RM 15.4) (left) and Little Darby Creek (2014) at RM 15.3 at St. Rt. 42 (upst. view).

Discussion of Little Darby Creek mussel status from downstream St. Rt. 42 off Goodson Rd. (RM 13.35) to Taylor Blair Rd. (RM 8.2) in West Jefferson is provided as part of an assessment of storm water impacts to macroinvertebrate communities discussed above (p. 114-115). While no historical sampling has been conducted by Ohio EPA at sites in this reach, 2014 and 2015 mussel surveys revealed site diversity ranging between one and seven species at six different sampling sites; lowest diversity was associated with sites potentially affected by commercial/industrial storm water impacts in the West Jefferson area, relatively

recent sewage plant upsets in 2011 and 2013 at the Jefferson Lodge MHP at RM 9.0 ([p. 232](#)), and non-point source nutrient impacts. In summary, excessive sedimentation and associated sediment contaminants (nitrates, ammonia, and pesticides) could potentially impact mussel communities in this reach. Additionally, there could be the potential for some localized accumulations of sediment metals downstream from a few of the small tributaries draining commercial/industrial areas east from St. Rt. 29 to Little Darby Creek, which also have the potential to negatively impact mussel diversity (Wang et al. 2017). Embedded substrates and/or moving bedload also destabilized some reaches and appeared to affect mussel abundance and diversity.

There was a decline in mussel diversity comparing 2001 data collected from near U.S. Rt. 40 (RM 6.4) with 2014 data collected at Middle Pike (RM 7.3). Nine mussel taxa were observed or collected at RM 6.4 in 2001 compared to four mussel species collected in 2014 at the site about one mile upstream (Table 13). Issues potentially impacting mussel populations in this reach included excessive silt, sediment, and nutrients from storm water and agricultural tributary runoff.

There was also a slight decline in mussel diversity downstream from West Jefferson (RM 3.95/3.8) where no mussel species were observed in 2014 and two species in 2001. The West Jefferson WWTP has been operated consistently during this time span, but there were upsets in 2005 and 2008 that could possibly have affected mussel populations and which may still have been evident in the 2014 results.

The lower reach of Little Darby Creek at Alkire Rd. (RM 0.07) showed essentially no change between 2001, when one mussel species was collected, and 2014, when no live mussels or fresh dead shells were seen (Table 13). Despite having generally excellent instream habitat quality at this location, an open canopy and reduced shading were evident; this open canopy and reduced stream shading have likely allowed for nutrient enrichment signatures to manifest themselves at this location (*e.g.* wide diel D.O. swings, elevated benthic chlorophyll *a*).

Spring Fork reflected stable mussel diversity in the upper watershed (RMs 13.3 to 7.7) despite some local channelization activities and riparian removal, and subsequent flashiness and erosion. Only one or two common species of mussels were generally present at sites in 2001/2002 and 2014 (Table 13). There were some riparian width improvements in certain reaches with evidence of increased in habitat stability. Stretches of Spring Fork from RMs 3.7 to 3.3 and RMs 0.65 to 0.1 generally has courser substrates and more stable, diverse instream habitat features. Trends in mussel diversity throughout these reaches reflected little change across years (one to three mussel species at each site in 2002, 2007, and 2014)

Mussel diversity in Treacle Creek was generally similar between the two survey years. At the sampling location near the Winget Rd. covered bridge (RM 0.78), one mussel species (giant floater or creeper) was collected during both the 2014 and 2001 survey (Table 13). There is potential for expansion of mussel abundance and diversity if current issues are resolved (excess nutrients, sedimentation, spills, organic enrichment, low ambient D.O.) (Table 14, Table 15, Table 16).

Other Tributaries Discussion

Of the smaller tributaries, Flat Branch, Buck Run, and Sugar Run supported a similar mussel diversity in 2014 compared to what was seen in 2001. Sampling sites on all three streams supported either no mussels or only a very limited fauna represented by just one or a couple of species (Table 13). Sampling in Sugar Run documented low D.O. exceedances with measured nutrient enrichment due to runoff from row crop agriculture, manure applications, unsewered areas, and reported spills (Table 14 and Table 15). Flat

Branch sediments contained elevated phosphorus and many reported spills in the watershed had the potential to affect mussel diversity (Table 32). Buck Run had the highest sediment ammonia concentration collected in the Big Darby watershed in 2014 with a measured value (1100 mg/kg at RM 2.16, Table 32) capable of affecting mussels (USEPA 2013; Augspurger et. al 2003; Newton et. al 2003; Bartsch et al. 2003; Frazier et. al 1996; Thurston et. al 1974).

Spain Creek mussel diversity declined in 2014 compared to 2001 (zero species in 2014 and two in 2001) (Table 13). There was substantial riparian removal and channelization activities on Spain Creek at RMs 0.5-0.4 between September 2004 and August 2005 with a new armored channel created between RMs 0.47 and 0.40 (Figure 86). Excessive sedimentation and unstable sand bedload movement was observed at the sampling location near the mouth. The North Lewisburg WWTP may have provided an additional source of environmental stress to Spain Creek at RM 0.1 via a pattern of NPDES effluent permit limit violations in the time period leading up to the 2014 survey. Phosphorus, D.O., *E. coli* bacteria, and TSS violations occurred in 2012-14 along with more recent ammonia issues measured in 2016 which could have impacted mussels (Appendix I). Interaction between Ohio EPA and the facility continues in efforts to address the ongoing noncompliance; more information on this facility and their efforts to improve effluent quality can be found within the [NPDES Permitted Facilities](#) portion of this document.

Pleasant Run mussel diversity declined from three species observed in 2001 to zero in the 2014 survey (Table 13). In 2001, it was noted that Pleasant Run showed signs of flashy hydrology with some down-cutting and deeply eroded banks within the entrenched channel, likely due to channelization activities. Habitat quality has declined at this location and examination of historical imagery has revealed substantial and complete channelization, and riparian vegetation removal immediately adjacent and upstream from the sampling location which occurred between 2007 and 2008. During the 2014 sampling, observations were made of unstable, deep sand and gravel bedload in the entrenched channel, a situation not conducive to stable mussel habitat (Haag 2012; Ohio EPA 2004).

Hellbranch Run showed a decline in mussel diversity from 2002 to 2014 in the reach near its confluence with Big Darby Creek (0 species in 2014 and three in 2002) (Table 13). Due to storm water runoff (suburban and agricultural), Hellbranch Run hydrology has become flashy with resultant erosion, increasing siltation, and embedding substrates, all to the detriment of mussels (Ohio EPA 2004; Haag 2012). Additionally, poor quality WWTP effluent from the now abandoned Timberbrook WWTP likely contributed to the depauperate mussel community in the lower reach (Ohio EPA 2004, Table 11, Goudreau et al. 1992). With the closure of the Timberbrook WWTP in 2012 and several recent storm water retention and treatment projects implemented upstream (*e.g.*, stream channel naturalization projects and wetland enhancements), there is optimism for better water quality and stable mussel habitat to be restored in lower Hellbranch Run. From field notes and observations in 2014, lower Hellbranch Run substrates were more stable with loose large gravel riffles and functional pools with rocky substrates – good habitat for mussels and fish host. Furthermore, when the restored sinuous lower channel is opened, there will be further opportunity for mussel proliferation within the more diverse habitat created (Figure 45).

Big Darby Creek Mussel Mortality

Ohio EPA Division of Surface was alerted about observations of high levels of freshwater mussel mortality in Big Darby Creek in early October, 2016. A study plan was prepared with the goal of collecting chemical data at locations in the portion of Big Darby Creek where there were reports of mussel mortality in order to determine if the cause of the mortality might be of chemical origin, and if so, to discover potential source(s) of chemical contamination.

Four locations within the Big Darby Creek mainstem were selected based upon input from partnering agencies investigating and documenting mussel mortality, as well as where recent baseline chemistry data had been collected prior to observed mussel mortality as a part of the 2014 biosurvey (Table 12).

Table 12. Big Darby Creek sampling locations, October 2016.

Station Name	Station ID	River Mile	Latitude	Longitude
1: Big Darby NE of N Lewisburg @ N. Lewisburg Rd	V07P59	76.53	40.2497	-83.5331
2: Big Darby 1.0 mi DST Lucas Rd adj Metropark Levee	V06K01	43.5	40.0008	-83.2589
3: Big Darby at Darbydale @ McKinley Bridge	V07S05	29.2	39.8486	-83.1889
4: Big Darby @ SR-316 at Darbyville	601300	13.36	39.7008	-83.1097

At each location, chemistry samples were collected and analyzed for the concentrations of a variety of conventional chemical parameters; atrazine concentrations; the presence or absence of common toxin-producing cyanobacteria (blue-green algae); and, if present, concentrations of commonly found algal toxins. Additional measurements of temperature (°C), dissolved oxygen saturation and concentration (mg/L), pH (S.U.) and temperature-corrected specific conductance (µS/cm) were made *in-situ* alongside chemistry sample collection at each sampling location using a multi-parameter field meter.

The concentration range and central tendency of conventional parameters, nutrients, metals, and atrazine were directly compared to the most recent baseline datasets available, i.e., the 2001/2002 and 2014 biosurvey data, as well as a long term monthly to quarterly-sampled dataset available from Big Darby Creek RM 13.36 (601300). None of the chemical parameters analyzed exhibited atypical departure from baseline conditions, therefore it remained inconclusive whether the observed mussel mortality was caused by a chemical source.

An additional long term ambient chemical monitoring station was added within the Little Darby sub-watershed (Little Darby Creek at West Jefferson, RM 7.35; V06G28) in early 2017. Monthly chemical samples will be collected at this location, as well as at Big Darby Creek RM 13.36 moving forward.

Table 13. Freshwater mussel species (Unionidae) collected live or fresh-dead in the Big Darby Creek basin study area, Trends 2000-2 to 2014-15. **FE** = Federally endangered. **FT** = Federally Threatened. **PE** = Proposed Fed. Endangered designation. **SE** = State endangered. **ST** = State threatened. **SC** = Species of Concern.

Stream River Mile	YEAR	<i>Alasmidonta marginata</i> (Elktoe) SE	<i>Alasmidonta viridis</i> (Slippershell)	<i>Amblema plicata</i> (Threeridge)	<i>Anodontoides ferussacianus</i> (Cylindrical Papershell)	<i>Elliptiio dilatata</i> (Spike)	<i>Epioblasma triquetra</i> SE PE (Snuffbox)	<i>Fusconaia flava</i> (Wabash Pigtoe)	<i>Lampsilis cardium</i> (plain Pocketbook)	<i>Lampsilis fasciola</i> SC (Wavy-rayed Lampmussel)	<i>Lampsilis radiata luteola</i> (Fatmucket)	<i>Lasmigona complanata</i> (White Heelsplitter)	<i>Lasmigona compressa</i> SC (Creek Heelsplitter)	<i>Lasmigona costata</i> (Fluted shell)	<i>Leptodea fragilis</i> (Fragile Papershell)	<i>Megalanaia nervosa</i> (Washboard) SE	<i>Obovaria subrotunda</i> (Round Hickorynut)	<i>Pleurobema clava</i> (Clubshell) FE	<i>Pleurobema sintoxia</i> SC (Round Pigtoe)	<i>Pleurobema cordatum</i> (Ohio Pigtoe)PE	<i>Potamilus alatus</i> (Pink Heelsplitter)	<i>Pyganodon grandis</i> (Giant Floater)	<i>Ptchobranchus fasciolaris</i> SC (Kidneyshell)	<i>Quadrula cylindrica cylindrica</i> SE (Rabbitsfoot) FT	<i>Quadrula Quadrula</i> (Mapleleaf)	<i>Strophitus undulatus</i> (Creeper)	<i>Toxolasma parvum</i> (Lilliput)	<i>Tritogonia verrucosa</i> (Pistolgrip)	<i>Truncilla truncata</i> (Deertoe) SC	<i>Utterbackia imbecillis</i> (Paper Pondshell)	<i>Villosa iris iris</i> (Rainbow)	Total Taxa per Site	
Big Darby Creek (02-200-000)																																	
81.0	2014																									X						1	
82-80	2008																																0
83-78	2001																																0
76.5	2014				X						X												X				X				X		5
76.5	2001					X					X													X									3
69.3 (68.35)	2014					X					X													X									3
69.4	2001					X					X			X										X									4
69.4	9/'00					X																											1
69.4	7/'00			X		X		X			X			X										X			X					X	8
66.2	2014					X		X	X		X		X											X									6
67.2- 66.0	2002				X	X			X		X													X			X					X	7

Stream River Mile	YEAR	<i>Alasmidonta marginata</i> (Elktoe) SE	<i>Alasmidonta viridis</i> (Slippershell)	<i>Amblema plicata</i> (Threeridge)	<i>Anodontoides ferussacianus</i> (Cylindrical Papershell)	<i>Elliptio dilatata</i> (Spike)	<i>Epioblasma triquetra</i> SE PE (Snuffbox)	<i>Fusconaia flava</i> (Wabash Pigtoe)	<i>Lampsilis cardium</i> (Plain Pocketbook)	<i>Lampsilis fasciola</i> SC (Wavy-rayed Lampmussel)	<i>Lampsilis radiata luteola</i> (Fatmucket)	<i>Lasmigona complanata</i> (White Heelsplitter)	<i>Lasmigona compressa</i> SC (Creek Heelsplitter)	<i>Lasmigona costata</i> (Fluted shell)	<i>Leptodea fragilis</i> (Fragile Papershell)	<i>Megalanaiaas nervosa</i> (Washboard) SE	<i>Obovaria subrotunda</i> (Round Hickorynut)	<i>Pleurobema clava</i> (Clubshell) FE	<i>Pleurobema sintoxia</i> SC (Round Pigtoe)	<i>Pleurobema cordatum</i> (Ohio Pigtoe)PE	<i>Potamilus alatus</i> (Pink Heelsplitter)	<i>Pyganodon grandis</i> (Giant Floater)	<i>Ptchobranchus fasciolaris</i> SC (Kidneyshell)	<i>Quadrula cylindrica cylindrica</i> SE (Rabbitsfoot) FT	<i>Quadrula Quadrula</i> (Mapleleaf)	<i>Strophitus undulatus</i> (Creeper)	<i>Toxolasma parvum</i> (Lilliput)	<i>Tritogonia verrucosa</i> (Pistolgrip)	<i>Truncilla truncata</i> (Deertoe) SC	<i>Utterbackia imbecillis</i> (Paper Pondshell)	<i>Villosa iris iris</i> (Rainbow)	Total Taxa per Site			
Big Darby Creek (02-200-000)																																			
63.9	2014					X					X											X											3		
64.4	2001																																	0	
63.8	9/'00			X		X					X																							3	
63.8	7/'00			X		X		X	X	X	X			X									X				X							9	
62.75	2014					X		X	X		X																								4
62.9	2001										X											X												2	
59.9	2014			X		X			X	X																							X	5	
58.1	2000					X					X												X				X						X	5	
54.1	2014			X		X				X	X												X				X								6
54.1	2001																																		0
54.2	9/'00																																		0
54.2	7/'00					X					X																X								3
53.9	2001										X												X												2

Stream River Mile	YEAR	<i>Alasmidonta marginata</i> (Elktoe) SE	<i>Alasmidonta viridis</i> (Slippershell)	<i>Amblema plicata</i> (Threeeridge)	<i>Anodontoides ferussacianus</i> (Cylindrical Papershell)	<i>Elliptio dilatata</i> (Spike)	<i>Epioblasma triquetra</i> SE PE (Snuffbox)	<i>Fusconaia flava</i> (Wabash Pigtoe)	<i>Lampsilis cardium</i> (Plain Pocketbook)	<i>Lampsilis fasciola</i> SC (Wavy-rayed Lampmussel)	<i>Lampsilis radiata luteola</i> (Fatmucket)	<i>Lasmigona complanata</i> (White Heelsplitter)	<i>Lasmigona compressa</i> SC (Creek Heelsplitter)	<i>Lasmigona costata</i> (Fluted shell)	<i>Leptodea fragilis</i> (Fragile Papershell)	<i>Megalonaia nervosa</i> (Washboard) SE	<i>Obovaria subrotunda</i> (Round Hickorynut)	<i>Pleurobema clava</i> (Clubshell) FE	<i>Pleurobema sintoxia</i> SC (Round Pigtoe)	<i>Pleurobema cordatum</i> (Ohio Pigtoe)PE	<i>Potamilus alatus</i> (Pink Heelsplitter)	<i>Pyganodon grandis</i> (Giant Floater)	<i>Ptchobranthus fasciolaris</i> SC (Kidneyshell)	<i>Quadrula cylindrica cylindrica</i> SE (Rabbitsfoot) FT	<i>Quadrula Quadrula</i> (Mapleleaf)	<i>Strophitus undulatus</i> (Creeper)	<i>Toxolasma parvum</i> (Lilliput)	<i>Tritogonia verrucosa</i> (Pistolgrip)	<i>Truncilla truncata</i> (Deertoe) SC	<i>Utterbackia imbecillis</i> (Paper Pondshell)	<i>Villosa iris iris</i> (Rainbow)	Total Taxa per Site	
Big Darby Creek (02-200-000)																																	
53.1	7/'00							X			X			X									X			X						5	
52.1	2001																						X										1
50.95	2014					X			X	X	X																						4
52.0	2001																																0
49.4	2014																																0
49.7	2001		X	X		X		X	X		X			X								X											8
44.9	2006					X					X												X										3
43.2	2014					X																											1
41.6	2014							X			X																						2
42.1	2001								X	X	X												X										4
42.0	2006							X	X		X												X										4
38.9	2014										X																						1
38.9	2002					X					X												X										3

Stream River Mile	YEAR	<i>Alasmidonta marginata</i> (Elktoe) SE	<i>Alasmidonta viridis</i> (Slippershell)	<i>Amblema plicata</i> (Threeridge)	<i>Anodontoides ferussacianus</i> (Cylindrical Papershell)	<i>Elliptio dilatata</i> (Spike)	<i>Epioblasma triquetra</i> SE PE (Snuffbox)	<i>Fusconaia flava</i> (Wabash Pigtoe)	<i>Lampsilis cardium</i> (Plain Pocketbook)	<i>Lampsilis fasciola</i> SC (Wavy-rayed Lampmussel)	<i>Lampsilis radiata luteola</i> (Fatmucket)	<i>Lasmigona complanata</i> (White Heelsplitter)	<i>Lasmigona compressa</i> SC (Creek Heelsplitter)	<i>Lasmigona costata</i> (Fluted shell)	<i>Leptodea fragilis</i> (Fragile Papershell)	<i>Megalaniais nervosa</i> (Washboard) SE	<i>Obovaria subrotunda</i> (Round Hickorynut)	<i>Pleurobema clava</i> (Clubshell) FE	<i>Pleurobema sintoxia</i> SC (Round Pigtoe)	<i>Pleurobema cordatum</i> (Ohio Pigtoe)PE	<i>Potamilus alatus</i> (Pink Heelsplitter)	<i>Pyganodon grandis</i> (Giant Floater)	<i>Ptchobranchus fasciolaris</i> SC (Kidneyshell)	<i>Quadrula cylindrica cylindrica</i> SE (Rabbitsfoot) FT	<i>Quadrula Quadrula</i> (Mapleleaf)	<i>Strophitus undulatus</i> (Creeper)	<i>Toxolasma parvum</i> (Lilliput)	<i>Tritogonia verrucosa</i> (Pistolgrip)	<i>Truncilla truncata</i> (Deertoe) SC	<i>Utterbackia imbecillis</i> (Paper Pondshell)	<i>Villosa iris iris</i> (Rainbow)	Total Taxa per Site
Big Darby Creek (02-200-000)																																
38.35	2014					X		X	X		X												X									5
Low-Head Dam (RM 37.27)																																
34.2	2014					X																	X				X					3
34.2	2001														X																	1
29.25	2014	X				X			X		X												X						X			6
28.6	2002	X							X		X			X	X						X	X	X						X			9
27.95	2014					X					X																					2
26.9	2001																															0
26.7	2014																															0
26.0	2014																															0
26.1	2002							X	X	X	X				X																	5
23.9	2014																															0
23.8	2001								X	X					X								X	X								5

Stream River Mile	YEAR	<i>Alasmidonta marginata</i> (Elktoe) SE	<i>Alasmidonta viridis</i> (Slippershell)	<i>Amblema plicata</i> (Threeridge)	<i>Anodontoides ferussacianus</i> (Cylindrical Papershell)	<i>Elliptiio dilatata</i> (Spike)	<i>Epioblasma triquetra</i> SE PE (Snuffbox)	<i>Fusconaia flava</i> (Wabash Pigtoe)	<i>Lampsilis cardium</i> (Plain Pocketbook)	<i>Lampsilis fasciola</i> SC (Wavy-rayed Lampmussel)	<i>Lampsilis radiata luteola</i> (Fatmucket)	<i>Lasmigona complanata</i> (White Heelsplitter)	<i>Lasmigona compressa</i> SC (Creek Heelsplitter)	<i>Lasmigona costata</i> (Fluted shell)	<i>Leptodea fragilis</i> (Fragile Papershell)	<i>Megalanaia nervosa</i> (Washboard) SE	<i>Obovaria subrotunda</i> (Round Hickorynut)	<i>Pleurobema clava</i> (Clubshell) FE	<i>Pleurobema sintoxia</i> SC (Round Pigtoe)	<i>Pleurobema cordatum</i> (Ohio Pigtoe)PE	<i>Potamilus alatus</i> (Pink Heelsplitter)	<i>Pyganodon grandis</i> (Giant Floater)	<i>Ptchobranthus fasciolaris</i> SC (Kidneyshell)	<i>Quadrula cylindrica cylindrica</i> SE (Rabbitsfoot) FT	<i>Quadrula Quadrula</i> (Mapleleaf)	<i>Strophitus undulatus</i> (Creeper)	<i>Toxolasma parvum</i> (Lilliput)	<i>Tritogonia verrucosa</i> (Pistolgrip)	<i>Truncilla truncata</i> (Deertoe) SC	<i>Utterbackia imbecillis</i> (Paper Pondshell)	<i>Villosa iris iris</i> (Rainbow)	Total Taxa per Site	
Big Darby Creek (02-200-000)																																	
22.25	2014																				X											1	
22.0	2014								X		X																						2
22.5	2001								X													X											2
19.5	2014					X			X	X	X	X		X	X				X		X		X		X	X			X	X			14
19.1	2014			X		X		X	X	X	X			X	X						X		X							X			11
19.1	2001	X				X	X	X	X	X	X	X		X	X		X		X		X		X	X	X	X			X	X		X	20
15.8	2002							X															X										2
15.1	2002																							X									0
13.2	2014																				X		X										2
13.5	2001																						X										1
11.2	2014										X			X													X		X				4
11.2	2002	X		X		X			X	X	X	X		X	X	X							X						X	X		X	14

Stream River Mile	YEAR	<i>Alasmidonta marginata</i> (Elktoe) SE	<i>Alasmidonta viridis</i> (Slippershell)	<i>Amblema plicata</i> (Threeridge)	<i>Anodontoides ferussacianus</i> (Cylindrical Papershell)	<i>Elliptio dilatata</i> (Spike)	<i>Epioblasma triquetra</i> SE PE (Snuffbox)	<i>Fusconaia flava</i> (Wabash Pigtoe)	<i>Lampsilis cardium</i> (Plain Pocketbook)	<i>Lampsilis fasciola</i> SC (Wavy-rayed Lampmussel)	<i>Lampsilis radiata luteola</i> (Fatmucket)	<i>Lasmigona complanata</i> (White Heelsplitter)	<i>Lasmigona compressa</i> SC (Creek Heelsplitter)	<i>Lasmigona costata</i> (Fluted shell)	<i>Leptodea fragilis</i> (Fragile Papershell)	<i>Megalanaia nervosa</i> (Washboard) SE	<i>Obovaria subrotunda</i> (Round Hickorynut)	<i>Pleurobema clava</i> (Clubshell) FE	<i>Pleurobema sintoxia</i> SC (Round Pigtoe)	<i>Pleurobema cordatum</i> (Ohio Pigtoe)PE	<i>Potamilus alatus</i> (Pink Heelsplitter)	<i>Pyganodon grandis</i> (Giant Floater)	<i>Ptchobranthus fasciolaris</i> SC (Kidneyshell)	<i>Quadrula cylindrica cylindrica</i> SE (Rabbitsfoot) FT	<i>Quadrula Quadrula</i> (Mapleleaf)	<i>Strophitus undulatus</i> (Creeper)	<i>Toxolasma parvum</i> (Lilliput)	<i>Tritogonia verrucosa</i> (Pistolgrip)	<i>Truncilla truncata</i> (Deertoe) SC	<i>Utterbackia imbecillis</i> (Paper Pondshell)	<i>Villosa iris iris</i> (Rainbow)	Total Taxa per Site	
Big Darby Creek (02-200-000)																																	
9.15	2014																															0	
7.65	2014																																0
8.4	2002			X				X	X		X					X				X	X												7
5.3	2002														X																		1
3.1	2014																																0
3.2RR	2012								X	X	X				X						X												5
3.2	2001								X																								1
Flat Branch (02-223-000)																																	
0.8	2014				X																												1
0.9	2001																					X											1
1.0RR	1997										X											X											2
Spain Creek (02-222-000)																																	
0.1	2014																																0
0.01	2001										X															X							2

Stream River Mile	YEAR	<i>Alasmidonta marginata</i> (Elktoe) SE	<i>Alasmidonta viridis</i> (Slippershell)	<i>Amblema plicata</i> (Threeridge)	<i>Anodontoides ferussacianus</i> (Cylindrical Papershell)	<i>Elliptio dilatata</i> (Spike)	<i>Epioblasma triquetra</i> SE PE (Snuffbox)	<i>Fusconaia flava</i> (Wabash Pigtoe)	<i>Lampsilis cardium</i> (Plain Pocketbook)	<i>Lampsilis fasciola</i> SC (Wavy-rayed Lampmussel)	<i>Lampsilis radiata luteola</i> (Fatmucket)	<i>Lasmigona complanata</i> (White Heelsplitter)	<i>Lasmigona compressa</i> SC (Creek Heelsplitter)	<i>Lasmigona costata</i> (Fluted shell)	<i>Leptodea fragilis</i> (Fragile Papershell)	<i>Megalaniaas nervosa</i> (Washboard) SE	<i>Obovaria subrotunda</i> (Round Hickorynut)	<i>Pleurobema clava</i> (Clubshell) FE	<i>Pleurobema sintoxia</i> SC (Round Pigtoe)	<i>Pleurobema cordatum</i> (Ohio Pigtoe)PE	<i>Potamilus alatus</i> (Pink Heelsplitter)	<i>Pyganodon grandis</i> (Giant Floater)	<i>Ptchobranthus fasciolaris</i> SC (Kidneyshell)	<i>Quadrula cylindrica cylindrica</i> SE (Rabbitsfoot) FT	<i>Quadrula Quadrula</i> (Mapleleaf)	<i>Strophitus undulatus</i> (Creeper)	<i>Toxolasma parvum</i> (Lilliput)	<i>Tritogonia verrucosa</i> (Pistolgrip)	<i>Truncilla truncata</i> (Deertoe) SC	<i>Utterbackia imbecillis</i> (Paper Pondshell)	<i>Villosa iris iris</i> (Rainbow)	Total Taxa per Site	
Pleasant Run (02-221-000)																																	
0.35	2014																															0	
0.4	2001		X					X			X																						3
0.4RR	1997										X																						1
Buck Run (02-209-000)																																	
0.8	2014																																0
0.01	2001																					X											1
Sugar Run (02-206-000)																																	
6.9	2001																														X		1
5.5	2001																																0
5.4	2014																																0
0.5	2001																																0
0.43	2014																																0
Hellbranch Run (02-206-000)																																	
5.75	2014																																0

Stream River Mile	YEAR	<i>Alasmidonta marginata</i> (Elktoe) SE	<i>Alasmidonta viridis</i> (Slippershell)	<i>Amblema plicata</i> (Threeridge)	<i>Anodontoides ferussacianus</i> (Cylindrical Papershell)	<i>Elipitio dilatata</i> (Spike)	<i>Epioblasma triquetra</i> SE PE (Snuffbox)	<i>Fusconaia flava</i> (Wabash Pigtoe)	<i>Lampsilis cardium</i> (Plain Pocketbook)	<i>Lampsilis fasciola</i> SC (Wavy-rayed Lampmussel)	<i>Lampsilis radiata luteola</i> (Fatmucket)	<i>Lasmigona complanata</i> (White Heelsplitter)	<i>Lasmigona compressa</i> SC (Creek Heelsplitter)	<i>Lasmigona costata</i> (Fluted shell)	<i>Leptodea fragilis</i> (Fragile Papershell)	<i>Megalanaia nervosa</i> (Washboard) SE	<i>Obovaria subrotunda</i> (Round Hickorynut)	<i>Pleurobema clava</i> (Clubshell) FE	<i>Pleurobema sintoxia</i> SC (Round Pigtoe)	<i>Pleurobema cordatum</i> (Ohio Pigtoe)PE	<i>Potamilus alatus</i> (Pink Heelsplitter)	<i>Pyganodon grandis</i> (Giant Floater)	<i>Ptchobranthus fasciolaris</i> SC (Kidneyshell)	<i>Quadrula cylindrica cylindrica</i> SE (Rabbitsfoot) FT	<i>Quadrula Quadrula</i> (Mapleleaf)	<i>Strophitus undulatus</i> (Creeper)	<i>Toxolasma parvum</i> (Lilliput)	<i>Tritogonia verrucosa</i> (Pistolgrip)	<i>Truncilla truncata</i> (Deertoe) SC	<i>Utterbackia imbecillis</i> (Paper Pondshell)	<i>Villosa iris iris</i> (Rainbow)	Total Taxa per Site	
3.7	2001										X																					1	
1-0.7	2014																																0
0.5	2002							X																		X						X	3
Little Darby Creek (02-210-000)																																	
34.7	2014										X																					1	
34.6	2001																					X											1
33.2	2002			X				X																									2
26.5	2002			X	X	X		X	X		X			X				X				X	X			X						X	12
24.5	2001			X				X		X	X						old																4
24.46+OT	2014			XO		XO		O	O	O	O		X					O					O	O		O						O	12
23.2	2002			X		X		X															X										4
20.5	2014																																0
20.5	2002			X		X																	X										3
19.8	2007			X		X		X		X	X							X				X	X			X							9
17.5	2007			X		X			X	X													X										5

Stream River Mile	YEAR	<i>Alasmidonta marginata</i> (Elktoe) SE	<i>Alasmidonta viridis</i> (Slippershell)	<i>Amblema plicata</i> (Threeridge)	<i>Anodontoides ferussacianus</i> (Cylindrical Papershell)	<i>Elliptio dilatata</i> (Spike)	<i>Epioblasma triquetra</i> SE PE (Snuffbox)	<i>Fusconaia flava</i> (Wabash Pigtoe)	<i>Lampsilis cardium</i> (Plain Pocketbook)	<i>Lampsilis fasciola</i> SC (Wavy-rayed Lampmussel)	<i>Lampsilis radiata luteola</i> (Fatmucket)	<i>Lasmigona complanata</i> (White Heelsplitter)	<i>Lasmigona compressa</i> SC (Creek Heelsplitter)	<i>Lasmigona costata</i> (Fluted shell)	<i>Leptodea fragilis</i> (Fragile Papershell)	<i>Megalanaia nervosa</i> (Washboard) SE	<i>Obovaria subrotunda</i> (Round Hickorynut)	<i>Pleurobema clava</i> (Clubshell) FE	<i>Pleurobema sintoxia</i> SC (Round Pigtoe)	<i>Pleurobema cordatum</i> (Ohio Pigtoe)PE	<i>Potamilus alatus</i> (Pink Heelsplitter)	<i>Pyganodon grandis</i> (Giant Floater)	<i>Ptchobranchus fasciolaris</i> SC (Kidneyshell)	<i>Quadrula cylindrica cylindrica</i> SE (Rabbitsfoot) FT	<i>Quadrula Quadrula</i> (Mapleleaf)	<i>Strophitus undulatus</i> (Creeper)	<i>Toxolasma parvum</i> (Lilliput)	<i>Tritogonia verrucosa</i> (Pistolgrip)	<i>Truncilla truncata</i> (Deertoe) SC	<i>Utterbackia imbecillis</i> (Paper Pondshell)	<i>Villosa iris iris</i> (Rainbow)	Total Taxa per Site		
Little Darby Creek (02-210-000)																																		
17.25	2014			X		X		X		X	X			X				X					X			X						X	10	
17.3	2007			X		X		X	X		X	X		X				X				X	X									X	11	
17.0	2001			X		X		X	X	X	X							X					X			X						X	10	
15.3	2014																																	0
15.4	2007			X		X					X			X									X								X		6	
15.3	2002					X					X												X											3
15.4	2001					X																												1
13.35	2015					X			X		X												X									?	5	
12.45	2015			X		X		X	X		X	?						old					X										old	7
12.88	2015																						X										old	1
9.2-9.1	2015			X		X			X														X	old										4
8.95	2014					X																												1
8.84-8.6	2015			X		X		X	X		X												X											6
7.3	2014			X		X					X											X												4

Stream River Mile	YEAR	<i>Alasmidonta marginata</i> (Elktoe) SE	<i>Alasmidonta viridis</i> (Slippershell)	<i>Amblema plicata</i> (Threeridge)	<i>Anodontoides ferussacianus</i> (Cylindrical Papershell)	<i>Elliptio dilatata</i> (Spike)	<i>Epioblasma triquetra</i> SE PE (Snuffbox)	<i>Fusconaia flava</i> (Wabash Pigtoe)	<i>Lampsilis cardium</i> (Plain Pocketbook)	<i>Lampsilis fasciola</i> SC (Wavy-rayed Lampmussel)	<i>Lampsilis radiata luteola</i> (Fatmucket)	<i>Lasmigona complanata</i> (White Heelsplitter)	<i>Lasmigona compressa</i> SC (Creek Heelsplitter)	<i>Lasmigona costata</i> (Fluted shell)	<i>Leptodea fragilis</i> (Fragile Papershell)	<i>Megalanaia nervosa</i> (Washboard) SE	<i>Obovaria subrotunda</i> (Round Hickorynut)	<i>Pleurobema clava</i> (Clubshell) FE	<i>Pleurobema sintoxia</i> SC (Round Pigtoe)	<i>Pleurobema cordatum</i> (Ohio Pigtoe)PE	<i>Potamilus alatus</i> (Pink Heelsplitter)	<i>Pyganodon grandis</i> (Giant Floater)	<i>Ptchobbranchus fasciolaris</i> SC (Kidneyshell)	<i>Quadrula cylindrica cylindrica</i> SE (Rabbitsfoot) FT	<i>Quadrula Quadrula</i> (Mapleleaf)	<i>Strophitus undulatus</i> (Creeper)	<i>Toxolasma parvum</i> (Lilliput)	<i>Tritogonia verrucosa</i> (Pistolgrip)	<i>Truncilla truncata</i> (Deertoe) SC	<i>Utterbackia imbecillis</i> (Paper Pondshell)	<i>Villosa iris iris</i> (Rainbow)	Total Taxa per Site	
Little Darby Creek (02-210-000)																																	
6.4	2001					X		X	X	X	X											X	X			X					X	9	
3.95	2014																																0
3.8	2001							X			X																						2
0.2	2014																																0
0.5	2001																					X											1
Spring Fork (02-211-000)																																	
13.3	2001				X																												1
10.0	2014							X			X																						2
10.1	2002				X																												1
7.7	2014				X																												1
7.7	2001																																0
Spring Fork (02-211-000)																																	
3.7	2007			X				X														X											3
3.5	2007			X						X	X																						3

Stream River Mile	YEAR	<i>Alasmidonta marginata</i> (Elktoe) SE	<i>Alasmidonta viridis</i> (Slippershell)	<i>Amblema plicata</i> (Threeridge)	<i>Anodontoides ferussacianus</i> (Cylindrical Papershell)	<i>Elliptiio dilatata</i> (Spike)	<i>Epioblasma triquetra</i> SE PE (Snuffbox)	<i>Fusconaia flava</i> (Wabash Pigtoe)	<i>Lampsilis cardium</i> (Plain Pocketbook)	<i>Lampsilis fasciola</i> SC (Wavy-rayed Lampmussel)	<i>Lampsilis radiata luteola</i> (Fatmucket)	<i>Lasmigona complanata</i> (White Heelsplitter)	<i>Lasmigona compressa</i> SC (Creek Heelsplitter)	<i>Lasmigona costata</i> (Fluted shell)	<i>Leptodea fragilis</i> (Fragile Papershell)	<i>Megaloniaia nervosa</i> (Washboard) SE	<i>Obovaria subrotunda</i> (Round Hickorynut)	<i>Pleurobema clava</i> (Clubshell) FE	<i>Pleurobema sintoxia</i> SC (Round Pigtoe)	<i>Pleurobema cordatum</i> (Ohio Pigtoe)PE	<i>Potamilus alatus</i> (Pink Heelsplitter)	<i>Pyganodon grandis</i> (Giant Floater)	<i>Ptchobbranchus fasciolaris</i> SC (Kidneyshell)	<i>Quadrula cylindrica cylindrica</i> SE (Rabbitsfoot) FT	<i>Quadrula Quadrula</i> (Mapleleaf)	<i>Strophitus undulatus</i> (Creeper)	<i>Toxolasma parvum</i> (Lilliput)	<i>Tritogonia verrucosa</i> (Pistolgrip)	<i>Truncilla truncata</i> (Deertoe) SC	<i>Utterbackia imbecillis</i> (Paper Pondshell)	<i>Villosa iris iris</i> (Rainbow)	Total Taxa per Site
3.4-3.3	2002										X															X	X					3
0.65					X																											1
0.1	2007																					X										1
Treacle Creek (02-213-000)																																
0.75	2014																									X						1
0.7	2001																					X										1

Green or blue colors – those reaches compared

Yellow color – reaches affected by July/2000 Milford Center spill, just upstream and prior to spill, or sampled downstream prior to spill reaching that site

White color – no corresponding site to compare in different sample year

Orange color – location of dam presently on Big Darby Creek

OT – Ohio Dept. of Transportation survey at site during H.D. colonization before qualitative sample (ESI 2014)

Surface Water Chemistry

Surface water chemistry samples were collected from the Big Darby Creek watershed from April through October 2014, including water column chemistry, benthic chlorophyll-*a*, bacteria, and continuous water quality sonde samples. Primary chemistry sampling occurred from June through October, 2014 at 124 sampling locations from Big Darby Creek, Little Darby Creek, and many smaller tributaries within the Big Darby Creek watershed. Water quality sondes were deployed in 2015 at or near locations displaying biological impairment where either nutrient and/or organic enrichment was a suspected cause.

Chemistry sites were established in free-flowing sections of the streams and were sampled while wading in the stream or via a bucket lowered with a rope at bridge crossings. Water column samples were dispensed into appropriate containers, preserved, and delivered to Ohio EPA's Division of Environmental Services laboratory for analysis. Collected water was handled in accordance with the methods outlined in the Ohio EPA *Surface Water Field Sampling Manual* (Ohio EPA 2013b).

Stream flow data from the Darby Creek USGS gage at Darbyville (USGS 03230500) was used to illustrate flow trends in the Darby Creek watershed during 2014 chemistry sampling. Water and bacteria sample collection dates are noted in Figure 69. Generally speaking, flow conditions from June through the beginning of September were similar to the historic average with the exception of a few storm events. During the months of September and October, stream flows were lower than the historical average.

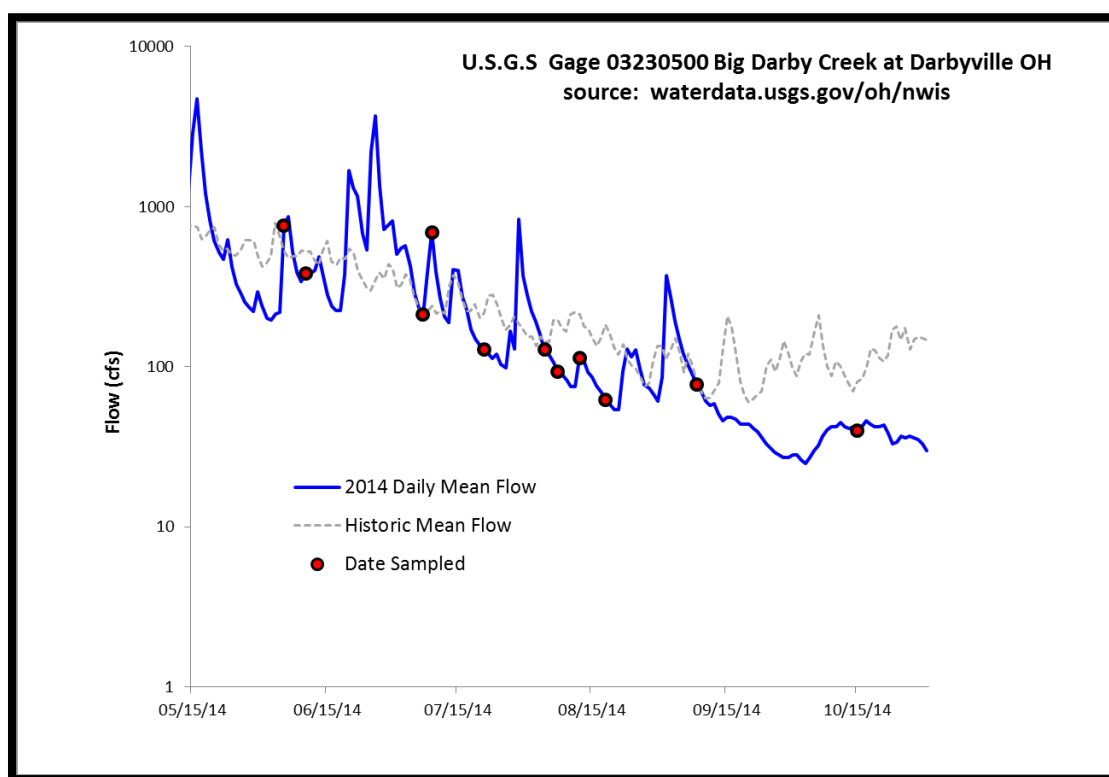


Figure 69. Mean flow conditions for Big Darby Creek at the USGS gage at Darbyville from May 2014 to October 2014. USGS provisional data

Water chemistry samples were collected during a variety of flow conditions in the study area over the 2014 sampling period. Surface water chemistry samples were analyzed for metals, nutrients, semi-volatile organic compounds, herbicides, bacteria, pH, temperature, conductivity, dissolved oxygen (D.O.), and suspended and dissolved solids (Appendix F). Stream temperature, pH, conductivity, D.O., and percent D.O. saturation were measured within the stream during each sample collection using a handheld meter. Chemicals or physical parameters found to be in exceedance of the Ohio WQS criteria are reported in Table 14 and Table 15. Concentrations of key nutrient parameters are presented in Table 16 and will be discussed in detail later in this section along with additional chemical parameters.

E. coli samples were collected during the designated recreation season of May 1 through October 31, 2014 and compared to the Ohio Water Quality Standards (WQS) recreation use criteria in effect at the time. During that timeframe, stream samples intended for bacterial analysis were collected during the same sampling events as those that were analyzed for other chemistry parameters. Bacteria samples were collected at 30 locations; all but four were found to be in non-attainment of the applicable WQS criterion. Bacteria data are more specifically discussed in the [Recreation Use](#) portion of this report.

Continuous multi-parameter water quality sondes were deployed at 35 locations along Big Darby Creek, Little Darby Creek, and their tributaries to monitor hourly fluctuations of temperature, D.O., pH, and specific conductance (conductivity), typically over a two-day time period. Sites were selected to represent the general watershed area as well as target areas of concern (*e.g.*, point sources or historically impaired areas). During the sonde deployments, benthic and sestonic (water column) chlorophyll-*a* concentrations were measured at selected sites in order to perform a trophic state evaluation and identify possible areas of nutrient enrichment. Substantial discussion regarding water quality sonde results and trophic evaluations are included in [Chemistry Results and Discussion](#) section below.

The concentrations of certain chemicals and physical parameters in surface water are subject to the Ohio WQS outlined in OAC 3745-1. An exceedance of a particular water quality criterion does not represent, in and of itself, stream impairment; rather, if biological impairment is present, the exceedances help develop a body of evidence that identifies the conditions that are causing impairment to the aquatic life. D.O. concentrations were compared to both aquatic life use Outside Mixing Zone Minimum (OMZM) and Average (OMZA) criteria (5.0 and 6.0 mg/l respectively for EWH). The magnitude of an exceedance is presented as the most extreme value measured that exceeds the criterion. The count of consecutive exceedances and the proportion of samples which exceeded the criterion are listed in parentheses. Exceedance summaries are presented in Table 14 and Table 15, while individual areas/sites are discussed in more detail in the Results and Discussion section.

Numerous iron exceedances of the Agricultural Water Supply criterion were observed throughout the study area and is likely a result of naturally existing high background concentrations. Iron is abundant in the soils and geology in the area and elevated iron concentrations are routinely found in many ground water and surface water sources in this part of Ohio.

For other chemicals (*e.g.*, nutrients), Ohio EPA has developed benchmark concentrations based on decades of ecological monitoring and incorporating statistical analysis of many thousands of biological and chemical data. These nutrient targets, detailed in Table 16, are not water quality standards; however, they can be used to identify where a stream may be impaired or susceptible to future degradation in water quality due to nutrient enrichment.

Table 14. Summary of exceedances of the Ohio Water Quality Standards criteria (OAC3745-1) for chemical/physical parameters measured in the Big Darby Creek watershed, 2014. Bacteria exceedances are presented separately in the Recreation Use Section.

River Mile	Location	Parameter (value – µg/l unless noted)
Big Darby Creek (02-200-000) EWH and CWH Existing		
81.6	Lane off old U.S. Route 33	D.O. mg/l (4.22, 1.15, 4.78 ^a)
Big Darby Creek (02-200-000) EWH Existing		
58.8	S.E. of Unionville Center	Iron (7660 ^c)
51.1	Dst. Plain City	D.O. mg/l (3.09 ^a), Iron (5540 ^c)
43.5	Dst. Lucas Rd.	Iron (10800 ^c)
41.7	Hubbard Rd.	Iron (5860 ^c)
19.1	S. of Orient	Iron (5360 ^c)
13.3	Darbyville	Iron (5200 ^c)
Little Darby Creek (02-210-000) EWH and CWH Existing		
40.1	Mechanicsburg	Barium (277 ^d), Iron (9930 ^c)
38.8	Dst. Mechanicsburg	Iron (6460 ^c)
Buck Run (02-209-000) WWH Existing		
7.8	SR 245	Iron (5090 ^c)
2.16	Sam Reed Rd.	Iron (6220, 8110 ^c)
Robinson Run (02-207-000) WWH Existing		
0.7	U.S. Route 42	D.O. mg/l (2.82 ^a) Iron (11500 ^c)
Sugar Run (02-206-000) WWH Existing		
5.4	U.S. Route 42	Iron (5410 ^c)
0.4	Plain City	D.O. mg/l (3.81, 2.85 ^a) Iron (10800, 15000 ^c)
Treacle Creek (02-213-000) EWH Existing		
0.8	Winget Rd.	D.O. mg/l (4.36, 4.50, 4.85, 3.31, 1.59, 0.15 ^a) D.O. mg/l (5.8, 3.53, 2.34 ^b)
Barron Creek (02-212-000) WWH Existing		
0.2	State Route 38	D.O. mg/l (3.73 ^a)
Spring Fork (02-211-000) EWH Existing		
7.8	S.E. of Rosedale	D.O. mg/l (4.41 ^a) Iron (7040, 10100 ^c)
Trib. to Little Darby Ck. (14.35) (02-210-008) Undesignated		
0.2	State Route 29 at Snyder Lane	D.O. mg/l (3.06 ^a) Barium (243 ^d)
Hamilton Run (02-204-002) MWH-C Existing		
4.4	Off Alton-Darby Rd.	D.O. mg/l (2.77 ^a)
Clover Groff Run (02-204-001) MWH-C Existing		
3.6	Dst. Timberbrook WTP	Copper (47.7 ^e)
^a Exceedance of the aquatic life Outside Mixing Zone Minimum for D.O. statewide criteria. ^b Exceedance of the aquatic life Outside Mixing Zone 24 hr. Average for D.O. statewide criteria ^c Exceedance of the statewide water quality criteria for the protection of agricultural uses. ^d Exceedance of the aquatic life Outside Mixing Zone Average (OMZA) Ohio River Basin criteria. ^e Exceedance of the aquatic life Outside Mixing Zone Maximum (OMZM) statewide criteria.		

Table 15. Exceedances of Ohio Water Quality Standards criteria (OAC 3745-1) for chemical and physical parameters derived from diel monitoring. The duration is the count of consecutive hours that exceeded the criterion. The magnitude of an exceedance is presented as the most extreme value measured that exceeds the criterion and is presented in (parenthesis) after the duration. 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 D.O. criterion. Information presented in the table was derived from five unique field surveys: August 5-7, 2014 (35 sites; 45-50 hrs.); September 24 – October 1, 2014 (4 sites; 165 hrs.), May 18 – June 3, 2015 (2 sites, 380+ hrs.), September 1-3, 2015 (7 sites; 45-50 hrs.), and September 25 – October 1, 2015 (3 sites; 145 hrs.). Sonde water quality monitors record hourly readings for the duration of the deployment. Applicable water quality criteria include: minimum D.O.^a, average D.O.^b, maximum temperature^c, pH^d, and specific conductance^e.

River Mile	Location	Parameter (D.O.-mg/L, Temp-°C, pH-SU & Sp. Cond.-µS/cm)	Comments
Big Darby Creek (02-200-000)		EWI Existing	
78.44	S.E. of Middleburg at County Road 153	None (August 2014)	
76.54	N.E. of North Lewisburg at North Lewisburg Rd.	None (August 2014)	D.O. range high (6.94 mg/L)
64.38	Upst. Buck Run, adjacent Middleburg-Plain City Rd.	None (August 2014)	
62.60	S.E. of Bridgeport at State Route 38	None (August 2014)	D.O. unknown - sensor failure
51.10	S. of Plain City at Cemetery Pike	None (August 2014)	Dst. Plain City WWTP
38.33	E. of West Jefferson, Dst. Darbycrest	None (August 2014)	
37.5	Upst. Darby-Dan Dam	None (August 2014)	
34.2	Near Georgesville at Alkire Road, Upst. BDC/LDC confluence	None (August 2014)	
26.8	Upst. Gay Run, adjacent Harrisburg-Georgesville Rd.	None (August 2014)	
25.23	Near Harrisburg at U.S. Route 62	None (August 2014)	
22.97	Approx. 200 ft. upst. PCI WWTP Outfall	None (August 2014)	
22.45	Dst. PCI WWTP, upst. Snake Island	None (August 2014)	Dst. PCI WWTP
21.35	Dst. Snake Island	None (August 2014)	
19.1	S. of Orient at Darby Creek Road	None (August 2014)	D.O. unknown - sensor failure
11.3	S.E. of Darbyville at end of Darby Rd.	None (August 2014)	
7.4	S.E. of Darbyville, Dst. Westfall Aggregate	None (August 2014)	pH unknown - sensor failure

River Mile	Location	Parameter (D.O.-mg/L, Temp-°C, pH-SU & Sp. Cond.-µS/cm)	Comments
3.2	Near Fox at State Route 104	None (August 2014)	
Flat Branch (02-223-000)		MWH-C Existing	
0.90	S.E. of Middleburg, Dst. U.S. Route 33	None (August 2014)	D.O. range high (6.55 mg/L)
Spain Creek (02-222-000)		EWB Existing	
0.01	E. of North Lewisburg at mouth	None (August 2014)	Dst. North Lewisburg WWTP D.O. range elevated (5.03 mg/L)
Buck Run (02-209-000)		WWH Existing	
0.01	Near Bridgeport at mouth	None (August 2014)	
Robinson Run (02-207-000)		WWH Existing	
0.73	N. of Plain City at U.S. Route 42	None (August 2014)	
Sugar Run (02-206-000)		WWH Existing	
5.4	Near Arnold at U.S. Route 42	D.O. min: 8(3.4), 6(3.6), 4(3.7), 2(3.9), 1(3.9, 3.9, 3.0, 3.8) (May-June 2015)	Sp. cond. elevated peaks (1732, 1463 µS/cm)
		D.O. avg: 23(4.8), 2 (4.9) (May-June 2015)	D.O. range high (6.4 mg/L)
		None (September 2015)	Sp. cond. elevated peaks (1263, 1083 µS/cm) D.O. range very high (8.09 mg/L)
0.43	Near Plain City at Cemetery Pike	None (August 2014)	
Fitzgerald Ditch (02-205-000)		WWH Existing	
0.55	At Plain City-Georgesville Rd.	None (August 2014)	D.O. range elevated (5.87 mg/L)
Little Darby Creek (02-210-000)		EWB & CWH Existing	
40.1	Near Mechanicsburg at W. Sandusky St.	None (August 2014)	
39.57	At State Route 29	None (Sept.-Oct. 2015)	
39.49	At Landmark storm water/sump pipe, approx. 0.1 mi dst State Route 29	None (Sept.-Oct. 2015)	
38.78		None (August 2014)	Dst. Mechanicsburg WWTP

River Mile	Location	Parameter (D.O.-mg/L, Temp-°C, pH-SU & Sp. Cond.-µS/cm)	Comments
	Dst. Mechanicsburg WWTP at Wing Rd.	None (Sept.-Oct. 2015)	
Little Darby Creek (02-210-000)		EWI Existing	
34.7	N.E. of Mechanicsburg at Irwin Rd.	None (September 2015)	
29.46	W. of Chuckery at Axe Handle Rd.	None (August 2014)	
		None (Sept.-Oct. 2014)	
24.46	E. of Rosedale at Rosedale-Plain City Rd.	None (August 2014)	
20.5	N.E. of Plumwood at Bradley Rd.	None (August 2014)	
14.9	At bend in Goodson Rd. (just dst of U.S. 42)	None (August 2014)	
3.95	At end of Roberts Rd.	None (August 2014)	Dst. West Jefferson WWTP (far-field effects)
0.07	Near Georgesville at Alkire Rd.	None (August 2014)	D.O. range very high (7.08 mg/L)
Treacle Creek (02-213-000)		EWI Existing	
0.78	Upst. Winget Rd. covered bridge	D.O. min: 34 (0.2) (August 2014)	D.O. range elevated (6.26 mg/L)
		D.O. avg: 24(1.8) (August 2014)	
		D.O. min: 39(2.2), 36(3.9), 4(4.7), 3(4.6), 2(4.8) (Sept.-Oct. 2014)	
		D.O. avg: 142 (3.2) (Sept.-Oct. 2014)	
		D.O. min: 11(4.4), 8(4.7), 3(4.8), 1(4.9) (September 2015)	
		D.O. avg: 30(4.8) (September 2015)	

River Mile	Location	Parameter (D.O.-mg/L, Temp-°C, pH-SU & Sp. Cond.-µS/cm)	Comments
0.58	Dst. Winget Rd. covered bridge	Unknown (Sept.-Oct 2014)	All sensors buried in stream substrate: perturbed from vandalism
0.02	Upst. mouth	D.O. min: 165(0.1) (Sept.-Oct. 2014)	D.O. range high (6.3 mg/L)
		D.O. avg: 143(0.1) (Sept.-Oct. 2014)	
		D.O. min: 10(4.3), 9(3.9), 8(4.3), 5(4.4), 2(4.7), 1(4.6) (May-June 2015)	
		D.O. min: 20(3.6), 17(4.1) (September 2015)	
		D.O. avg.: 30(4.3) (September 2015)	
Wamp Ditch (02-210-001)		WWH Existing	
0.1	S. of Chuckery at Finley Guy Rd.	D.O. min: 6(3.7), 5(3.5), 1(3.6) (September 2015)	D.O. range high (6.43 mg/L)
Spring Fork (02-211-000)		EWH Existing	
7.8	S.E. of Rosedale at Rosedale-Milford Center Rd.	None (August 2014)	
Trib. to Big Darby Creek (RM 27.93) (02-200-021)		WWH Existing	
0.7	At State Route 665 dst. Darbydale WWTP	None (August 2014)	Dst. Darbydale WWTP Sp. cond. elevated peaks (1798, 1782 µS/cm)
Hellbranch Run (02-204-000)		WWH Existing	
0.98	N. of Harrisburg at Lambert Rd.	None (August 2014)	
		None (September 2015)	
Springwater Run (02-203-000)		WWH Existing/CWH Recommended	
0.8	At Harrisburg-Georgesville Rd.	None (September 2015)	
Notes:			
ª Applicable minimum 24-hour period D.O. criterion - EWH: 5.0 mg/L, WWH: 4.0 mg/L, MWH: 3.0 mg/L (see OAC 3745-1-07, Table 7-1).			
ª Applicable average 24-hour D.O. criterion - EWH: 6.0 mg/l, WWH: 5.0 mg/L, MWH: 4.0 mg/L (see OAC 3745-1-07, Table 7-1).			
ª Ohio River basin daily average and maximum temperature criteria apply; see OAC 3745-1-07, Table 7-14(A).			
ª The criterion for pH is 6.5-9.0 S.U. over a 24-hour average.			
ª The criterion for specific conductance is 2400 µS/cm over a 24-hour average.			

Table 16. Seasonal geometric mean values (mg/l) for nutrients calculated from grab samples collected in Big Darby Creek HUC-12 watersheds. Target levels for total phosphorus (TP) and nitrate-nitrite are dependent on aquatic life use designation and drainage area, and are outlined in Table 17. **Highlighted** concentrations are greater than statewide recommended targets (Ohio EPA 1999).

<i>Headwaters (drainage area < 20 mi²)</i>	
05060001-19-01: Headwaters Big Darby Creek	
83.20	(Big Darby Creek) – TP (0.019), NO _{3/2} (0.150)
81.90	(Big Darby Creek) – TP (0.018), NO _{3/2} (0.068)
81.60	(Big Darby Creek) – TP (0.011), NO _{3/2} (0.061)
81.10	(Big Darby Creek) – TP (0.022), NO _{3/2} (0.050)
80.75	(Big Darby Creek) – TP (0.023), NO _{3/2} (0.279)
79.23	(Big Darby Creek) – TP (0.020), NO _{3/2} (0.179)
3.20 *	(Flat Branch) – TP (0.061), NO _{3/2} (0.087)
2.84	(Outfall: Flat Br.) – TP (0.153) , NO _{3/2} (0.063)
0.90 *	(Flat Branch) – TP (0.051), NO _{3/2} (0.145)
05060001-19-02: Spain Creek–Big Darby Creek	
78.44	(Big Darby Creek) – TP (0.050) , NO _{3/2} (0.556)
0.40	(Trib.: BDC 69.40) – TP (0.027), NO_{3/2} (1.088)
0.20	(Trib.: BDC 77.29) – TP (0.023), NO _{3/2} (0.810)
3.61	(Little Darby Creek) – TP (0.013), NO_{3/2} (1.812)
0.34	(Little Darby Creek) – TP (0.021), NO_{3/2} (0.950)
0.20	(Hay Run) – TP (0.029), NO_{3/2} (1.336)
3.70	(Spain Creek) – TP (0.021), NO_{3/2} (0.936)
0.01	(Spain Creek) – TP (0.030), NO_{3/2} (1.807)
0.01	(Pleasant Run) – TP (0.021), NO_{3/2} (0.682)
05060001-19-03: Buck Run	
10.4	(Buck Run) – TP (0.037), NO _{3/2} (0.087)
7.80	(Buck Run) – TP (0.035), NO _{3/2} (0.131)
05060001-19-04: Sugar Run	
5.40	(Sugar Run) – TP (0.086) , NO _{3/2} (0.247)
0.43	(Sugar Run) – TP (0.110) , NO _{3/2} (0.666)
05060001-19-05: Robinson Run–Big Darby Creek	
0.20	(Sweeny Run) – TP (0.118) , NO _{3/2} (0.575)
2.10	(Robinson Run) – TP (0.088) , NO _{3/2} (0.834)
0.73	(Robinson Run) – TP (0.144) , NO _{3/2} (0.509)
05060001-20-01: Headwaters Treacle Creek	
11.80	(Treacle Creek) – TP (0.042), NO_{3/2} (0.809)
6.00	(Treacle Creek) – TP (0.027), NO_{3/2} (1.695)
0.60	(Howard Run) – TP (0.017), NO_{3/2} (1.095)
05060001-20-02: Proctor Run–Treacle Creek	
4.90	(Proctor Run) – TP (0.057) , NO_{3/2} (1.333)
1.60	(Proctor Run) – TP (0.026), NO_{3/2} (1.362)
05060001-20-03: Headwaters Little Darby Creek	
40.10	(Little Darby Creek) – TP (0.013), NO_{3/2} (2.094)
39.50	(Outfall: LDC 39.5) – TP (0.252) , NO_{3/2} (7.525)
39.30	(Little Darby Creek) – TP (0.016), NO_{3/2} (2.309)
38.78	(Little Darby Creek) – TP (0.060) , NO_{3/2} (1.970)
0.95	(Lake Run) – TP (0.021), NO_{3/2} (0.976)
0.27	(Jumping Run) – TP (0.036), NO_{3/2} (2.951)
0.60	(Clover Run) – TP (0.018), NO _{3/2} (0.955)
0.10	(Trib.: LDC 39.58) – TP (0.019), NO _{3/2} (1.180)
05060001-20-04: Spring Fork	
10.08	(Spring Fork) – TP (0.023), NO _{3/2} (0.350)
7.80	(Spring Fork) – TP (0.042), NO_{3/2} (0.785)
05060001-20-05: Barron Creek–Little Darby Creek	
0.20	(Barron Creek) – TP (0.047), NO _{3/2} (0.731)
0.10	(Wamp Ditch) – TP (0.049), NO _{3/2} (0.480)
05060001-20-06: Thomas Ditch–Little Darby Creek	
0.20	(Trib.: LDC 14.35) – TP (0.026), NO _{3/2} (0.125)
0.50	(Trib.: LDC 13.70) – TP (0.020), NO _{3/2} (0.226)
0.10	(Trib.: LDC 12.88) – TP (0.038), NO_{3/2} (9.864)
0.10	(Outlet to Trib.: 9.1) – TP (0.019), NO _{3/2} (0.125)
05060001-21-01: Worthington Ditch–Big Darby Creek	
0.55	(Fitzgerald Ditch) – TP (0.207) , NO_{3/2} (3.972)
0.24	(Worth. Ditch) – TP (0.058), NO_{3/2} (2.655)
0.18	(Ball. Jones Ditch) – TP (0.035), NO _{3/2} (0.657)
05060001-22-01: Hellbranch Run	
7.00 *	(Clover Groff Run) – TP (0.183), NO _{3/2} (0.251)
6.60 *	(Clover Groff Run) – TP (0.163), NO _{3/2} (0.237)
5.85 *	(Clover Groff Run) – TP (0.152), NO _{3/2} (0.221)
5.50 *	(Clover Groff Run) – TP (0.120), NO _{3/2} (0.218)
5.00 *	(Clover Groff Run) – TP (0.151), NO _{3/2} (0.197)
4.70 *	(Clover Groff Run) – TP (0.182), NO _{3/2} (0.235)
3.60 *	(Clover Groff Run) – TP (0.163), NO _{3/2} (0.278)
0.14	(Clover Groff Run) – TP (0.110) , NO _{3/2} (0.589)
4.92 *	(Hamilton Run) – TP (0.097), NO _{3/2} (0.139)
4.40 *	(Hamilton Run) – TP (0.071), NO _{3/2} (0.154)
4.05 *	(Hamilton Run) – TP (0.108), NO _{3/2} (0.139)
3.34 *	(Hamilton Run) – TP (-), NO _{3/2} (-)
0.80	(Hamilton Run) – TP (0.110) , NO _{3/2} (0.527)
0.10	(Hamilton Run) – TP (0.120) , NO_{3/2} (1.473)
0.10	(McCoy Run) – TP (0.112) , NO _{3/2} (0.679)
05060001-22-02: Gay Run–Big Darby Creek	
2.20	(Gay Run) – TP (0.058), NO_{3/2} (1.553)
0.72	(Trib.: BDC 27.93) – TP (0.700) , NO_{3/2} (14.120)
0.20	(Smith Ditch) – TP (0.042), NO_{3/2} (2.261)
05060001-22-03: Greenbrier Creek–Big Darby Creek	
0.80	(Springwater Run) – TP (0.023), NO_{3/2} (1.214)
0.74	(Trib.: BDC 20.20) – TP (0.026), NO _{3/2} (0.516)
0.10	(Trib.: BDC 23.77) – TP (0.009), NO _{3/2} (0.178)

Wadable Stream (drainage area ≥ 20 mi² to < 200 mi²)**05060001-19-02: Spain Creek–Big Darby Creek**

76.53 (Big Darby Creek) – TP (0.020), NO_{3/2} (0.637)
 69.50 (Big Darby Creek) – TP (0.027), NO_{3/2} (0.750)

05060001-19-03: Buck Run

2.16 (Buck Run) – TP (0.075), NO_{3/2} (0.282)
 0.01 (Buck Run) – TP (0.085), NO_{3/2} (0.515)

05060001-19-05: Robinson Run–Big Darby Creek

66.10 (Big Darby Creek) – TP (0.035), NO_{3/2} (0.762)
 64.38 (Big Darby Creek) – TP (0.036), NO_{3/2} (0.727)
 62.60 (Big Darby Creek) – TP (0.035), NO_{3/2} (0.857)
 58.80 (Big Darby Creek) – TP (0.071), NO_{3/2} (0.798)
 54.10 (Big Darby Creek) – TP (0.043), NO_{3/2} (0.795)
 52.11 (Big Darby Creek) – TP (0.050), NO_{3/2} (0.766)
 51.10 (Big Darby Creek) – TP (0.046), NO_{3/2} (1.341)

05060001-20-02: Proctor Run–Treacle Creek

0.78 (Treacle Creek) – TP (0.050), NO_{3/2} (0.568)

05060001-20-03: Headwaters Little Darby Creek

34.70 (Little Darby Creek) – TP (0.040), NO_{3/2} (1.524)

05060001-20-04: Spring Fork

0.75 (Spring Fork) – TP (0.036), NO_{3/2} (1.401)

05060001-20-05: Barron Creek–Little Darby Creek

29.46 (Little Darby Creek) – TP (0.041), NO_{3/2} (1.040)
 27.47 (Little Darby Creek) – TP (0.040), NO_{3/2} (1.197)
 24.46 (Little Darby Creek) – TP (0.062), NO_{3/2} (1.291)
 20.50 (Little Darby Creek) – TP (0.054), NO_{3/2} (0.853)

05060001-20-06: Thomas Ditch–Little Darby Creek

17.25 (Little Darby Creek) – TP (0.048), NO_{3/2} (1.015)
 13.35 (Little Darby Creek) – TP (0.046), NO_{3/2} (0.940)
 8.90 (Little Darby Creek) – TP (0.038), NO_{3/2} (1.094)
 7.35 (Little Darby Creek) – TP (0.049), NO_{3/2} (0.500)
 3.95 (Little Darby Creek) – TP (0.053), NO_{3/2} (2.040)
 0.07 (Little Darby Creek) – TP (0.050), NO_{3/2} (2.022)

05060001-21-01: Worthington Ditch–Big Darby Creek

49.46 (Big Darby Creek) – TP (0.059), NO_{3/2} (1.198)

05060001-22-01: Hellbranch Run

9.40 (Hellbranch Run) – TP (0.107), NO_{3/2} (0.538)
 7.29 (Hellbranch Run) – TP (0.091), NO_{3/2} (0.467)
 5.80 (Hellbranch Run) – TP (0.093), NO_{3/2} (0.581)
 0.98 (Hellbranch Run) – TP (0.081), NO_{3/2} (0.613)
 0.90 (Hellbranch Run) – TP (0.097), NO_{3/2} (0.519)

Small River (drainage area ≥ 200 mi² to < 1000 mi²)**05060001-21-01: Worthington Ditch–Big Darby Creek**

43.50 (Big Darby Creek) – TP (0.063), NO_{3/2} (0.948)

05060001-21-02: Silver Ditch–Big Darby Creek

41.75 (Big Darby Creek) – TP (0.057), NO_{3/2} (1.114)
 39.76 (Big Darby Creek) – TP (0.056), NO_{3/2} (0.987)
 38.90 (Big Darby Creek) – TP (0.068), NO_{3/2} (1.482)
 38.33 (Big Darby Creek) – TP (0.054), NO_{3/2} (1.352)
 37.50 (Big Darby Creek) – TP (0.114), NO_{3/2} (1.346)
 34.20 (Big Darby Creek) – TP (0.057), NO_{3/2} (0.972)
 7.40 (Big Darby Creek) – TP (0.048), NO_{3/2} (1.569)

05060001-22-02: Gay Run–Big Darby Creek

29.20 (Big Darby Creek) – TP (0.097), NO_{3/2} (1.398)
 27.95 (Big Darby Creek) – TP (0.058), NO_{3/2} (1.418)
 26.80 (Big Darby Creek) – TP (0.044), NO_{3/2} (1.701)

05060001-22-03: Greenbrier Creek–Big Darby Creek

25.23 (Big Darby Creek) – TP (0.045), NO_{3/2} (1.317)
 23.75 (Big Darby Creek) – TP (0.047), NO_{3/2} (1.270)
 22.97 (Big Darby Creek) – TP (0.043), NO_{3/2} (1.313)
 22.25 (Big Darby Creek) – TP (0.055), NO_{3/2} (1.168)
 21.35 (Big Darby Creek) – TP (0.059), NO_{3/2} (1.342)
 19.83 (Big Darby Creek) – TP (0.055)¹, NO_{3/2} (0.480)¹
 19.10 (Big Darby Creek) – TP (0.054), NO_{3/2} (1.456)

05060001-22-04: Lizard Run–Big Darby Creek

13.36 (Big Darby Creek) – TP (0.057), NO_{3/2} (1.888)
 11.30 (Big Darby Creek) – TP (0.048), NO_{3/2} (1.539)
 3.20 (Big Darby Creek) – TP (0.054), NO_{3/2} (1.743)

* Modified Warmwater Habitat

¹ Single sample

Table 17. Ohio Water Quality Standards criteria (OAC 3745-1) for dissolved oxygen (D.O.) and target nutrient concentrations (Ohio EPA 1999) for indicated aquatic life use designations assigned to streams in the Big Darby Creek watershed.

Chemical Parameter	Headwaters: (Drainage < 20mi ²)	Wadable Streams: (20mi ² < Drainage < 200mi ²)	Small rivers: (200mi ² < drainage < 1000mi ²)
Modified Warmwater Habitat (MWH)			
Total Phosphorous ¹	0.34 mg/l	0.28 mg/l	0.25 mg/l*
Nitrate+Nitrite ¹	1.0 mg/l	1.6 mg/l	2.2 mg/l*
Dissolved Oxygen ²	3.0 mg/l (acute, OMZM), 4.0 mg/l (24-hr avg., OMZA)		
Warmwater Habitat (WWH)			
Total Phosphorous ¹	0.08 mg/l	0.1 mg/l	1.5 mg/l*
Nitrate+Nitrite ¹	1.0 mg/l		1.5 mg/l*
Dissolved Oxygen ²	4.0 mg/l (acute, OMZM), 5.0 mg/l (24-hr avg., OMZA)		
Exceptional Warmwater Habitat (EWH)			
Total Phosphorous ¹	0.05 mg/l		0.10 mg/l
Nitrate+Nitrite ¹	0.5 mg/l		1.0 mg/l
Dissolved Oxygen ²	5.0 mg/l (acute, OMZM), 6.0 mg/l (24-hr avg., OMZA) Coldwater Habitat (CWH): 6.0 mg/l (acute, OMZM), 7.0 mg/l (24-hr avg., OMZA)		
Notes:			
¹ Associations Document (Ohio EPA 1999) target concentrations			
² Water Quality Standards criteria			
*For informational purposes only. Streams of this size classification and use designation combination do not exist in the Big Darby Creek watershed.			

Chemistry Results and Discussion

Surface water chemistry grab samples were collected from 124 sampling locations within the Big Darby Creek watershed on five to eight different dates during the summer of 2014. The chemistry grab samples collected during this survey directly represent approximately 1 to 2% of the overall calendar year. Therefore, trends in average chemical concentrations from one site to the next or between survey years should be put in the context of comparing a series of snapshots, with an understanding that chemical concentrations higher and lower than the specific ranges measured in this study may occur.

To determine whether a stream sampling location is meeting its designated aquatic life use goals, Ohio EPA ultimately relies on measurements of the quality and makeup of the stream's fish and macroinvertebrate communities. One of the foremost uses of chemical data presented in this report is to provide a backdrop to the fish and macroinvertebrate aquatic life use attainment results, with the stream chemistry providing a line of evidence that can point to likely causes and sources of any changes observed in the stream biology. In the most literal sense, aquatic species incorporate the chemistry of their surroundings over the course of their lifespan; these biological communities are the most reliable indicators of longer term water quality trends.

One of the most widespread causes of diminished surface water quality in Ohio today is nutrient enrichment. With respect to nutrient enrichment, streams within the Big Darby Creek watershed have excellent water quality relative to other watersheds in central Ohio, and this watershed has in many ways improved over recent years. However, there were localized areas, typically within smaller tributary streams, where the effects of excess nutrients were evident and likely caused impairment. High

concentrations of nutrients in a body of water can accelerate cycles of primary productivity and decomposition to a point where oxygen resources become depleted or harmful byproducts begin to accumulate, *i.e.*, hypoxia or the various toxins released from Harmful Algae Blooms (HABs). Where it is evident, nutrient enrichment detracts from the usability of Ohio's surface water resources and at the same time negatively impacts resident populations of aquatic organisms.

Nutrients measured at each sampling location included ammonia, nitrate+nitrite (NO_3+NO_2), total Kjeldahl nitrogen (TKN), total phosphorus (TP), and orthophosphate. Ohio streams are usually considered to be saturated in nitrate (given here as the sum of nitrate and nitrite, NO_3+NO_2), an inorganic form of nitrogen that is available for direct algal and plant uptake. This means that additional nitrate inputs to a stream do not always equate to additional primary productivity. Elevated concentrations of nitrate are not typically considered the most proximate cause of the ecological impacts stemming from nutrient enrichment in local freshwater streams; however high nitrate concentrations are a specific concern in relation to human health via public drinking water supplies. The Big Darby Creek watershed does not contain any surface-water public water supplies.

Total phosphorous concentrations, on the other hand, are generally considered the limiting nutrient to primary productivity in surface waters of this region. Ohio streams that have high TP concentrations have been correlated with stream conditions that are dominated by pollution tolerant, less diverse biological communities and vice versa (Ohio EPA 1999). When the biology of a stream such as Big Darby Creek has been impaired by nutrient enrichment, a Total Maximum Daily Load (TMDL), or a 'pollution diet', is developed which often focuses on limiting phosphorous. TMDLs were developed for the Big Darby Creek watershed following the 2001-2002 watershed assessment (Ohio EPA 2006).

Big Darby Creek watershed TMDLs drew upon the same source data and analysis that was used to develop the surface water nutrient concentration targets recommended by Ohio EPA in the 1999 report *Association Between Nutrients, Habitat and the Aquatic Biota in Ohio Rivers and Streams.* (Ohio EPA 1999). This document established statewide nutrient targets for tiered aquatic life use designations using multiyear data from the period of June 15 through October 15. This document serves as a basis of comparison for 2014 Darby Creek nutrient data.

The geometric means (geomean) of NO_3+NO_2 and TP chemistry concentration data from the Big Darby Creek watershed were compared to target concentrations detailed in Ohio EPA 1999. Sample results from outside the June 15th through October 15th, 2014 timeframe were excluded from the discussion below in order to provide a direct comparison between Big Darby Creek watershed nutrient concentration data and target concentrations detailed in the 1999 "Associations Document". Geomeans are the measure of central tendency used to describe the majority of the chemical data results within this report; a geomean minimizes the influence of extremely high or low data points considered "outliers". Furthermore, geomeans of chemical data facilitate direct comparison with target criteria, which are given in the form of a geomean. A complete data set, detailing nutrient and other chemical parameters, can be found in Appendix F.

Chemicals that have been linked in the past to the degradation of Big Darby Creek watershed biological communities, or those that indicate degrading conditions, specifically the nutrients TP, NO_3+NO_2 , total ammonia, and TKN were highlighted for discussion below. Figure 70 through Figure 73 below present chemical data, as well as geomeans, from both 2001 and 2014. Chemical concentration data is plotted by river mile for total ammonia, TP, NO_3+NO_2 , and TKN. Individual sampling events are depicted as open

circles and the 2014 geomean from each site is plotted as a darkened circle. For comparison purposes, 2001 geomean concentrations (where available) are shown as an asterisk (Ohio EPA 2004).

Forty-nine of the 121 locations (40%) sampled for chemistry in 2014 yielded geometric means that exceeded statewide targets for NO_3+NO_2 and/or TP. The geometric means for NO_3+NO_2 and TP measured in the Big Darby watershed that exceeded nutrient target concentrations are highlighted in Table 16.

Big Darby Creek Mainstem and Tributaries

Thirty-seven locations on the Big Darby Creek mainstem were sampled and evaluated for surface water chemistry. Many of these samples were collected in conjunction with biological monitoring locations throughout the summer of 2014. Chemical water quality conditions in Big Darby Creek were generally within target ranges, and most locations were free from problematic levels of chemical pollutants or exceedances of Ohio WQS criteria.

Big Darby Creek Mainstem Longitudinal & Aggregated Nutrient Plots

The analytical results for the selected nutrient parameters which are typically associated with poorly performing biological communities, TP, NO_3+NO_2 , ammonia and TKN, were plotted for each site on the Big Darby Creek mainstem longitudinally by river mile in Figure 70-Figure 73 and are discussed in detail below. A complete set of chemical sampling results is located in Appendix F. TP concentrations in the Big Darby mainstem were mostly at or below threshold concentrations for Exceptional Warmwater Habitat (EWH) and the TP concentrations measured in 2014 were typically lower than those measured in 2001 (Figure 74). Nitrate concentrations (as nitrate+nitrite) were generally in excess of EWH benchmarks, though appeared slightly decreased compared to 2001 (Figure 74). TKN concentrations also appeared to decrease from 2001 to 2014 (Figure 74).

Big Darby Creek TP

Several areas along the Big Darby Creek mainstem had TP concentrations that were approaching or above the applicable EWH target concentrations, though TP appeared to be adequately assimilated as there was no aquatic life use impairment documented around these areas. (Figure 70). At RM 78.4 at Logan County Road 153 in the headwaters region of Big Darby Creek, there was a 0.047 mg/l geomean concentration of TP, which is just below the EWH threshold of 0.05 for drainage areas less than 200 square miles. In 2001, the geomean at this site was considerably higher at 0.14 mg/l. Elevated TP was also found at RM 58.8, downstream from Unionville Center.

Samples collected within and downstream from Plain City, from approximately RMs 49-52, had geomean TP concentrations at or slightly above the 0.05 mg/l EWH threshold. However, TP concentrations in this reach of Big Darby Creek were reduced by approximately half as compared to the TP concentrations measured in 2001. The highest single-sample TP concentration (0.66 mg/l) and the highest geomean concentration (0.11 mg/l) were recorded at RM 37.5, upstream from the impoundment at RM 37.2. TP geomean concentration at RM 29.2 (0.097 mg/l), downstream from Trapper John's Canoe Livery, was approaching the EWH target and was higher than the sampling locations immediately upstream and downstream. It is possible, however, that sample results at RM 29.2 were influenced by the incompletely mixed effluent from the Oak Hills MHP wastewater treatment facility, located immediately upstream from this sampling location.

Big Darby Creek Nitrate

Tile drained row-crop production land use and municipal wastewater treatment plants each contribute to elevated nitrate concentration in streams within the Big Darby Creek watershed. From the headwaters to the mouth, nitrate concentrations increase in a nearly linear fashion with increasing drainage area; several spikes in concentration are evident immediately downstream from wastewater treatment plants. For example, the geomean $\text{NO}_3 + \text{NO}_2$ concentration in Big Darby Creek increases nearly twofold from 0.77 mg/l upstream from the Plain City WWTP (RM 52.1) to 1.34 mg/l downstream from the Plain City WWTP (RM 51.1) (Figure 71). With the exception of the upstream-most five sites sampled in the headwaters, all sampling locations were near or in excess of the EWH target for nitrate.

Big Darby Creek Ammonia

Any elevated ammonia concentrations in the Big Darby Creek watershed would be of particular concern because of the potential for ammonia to negatively affect the Big Darby's uniquely rich biological communities. Ammonia concentrations in the Big Darby mainstem were in large part below detectable levels, represented in Figure 72 by a value of 0.025 (which is half of the 0.05 mg/l analytical reporting limit). These concentrations are similar to the results of the last watershed survey, where most sampling locations had below detection limit levels of ammonia. The geomean concentration of ammonia downstream from the Plain City WWTP in 2001 (0.34 mg/l) was much greater than other sampling locations in Big Darby Creek. This phenomenon was not observed in 2014 where ammonia concentrations in the vicinity of Plain City were greatly diminished compared to 2001.

Only one site on the Big Darby Creek mainstem from 2014 had both individual ammonia grab samples and a geomean that were consistently above background levels and in excess of ecoregion reference concentrations. Downstream from Trapper John's Canoe Livery and the McKinley Bridge at RM 29.2, the ammonia geomean concentration was 0.15 mg/l, just above the 95th percentile for a stream of this size within the ECBP ecoregion. Due to stream access considerations, samples at this location were collected along the descending right bank and potentially fell within the effluent mixing zone of the Oak Hills MHP wastewater treatment facility. However, Ohio EPA has recently received and approved an NPDES permit modification to increase the capacity of the Darbydale WWTP, and once completed, will accept wastewater from both the Oak Hills and Pleasant Acres MHP. Subsequent retirement of both the Oak Hills and Pleasant Acres MHP WWTPs should help improve water quality throughout this reach of Big Darby Creek.

Big Darby Creek TKN

TKN concentration, the sum of organic nitrogen and ammonia, can indicate that surface waters are enriched with organic material. Poorly functioning wastewater treatment or improper disposal of waste material can both be a source of TKN. TKN concentrations have diminished over time in Big Darby Creek and are well within ecoregion-based benchmark concentrations (Figure 73). Big Darby at RM 23.75, west of Orient at SR-762, had a slightly increased concentration of TKN compared to 2001 (0.37 mg/l vs. 0.31 mg/l).

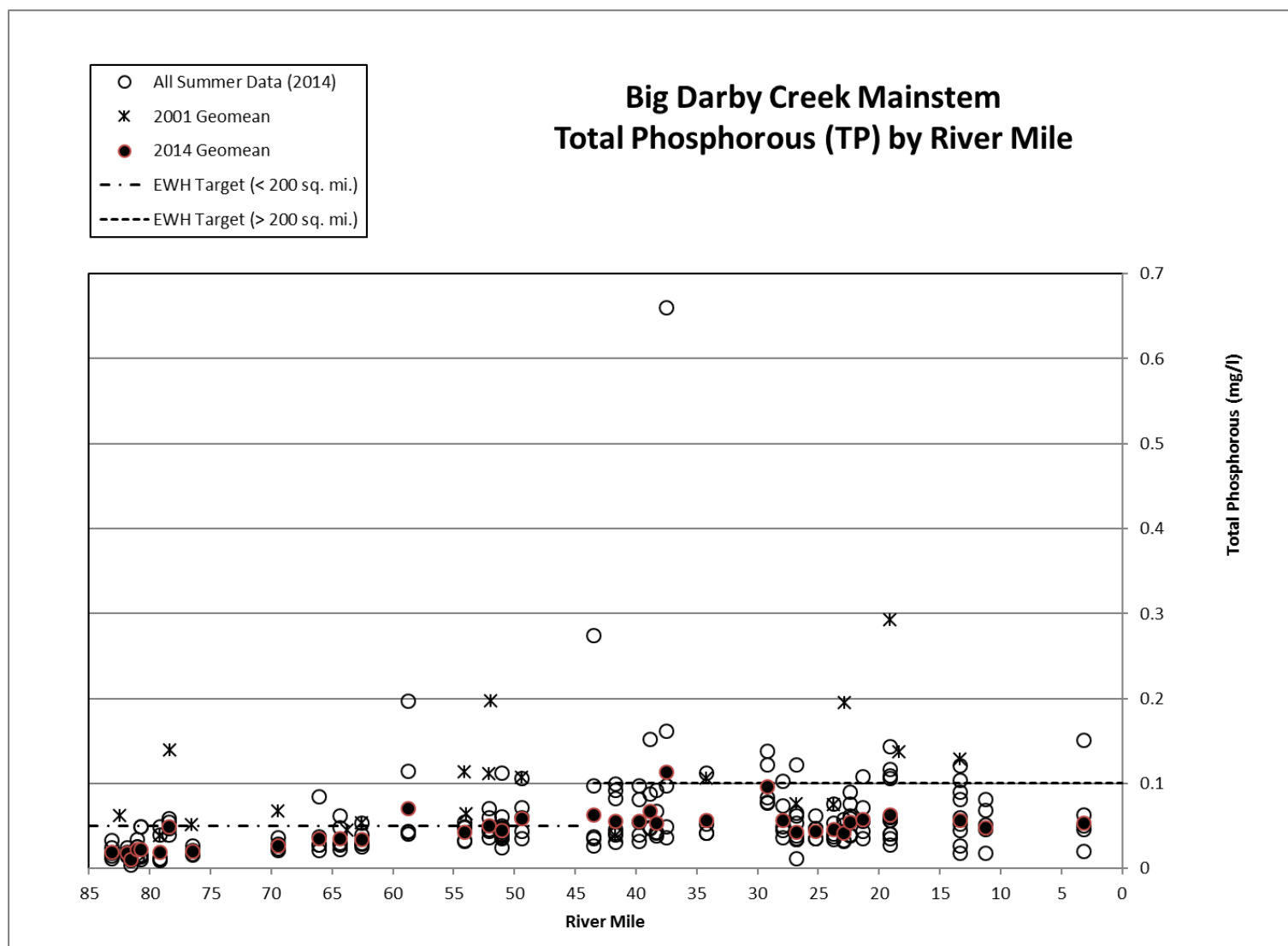


Figure 70. Total Phosphorus concentration results from the Big Darby Creek mainstem with geometric mean and specified target concentrations, 2014 and 2001.

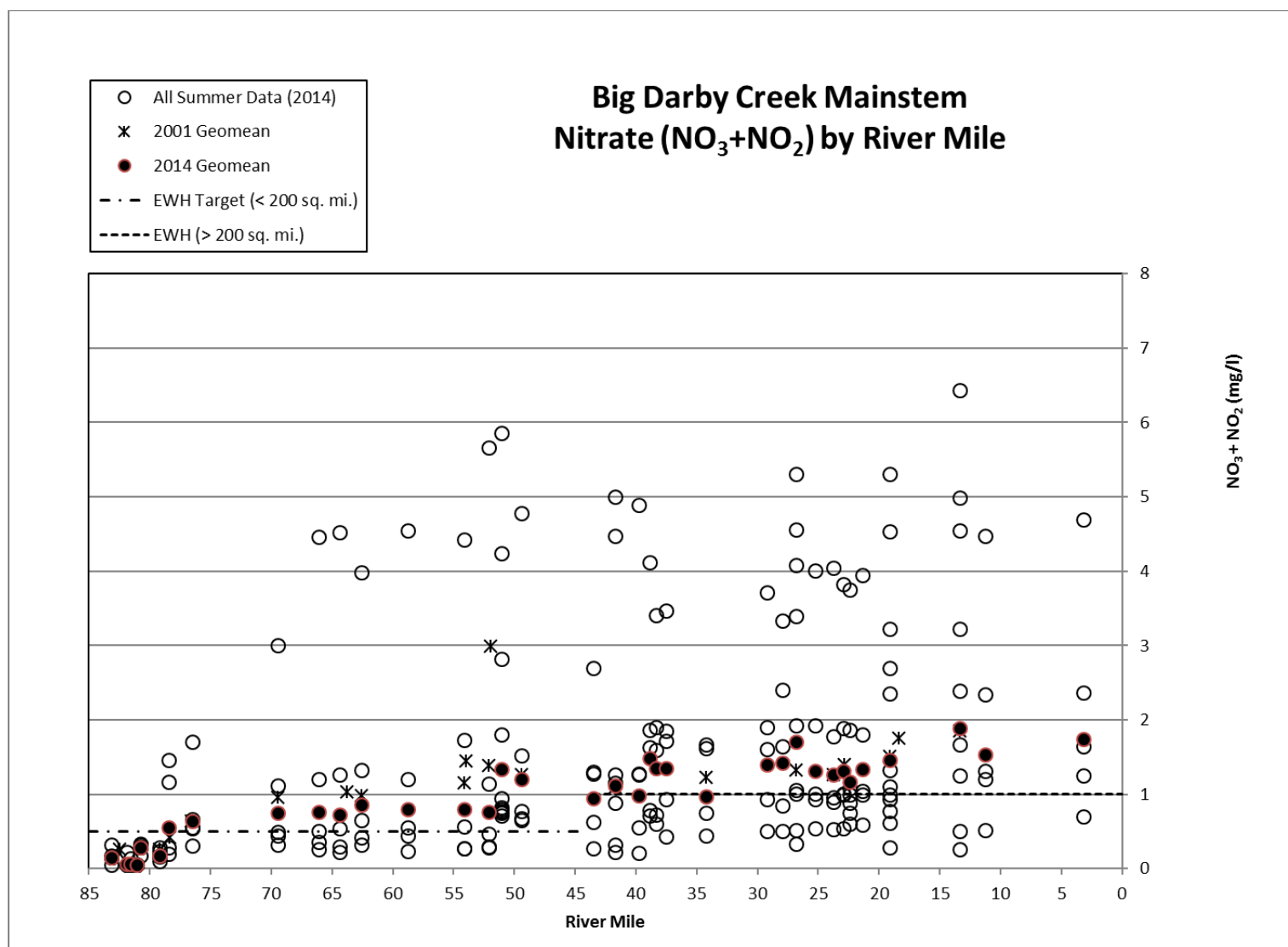


Figure 71. Nitrate-nitrite concentration results from the Big Darby Creek mainstem with geometric mean and specified target concentrations, 2014 and 2001.

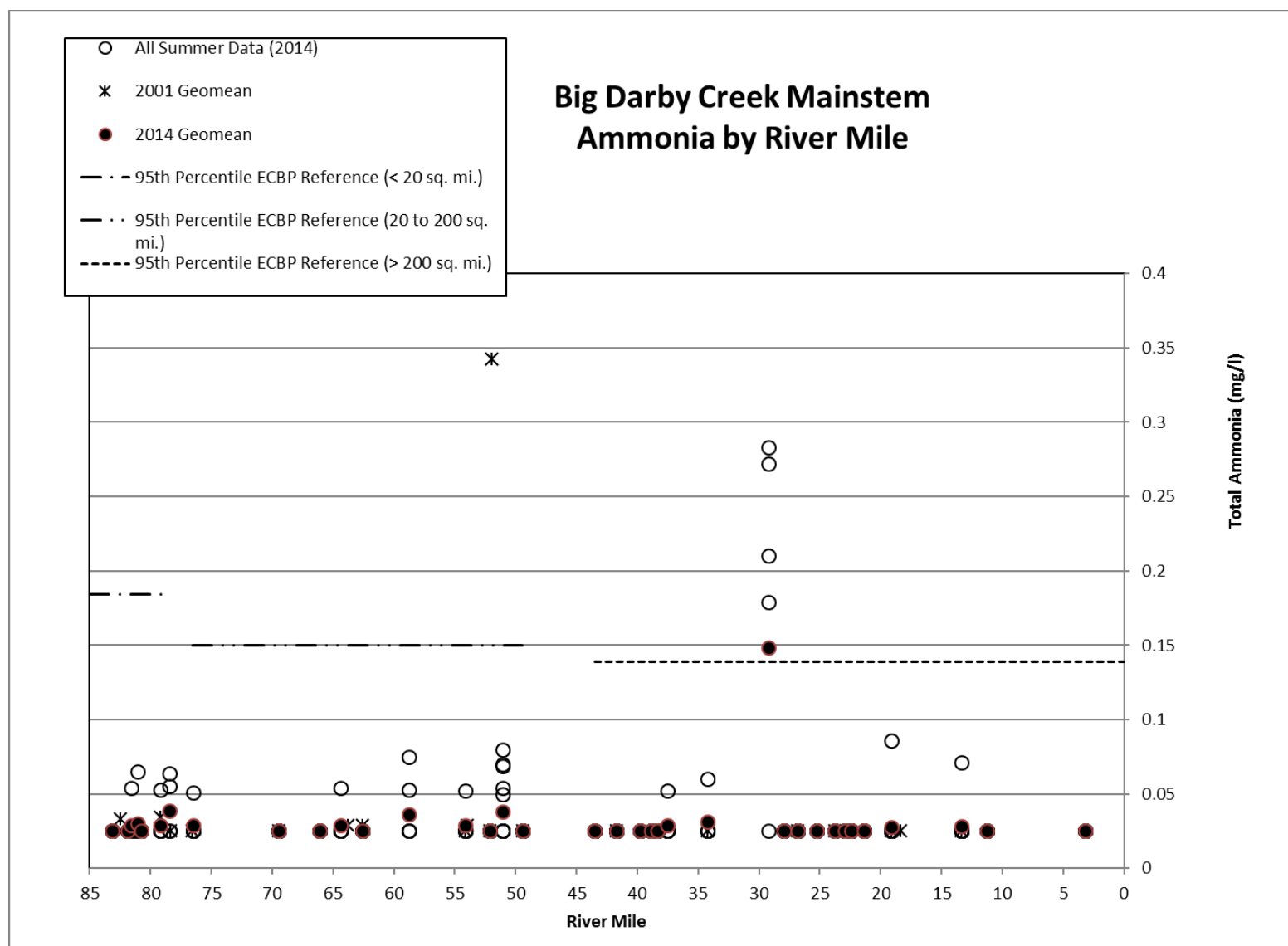


Figure 72. Total ammonia concentration results from the Big Darby Creek mainstem with geometric mean and specified ECBP reference concentrations, 2014 and 2001.

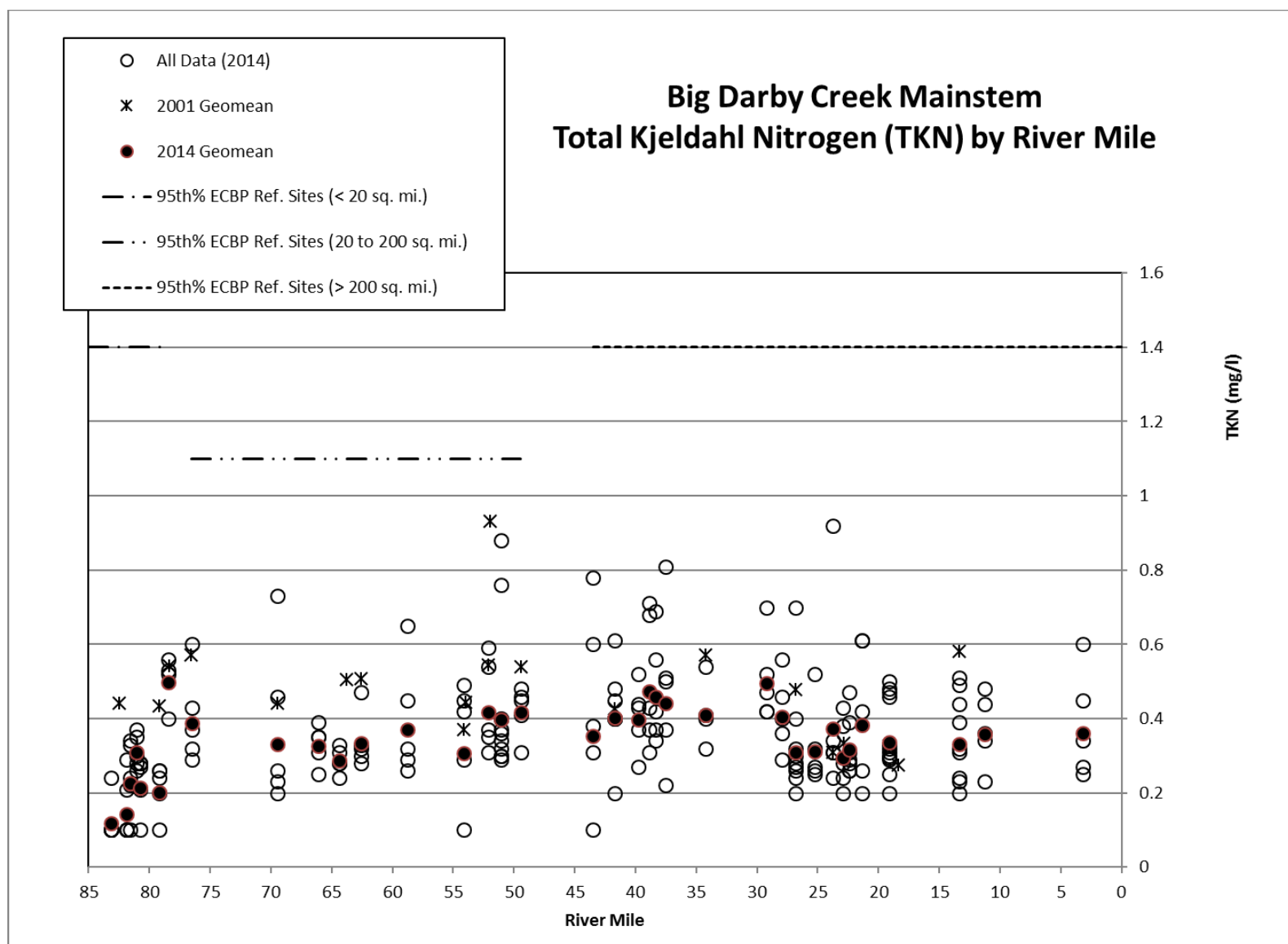


Figure 73. Total Kjeldahl nitrogen concentration results from the Big Darby Creek mainstem with geometric mean and specified target concentrations, 2014 and 2001.

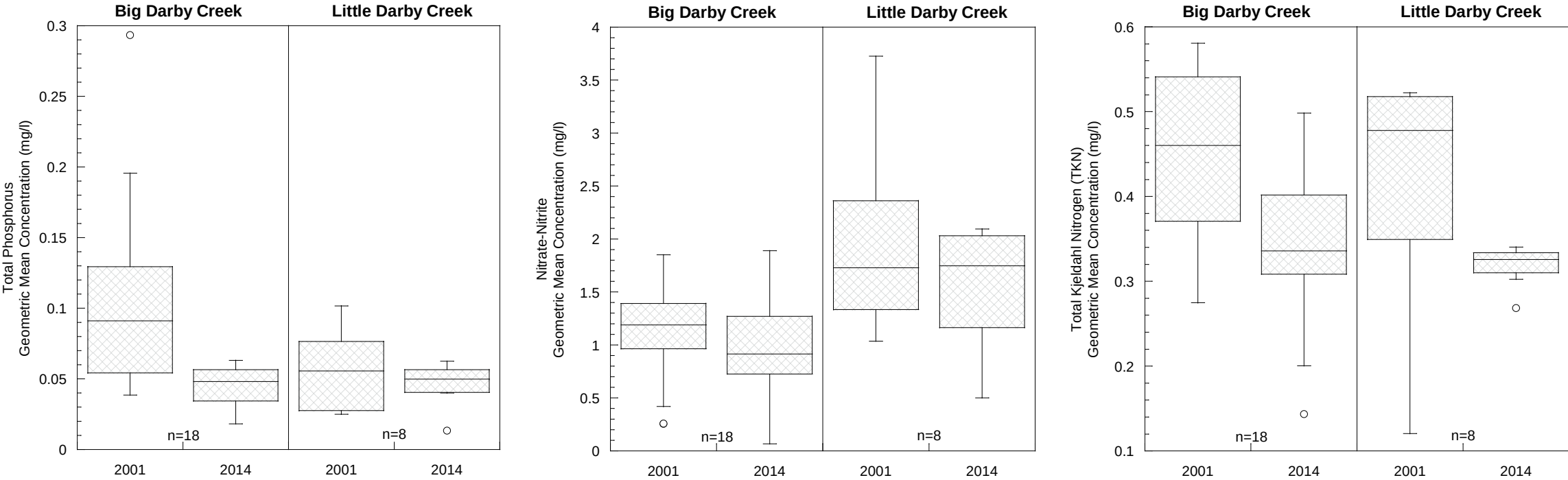


Figure 74. Aggregated geometric mean concentration of total phosphorus (left), nitrate-nitrite (middle), and total Kjeldahl nitrogen (right) from paired sampling locations/reaches within Big and Little Darby creeks, 2001 and 2014.

Selected Site-Specific Discussion

Big Darby Creek RM 78.4 and Flat Branch

Within the upper reaches of Big Darby Creek at RM 78.4, downstream from Flat Branch, the aquatic life use was negatively affected in 2001 by high concentrations of total suspended solids (TSS) entering from Flat Branch. TSS concentrations within Flat Branch in 2014 were reduced by 65% compared to 2001 (17 mg/l versus 49 mg/l). Given that Flat Branch was the main contributor of TSS to Big Darby Creek RM 78.4 in 2001, it follows that similar margins of TSS reduction were also observed in Big Darby Creek at this location. TP concentrations were also lower in both Flat Branch and Big Darby Creek RM 78.4 compared to 2001 (Table 18 and Table 19).

Flat Branch flows through a portion of the Honda of America Manufacturing Inc. property and this tributary has historically been negatively impacted by storm water runoff. Since the 2001 study, Honda has constructed wetlands to mitigate storm water impacts to Flat Branch and established a buffer zone around Flat Branch. These actions appear to have had a positive impact on Flat Branch and the Big Darby by reducing TSS and particle-bound phosphorous concentrations.

In 2001, an acutely toxic concentration of copper (81 µg/l) was measured in Flat Branch, attributed to an algaecide used in upstream storm water basins. This problem was not apparent in 2014, where the geomean copper concentration was 3.5 µg/l in Flat Branch with a maximum of 4.8 µg/l.

Table 18. Selected water quality parameters and aquatic life use indices from Big Darby Creek RM 78.4, 2014 and 2001.

Big Darby Creek RM 78.4 (V07P61) SE of Middleburg at Co. Rd. 153 EWH - Headwaters		
Parameter	2001 Geomean (mg/l) n=6	2014 Geomean (mg/l) n=7
TP	0.139	0.050
Ammonia	< RL (0.05)	0.039
NO ₃ +NO ₂	0.42	0.56
TKN	0.54	0.50
TSS	37	14
TDS	310	504
	2001	2014
ALU Attainment	<i>Partial</i>	<i>Full</i>
IBI, fish	37.3*	54
ICI, macroinvertebrate	52	48

Table 19. Selected water quality parameters and aquatic life use indices from Flat Branch RM 0.8, 2014 and 2001.

Flat Branch RM 0.8 (V07P60) Near U.S.-Route 33 MWH-C - Headwaters		
Parameter	2001 Geomean (mg/l) n=5	2014 Geomean (mg/l) n=8
TP	0.087	0.051
Ammonia	0.040	0.040
NO ₃ +NO ₂	0.18	0.15
TKN	0.59	0.68
TSS	49	17
TDS	294	480
	2001	2014
ALU Attainment	<i>Full</i>	<i>Full</i>
IBI (fish)	28	45
ICI (macroinvertebrate)	50	44

Spain Creek

Spain Creek is a 9.6 square mile drainage area tributary that enters Big Darby Creek east of North Lewisburg at RM 74.3; it is designated as EWH/CWH in the Ohio WQS. Two sites on Spain Creek were assessed in 2014, one site upstream from North Lewisburg at RM 3.7 and another site near the mouth of Spain Creek at RM 0.01 (Table 20). Spain Creek RM 0.01 is one of the few sites in the entire 2014 Big Darby Creek study area that had a decline in aquatic life use attainment status since the last study.

On July 4, 2014, Ohio EPA was alerted to land clearing and the potential filling of wetlands and small drainage areas at a parcel of land upstream from the RM 3.7 stream site. Chemistry samples collected at RM 3.7 four days later, during a runoff event on July 8, 2014, had an elevated TSS concentration of 95 mg/l. Subsequent sampling events at RM 3.7 had TSS concentrations that were less than 5 mg/l. At RM 0.01, the early July sampling event took place on July 7, 2014, prior to the storm event that was captured in the sampling upstream at RM 3.7 the following day. June and July TSS concentrations at RM 0.01 ranged from 5 to 21 mg/l and were less than 5 mg/l for the remainder of the summer.

Despite both fish and macroinvertebrates fully meeting the existing EWH designation, declines in the presence and abundance of cold-water macroinvertebrate taxa and an increase in tolerant taxa compared to 2001 lead to partial attainment of the CWH use designation at this lower location. This was attributed primarily to sedimentation and siltation related to the riparian habitat alternation upstream in Spain Creek as well as localized riparian alterations in the vicinity of RM 0.01.

At RM 0.01, ammonia, TP and TKN were diminished compared to 2001, while TSS was slightly elevated. Overall, nutrient and TSS concentrations were lower in 2014 vs 2001 at RM 3.7. The North Lewisburg WWTP may have provided an additional source of environmental stress to Spain Creek at RM 0.01 via a pattern of NPDES effluent permit limit violations in the time period leading up to the 2014 survey. Violations of effluent limits for dissolved oxygen, total phosphorous, total suspended solids and *E. coli* each occurred on multiple occasions throughout the summer of 2014. Interaction between Ohio EPA and the facility continues in efforts to address the ongoing noncompliance; more information on this facility

and their efforts to improve effluent quality can be found within the [NPDES Permitted Facilities](#) portion of this document.

Table 20. Selected water quality parameters and aquatic life use indices from Spain Creek, 2014 and 2001.

Spain Creek RM 3.7 (V06G31) At Gilbert Rd. EWH/CWH - Headwaters		
Parameter	2001 Geomean (mg/l) n=5	2014 Geomean (mg/l) n=8
TP	0.035	0.021
Ammonia	0.038	0.025
NO ₃ +NO ₂	1.04	0.94
TKN	0.34	0.25
TSS	14	9 (95 max)
TDS	376	382
	2001	2014
ALU Attainment	<i>Full</i>	<i>Full</i>
IBI (fish)	56	54
ICI (macroinvertebrate)	44	58
Number Macroinvertebrate Taxa	72	73
Number Cold water macroinvertebrate taxa	5	6
Number Sensitive Macroinvertebrate Taxa	19	22
Number Tolerant macroinvertebrate taxa	7	3
Number EPT macroinvertebrate taxa	18	19
Spain Creek RM 0.01 (V07P58) E. of N. Lewisburg at mouth EWH&CWH – Headwaters		
TP	0.151	0.03
Ammonia	0.055	0.025
NO ₃ +NO ₂	1.10	1.81
TKN	0.597	0.2
TSS	5	7
TDS	452	425
	2001	2014
ALU Attainment	<i>Full</i>	<i>Partial</i> (CWH macroinvertebrates)
IBI, fish	53	58
ICI, macroinvertebrate	56	52
Number Macroinvertebrate Taxa	66	94
Number Cold water macroinvertebrate taxa	3	2
Number Sensitive macroinvertebrate taxa	20	20
Number Tolerant macroinvertebrate taxa	7	18
Number EPT macroinvertebrate taxa	19	17

Sugar Run

Sugar Run joins Big Darby Creek downstream from Plain City at RM 50.9. Exceedances of the dissolved oxygen OMZM (2.85, 3.81 mg/l) were noted at RM 0.4, nearest the confluence; however, this site was in full attainment of WWH.

Sugar Run at RM 5.4 had very similar biological scores between 2001 and 2014 and was in partial attainment of the existing WWH use in each survey. Deficiencies in the stream biology at RM 5.4 were attributed to excessive sedimentation and a modified flow regime, which was exacerbated by nutrient enrichment. The biology has not shown improvement despite apparent reductions in ammonia, nutrients, TSS and TDS (Table 21). Continuous sonde monitoring data revealed several instances of high specific conductivity were recorded at RM 5.4, with peaks of 1732 and 1463 $\mu\text{S}/\text{cm}$, and, on 8/20/2014, a backwater pool that was isolated from the main channel had a conductivity of 4458 $\mu\text{S}/\text{cm}$. It is possible that an unknown source of high specific conductivity is intermittently impacting this reach of Sugar Run to a degree that negatively affects aquatic life.

Table 21. Selected water quality parameters and aquatic life use indices from Sugar Run, 2014 and 2001.

Sugar Run, RM 5.4, V06K08 At U.S. Route 42 WWH - Headwaters		
Parameter	2001 Geomean (mg/l) n=5	2014 Geomean (mg/l) n=5
Total P	0.136	0.086
Ammonia	0.099	0.025
NO ₃ +NO ₂	6.66 (n=1)	0.25
TKN	1.1	0.68
TSS	17	7
TDS	496	388
	2001	2014
ALU Attainment	<i>Partial</i> (IBI)	<i>Partial</i> (IBI)
IBI, fish	34*	34*
ICI, macroinvertebrate	Good	Good

Hellbranch Run and Tributaries

The Hellbranch Run watershed, and subsequent Hamilton Run and Clover Groff sub-watersheds, are situated at the western edge of the greater Columbus metropolitan area. In general terms, the streams of this watershed exhibit lower water quality and perform more poorly in terms of aquatic life use compared to similarly sized streams in the overall Big Darby watershed. Hamilton Run and Clover Groff Run were sampled near the mouths of each stream as they come together to form Hellbranch Run. Both of these streams were in non-attainment of WWH aquatic life use in 2001 and remained so in 2014.

In Hamilton Run, nutrient concentrations were diminished compared to 2001, with a greater than 50% reduction in both total phosphorous and ammonia. Unfortunately, nutrient inputs in Hamilton Run will

need to be reduced even further to coincide with the WWH target concentrations of 0.08 mg/l TP and 1.0 mg/l NO₃ (Table 22).

Clover Groff Run had similar nutrient concentrations to Hamilton Run in 2014. However, unlike Hamilton Run, Clover Groff did not exhibit an improvement in nutrient concentrations between 2001 and 2014. TP concentrations (0.11 mg/l) were slightly above the WWH target and other nutrient concentrations were relatively similar between years (Table 23). Table 22 and Table 23 below illustrate general trends between survey years 2001 and 2014. Generally deficient habitat throughout many segments in the upper reaches of these two tributaries, combined with extensive hydrological modifications likely exacerbate attendant water chemistry issues present in these two streams.

Table 22. Selected water quality parameters and aquatic life use indices from Hamilton Run, 2014 and 2001.

Hamilton Run, RM 0.1-0.4, (V07P15/203344) Near Alton at U.S. Route 40 and at mouth WWH - Headwaters		
Parameter	2001 Geomean (mg/l) n=9, RM 0.4	2014 Geomean (mg/l) n=8, RM 0.1
Total P	0.27	0.12
Ammonia	0.080	0.038
NO₃+NO₂	1.84	1.47
TKN	0.83	0.61
TSS	9	10
TDS	--	511
	2001	2014
ALU Attainment	<i>Non</i>	<i>Non</i>
IBI (fish)	24*	22*
ICI (macroinvertebrate)	40	Marg. Good

Table 23. Selected water quality parameters and aquatic life use indices from Clover Groff Run, 2014 and 2001.

Clover Groff Run, RM 0.14 – 0.78 (V07S52 - 2001/V07P14 – 2014) Near Alton at U.S. Route 40 and near Alton @ Alton Rd. WWH - Headwaters		
Parameter	2001 Geomean (mg/l) n=9	2014 Geomean (mg/l) n=7
Total P	0.12	0.11
Ammonia	0.053	0.051
NO₃+NO₂	0.63	0.59
TKN	0.67	0.60
TSS	4	9
TDS	397	394
	2001	2014
ALU Attainment	<i>Non</i>	<i>Non</i>
IBI (fish)	28*	26*
ICI (macroinvertebrate)	20*	Marg. Good

Little Darby Creek Mainstem and Tributaries

Little Darby Longitudinal Nutrient Plots

Fourteen locations were sampled along approximately 40 river miles of Little Darby Creek. TP, NO₃+NO₂, ammonia and TKN were plotted by river mile for each site on Little Darby Creek (Figure 75-Figure 78). A complete set of chemical sampling results is located in Appendix F. Nutrient concentrations in 2014 were generally lower than the concentrations measured during the last watershed-scale survey in 2001; however, TP and NO₃+NO₂ concentrations remained elevated compared to EWH target concentrations (Figure 74).

Little Darby Creek TP

Total phosphorous geomean concentrations in the Little Darby ranged from 0.01 to 0.06 mg/l. The EWH target concentration for drainage areas less than 200 mi² is 0.05 mg/l. The maximum and geomean TP concentrations were slightly higher at RM 38.8, downstream from Mechanicsburg at Wing Rd, and RM 24.46, east of Rosedale at Rosedale Plain City Rd. compared to the Little Darby Creek sites overall (Figure 75).

Little Darby Nitrate-Nitrite

Of the fourteen Little Darby sampling locations, thirteen had geomean NO₃+NO₂ concentrations that were above the EWH target. The four sites nearest the headwaters, in the vicinity of Mechanicsburg, had geomean nitrate concentrations that were higher than in the 2001 survey; this is in contrast to sampling locations from RM 29.46, just downstream from the Treacle Creek confluence, to the mouth where 2014 nitrate concentrations were similar to or less than 2001 concentrations (Figure 76).

Little Darby Creek Ammonia

Geomean total ammonia concentrations in Little Darby Creek ranged from less than the analytical detection limit (< 0.05 mg/l) at RMs 0.07, 3.95, 13.35, and 17.25 to a maximum geomean concentration of 0.036 mg/l at RM 34.7 at Irwin Rd downstream from Mechanicsburg (Figure 77). Higher total ammonia concentrations were measured in the upstream half of the watershed where two single-sample maximum concentrations (0.14 mg/l at RM 34.7 and 0.13 mg/l at RM 39.3) approached the 95th percentile ecoregion reference value. From RMs 39.3 to 29, the 2014 geomean ammonia concentrations were marginally higher than in 2001.

Little Darby Creek TKN

In a pattern similar to the Big Darby Creek mainstem, organic nitrogen concentrations in Little Darby Creek were lower in 2014 than in 2001. The highest geomean TKN (0.36 mg/l) was measured at RM 17.3, southeast of Plumwood, and this was lower than all of the geomean concentrations measured in 2001 (Figure 78).

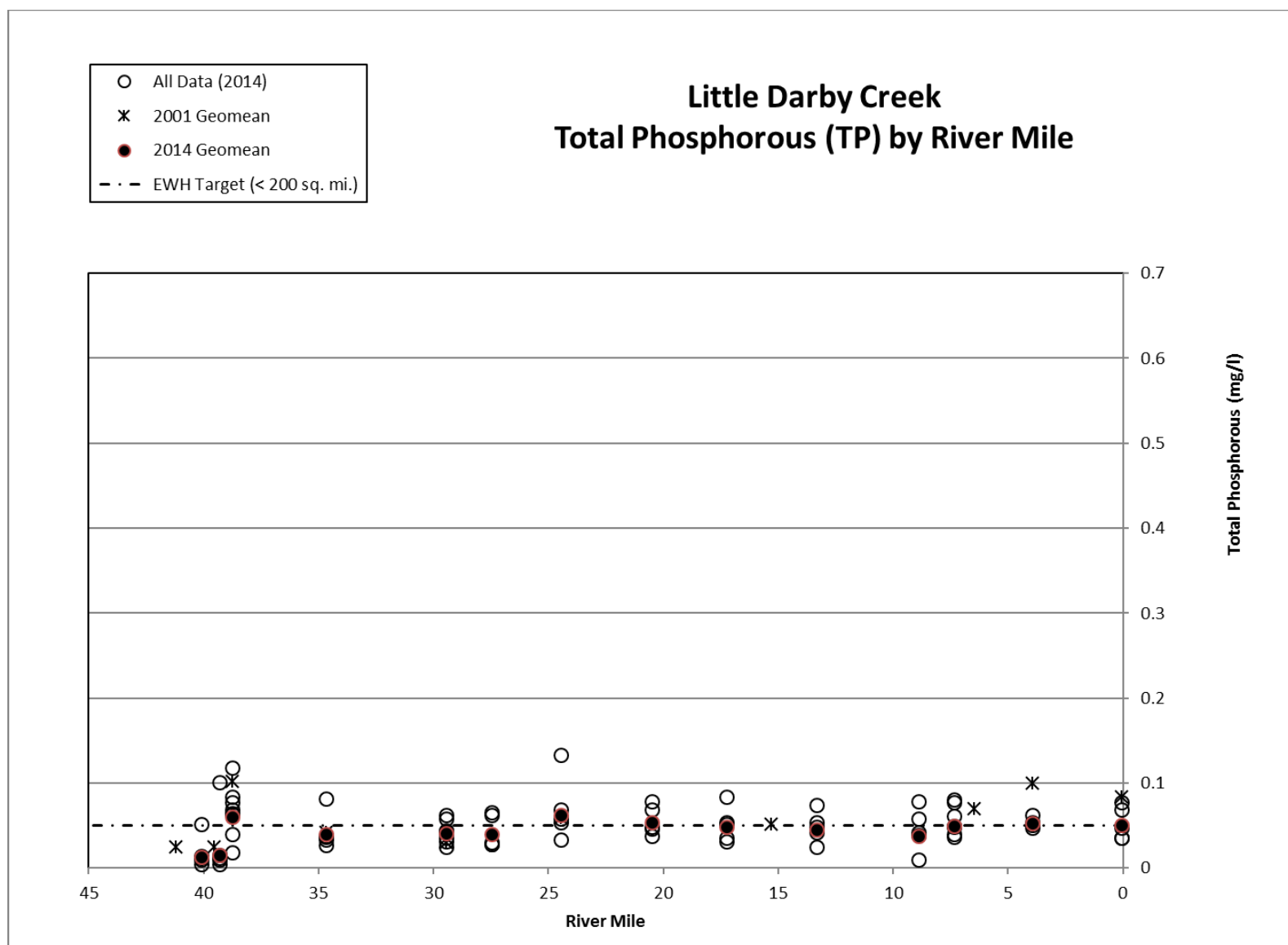


Figure 75. Total phosphorus concentration results from Little Darby Creek with geometric mean and specified target concentrations, 2014 and 2001.

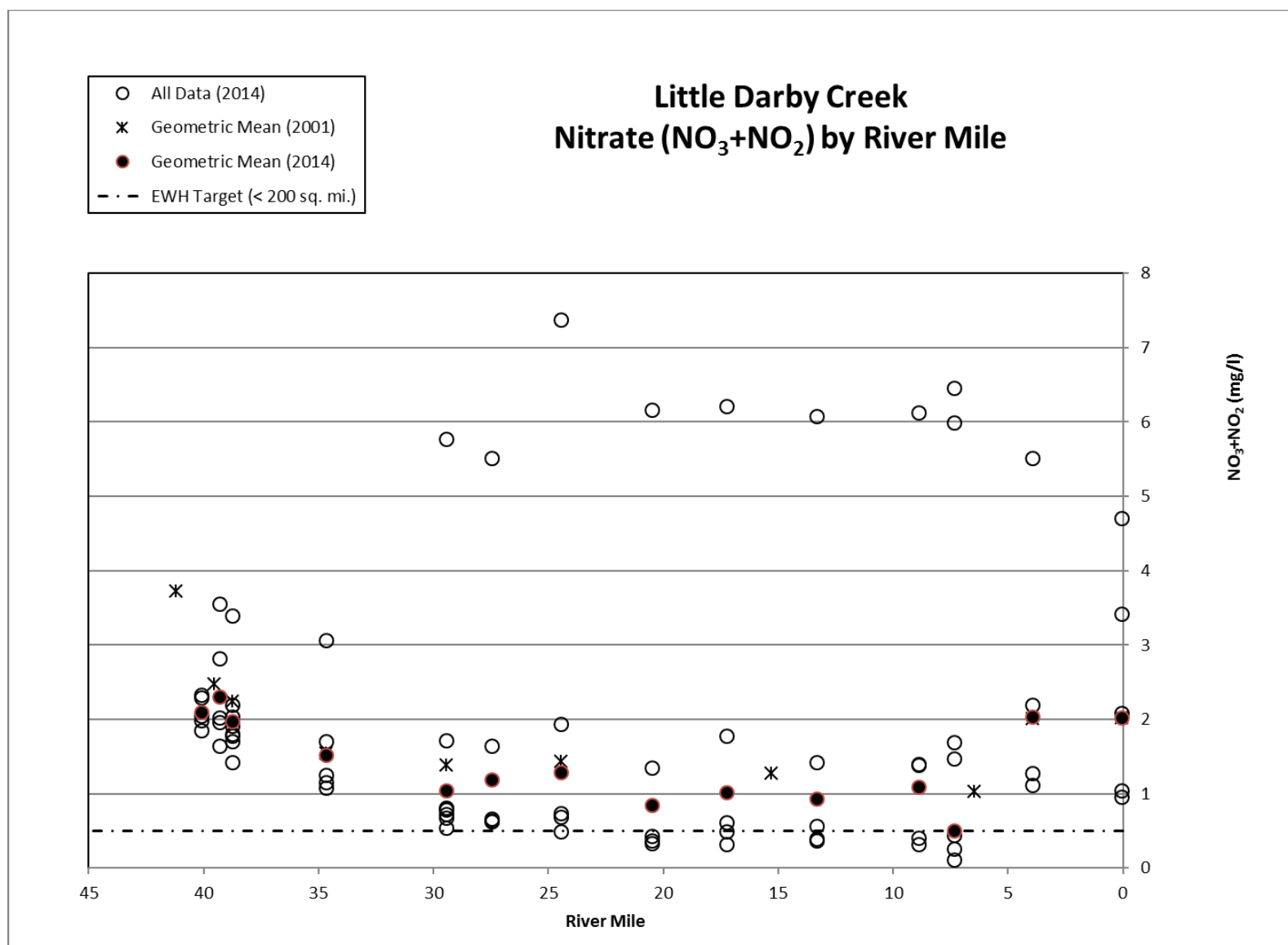


Figure 76. Nitrate-nitrite concentration results from Little Darby Creek with geometric mean and specified target concentrations, 2014 and 2001.

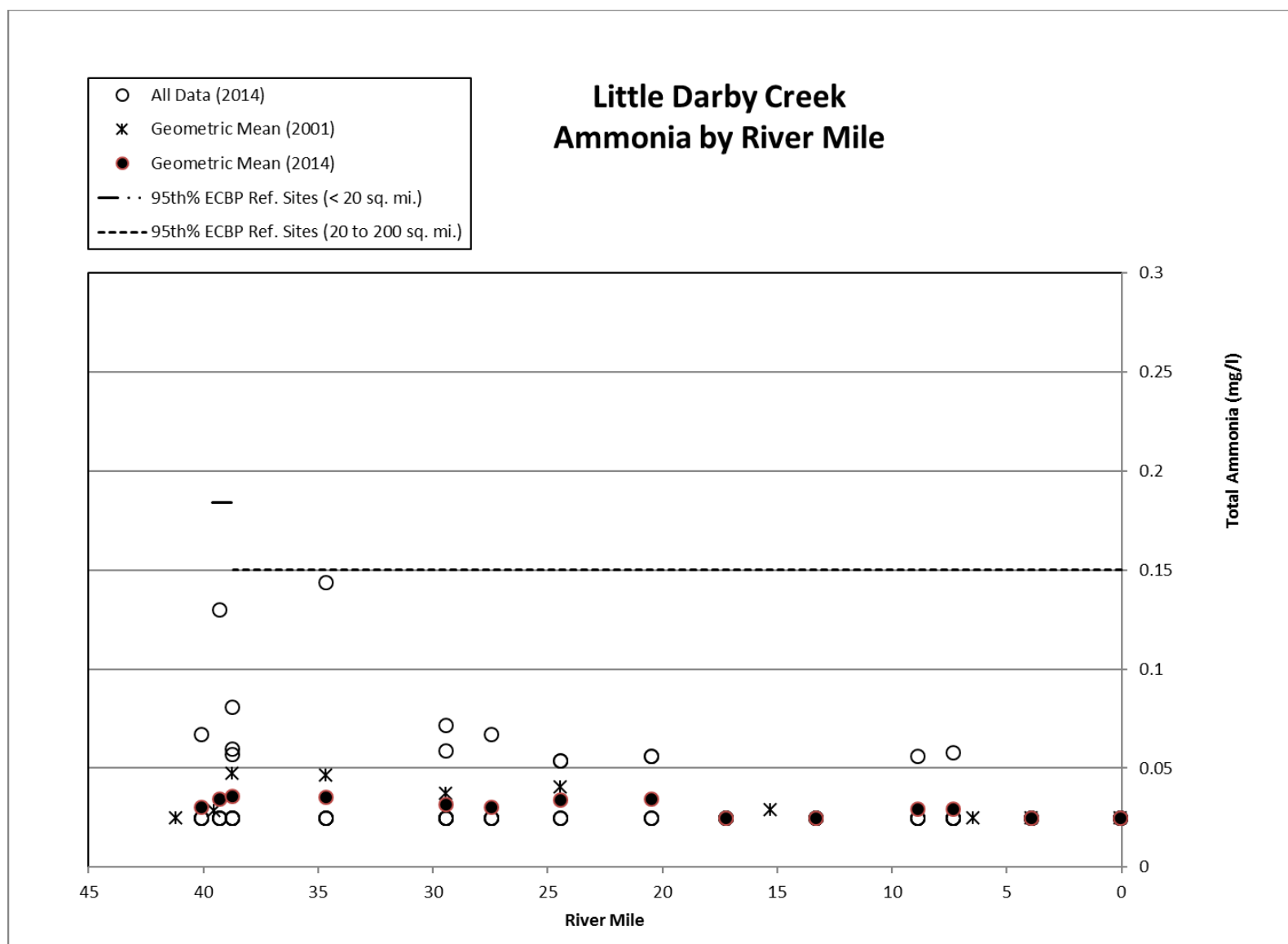


Figure 77. Total ammonia concentration results from Little Darby Creek with geometric mean and specified ECBP reference concentrations, 2014 and 2001.

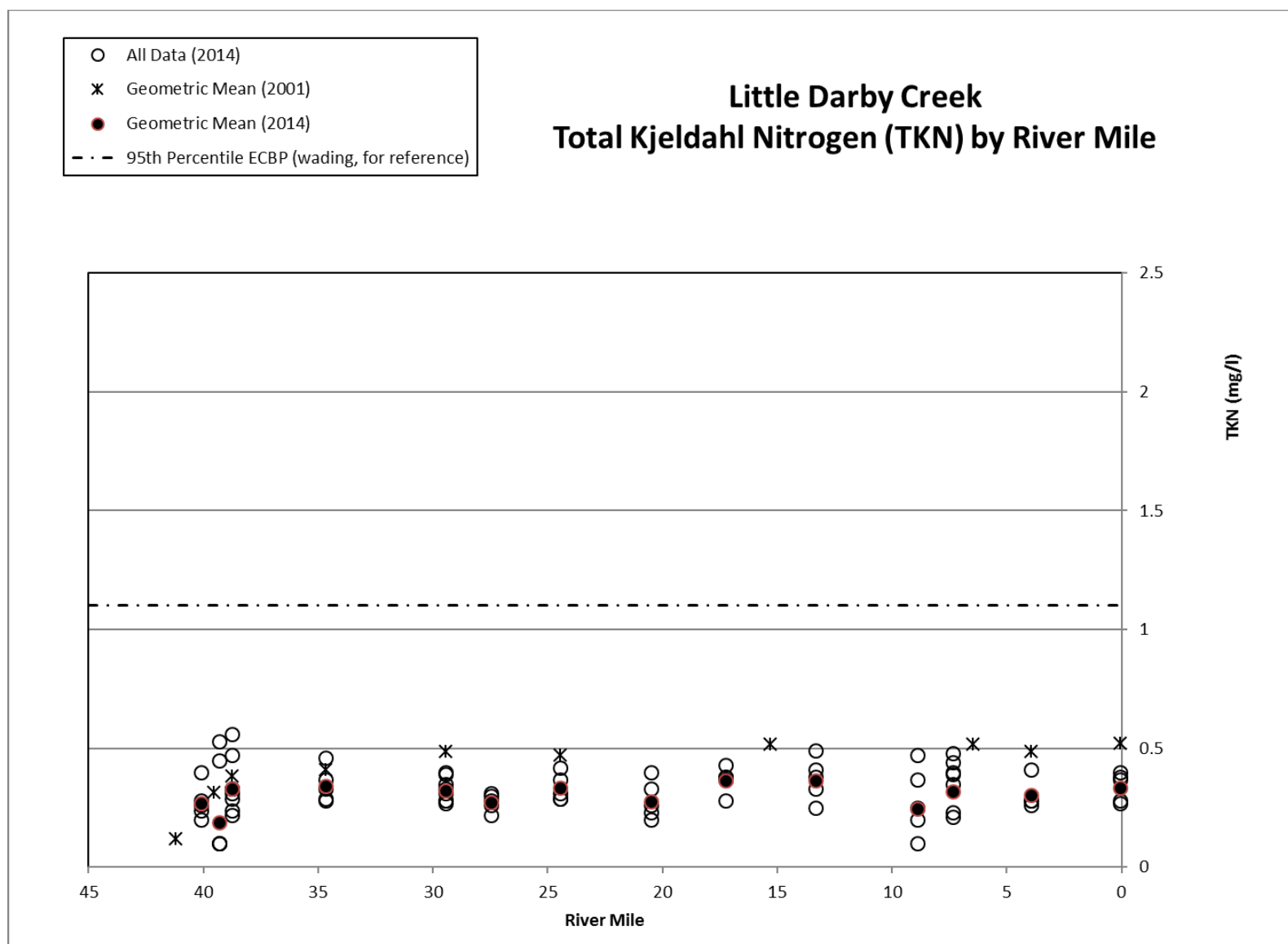


Figure 78. Total Kjeldahl nitrogen concentration results from Little Darby Creek with geometric mean and specified target concentrations, 2014 and 2001

Selected Site-Specific Discussion

Mechanicsburg Vicinity

In 2001, Little Darby Creek was in partial attainment in the vicinity of RMs 39.3 to 39.6, downstream from State Route 29 in Mechanicsburg. The aquatic life use attainment status at Little Darby Creek RM 34.7, downstream from Mechanicsburg at Irwin Rd., declined from full attainment of EWH criteria to partial attainment. Both fish and macroinvertebrate indices were lower in 2014, as well as the QHEI score. The cause of biological community decline was ascribed to habitat alterations and sedimentation rather than chemical pollutants, and this observation was supported by a trend of improved chemical water quality over time.

Table 24. Selected water quality parameters and aquatic life use indices from Little Darby Creek RM 34.7, 2014 and 2001.

Little Darby Creek RM 34.7 (V06S05) N.E. of Mechanicsburg at Irwin Rd. EWH - Wading		
Parameter	2001 Geomean (mg/l) n=5	2014 Geomean (mg/l) n=5
TP	0.042	0.040
Ammonia	0.046	0.035
NO ₃ +NO ₂	1.55	1.52
TKN	0.41	0.34
TSS	8	6
TDS	480	475
	2001	2014
ALU Attainment	<i>Full</i>	<i>Partial</i>
IBI (fish)	49	46 ^{NS}
MIwb (fish)	-	8.50*
ICI (macroinvertebrate)	56	50

Treacle Creek

Treacle Creek is a 36 mi² drainage area tributary near the headwaters of the Little Darby Creek watershed. The Treacle Creek sampling location nearest the mouth, at RM 0.78 (V06S11), is located in a part of Treacle Creek that has relatively poor quality physical habitat due, in part, to this stream reach being historically dredged and straightened. This site was in non-attainment of the designated EWH aquatic life use in both 2001 and 2014.

Nutrient concentrations, as measured just upstream from the Winget Rd. bridge crossing, were generally lower at RM 0.78 in 2014 versus 2001. However, the geomean TSS concentration remained elevated at 31 mg/l. The exact same geomean concentration was measured both in 2001 and 2014, once again placing it among the sites having the highest geomean TSS concentration in the entire Big Darby Creek watershed during the 2014 survey (Table 25).

Treacle Creek was found to have consistently low concentrations of D.O. in 2014, and it appears the lower reaches of Treacle Creek may have further deteriorated in this respect since the last survey. There were six WQS exceedances of the Outside Mixing Zone Minimum (OMZM) criterion for EWH, ranging from a nearly anoxic 0.15 mg/l (measured downstream from the bridge crossing, near RM 0.1) to 4.36 mg/l D.O. There were also three exceedances of the Outside Mixing Zone Average (OMZA) criterion: 2.34, 3.53 and 5.8 mg/l.

During the July 23, 2014 sampling event, field staff noted an accumulation of grain in the stream immediately downstream from a concrete ford that spans Treacle Creek. The grain appeared to be wheat and this occurred at a time when nearby wheat fields were being harvested. Dissolved oxygen readings were taken within the area of stream where the grain was observed, in the vicinity of the Treacle Creek bridge; values were in a normal range. During the next sampling pass on August 7, 2014, grain was still observed in the stream and had dispersed over a larger area. Despite obvious decomposition of some of the grain at this point, dissolved oxygen measurements upstream and downstream from the area where the grain was located were similar (7.85 and 7.95 mg/l, respectively). The grain persisted in the stream at this site through at least September 24, 2014, when a series of continuous water quality sondes were deployed upstream, within, and downstream from this reach and documented very low dissolved oxygen concentrations within the portion of Treacle Creek between RM 0.78 and the mouth (Table 15). Follow-up water quality sonde monitoring in 2015 still indicated a depressed D.O. regime, with both minimum and average D.O. concentration exceedances; however, the severity of the exceedances appeared to be lessened compared to 2014. The persistence of D.O. concentration exceedances through multiple years may indicate a chronic condition driven primarily by excess organic enrichment; the grain spill in 2014 likely exacerbated existing conditions, resulting in the lower D.O. concentration observed in 2014.

Organic enrichment was an obvious factor contributing to biological impairment at this location. Likely sources include excess organic waste from cattle intrusion into the stream and the acute impacts from the documented grain spill.

Table 25. Selected water quality parameters and aquatic life use indices from Treacle Creek RM 0.78, 2014 and 2001.

Treacle Creek RM 0.78 (V06S11) Upst. Winget Rd. EWH - Wading		
Parameter	2001 Geomean (mg/l) n=12	2014 Geomean (mg/l) n=6
Total P	0.07	0.05
Ammonia	0.071	0.048
NO ₃ +NO ₂	2.34	0.57
TKN	0.64	0.40
TSS	31	31
TDS	410	388
	2001	2014
ALU Attainment	Not Applicable	Non
IBI (fish)	-	45*
MIwb (fish)	-	8.55*
ICI (macroinvertebrate)	Marg. Good*	26*

West Jefferson Area Industrial Park Development

In the vicinity of West Jefferson near the Interstate 70 and State Route 29 interchange, several small tributaries to Little Darby Creek drain an area that has seen significant development in the decade leading up to the 2014 survey, including the construction of warehouses and distribution facilities. Four tributaries, entering Little Darby Creek from RMs 14.35 to 9.1, were sampled in an effort to document the potential influence of storm water from this area on the overall water quality of Little Darby Creek. The drainage area of the tributaries sampled ranged from approximately 0.3 to 1.3 square miles. Each location was sampled five times, with the exception of the tributary at Little Darby RM 14.35 which was dry during two of the five sampling passes.

Table 17 below details selected chemical parameters from these tributaries, as well as three locations on Little Darby Creek: RM 17.25, upstream from the area of development; RM 13.35, within the area of development; and RM 8.85, downstream from the area of development and immediately downstream from the Jefferson Lodge MHP wastewater treatment plant. Concentrations of metals within the tributaries in this area were largely similar to background conditions in the larger Little Darby Creek watershed; for these and other chemical parameters, see Appendix F.

At the upstream end of this area, the trib. to Little Darby Creek at RM 14.35 had elevated concentrations of TKN (0.96 mg/l), and very high levels of TDS and conductivity (1163 mg/l, 2104 $\mu\text{S}/\text{cm}$) that were approaching the OMZA WQS criterion of 1500 mg/l for TDS (equivalent to a conductivity of 2400 $\mu\text{S}/\text{cm}$ at 25°C). Two WQS criteria exceedances were noted here: 3.06 mg/l dissolved oxygen and 243 $\mu\text{g}/\text{l}$ barium. This is an extremely small tributary (0.3 mi^2 drainage area) that did not flow during the driest months of the 2014 summer. Despite the overall poor water quality of this tributary, it is unlikely that it will have significant negative impacts on biological communities in Little Darby Creek over the long term because of the small size of this sub-watershed relative to Little Darby Creek. However, localized and short term impacts could have the potential to negatively impact biological communities, especially during periods of substantial flow from this tributary. Water quality conditions within this tributary could potentially benefit from the implementation of storm water best management practices on the upstream landscape.

The Trib. to Little Darby Creek at RM 13.7 at the St. Rt. 29 culvert had chemical concentrations that were similar to background conditions found elsewhere in the Little Darby watershed. Low levels of nutrients and dissolved solids were measured.

The Trib. to Little Darby Creek at RM 12.88 was sampled just downstream from I-70 at the extension of Snyder Lane. This tributary had elevated TDS and conductivity (639 mg/l and 1068 $\mu\text{S}/\text{cm}$) and persistently had high concentrations of nitrate (ranging from 6.53 to 15.1 mg/l, geomean of 9.86 mg/l). The high nitrate concentrations within this tributary represented an anomaly in comparison to the rest of the Little Darby watershed and warrant further investigation. However, other nutrient concentrations in this tributary were similar to those found in the nearby Little Darby sampling locations.

At the downstream end of this section of Little Darby Creek, a 0.3 mi^2 drainage area tributary joins at RM 9.1. Nutrients and dissolved solids in this tributary were similar or in lower concentration than nearby tributary streams.

Water quality within the four tributary streams near the West Jefferson area industrial park development was generally sub-par compared to the Little Darby; however, these tributaries are very small compared

to Little Darby Creek and concentrations of nutrients, total dissolved solids and conductivity in Little Darby Creek did not change substantially when comparing sites immediately upstream and downstream from the small tributaries within this reach. Careful implementation and adherence to storm water best management practices, within the drainage areas of smaller tributary streams, is a priority in protecting this reach of Little Darby Creek from the potential for deteriorating water quality and non-attainment of aquatic life use criteria.

Table 26. Selected chemical geomean concentrations from Little Darby Creek and unnamed tributary streams to Little Darby Creek in 2014 near the West Jefferson Industrial Parks. Tributary streams are in gray shaded columns and the river mile which they join Little Darby Creek is presented in (parenthesis).

	L. Darby Ck. RM 17.25	LDC Trib. (RM 14.35)	LDC Trib. (RM 13.7)	L. Darby Ck. RM 13.35	LDC Trib. (RM 12.88)	LDC Trib. (RM 9.10)	L. Darby Ck. RM 8.85
Drainage Area, mi²	142	0.3	1.3	149	0.6	0.3	161
Number of Samples	5	3	5	5	5	5	5
Ammonia, mg/l	< 0.05	< 0.05	0.057	< 0.05	< 0.05	0.051	0.050
Nitrate, mg/l	1.01	0.12	0.26	0.94	9.86	0.14	1.09
Total P, mg/l	0.048	0.026	0.02	0.046	0.038	0.019	0.038
Suspended Solids, mg/l	6	7	10	8	9	13	13
TKN, mg/l	0.36	0.96	0.36	0.36	0.38	0.25	0.32
Dissolved Solids, mg/l	429	1163	311	422	639	183	423
Conductivity (μS/cm)	710	2104	541	700	1068	314	698

Atrazine and Glyphosate

Table 27 lists atrazine results from streams within the Big Darby Creek watershed. Twenty-four sites were screened for the organic herbicides atrazine and glyphosate. Glyphosate was not detected in the water column at any locations in Table 27. Atrazine was found in the water column at nine sampling locations, in concentrations as high as 17 µg/l measured near the mouth of the Little Darby Creek at Alkire Rd at RM 0.07. Higher concentrations of atrazine were measured earlier in the sampling season, especially on June 5, 2014, versus later in the summer; this likely coincides with the timing of agricultural herbicide application and spring runoff events.

Table 27. Atrazine surface water concentration sampling results from the Big Darby Creek watershed, 2014.

STORET	Location	River Mile	HUC-12	No. of samples	Atrazine Geomean (µg/l)
Big Darby Creek (02-200-000)					
V06W04	At Plain City, Upst. U.S. Route. 42 and Rancho	54.10	05060001 19 05	6	0.34
V07S09	S. of Plain City at Cemetery Pike	51.10	05060001 19 05	1	< 0.2 µg/L
603100	N. Of West Jefferson at Hubbard Rd.	41.75	05060001 21 02	3	1.8
V07S05	At Darbydale at McKinley Bridge	29.20	05060001 22 02	2	3.2
V07G73	Upst. Gay Run, adj. Harrisburg-Georgesville Rd	26.85	05060001 22 02	1	< 0.2 µg/L
V07P41	S. of Orient at Darby Creek Rd.	19.10	05060001 22 03	3	0.7
601300	At Darbyville at State Route 316	13.36	05060001 22 04	1	< 0.2 µg/L
600970	Near Fox at State Route 104	3.20	05060001 22 04	2	2.3
Little Darby Creek (02-210-000)					
V06S10	Dst. Mechanicsburg WWTP at Wing Rd.	38.78	05060001 20 03	7	0.3
V06Q01	N.E. of Plumwood at Bradley Rd.	20.50	05060001 20 05	7	0.3
V06G28	At West Jefferson at Middle Pike	7.35	05060001 20 06	1	< 0.2 µg/L
601130	At Georgesville at Alkire Rd.	0.07	05060001 20 06	2	4.5
Flat Branch (02-223-000)					
V07P60	S.E. of Middleburg, Near U.S. Route 33	0.90	05060001 19 01	1	< 0.2 µg/L
Spain Creek (02-222-000)					
V07P58	E. of North Lewisburg near mouth	0.01	05060001 19 02	1	< 0.2 µg/L
Pleasant Run (02-221-000)					
V07P56	N.E. of Woodstock at mouth	0.01	05060001 19 02	7	0.3
Buck Run (02-209-000)					
V06P07	S. of Marysville at Sam Reed Rd.	2.16	05060001 19 03	1	< 0.2 µg/L
Robinson Run (02-207-000)					
V06W05	N. of Plain City at U.S. Route 42	0.73	05060001 19 05	1	0.24
Sugar Run (02-206-000)					
V06K08	At Arnold at U.S. Route 42	5.40	05060001 19 04	7	0.3
V07S13	Near Plain City at Cemetery Pike	0.43	05060001 19 04	1	< 0.2 µg/L

STORET	Location	River Mile	HUC-12	No. of samples	Atrazine Geomean (µg/l)
Treacle Creek (02-213-000)					
V06S11	At Winget Rd. covered bridge	0.78	05060001 20 02	8	0.2
Spring Fork (02-211-000)					
V06Q10	Spring Fork Se Of Rosedale @ Rosedale-Milford Center Rd.	7.80	05060001 20 04	1	< 0.2 µg/L
Hellbranch Run (02-204-000)					
V07P11	Hellbranch Run N Of Harrisburg @ Lambert Rd.	0.98	05060001 22 01	4	0.7
Hamilton Run (02-204-002)					
203344	Hamilton Run Near Alton @ Mouth	0.10	05060001 22 01	1	< 0.2 µg/L
Clover Groff Run (02-204-001)					
V07P14	Clover Groff Run at Alton @ Alton Rd.	0.14	05060001 22 01	1	< 0.2 µg/L
Note: Glyphosate data not shown (all results were non-detect)					

Water Quality Sonde Exceedance Summary

Multi-parameter water quality sondes were deployed to monitor temperature, dissolved oxygen (D.O.), pH and specific conductance (conductivity). Temperature, dissolved oxygen and pH are influenced by diel patterns. These diel patterns have the greatest impact for streams during certain critical conditions that include 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 parameters throughout the diel cycle. Grab readings differ because they only represent one point on the diel curve. While they are effective at characterizing water quality parameters that change based on hydrologic regime or season, they can miss or not fully characterize parameters that exhibit diel patterns. When the diel fluctuations are of concern, continuous monitoring at regular intervals throughout the diel cycle is needed to characterize the parameter of concern.

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 they are affected by similar factors. In addition, dissolved oxygen 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 dissolved oxygen 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 due to dissolved oxygen concentrations reaching super saturation during the day and subsequently depleted 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, dissolved oxygen does not exhibit strong diel trends in warm low flow. Either primary productivity is limited or decomposition of organic matter in the stream is controlling the dissolved oxygen concentrations. Sonde monitoring contributes to the body of evidence to identify dissolved oxygen trends that are more influenced by primary productivity or decomposition.

Diel patterns in pH are also reflective 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 dissolved oxygen.

Thirty-five sites were sampled with water quality sondes in the first year of the study (2014) to represent general watershed conditions as well as target areas of concern (*e.g.*, point sources or historically impaired areas). The land use in the watershed is predominantly high quality agriculture; however, local point sources have impacts, especially on smaller tributaries where many are located.

Critical conditions for temperature and dissolved oxygen 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 in low flow conditions from June to September.

As noted above, the most extensive survey was conducted from August 5 to 7, 2014 in the mainstem of Big and Little Darby creeks and in their tributaries. Here, 35 sites were monitored with sensors spanning a period of 45-50 hours. In 2014, weather conditions were generally cooler and wetter than normal and the conditions sampled were not ideal for assessing low-flow stress (Figure 79). Daily streamflow was typically above the long-term median. However, the conditions were still sufficient to describe general stream conditions. This survey is noted on Figure 79 with a light red vertical band. One additional and localized survey occurred in 2014: a week-long survey from September 24 to October 1 to assess the impact of a grain spill on Treacle Creek (not shown on Figure 79). Flow conditions (for the mainstem Big Darby Creek) were much lower than normal during this period and air temperature was higher than normal.

In 2015, three follow-up surveys occurred. The primary survey was conducted on September 1 to 3 to assess six impaired sites and help determine the contribution of nutrient and organic enrichment to the impairment. One additional site was assessed for high specific conductance. All seven of these sites occurred on Little Darby Creek and other smaller tributaries. In late-spring and early-summer (May 18 to June 18), two sites were monitored for organic enrichment and specific conductance; in early fall (September 25 to October 1) three sites were monitored around Mechanicsburg village on Little Darby Creek to assess the impact from an agricultural cooperative and its storm water and sump discharge to this same stream. During the 2015 sampling season, weather conditions were normal for air temperature but wetter in the first half of the period and about normal during the second half of the period (Figure 80). Daily streamflow was above the median from mid-June until late September but the early- and late-September surveys were near normal; this was an acceptable critical, low flow condition. Both of these surveys are plotted with a light red vertical band on Figure 80.

Summary plots of all data collected (both in 2014 and 2015) are included in Appendix H of the companion document to this report. Note, in Appendix H, that the summary plots are organized by site and contain all of the individual surveys in chronological order before advancing to the next site. The plots were created from hourly readings taken for temperature, dissolved oxygen, pH, and specific conductance.

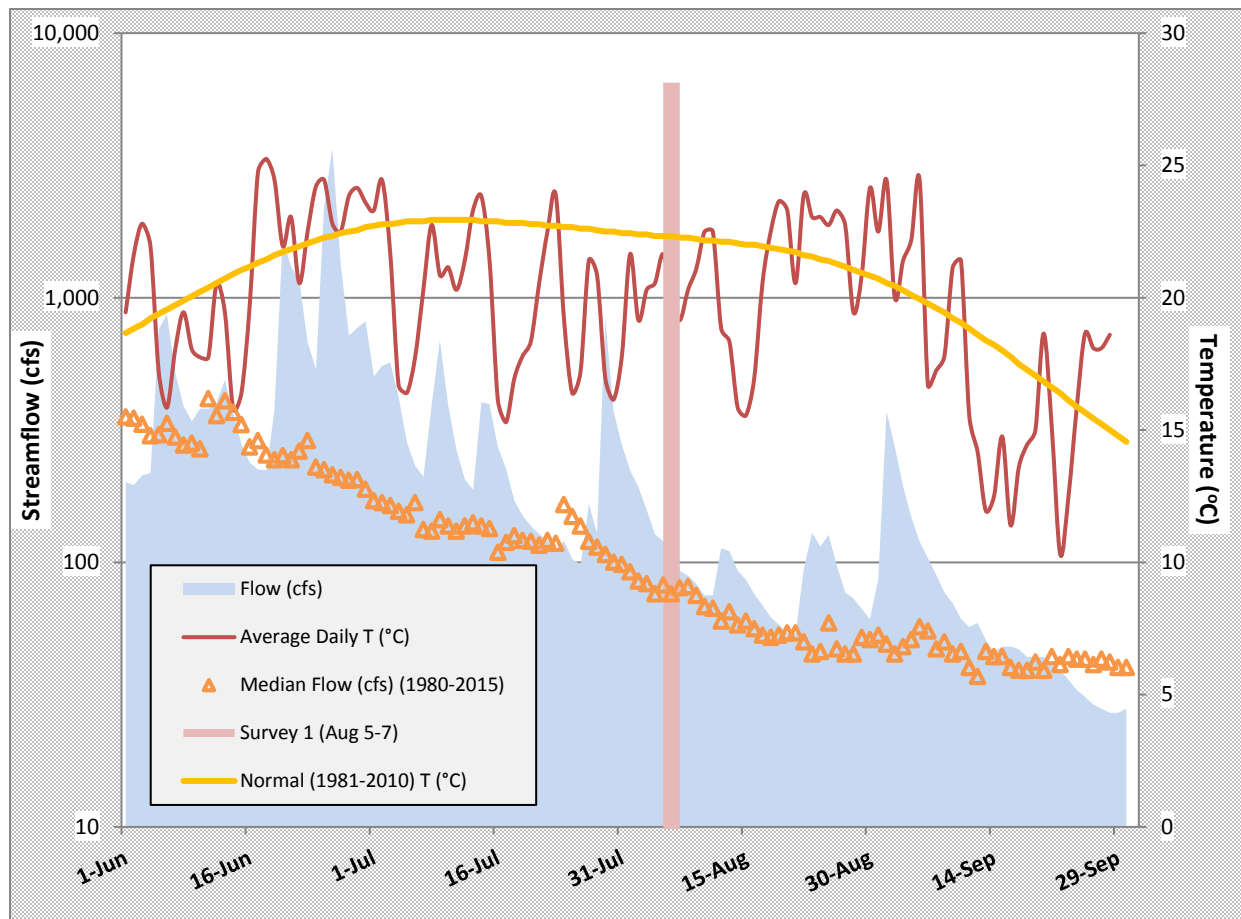


Figure 79. Graph of average daily streamflow relative to the daily median streamflow (USGS 03230500 Big Darby Creek at Darbyville OH) for the period June 1 to October 1, 2014. The median streamflow was taken from the period 1980-2015. Also included are the average and normal daily air temperature (NOAA GHCND: USC00334681 near London, OH) for the sampling season. The USGS Darbyville gage is near the mouth of Big Darby Creek watershed.

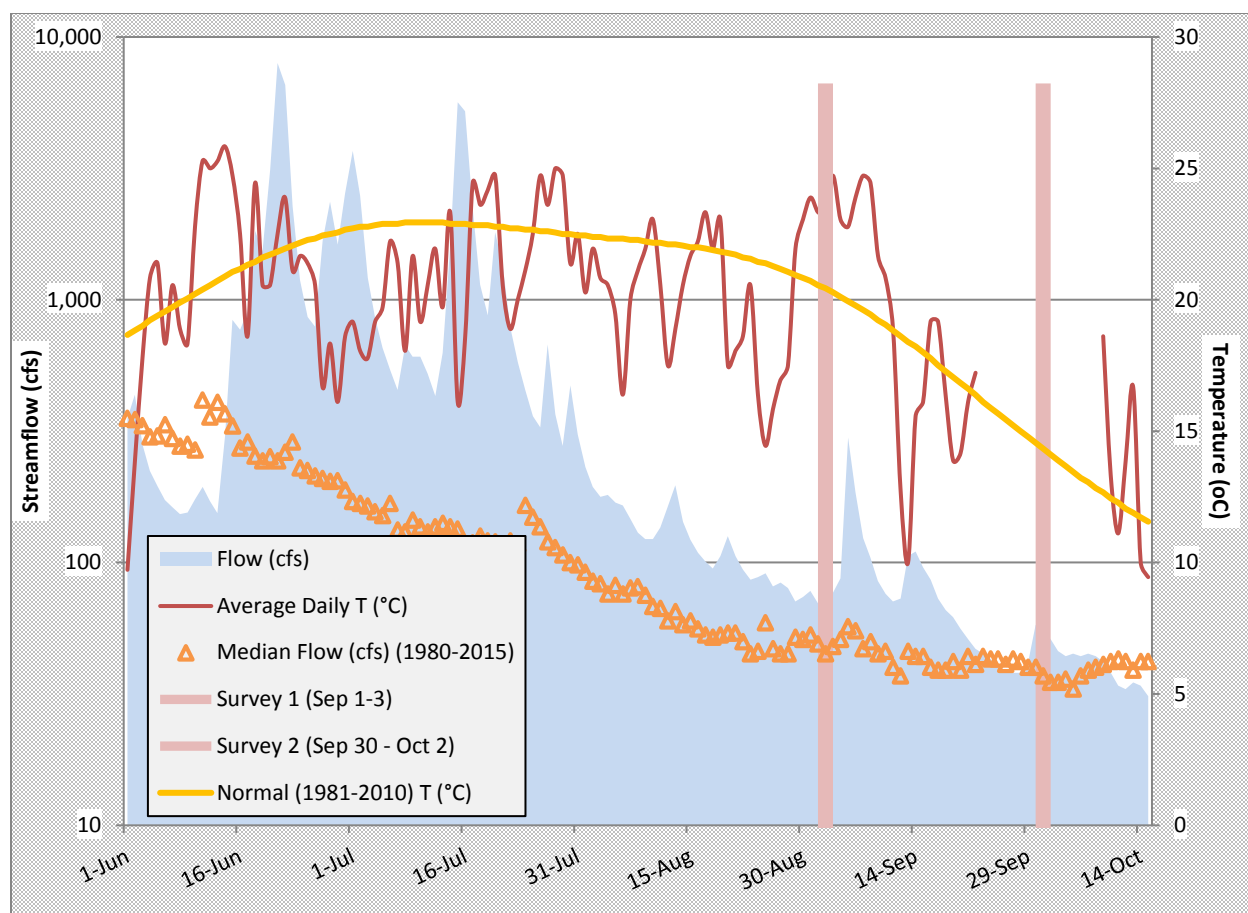


Figure 80. Graph of average daily streamflow relative to the daily median streamflow (USGS 03230500 Big Darby Creek at Darbyville OH) for the period June 1 to October 15, 2015. The median streamflow was taken from the period 1980-2015. Also included are the average and normal daily air temperature (NOAA GHCND: USC00334681 near London, OH) for the sampling season. Air temperature data was missing for the period 9/23 to 10/8. The USGS Darbyville gage is near the mouth of Big Darby Creek watershed.

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 at any time dissolved oxygen, 24-hour average dissolved oxygen, 24-hour average pH, and 24-hour average specific conductivity. Absolute minima or maxima exceedances are compared directly to hourly readings reported from the water quality sondes. An exceedance of the WQS criteria does not represent stream impairment; rather, if biological impairment is present, the exceedances help develop a body of evidence that identifies the conditions that are stressing aquatic life. A summary of the exceedances is presented in Table 15; dates of each survey (5 total) are noted in parentheses. The table includes descriptions of exceedances that are made based on Ohio EPA staff knowledge of specific sites.

There were no temperature exceedances at any site during the sampling period. Protection from increased temperature throughout the Darby Creek watershed can generally be attributed to substantial and sustained canopy shading from intact riparian vegetation, ground water contributions providing a sustained baseflow, and generally low prevalence of large glide/pool areas. The latter factor suggests that the gradient of meandering channels is naturally maintained. Temperatures from Big Darby Creek ranged

between 20-23°C. More significantly, temperature ranges from Little Darby Creek were, on average, much lower than Big Darby Creek, and were between 15-22°C. Average temperatures for the one Springwater Run location (CWH recommended) averaged 19-20°C.

No exceedances of the pH criterion for the 24-hr average between the values of 6.5-9.0 S.U. were observed for any site over any period.

Exceedances of the D.O. WQS criteria can be addressed through an absolute minimum or an average, both examined over rolling 24-hour time windows computed from the beginning to the end of the three-day survey. The most serious issues of D.O. exceedance occurred in Treacle Creek, a tributary to Little Darby Creek. Exceedances of minimum and average D.O. criteria (Table 15) occurred at both sites in the lower reach – at the mouth (RM 0.02) and at Winget Road (RM 0.78). For all surveys, two in 2014 and two in 2015, D.O. exceedances were observed, with the May-June 2015 showing the most serious minimums at the mouth. The grain spill at RM 0.78 was manifest in low D.O. observations soon after the event (survey conducted September to October 2014) through one year later (September 2015). The persistence of D.O. concentration exceedances through multiple years may indicate a chronic condition driven primarily by excess organic enrichment; the grain spill in 2014 likely exacerbated existing conditions, resulting in the lower D.O. concentration observed in 2014.

Three minimum D.O. exceedances were also observed in Wamp Ditch, a small tributary to Little Darby Creek that drains 5.5 mi² (Table 15). Relatively large D.O. swings (6.4 mg/L) observed at this location, coupled with the low D.O. concentrations observed here as well, indicated nutrient enrichment is likely contributing to documented aquatic life use impairment. Row-crop agriculture is the predominant land use within this small sub-basin and excess nutrients were identified as a contributing source of impairment. Several farm residences in the basin may have direct-discharge septic systems that can contribute an organic load.

The final D.O. issue existed in the upper reaches of Sugar Run at RM 5.4. This site experienced both minimum and average D.O. criteria exceedances, as well as high diel D.O. range (Table 15). Additionally, specific conductance was elevated (see discussion below). After exploring upstream land use, human development, and the lack of WWTP outfalls in this site's contributing drainage area (11.4 mi²), plausible sources of high specific conductance inputs at this location were unsewered homes in the nearby, upstream village of Arnold.

Specific conductance is not exposed to the same diel processes as the other parameters monitored with the water quality sondes. The specific conductance generally increases from higher to lower streamflow. The mainstem and tributaries of the Big and Little Darby creek system exhibited this typical trend. The presence of point sources influences specific conductance at low streamflow because streams typically have lower conductance than point sources. The tributary to Big Darby Creek at RM 27.93 is the receiving water from the Darbydale WWTP. Here, specific conductance was elevated, and peaks at 1798 and 1782 µS/cm were observed. The Darbydale WWTP is not served by a public water system and the elevated specific conductance is likely due to home water softeners discharging to the WWTP. The Darbydale WWTP did have minor permit limit violations for D.O. and TP in 2014, though did not have any specific conductance permit limit violations. More information regarding compliance summary for this facility can be found in the [NPDES Permitted Facilities](#) section of this document. In another part of the watershed, Sugar Run at U.S. Route 42, specific conductance was elevated and observed over two surveys with peaks at 1732, 1463, 1263 and 1083 µS/cm.

Trophic Evaluation

A gradient between two trophic states exist within streams, 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 are described as having low nutrients, low algal biomass and high clarity. Conversely, eutrophic systems are rich in nutrients, have high algal biomass, low clarity and have large dissolved oxygen (D.O.) 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 and the process is 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 high chlorophyll-*a* concentrations or wide diel D.O. swings (USGS 2014). Therefore, the focus for identifying eutrophication requires effective monitoring of the trophic state, which is dictated by primary production and respiration (Odum 1956). The objective of a trophic status evaluation is to position a stream along the trophic continuum.

Ohio and other states have been developing nutrient reduction strategies in recent years to address cultural eutrophication (USEPA 2015, Ohio EPA 2014, Miltner 2010, Heiskary and Markus 2003). Wide diel D.O. ranges associated with eutrophication are caused by excessive photosynthesis (O₂ production) during daylight hours and respiration at night. The most recent investigations by Ohio EPA have identified a diel D.O. range of 6.5 mg/L as an upper threshold generally protective of biological and stream quality; diel D.O. ranges greater than 6.5 mg/l are indicative of eutrophication in Ohio streams and are likely over-enriched (Ohio EPA 2014).

Chlorophyll concentrations from benthic algae (attached to bottom substrates) are measured as a proxy for algal community biomass in wadeable streams and small rivers, while chlorophyll concentrations measured from sestonic algae (suspended in the water column) serve as a proxy for algal abundance in large rivers. Physical factors such as width-depth ratio, time of travel, and longitudinal gradient 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 small streams. Miltner (2010) identified benthic chlorophyll levels that broadly demarcate enrichment status relative to Ohio. Streams with less than ~90 mg/m² can be considered least disturbed and atypical for Ohio. Benthic chlorophyll levels between 90-183 mg/m² are typical for Ohio streams with modest amounts of agriculture or wastewater loadings. Levels between 183-320 mg/m² are typical of streams draining agricultural landscapes or that are effluent dominated. Chlorophyll levels exceeding 320 mg/m² 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.

Ohio EPA published a report (Ohio EPA 1999) that analyzed associations between nutrient concentrations and the condition of fish and macroinvertebrate assemblages. The report proposed statewide water quality targets based on those associations (Table 17). These proposed targets were never adopted into rule as WQS criteria; however, they can serve as benchmarks for comparison. The presence of elevated nutrients increases the risk of eutrophication in streams, but cannot alone serve to identify eutrophication. Along with biological impairment, the primary indicators of enrichment are large diel D.O.

swings and elevated chlorophyll-*a* concentrations. These two factors, along with underperformance of biology relative to its local habitat, serve as lines of evidence to identify areas that may be over enriched.

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 a drop 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 (i.e., 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, D.O. 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 D.O. at the same time. The advantage of coupling the two sampling efforts is that the algae sampled represent the productivity reflected in the diel D.O. regime. In addition, while D.O. and chlorophyll-*a* sampling targets 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.

For trophic status evaluation, Ohio EPA designates “nutrient sites” where benthic/sestonic chlorophyll-*a* concentrations and diel D.O. ranges are monitored. Most of these sites coincide with grab sampling for chemistry, which are then used to characterize the seasonal nutrient availability. In the Big Darby Creek watershed, a trophic assessment was conducted at 28 of 35 locations where automated data loggers (i.e., sondes) were deployed in 2014 and at 10 sonde sampling locations in 2015.

The largest and most extensive, basin-wide sonde survey occurred from August 5th-7th, 2014 and assessed much of Big and Little Darby creeks and selected tributaries, while a second survey occurred in the upper reaches of Little Darby Creek from September 24th-October 1st, 2014 to assess the magnitude of impact from a grain spill in Treacle Creek at Winget Rd (V06S11, RM 0.78). The primary survey in 2015 occurred from September 1st-3rd and sought to clarify causes/sources of impairment to biological communities at six locations, while one location was assessed for high specific conductance; sites were situated in upper Sugar Run, upper Little Darby Creek, lower Treacle Creek, Wamp Ditch, and lower Hellbranch Run. The other surveys from 2015 include May 18th-June 3rd to assess conditions in lower Treacle Creek and upper Sugar Run, and from September 25th-October 1st to assess three locations in Little Darby Creek in and around the village of Mechanicsburg. Sonde sampling locations and criteria exceedances are displayed in Table 15.

Sampling events are expected to represent the potential of primary production. Therefore, the largest D.O. range found in these sampling events is used in the summary figures. The hourly samples from a 24-hour diel cycle are summarized in box plots that identify the minimum, maximum, average, median, 75th percentile and 25th percentile of concentration values measured. If benthic or sestonic algae were sampled in multiple surveys, the concentration corresponding to the highest D.O. range is shown. Summary plots of all data collected from both the 2014 and 2015 deployments are included in Appendix H. Instream nutrient concentrations are also considered as a contributing factor for assessing the trophic state. To

assess nutrient concentrations, the geometric mean of the samples collected from June 15 to October 15, corresponding to the biological assessment index period, is calculated. The critical data for assessing the trophic state are presented in Figure 81 through Figure 84. Figure 81 and Figure 82 are presented as longitudinally-spaced plots, showing data appropriately spaced by river mile to represent the spatial extent of sampling from Big and Little Darby creeks. Figure 83 shows all sites on tributaries to Big Darby Creek, but is not spaced longitudinally. Figure 84 displays data from sites located on tributaries to Little Darby Creek and are not presented longitudinally.

Diel D.O. ranges and chlorophyll-*a* concentration are the primary indicators of eutrophication. If both indicators fall into 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. After these 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 D.O. swings demonstrate that the nutrient load is not being locally 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 were considered. In this circumstance, biological community indices and characteristics of macroinvertebrate communities (EPT taxa) are further examined to determine whether biological performance underachieved relative to existing instream habitat quality (QHEI). Biological communities are also examined to determine whether there are declining trends in performance through time. Together, these factors were regarded in conjunction with eutrophication signatures to determine whether or not aquatic communities may be in threat of imminent declines due to nutrient enrichment.

Land cover throughout the Big Darby Creek watershed consists primarily of row-crop agriculture, making this watershed inherently more prone to eutrophication and nutrient over-enrichment. Despite this, many portions of the Big Darby Creek mainstem and middle/lower Little Darby Creek maintain functional riparian buffers that provide adequate stream shading, which helps regulate surface water temperature and curb excess primary productivity. There are, however, numerous areas throughout the watershed (*i.e.* upper Big and Little Darby creeks, many tributary streams) that have been channelized in the past and have reduced or non-functional riparian areas (Figure 7). Such areas would be more prone to nutrient over-enrichment.

Additionally, many areas throughout the Big Darby Creek watershed receive cold, ground water contributions that are a direct result of the region’s geologic history. Cool ground water contributions to streams can functionally ameliorate negative effects on stream biota that may arise from water chemistry issues such as nutrient enrichment and/or deficient instream habitat. This can potentially lead to the presence of one or more nutrient signatures, while stream biology remains relatively un-impacted.

Multiple locations throughout the Big Darby Creek watershed displayed signatures associated with nutrient enrichment (*e.g.* diel D.O. concentration swings, elevated chlorophyll-*a*). These sites will be discussed in further detail below. Locations that display nutrient enrichment indicators, especially those that do not display biological impairment, should be the focus of future monitoring efforts in the basin aimed at gauging trophic condition and nutrient enrichment impacts.

Big Darby Creek at RM 76.54 (V07P59) displayed modest indicators of nutrient enrichment, including a diel D.O. concentration range (6.9 mg/l) just over the benchmark threshold of 6.5 mg/l, while the benthic chlorophyll-*a* concentration at this location (181 mg/m²) was also very near the 1st tier of concern (182 mg/m²). Big Darby Creek at RM 38.33 (V06W19) displayed an elevated chlorophyll-*a* concentration (431 mg/m²) well above the 2nd tier of concern (320 mg/m²); however, diel D.O. concentration swings (4.1 mg/l) were well below the benchmark threshold. Several other locations had chlorophyll-*a* concentrations above the 1st tier of concern, but were not accompanied by diel D.O. concentration swings above the benchmark threshold (Figure 81). Biological community indices were not impaired at any of these locations, nor did they underperform relative to habitat conditions or display declining trends through time. Thus, these locations were not considered threatened by nutrient enrichment.

Several locations in Little Darby Creek also exhibited eutrophication signatures and were evaluated for nutrient enrichment impacts. Benthic chlorophyll-*a* concentrations at Little Darby Creek RM 14.9 (V07P66) (362 mg/m²) exceeded the 2nd tier of concern; however, diel D.O. ranges (3.5 mg/l) were well below the benchmark threshold of 6.5 mg/l. Little Darby Creek at RM 0.1 (601130) exhibited diel D.O. ranges (7.1 mg/l) above the threshold benchmark and dissolved inorganic nitrogen concentrations were just above target concentrations. Benthic chlorophyll-*a* samples could not be collected during 2014; however, 2015 benthic chlorophyll-*a* concentrations (274 mg/m²) exceeded the 1st tier of concern (Figure 82). Benthic chlorophyll-*a* concentrations (251 mg/m²) were also elevated at RM 29.46 (V06S04) but were not accompanied by diel D.O. concentration swings. Biological community indices were not impaired at any of these locations, nor did they underperform relative to habitat conditions or display declining trends through time. Thus, these locations were not considered threatened by nutrient enrichment.

Several tributaries to Big and Little Darby creeks displayed signs of eutrophication and were evaluated to determine the reasonable potential for nutrient enrichment causing impairment or threatening the stream segment.

Flat Branch is a tributary that joins Big Darby Creek in its headwaters region northwest of Marysville. Sonde data collected at RM 0.9 (V07P60) revealed diel D.O. concentration swings (6.6 mg/l) just above the 6.5 mg/l threshold, while the benthic chlorophyll-*a* concentration (141 mg/m²) was below the 1st tier of concern. Biological community performance was meeting existing ECBP MWH criteria. Fish community performance has improved substantially since 2001. Macroinvertebrate community performance, as indicated by the ICI, has declined slightly since 2001, though is still well within ecoregional expectations and higher than was observed in 1997. The ICI declined from a 50 in 2001 to a 44 in 2014; the ICI at this location in 1997 was a 38. Despite the slight decrease in ICI score from 2001 to 2014, the number of pollution sensitive taxa increased dramatically through time from 3 in 1997 and 6 in 2001, to 12 in 2014. The percentage of pollution intermediate caddisflies and tanytarsini midges also increased from 2001 to 2014, while the percent of pollution tolerant macroinvertebrates decreased over the same time period. It was deemed that, while the stream was enriched at this location, the site was not imminently threatened by eutrophication.

Sugar Run is a small, direct tributary that joins Big Darby Creek just south of Plain City. Historically, nutrient enrichment, among other stressors, have been a well-documented issue within Sugar Run, especially in the upper reaches (Ohio EPA 2004). For the current survey, fish community performance at RM 5.4 fell just short of existing ECBP WWH expectations with an IBI of 34 and has not improved since 2001, when an IBI of 34 was recorded. Macroinvertebrate community performance remained within the good range in both 2001 and 2014. Nutrient enrichment was evident at the most upstream site on Sugar Run (V06K08, RM 5.4). The diel D.O. range (8.1 mg/l) was well above the margin of concern. Both benthic and sestonic chlorophyll-*a* were collected at this location and, while benthic chlorophyll-*a* concentration (109 mg/m²) was below the 1st tier of concern, sestonic chlorophyll-*a* concentration (54.2 ug/l) was above the 1st tier of concern (Figure 83). Total phosphorus was above target concentrations at both locations on Sugar Run, while inorganic nitrogen was below target concentrations at both locations. Impairment in the fish community, coupled with large diel D.O. swings, indicated that nutrient enrichment is likely a contributing factor to impairment. Likely sources of nutrient enrichment in this segment of Sugar Run include, but are not limited to, row crop agriculture, manure application and runoff from fields, runoff from a golf course, and unsewered communities.

Fitzgerald Ditch is a small, direct tributary that joins Big Darby Creek south of Amity. The benthic chlorophyll-*a* concentration at RM 0.55 (V06G02) (433 mg/m²) was well above the 2nd tier of concern of 320 mg/m²; however, diel D.O. concentration ranges (5.9 mg/l) were below the threshold concentration of 6.5 mg/l. Biological community performance has improved since 2001 and is not underperforming relative to instream habitat. Despite exhibiting modest signs of nutrient enrichment, this location was not considered threatened by nutrient enrichment.

Several other Big Darby Creek tributaries displayed benthic chlorophyll-*a* concentrations that were above the first tier of concern (182 mg/m²), but did not display associated diel D.O. concentration swings that exceeded the threshold concentration of 6.5 mg/l. These locations included Spain Creek (V07P58, RM 0.01), Robinson Run (V06W05, RM 0.41), and Hellbranch Run (V07S47, RM 0.98) (Figure 83). These locations were not considered threatened by nutrient enrichment because all biological indices were attaining ECBP WWH criteria and no diel D.O. concentration swings in excess of 6.5 mg/l were recorded.

Treacle Creek is a tributary that joins Little Darby Creek northeast of Mechanicsburg. This small tributary has historically been impacted by a wide variety of stressors (Ohio EPA 2004). As a whole, biological performance has improved since 2001, especially in the upper reaches. However, continued non-attainment of both fish and macroinvertebrate community indices was observed at RM 0.78 (V06S11). Aside from obvious limitations to instream physical habitat, water chemistry issues were also well documented. Six sonde deployments were conducted at two locations near the mouth of Treacle Creek throughout 2014 and 2015 in an effort to elucidate impacts resulting from poor water chemistry (Figure 84). Modest diel D.O. concentration swings (6.3 mg/l) approaching the threshold concentration of 6.5 mg/l were recorded at RM 0.02 (V06G59) in May 2015 and benthic chlorophyll-*a* concentrations (238 mg/m²) above the 1st tier of concern were recorded at RM 0.78 in August 2014. Despite the occurrence of nutrient enrichment indicators, the overwhelming occurrence of organic enrichment (*e.g.*, diel D.O. sags) is likely the primary water quality issue driving biological impairment at this location. Sonde deployments revealed substantial D.O. sags, with a combination of minimum and 24-hour D.O. concentration exceedances regularly occurring over the six sonde deployments; minimum D.O. concentrations nearing 0 mg/l (anoxic) were recorded both at RM 0.78 and RM 0.02 in 2014 (Table 15). Diel D.O. concentration sags tended to be most severe in late summer and early fall and appeared to be further exacerbated by a grain spill that occurred during the summer of 2014. The organic enrichment

issue appears to be relatively chronic in nature, given to multiple diel D.O. sags observed across multiple sonde deployments through multiple years.

Wamp Ditch is a small tributary that joins Little Darby Creek east of Rosedale. Fish community performance met WWH ECBP expectations, but macroinvertebrate community performance was evaluated as fair and considered impaired. Sonde deployments in 2015 revealed diel D.O. concentration swings (6.4 mg/l) very near to the concentration threshold of 6.5 mg/l, while the benthic chlorophyll-*a* concentration (207 mg/m²) was above the 1st tier of concern. It is likely that nutrient enrichment is contributing to the observed impairment to macroinvertebrate communities in Wamp Ditch. Direct habitat alterations and sedimentation stemming from channelization activities are also contributing to observed biological impairment and are likely exacerbating nutrient enrichment at this location.

Spring Fork is a tributary that joins Little Darby Creek south of Rosedale. Sampling at RM 7.8 revealed a chlorophyll-*a* concentration (252 mg/m²) above the 1st tier of concern. However, the diel D.O. concentration range (4.4 mg/l) was well below the threshold concentration of 6.5 mg/l. Biological indices were fully attaining ECBP WWH criteria and did not underperform relative to instream habitat. Nutrient enrichment was not deemed to be threatening stream biology at this location.

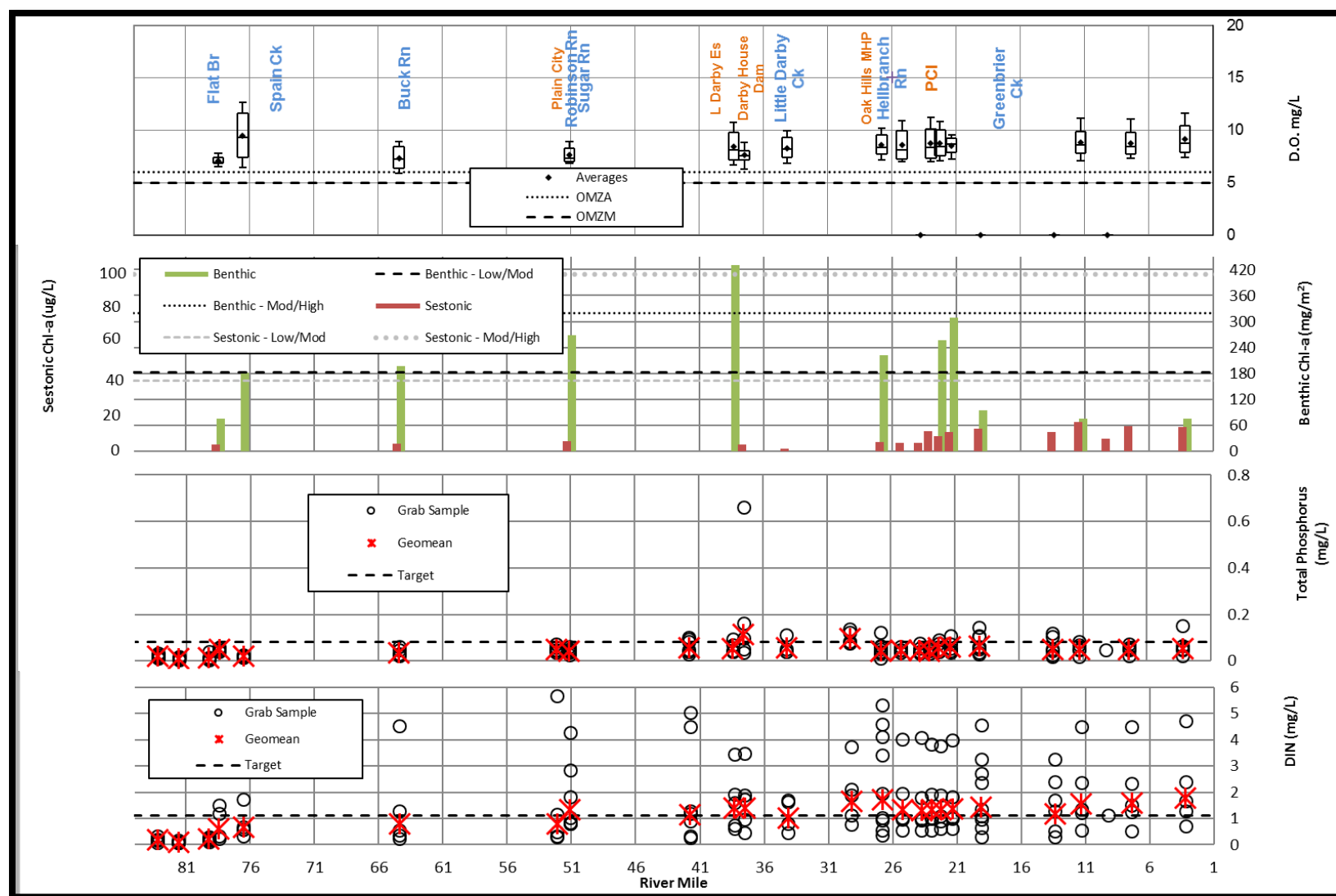


Figure 81. Longitudinal representation of D.O., benthic/sestonic chlorophyll-a, TP, and dissolved inorganic nitrogen (DIN) used for a trophic assessment of the Big Darby Creek mainstem. Relevant targets (Dodds 2006, Miltner 2010, Ohio EPA 1999, Ohio EPA 2014) for chlorophyll-a and nutrient concentrations are presented within their respective plots. All Big Darby Creek mainstem samples were collected during 2014.

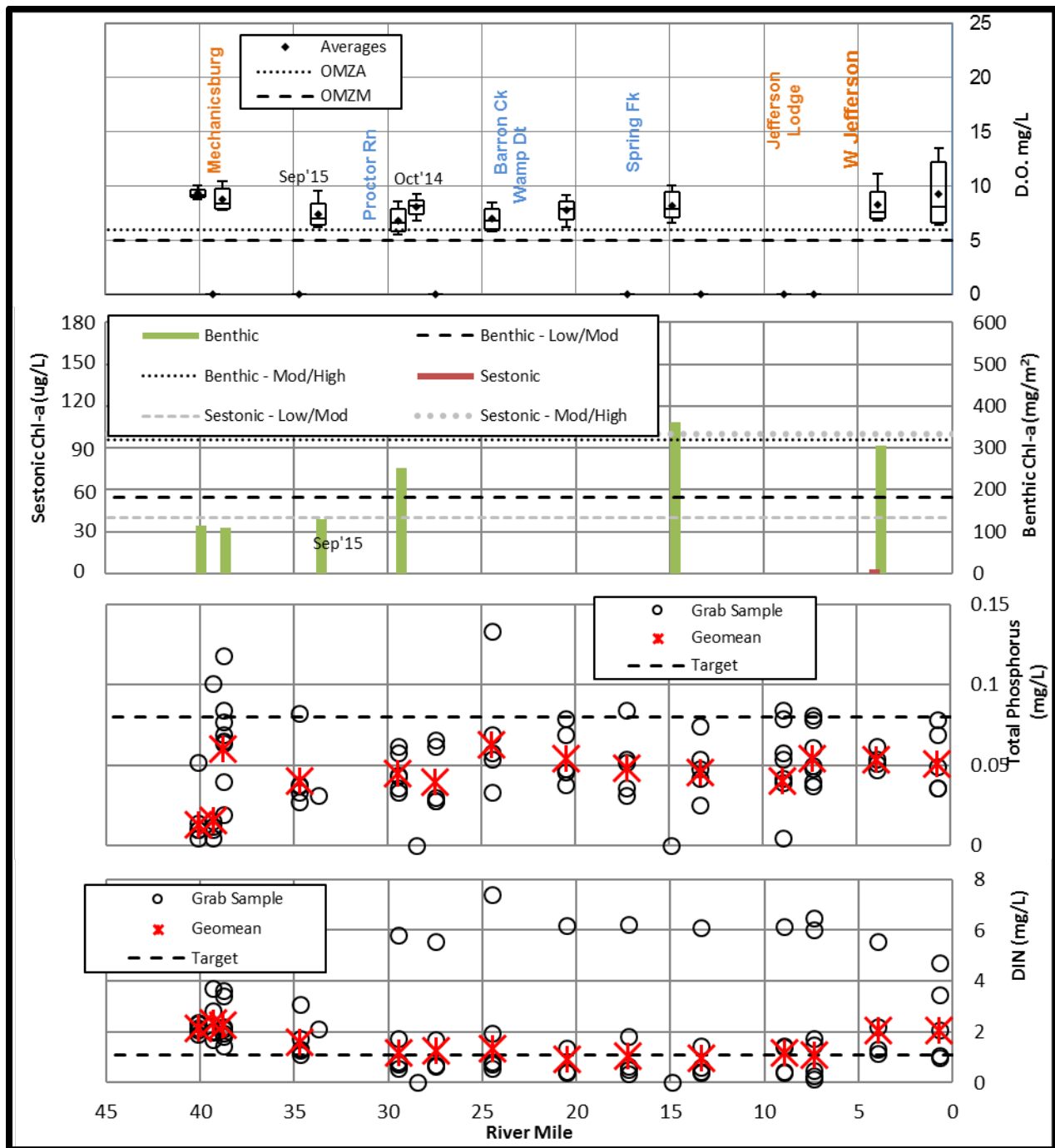


Figure 82. Longitudinal representation of D.O., benthic/sestonic chlorophyll-a, TP, and dissolved inorganic nitrogen (DIN) used for a trophic assessment of Little Darby Creek. Relevant targets (Dodds 2006, Miltner 2010, Ohio EPA 1999, Ohio EPA 2014) for chlorophyll-a and nutrient concentrations are presented within their respective plots. All but one of Little Darby Creek samples were collected during 2014; one site was collected in 2015 (RM 33.7) and is noted.

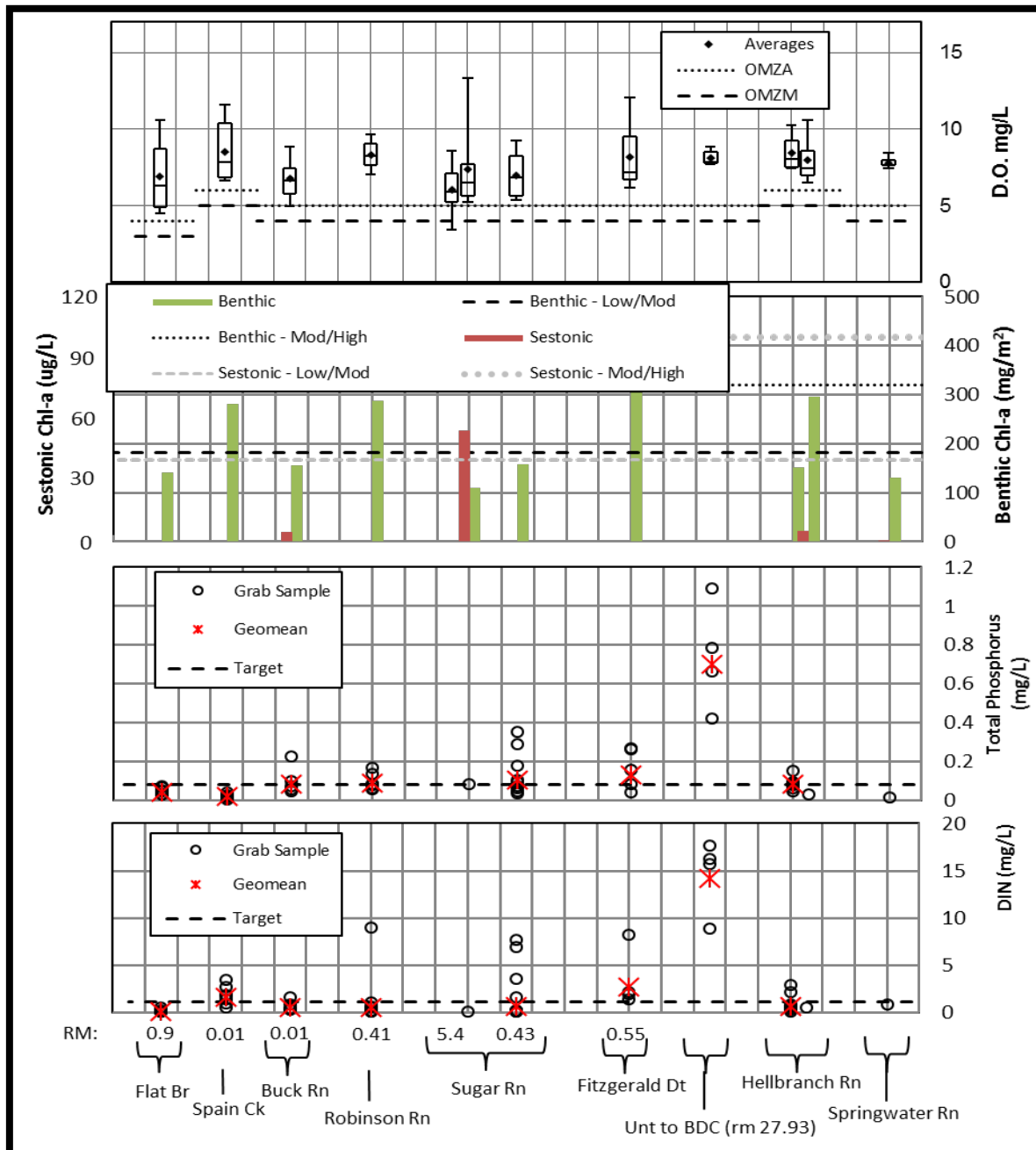


Figure 83. Longitudinal representation of D.O., benthic/sestonic chlorophyll-*a*, TP, and dissolved inorganic nitrogen (DIN) used for a trophic assessment of selected tributaries to Big Darby Creek. Relevant targets (Dodds 2006, Miltner 2010, Ohio EPA 1999, Ohio EPA 2014) for chlorophyll-*a* and nutrient concentrations are presented within their respective plots. Sonde surveys for tributaries occurred primarily in 2014. Additional sampling was conducted in 2015 at or near selected locations displaying biological impairment and are noted as such in the figure.

Sept. 15

May 15

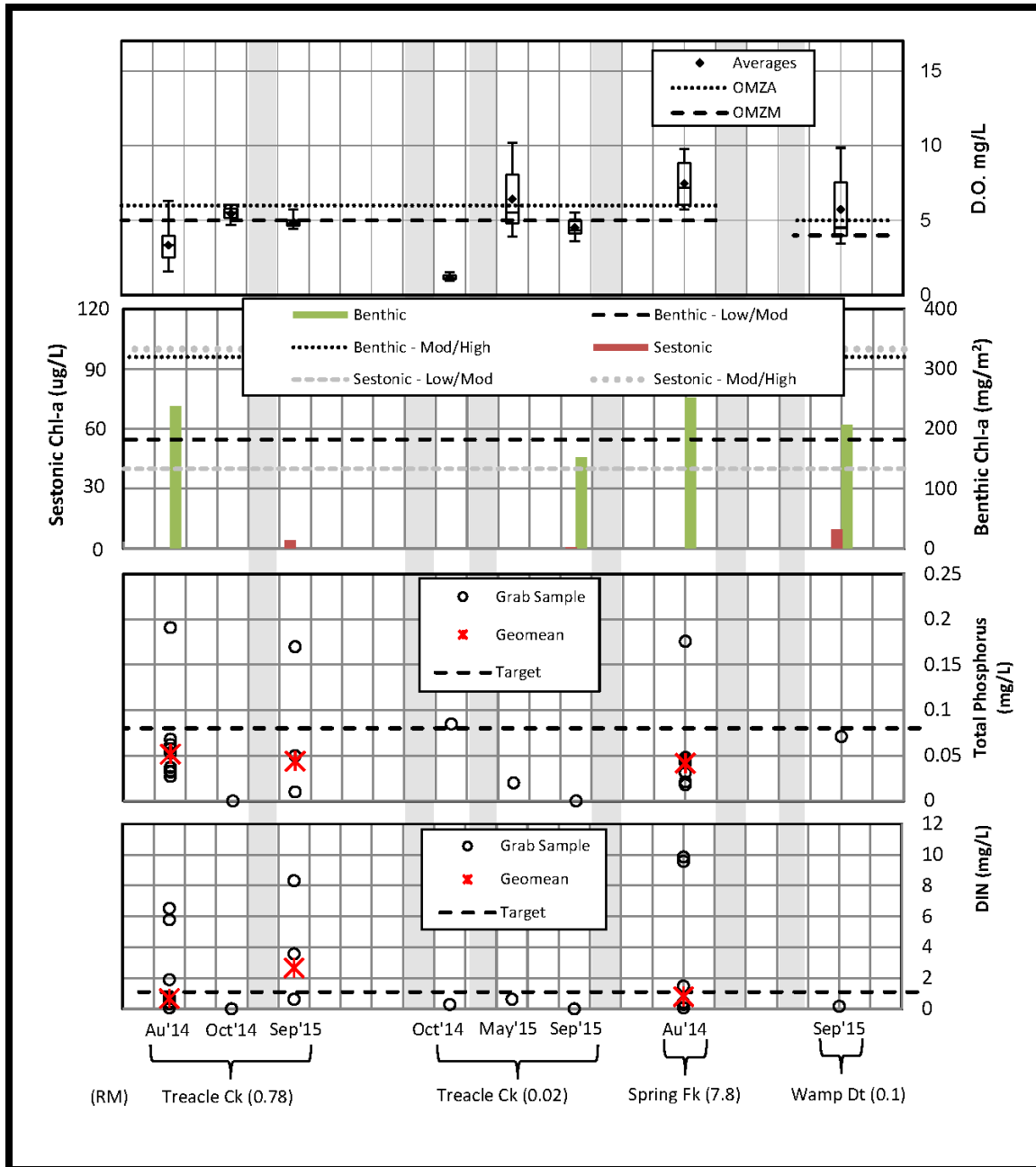


Figure 84. Longitudinal representation of D.O., benthic/sestonic chlorophyll-*a*, TP, and dissolved inorganic nitrogen (DIN) used for a trophic assessment of selected tributaries to Little Darby Creek. Relevant targets (Dodds 2006, Miltner 2010, Ohio EPA 1999, Ohio EPA 2014) for chlorophyll-*a* and nutrient concentrations are presented within their respective plots. Sonde surveys for tributaries occurred primarily in 2014. Additional sampling was conducted in 2015 at or near selected locations displaying biological impairment and are noted as such in the figure.

Stream Physical Habitat

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). 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 55 indicate limiting components of habitat are present and may be negatively influencing biological performance. However, due to the potential for compensatory stream features (*e.g.*, strong groundwater connectivity) or other watershed attributes, average QHEI scores below the benchmark WWH value of 60 do not necessarily preclude these streams from fully supporting WWH or even EWH assemblages. 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 (positive 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. Stream physical habitat was evaluated at 91 fish sampling locations in the Big Darby Creek watershed study area during the 2014 sampling season (Table 28, Appendix E).



Big Darby Creek downstream of Westfall Aggregate at RM 7.4

Big Darby Creek Mainstem and Tributaries

Stream physical habitat was evaluated at 34 locations along Big Darby Creek, where habitat quality ranged from good to excellent. Habitat quality was generally good in the headwaters portion and improved to excellent throughout the middle and lower mainstem. The mean mainstem QHEI score (80.1) indicated generally excellent habitat quality throughout. Habitat scores in 2014 were similar to historical values (Figure 85, Table 28).

Gravel and cobbles were generally the most predominant substrate types, with sand and boulders also frequently occurring at many locations. Substrate embeddedness and silt cover was largely considered normal, though locations in stretches of the headwaters portion (RMs 82-79) had more moderate amounts of siltation and embeddedness. Embeddedness is the degree that cobble, gravel, and boulder substrates are surrounded, impacted in, or covered by fine sand and silt. Extensive amounts of silt and embedded substrates are detrimental to benthic fishes (*e.g.*, darters, redhorse suckers) and many sensitive macroinvertebrate species. Excessive siltation and substrate embeddedness has the ability to cause impairment in biological communities.

The overwhelming presence of natural stream features (*i.e.*, good riffle quality, floodplain and riparian quality, good amounts and types of instream cover) throughout Big Darby Creek are necessary to support high quality aquatic communities found in this system. A majority of streams in the Big Darby Creek study area have substantial ground water input because of the glacial history and setting of the watershed. Substantial ground water connectivity can ameliorate effects from negative habitat attributes that may be present, especially in smaller headwater streams. It is important to protect this unique system by continued participation in programs and activities that help maintain the integrity of the high quality resources in this system, such as conservation tillage and other agricultural BMPs, increasing the amounts of streamside riparian and other natural areas, and promoting the use of exclusion fences where cattle have free access to streams.

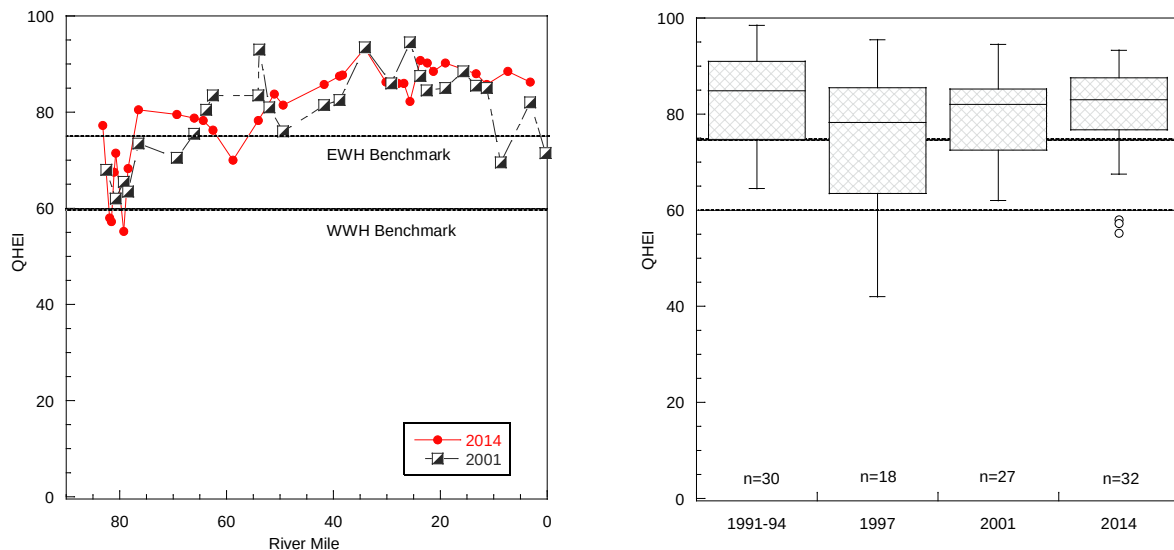


Figure 85. Longitudinal by river mile (left) and aggregated by year (right) QHEI scores for Big Darby Creek from selected years.

Flat Branch is a small tributary located in the headwaters of Big Darby Creek. A significant portion of this stream's approximately 14.46 mi² drainage area lies within the Honda of America property and has been historically been channelized. At the one location assessed downstream from U.S. Route 33, habitat quality was observed to be in the high-fair range, with a QHEI score of 53.75; this is substantially improved over the 2001 score of 38. Substrate quality at this location improved since 2001, consisting primarily of sand where historically silts were a more dominant component. Efforts have been made by Honda of America in the past to widen vegetated buffers and install storm water retention ponds and wetlands. These actions by Honda of America, along with other efforts to buffer this small stream, appear to be having a positive effect on instream habitat quality, and subsequent biological performance in the Flat Branch watershed.

Little Darby Creek (Logan Co.) joins Big Darby Creek just downstream from Flat Branch. The physical characteristics of these two streams differ immensely. It originates in the much hillier Cable moraine and coincides with an area of glaciated Ohio called the boulder belt where a high concentration of glacial erratics can be found. This stream also has a relatively steep gradient, which helps flush excess sediment quickly. It also benefits from substantial ground water connectivity that can ameliorate effects from negative habitat influences. A mean QHEI score of 69.5 at two locations assessed indicated good to excellent overall habitat quality. In addition to historical channelization activities, the site at RM 3.61 has

been subject to “dipping/channelization” activities in the past by a landowner in the vicinity (Ohio EPA 2004); this segment was dipped in 2002 and yielded a much lower QHEI score post-dipping (33) than was recorded in 2001 (72.5). QHEI scores at this location have improved (57.5), but are still not back to pre-dipping quality.

Spain Creek and Pleasant Run are both small tributaries to Big Darby Creek. Both streams originate from the east in the Cable moraine and benefit from substantial ground water connectivity and sufficient gradient. The mean QHEI score in Spain Creek declined slightly in 2014 (72.75) compared to 2001 (76). Examination of historical imagery has revealed removal of woody riparian vegetation and extensive channelization and channel relocation activities that have likely contributed to declines in habitat quality near the mouth of Spain Creek (Figure 86). These riparian removal and channel modification activities have likely contributed to the excess instream sediment and shifting, unstable bedload observed. Over time, these excess sediments should be flushed out by natural processes.



Figure 86. Historical imagery from lower Spain Creek. A) 2004, B) 2005, C) 2007, D) 2014. Note: 1) substantial riparian removal from the lower reaches of Spain Creek since 2004 and 2) construction of new, armored channel located to the south of the natural channel since 2004.

The QHEI score for Pleasant Run near the mouth (53.25) declined slightly since 2001 (60.5). Habitat quality has declined at this location and examination of historical imagery has revealed substantial and complete channelization, and riparian vegetation removal which occurred between 2007 and 2008 immediately adjacent to the sampling location near the mouth that have certainly contributed to observed habitat declines. Substantial ground water connectivity has likely ameliorated some effects from channelization activities and resulting negative habitat attributes in both Spain Creek and Pleasant Run.

QHEI scores from Buck Run ranged from fair in its headwaters to excellent near the mouth; a mean QHEI score of 63.5 at the three locations assessed indicated generally good habitat quality. The Buck Run sub-watershed consists primarily of a mix of row crop agriculture, livestock, and pasturage. Negative impacts from channelization (*e.g.*, siltation/embeddedness, monotonous channel development) are present in the upper reaches of Buck Run and its tributaries and continue to negatively impact habitat quality. Buck Run was sampled extensively between the late 1980s and early 2000s; mean QHEI scores generally improved over this time frame: 2001 (56.0, n=3), 1991-93 (60.8, n=6), and 1985-1990 (51.3, n=8). It is important to maintain adequate riparian buffers and continue participation in BMPs and other agricultural management programs to ensure continued gradual improvement of habitat quality.

Robinson Run, Sweeny Run, and Sugar Run are three small tributaries that join Big Darby Creek in the vicinity of Plain City. Habitat quality was assessed at two locations in Robinson Run and the mean QHEI score (77) indicated generally excellent habitat for a stream its size. The mean habitat score is slightly improved over the score observed in 2001 (69.5). The QHEI score from Sweeny Run was similar in 2014 (57.0) to that found in 2001 (59.0) at the one location assessed. Much of the length of Sweeny Run has been channelized in the past and is most influenced by agricultural activities in the upper reaches and the development of Plain City in the lower reaches.

Habitat quality was evaluated at two locations in Sugar Run and a mean QHEI score of 65.9 indicated generally good conditions in the segments evaluated. Habitat quality in Sugar Creek declined from the late 1980s/early 1990s into the early 2000s, with subsequent improvements occurring since 2001-02 (Figure 87). Habitat quality in the upper reaches of Sugar Run has been negatively impacted by channelization and related habitat alterations, areas of unrestricted livestock access, and areas of past and recent development. The construction of Rolling Meadows Golf Course contributed to habitat quality declines observed during the last survey; erosion and sediment delivery from this source has likely been attenuated, though the golf course still may be a source of excess nutrients. A housing development situated adjacent to Sugar Run and slightly upstream from one sampling location has been expanded since the last survey in 2001. Increased runoff from this development during precipitation events is likely contributing to the “flashy” aspect of this stream. A “flashy” stream is one that receives excessive overland runoff during precipitation events which causes a rapid and pronounced rise in stream discharge followed by a similar rapid decrease. This situation typically occurs in streams that have altered drainage networks or those that drain areas with a high density of impervious surfaces. Channelization,

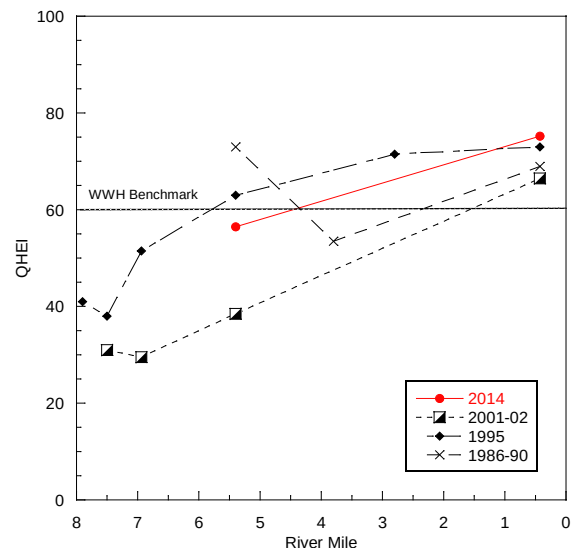


Figure 87. Longitudinal QHEI scores from Sugar Run for selected years.

increased use of drainage tile, and other associated impacts are likely contributing to the flashy and low flows observed in Sugar Creek. A stream with a flashy flow regime can have negative influences on the stream biota. Increased overland runoff can also result in significant erosion and sediment deposition in receiving streams, especially during periods of active construction activity. The construction of the housing development adjacent to Sugar Run near RM 5.4, in addition to upstream channelization and stream maintenance activities, has likely contributed excess sediment to the stream that has resulted in extensive substrate embeddedness and excess siltation. The combination of low and flashy stream flows, and pervasive substrate embeddedness are likely negatively impacting the biology at this location.

Worthington Ditch, Ballenger Jones Ditch, and Fitzgerald Ditch are three small tributaries that join Big Darby Creek from the east. QHEI scores for these three streams were in the low good to good range (Table 28). Worthington and Fitzgerald ditches have been channelized in the past nearly to their confluence with Big Darby Creek, while Ballenger-Jones Ditch has not been channelized as extensively. Row crop agriculture is the predominant land use draining these three streams, though there is some scattered residential development immediately adjacent to the streams in some locations. Substantial alteration of riparian buffer areas was evident, stemming both from historical channelization activities and in areas where housing is situated close to these streams. Sufficient gradient in these streams has helped them begin to recover natural habitat features, and ground water inputs are likely ameliorating present negative habitat attributes.

Smith Ditch is a small tributary that flows through Battelle-Darby Metro Park before joining Big Darby Creek. The QHEI score at the one location assessed (77.0) was indicative of excellent habitat quality. However, later in the year this stream was observed by Ohio EPA staff to have substantially less flow and was nearly dry in areas. Macroinvertebrate community performance was likely affected by these natural low flow conditions later in the year.

Springwater Run is a small stream that flows through the small village of Harrisburg before joining Big Darby Creek. A QHEI score of 50.25 at the one location assessed was indicative of generally fair overall habitat quality; the habitat score in 2014 was very similar to that recorded in 2001 (49.5). Springwater Run drains a very narrow end moraine, which contributes significantly to the cool, ground water character of this stream. Substantial ground water inputs to Springwater Run are likely ameliorating effects from negative habitat attributes that are present.

Habitat quality of an unnamed tributary to Big Darby Creek joining from the west at RM 23.61 was assessed at one location near its mouth; the QHEI score of 44.75 was indicative of generally fair habitat quality. Substrates consisted primarily of sand and gravel, with lesser amounts of cobble and boulders. Substantial ground water input to this stream helps overcome effects from negative habitat attributes that are present (*i.e.*, moderate siltation/embeddedness, <40 cm. pools, fair/poor stream development, sparse instream cover). This was the first time this tributary was assessed and, therefore, no historical comparisons or trend assessments were possible.

Hellbranch Run is one of the few significant tributaries that joins Big Darby Creek from the east. It originates and is solely contained within Franklin County. A mean QHEI score of 77.5 based on six sites assessed on Hellbranch Run was indicative of good to excellent overall habitat quality. Habitat quality appears to have improved through time. While the median QHEI score in Hellbranch Run has remained relatively constant through time, the range of individual scores from assessed sites has decreased, denoting general improvements as the majority of QHEI scores are now trending toward the median (Figure 88). Substrates in Hellbranch Run consisted primarily of cobble and gravel, with lesser amounts of sand and boulders. Many natural habitat attributes (*e.g.*, good stream development, cobble/gravel substrate type, fast current/eddies, moderate/high sinuosity) were found throughout Hellbranch Run and were far more common than were negative influence habitat attributes (*e.g.*, moderate/high substrate embeddedness, low sinuosity, fair/poor stream development). This is especially true for the middle and lower reaches of Hellbranch Run (Appendix E). The eastern half of the Hellbranch sub-watershed is being encroached upon by the rapid growth of the western Columbus area. Increased urban runoff from impervious surfaces (roads, parking lots, residential lawns), especially during precipitation events, is one of the major influences that urbanization is having on this sub-watershed. Increased urban runoff during precipitation events has likely increased the “flashy” aspect of this stream. A modified, “flashy” flow regime can negatively influence biological communities. Urban runoff can also convey undesired contaminants into receiving streams (*i.e.*, lawn pesticides and fertilizer, oil from impervious surfaces). Measures should be taken to further buffer the Hellbranch stream system from the effects of urbanization, especially in tributaries that drain into Hellbranch Run. Measures can include, but are not limited to, increasing the coverage of riparian vegetation buffers and increasing the use of “green” storm water infrastructure. The ultimate focus of these efforts should be on slowing down or intercepting overland runoff before it reaches receiving streams.

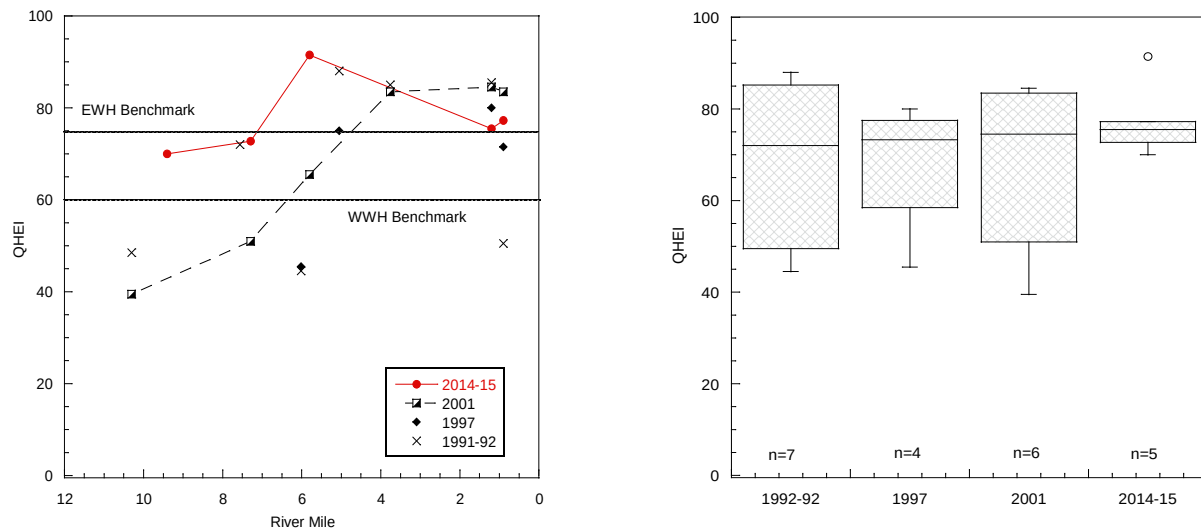


Figure 88. Longitudinal by river mile (left) and aggregate by year (right) QHEI scores from Hellbranch Run for selected years.

Hamilton Run and Clover Groff Run are the two principal tributaries to Hellbranch Run. Instream habitat quality was judged to be very similar in both of these small streams. Mean QHEI scores (49.8, 47.6) were indicative of generally fair macrohabitat quality in both Hamilton and Clover Groff runs, respectively. Both streams have a history of channelization activities, especially in their upper reaches. Moderate-influence negative habitat attributes were pervasive in both streams (*i.e.*, moderate/extensive siltation and embeddedness, fair/poor stream development, moderate /extensive riffle embeddedness). In many places, both streams displayed a high degree of incision and were disconnected from their immediate floodplain. This high degree of incision can exacerbate the habitat issues recorded in both of these streams by not allowing the stream to deposit excess silt and sediment into the floodplain and not affording the stream enough space to begin to regain natural habitat features. Additionally, a low gradient in these streams reduces overall stream power and ability to flush excess sediment, substantially slowing down the natural recovery process.

As discussed above, both of these streams are receiving stress from urban development, especially Clover Groff Run. Significant habitat restoration projects have been implemented in Clover Groff Run, with a few also occurring in Hamilton Run. These projects were designed to restore natural habitat features in these streams (*i.e.*, connectivity to riparian/floodplain, meanders, riffles), to buffer these systems from anthropogenic activity and associated impacts, and to restore as natural a hydrologic regime as possible (Figure 90). Future restoration efforts should be directed toward these goals. Habitat restoration projects like the ones discussed above will benefit not only Hamilton and Clover Groff runs, but, more importantly, they will also help protect water quality and the stream biota downstream in both Hellbranch Run and Big Darby Creek. Fish community performance throughout Hellbranch Run has improved immensely since it was last sampled in 2001. It is equally, if not more important, to consider biological performance downstream from these projects in Hellbranch Run as an indicator of project efficacy, rather than looking solely at site-specific biological and habitat improvement in either Hamilton Run or Clover Groff Run.

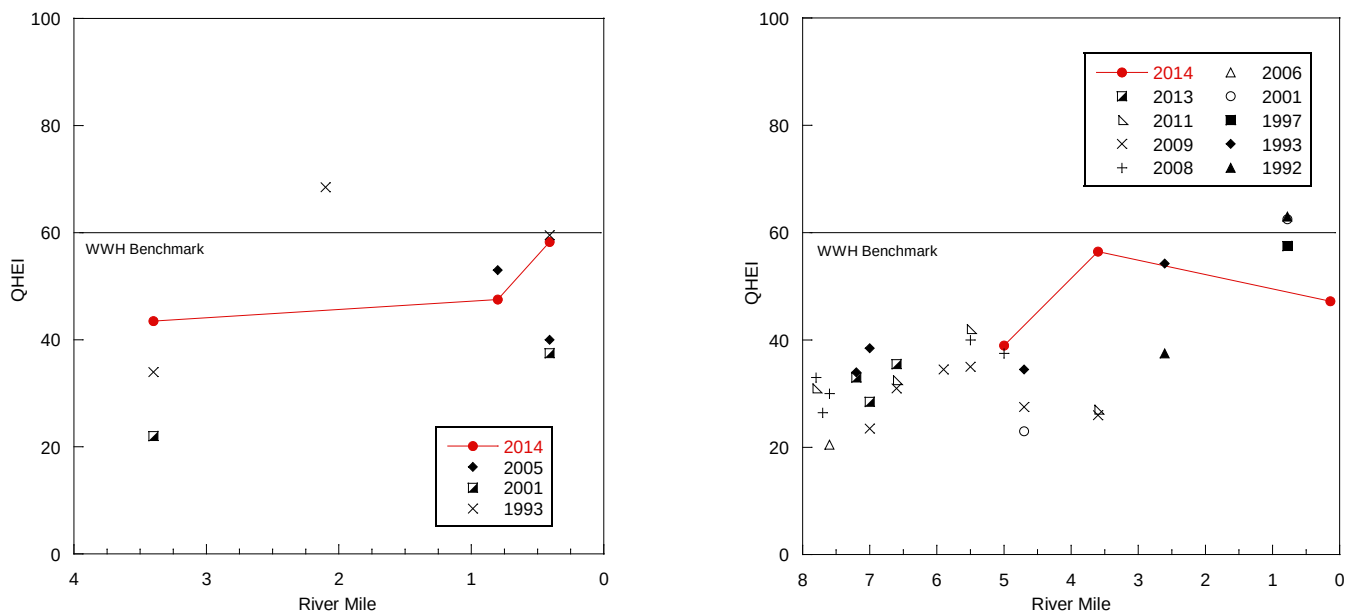


Figure 89. Longitudinal QHEI scores from Hamilton Run (left) and Clover Groff Run (right) for selected years.



Figure 90. Clover Groff Run RM 4.75 (V07G05) downstream from Roberts Rd. Notice that the stream is coupled with and spilling over into its immediate floodplain. This effectively slows down streamflow and reduces stream power under high flow conditions, and allows the stream to deposit excess sediment and other pollutants into the floodplain.

McCoy Run is a small tributary that joins Hamilton Run near its mouth and confluence with Hellbranch Run. The QHEI score (44.0) at the one location assessed was indicative of generally fair instream habitat quality; this score was similar to a mean QHEI score (41.5) recorded at two locations in 2005-06. McCoy Run displays many of the same negative habitat attributes that are present in both Hamilton and Clover Groff runs. Despite this, McCoy Run has a riparian corridor that consists of relatively mature shrubs and trees which provide a fair amount of shading to the stream. This stream also displays various characteristics consistent with a wetland-type stream (*i.e.*, silt/muck substrates, extensive amounts of aquatic macrophytes) which can naturally limit biological performance.

Little Darby Creek and Tributaries

Habitat quality was evaluated at 14 locations along Little Darby Creek, with QHEI narratives ranging from good to excellent. The mean QHEI score from all locations (79.0) indicated generally excellent habitat quality. QHEI scores have remained relatively constant through time (Figure 91). Gravels, sand, and cobbles were the predominant substrate types. The upper reaches of Little Darby Creek (headwaters to $\approx$ RM 20) have historically (>50 years) been subject to channelization activities. This has resulted in more monotonous channel development (riffle-run-pool sequences) and generally “weaker” riffles than found in downstream, un-channelized portions. This can be observed in the longitudinal graph in Figure 91, as QHEI scores are generally higher in the lower reaches that weren’t subject to historical channelization activities. There are also many areas along Little Darby Creek, especially in the upper reaches, that have had substantial riparian vegetation reductions and complete removal in areas. Riparian areas are an important component of overall stream habitat. These areas function to provide shading to streams and water temperature regulation, can filter out excess sediment before it reaches the stream, and can influence energy pathways and trophic structure within a stream. Removal of riparian vegetation can also make streambanks less stable, leading to more bank and channel erosion. There are also portions of upper Little Darby Creek where cattle have unrestricted access to the stream. Similar to riparian removal,

unrestricted cattle access can lead to increased bank and channel erosion and can also lead to excess nutrients, organic wastes, and siltation in the stream. Despite the stressors listed above, the headwaters portion of Little Darby Creek receives significant ground water input, which can ameliorate impacts from negative habitat attributes that may be present.

As discussed above, Little Darby Creek at RM 34.7 has been subject to historical channelization activities and though habitat has likely recovered to the fullest extent possible, this location still exhibited characteristics of a channelized stream. The sampling location at RM 34.7 displayed generally monotonous development that consisted of mainly glide type habitats. Instream cover was sparse, functional sinuosity was relatively low, and there were moderate amounts of siltation and substrate embeddedness. Stretches of Little Darby Creek surrounding the sampling location at RM 34.7 also displayed a highly modified character consistent with historical channelization activities (*i.e.*, low sinuosity, reduced riparian area, etc.). Low stream gradient in this portion of Little Darby Creek diminishes stream power and slows the flushing of excess sediment from these reaches (Figure 92). It is likely that the cumulative effects of negative habitat attributes stemming from historical channelization activities in this stretch of Little Darby Creek is causing the MIwb component of the fish community evaluation to deviate slightly from EWH expectations. For the remainder of the mainstem, habitat quality improved from generally good to generally excellent as sites progressed downstream into the un-channelized portions of Little Darby Creek.

It would be beneficial to establish more substantial riparian buffers along the length of Little Darby Creek, especially in the headwaters portions where there are stretches that have significant alteration or removal of riparian vegetation. It would also be beneficial to establish exclusion fences for cattle where they are allowed free access to streams in the Little Darby Creek watershed.

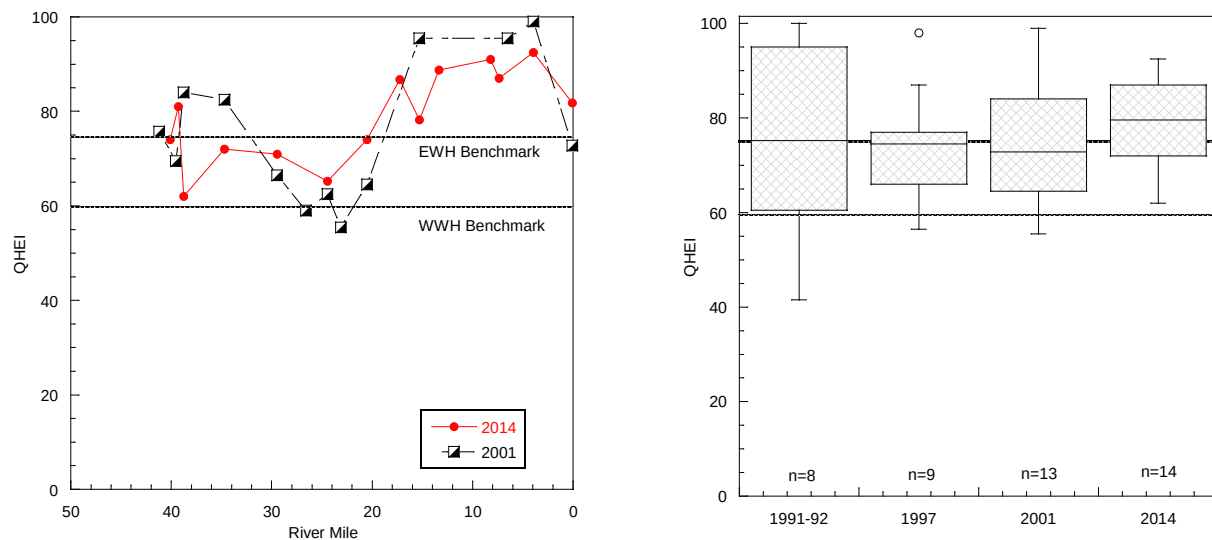


Figure 91. Longitudinal by river mile (left) and aggregate by year (right) QHEI scores from Little Darby Creek for selected years.

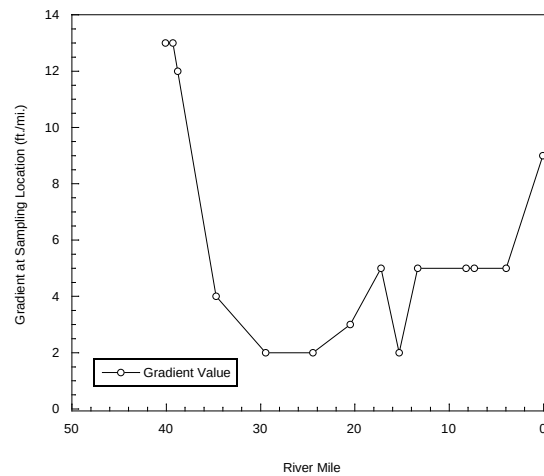


Figure 92. Stream gradient values (ft/mi) for sampling locations in Little Darby Creek, 2014.

Clover Run is a small tributary that joins Little Darby Creek immediately south of Mechanicsburg. It originates from the boulder belt of the Cable moraine and drains some of the hilliest portions of the entire Big Darby watershed. Because of this, Clover Run has sufficient stream gradient and substantial ground water input, both of which are desirable traits and benefit stream biology over the long term. Sufficient stream gradient will better enable a stream to flush excess silt and sediment from the system, and better enable a historically modified stream to regain and maintain natural stream features (*e.g.*, high quality riffles, deep pools on outside bends). A QHEI score of 65.0 at the one location assessed reflected generally good quality and was similar to the score recorded in 2001 (61.5). Differences in flow types present and pool depth accounted for the slightly higher score recorded in 2014.

Lake Run is a small tributary that joins Little Darby Creek just north of Mechanicsburg. It flows through the Cable moraine and has several glacial kettle lakes situated on or draining into it. The QHEI score in 2014 (77.0) was slightly higher than that observed in 2001 (72.0) and was indicative of generally excellent habitat quality. Jumping Run is a small tributary to Lake Run. The QHEI score at the one location assessed in 2014 (70.25) was higher than that observed in 2001 (64.0). Dominant substrate types in 2001 consisted of sand/silt, whereas gravel/sand was found to be the dominant types in 2014. Historical channelization and construction activities prior to 2001 accelerated delivery of excess sediment to these streams; additionally, the upper portions of Jumping Run are on active ditch maintenance by Champaign County engineers which can further accelerate delivery of excess sediment to these streams. The previous report asserted that excess sedimentation and associated substrate embeddedness were contributing to non-attainment of fish community indices at both locations. Biological performance here no longer appears limited by excess sediment and sufficient gradient has facilitated the flushing of excess sediment. Substantial ground water input ameliorates negative habitat attributes or other stressors that may be present. Improving riparian areas and stream buffers and continued participation in agricultural BMPs will only continue to benefit these small streams and keep them on a positive to stable trajectory regarding both habitat quality and biological community performance.

Treacle Creek is a tributary to Little Darby Creek that drains approximately 37 mi². It has a local gradient in the moderate-high range in its headwaters and middle reaches and drops into the low-moderate range toward the mouth where it transitions from ground moraine to end moraine. QHEI scores in the mid to upper reaches have consistently performed in the good range; however, QHEI scores near the mouth at Winget Rd. have consistently performed in the poor range (Figure 93). Thick silt deposits (Figure 94) blanketed the natural substrates throughout much of the sampling location. In all previous years evaluated, pasture land was present immediately adjacent to the stream and livestock were given free access to the stream. Although no cattle were observed in the stream in 2014, evidence of livestock activity and false banks were present upstream from Winget Rd (see below picture). Additionally, this portion of Treacle Creek and small tributaries upstream from this sampling location have been historically channelized and maintained to some extent more recently. The land use throughout the Treacle Creek drainage is predominantly row crop agriculture, which can also contribute excess sediment to the stream system as a whole. Significant ground water connectivity and proximity to higher quality stream segments ameliorated negative habitat attributes in Treacle Creek; these contributed to full attainment of biological communities at all locations except the most downstream location. Installation of cattle exclusion fences near the Winget Rd. sampling location and establishing more substantial riparian buffers throughout the Treacle Creek drainage will help to improve conditions here and elsewhere throughout this sub-watershed

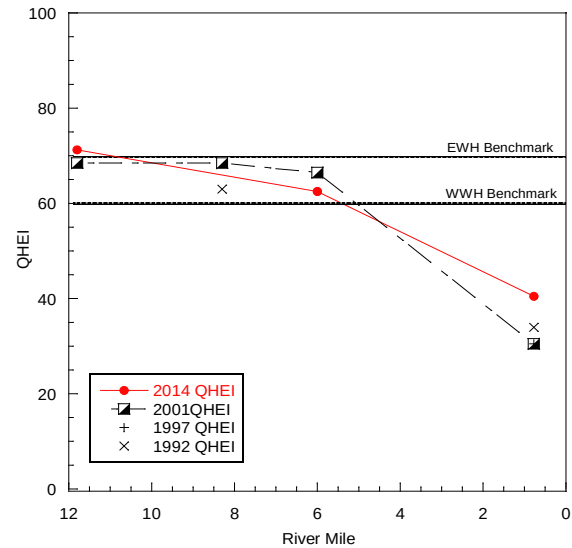


Figure 93. Longitudinal QHEI scores from Treacle Creek for selected years.



Figure 94. Treacle Creek RM 0.78 upstream from Winget Rd. Note the evidence of open pasture (top left and right) and lack of riparian buffer (left and right). The area of excess silt deposits visible on the bottom left exemplifies the dominant substrate type throughout much of the zone.

Proctor Run is a small tributary to Treacle Creek which originates in Champaign County in the boulder belt of the Cable moraine before transitioning into ground moraine in Union County. This stream receives substantial ground water input. Mean QHEI reach scores from 2014 (70.25) are nearly identical to those recorded in 2001 (70.5), denoting generally good to excellent habitat quality that has persisted through time.

Barron Creek and Wamp Ditch are two small streams that join Little Darby Creek just south of Chuckery. Both streams have been subjected to historical channelization activities and have drainages that consist primarily of agriculture, especially so in the headwaters portions of these streams. Both streams have low to no functional sinuosity and have deficient riparian buffers. The QHEI score in Barron Creek RM 0.2 (65.25) reflected good habitat quality. This lower location in Barron Creek hasn't been previously sampled for aquatic life, but a QHEI score from 2001 at RM 2.1 (46.0) was likely more reflective of the overall modified character of this stream. In 2014, Wamp Ditch still displayed many negative influence habitat attributes (low/no sinuosity, no riparian vegetation) consistent with a history of channelization and associated impacts. The "improvements" observed are likely flow related (*i.e.*, presence of riffles, pool depth), as 2001 was a significantly drier year overall than was 2014. Also, channelization activities in Wamp Ditch didn't appear as raw and unrecovered in 2014 when compared to 2001, as there were relatively stable grassed buffers on either side of the stream. Despite the slight improvements in QHEI scores, negative habitat attributes related to channelization activities were still pervasive throughout Wamp Ditch and likely contributed to impairment observed in the macroinvertebrate community. The complete lack of riparian vegetation and shading along Wamp Ditch likely exacerbated nutrient enrichment, which was an additional cause of impairment at this location.

Spring Fork is one of the larger Little Darby Creek tributaries at 12 miles long and a drainage area of 37.0 mi². The majority of Spring Fork flows through glacial moraine which contributes to the strong ground water inputs to this stream. The mean QHEI score from the three locations assessed (63.4) was indicative of good habitat quality. Habitat quality was generally similar compared to historical values; slight improvements were observed at the uppermost location, while slight declines were observed near RM 10.1 (Figure 95). Field observations from 2014 noted that the stream appeared to be recently channelized immediately upstream from the sampling location at RM 10.1. Examination of historical imagery revealed extensive riparian vegetation removal from this same segment since the last survey. Channelization activities and riparian removal have the ability to destabilize stream banks and can accelerate the delivery of excess sediment and silt to the receiving stream. These activities may have contributed to the localized impairment observed in the macroinvertebrate community at RM 10.1.

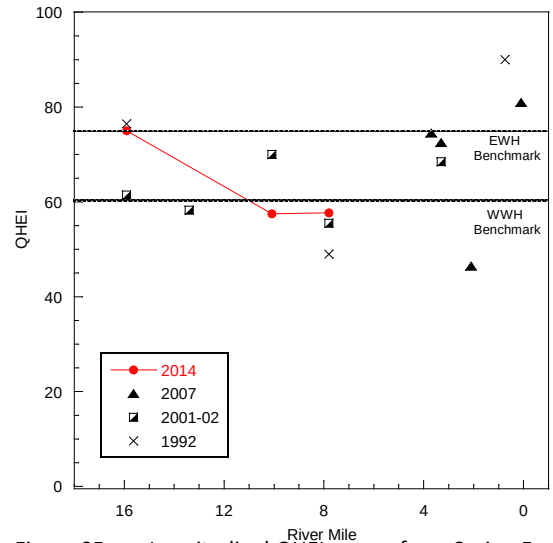


Figure 95. Longitudinal QHEI scores from Spring Fork for selected years.

Table 28. Summary of Qualitative Habitat Evaluation Index (QHEI) metric scores for the Big Darby Creek basin, 2014.

Stream	River Mile	Drain. Area (Mi ²)	Location	QHEI	Substrate	Cover	Channel	Bank	Pool	Riffle	Gradient
Big Darby Creek	83.2	1.5	IN HEADWATERS @ PRIVATE RESIDENCE	77.25	16.5	15	18	9.75	8	6	4
Big Darby Creek	81.9	2.2	S OF E LIBERTY, UPST LANE OFF OLD U.S. 33	58	13	12	10	5.5	4.5	3	10
Big Darby Creek	81.6	3.0	AT LANE OFF OLD U.S. RT. 33 (SHOWE PROPERTY)	57.25	12.5	9	13	4.75	6	2	10
Big Darby Creek	81.1	3.2	NE OF MIDDLEBURG, 0.4 MI UPST ST. RT. 287	67.5	13	13	13.5	5	10	3	10
Big Darby Creek	80.75	4.5	NE OF MIDDLEBURG @ ST. RT. 287	71.5	14.5	16	12.5	7	9	2.5	10
Big Darby Creek	79.23	5.6	SE OF MIDDLEBURG @ CO. RD. 157	55.25	13	10	11	6.25	5	2	8
Big Darby Creek	78.44	19.4	SE OF MIDDLEBURG @ CO. RD. 153	68.25	17.5	10	12.5	6.75	7	4.5	10
Big Darby Creek	76.53	32.0	NE OF NORTH LEWISBURG @ NORTH LEWISBURG RD.	80.5	16	14	16	8	12	4.5	10
Big Darby Creek	69.34	71.0	NW OF MILFORD CENTER @ COLLINS RD.	79.5	17	16	15.5	8	10	5	8
Big Darby Creek	66.1	85.0	AT MILFORD CENTER CEMETERY	78.75	18	16	17	7.75	10	4	6
Big Darby Creek	64.38	86.0	UPST BUCK RUN, ADJ. MIDDLEBURG-PLAIN CITY RD	78.25	17	19	17	5.25	10	4	6
Big Darby Creek	62.6	121.0	SE OF BRIDGEPORT @ ST. RT. 38	76.25	18	13	15.5	6.75	10	5	8
Big Darby Creek	58.8	131.0	SE OF UNIONVILLE CENTER, ADJ. ROBINSON RD.	70	13.5	16	11.5	6.5	10	4.5	8
Big Darby Creek	54.1	138.0	AT PLAIN CITY, UPST. U.S. RT. 42 AND RANCO	78.25	14.5	20	15.5	7.25	8	3	10
Big Darby Creek	51.1	157.0	S OF PLAIN CITY @ CEMETERY PIKE	83.75	18.5	16	15.5	7.25	12	6.5	8
Big Darby Creek	49.46	193.0	AT AMITY @ AMITY PIKE	81.5	16.5	14	15	9	12	5	10

Stream	River Mile	Drain. Area (Mi ²)	Location	QHEI	Substrate	Cover	Channel	Bank	Pool	Riffle	Gradient
Big Darby Creek	41.75	239.0	N OF WEST JEFFERSON @ HUBBARD RD.	85.75	18	17	15	8.75	12	5	10
Big Darby Creek	38.9	247.0	E OF WEST JEFFERSON @ U.S. RT. 40	87.5	18	18	17	8.5	12	6	8
Big Darby Creek	38.33	248.0	E OF WEST JEFFERSON, DST. DARBYCREST	87.75	19	18	16.5	8.75	11	6.5	8
Big Darby Creek	34.15	253.0	AT GEORGESVILLE @ ALKIRE RD.	93.25	19	20	17	8.75	11	7.5	10
Big Darby Creek	30.17	448.0	UPST. DARBYDALE @ ST. RT. 665	86.25	17	16	16.5	9.75	11	6	10
Big Darby Creek	27.95	450.0	DST. DARBYDALE, UPST. TRIB @ POWER LINES	86	18	15	16.5	8	12	6.5	10
Big Darby Creek	26.8	454.0	UPST GAY RUN, ADJ HARRISBURG-GEORGESVILLE RD	86	18	14	17	10	10	7	10
Big Darby Creek	25.7	495.0	0.5 MI. DST. HELLBRANCH RUN AND I-71	82.25	15	16	16.5	5.75	12	7	10
Big Darby Creek	23.75	501.0	W OF ORIENT @ ST. RT. 762	90.75	18	20	17.5	7.25	12	6	10
Big Darby Creek	22.45	503.0	DST. PCI WWTP, UPST. SNAKE ISLAND	90.25	18	20	17.5	6.75	12	6	10
Big Darby Creek	21.35	506.0	NEAR GRAVEL PIT @ END OF LANE	88.5	17	17	17	9	12	6.5	10
Big Darby Creek	19.1	513.0	S OF ORIENT @ DARBY CREEK RD.	90.25	17	18	18	8.25	12	7	10
Big Darby Creek	13.36	534.0	AT DARBYVILLE @ ST. RT. 316	88	17	16	16.5	9.5	12	7	10
Big Darby Creek	11.3	537.0	SE OF DARBYVILLE @ END OF DARBY RD.	85.75	17	17	16.5	8.25	11	6	10
Big Darby Creek	7.4	545	SE OF DARBYVILLE, E OF RENICK CEMETERY	88.5	18	18	18.5	7	12	7	8
Big Darby Creek	3.2	552	NEAR FOX @ ST. RT. 104	86.25	18	17	17.5	7.75	11	7	8
Flat Branch	0.9	13	SE OF MIDDLEBURG, NEAR U.S. RT. 33	53.75	11.5	10	10.5	5.75	6	4	6
Little Darby Creek (BDC Headwaters)	3.61	3.1	AT ST. RT. 287	57.5	15	7	12	5.5	4.5	5.5	8

Stream	River Mile	Drain. Area (Mi ²)	Location	QHEI	Substrate	Cover	Channel	Bank	Pool	Riffle	Gradient
Little Darby Creek (BDC Headwaters)	0.34	7.2	AT CRATTY RD.	81.5	17.5	15	16	8	9	6	10
Spain Creek	3.7	6.3	W OF NORTH LEWISBURG @ GILBERT RD.	72.25	16.5	15	15.5	4.25	7.5	3.5	10
Spain Creek	0.01	9.6	E OF NORTH LEWISBURG @ MOUTH	73.25	14	18	14	4.75	8	4.5	10
Pleasant Run	0.01	9.4	NE OF WOODSTOCK @ MOUTH	53.25	13	8	10.5	2.75	6	3	10
Buck Run	10.4	4.8	AT ALLEN CENTER-POTTERSBU RG RD.	50.5	7.5	11	9.5	8.5	8	0	6
Buck Run	7.8	9	AT ST. RT. 245	60	12.5	10	14	7.5	8	2	6
Buck Run	0.01	29.8	AT BRIDGEPORT NEAR MOUTH	80	15.5	18	16	5	10	5.5	10
Robinson Run	2.1	9.7	N OF PLAIN CITY @ ST. RT. 736 (MIDDLE CROSSING)	67.75	14.5	12	13.5	7.75	8	2	10
Robinson Run	0.73	10.5	AT U.S. RT. 42	86.25	18	18	16	6.75	12	5.5	10
Sweeny Run	0.2	3.9	NEAR MOUTH	57	12.5	10	10	6	7	3.5	8
Sugar Run	5.4	11.4	AT U.S. RT. 42	56.5	13.5	12	10.5	5.5	5	4	6
Sugar Run	0.43	19.4	AT CEMETERY PIKE	75.25	17	16	16	5.25	7	4	10
Worthington Ditch	0.24	4.6	N OF AMITY @ PLAIN CITY-GEORGESVILLE RD.	63.5	15	10	11.5	6.5	7	3.5	10
Ballenger Jones Ditch	0.18	7.3	AT PLAIN CITY-GEORGESVILLE RD.	67	13.5	14	16	3	7	3.5	10
Fitzgerald Ditch	0.55	5.9	AT PLAIN CITY-GEORGESVILLE RD.	55.75	15.5	7	10.5	5.25	5.5	4	8
Little Darby Creek	40.1	8.2	AT MECHANICSBURG @ W. SANDUSKY ST.	74	15.5	17	12.5	5	11.5	4.5	8
Little Darby Creek	39.3	12.2	UPST. MECHANICSBURG WWTP	81	17.5	20	13	2	12	6.5	10
Little Darby Creek	38.78	12.7	DST. MECHANICSBURG WWTP @ WING RD.	62	14.5	13	10	5.5	7	2	10
Little Darby Creek	34.7	26	NE OF MECHANICSBURG @ IRWIN RD.	72	15.5	15	14	7.5	8	6	6

Stream	River Mile	Drain. Area (Mi ²)	Location	QHEI	Substrate	Cover	Channel	Bank	Pool	Riffle	Gradient
Little Darby Creek	29.46	70	W OF CHUCKERY @ AXE HANDLE RD.	71	17	16	11	6	11	4	6
Little Darby Creek	24.46	78	E OF ROSEDALE @ ROSEDALE-PLAIN CITY RD.	65.25	13	15	11	7.75	10	4.5	4
Little Darby Creek	20.5	98	NE OF PLUMWOOD @ BRADLEY RD.	74	16.5	15	11	8	12	5.5	6
Little Darby Creek	17.25	142	SE OF PLUMWOOD @ LITTLE DARBY RD. FORD	86.75	16	17	17	9.75	11	6	10
Little Darby Creek	15.3	147	NW OF WEST JEFFERSON @ U.S. RT 42	78.25	14.5	18	15.5	3.75	12	6.5	8
Little Darby Creek	13.35	149	NW OF WEST JEFFERSON, 1.9 MI. DST U.S. RT. 42	88.75	14.5	19	17	9.75	12	6.5	10
Little Darby Creek	8.2	161	AT WEST JEFFERSON @ TAYLOR BLAIR RD.	91	18	19	17	9	12	6	10
Little Darby Creek	7.35	162	AT WEST JEFFERSON @ MIDDLE PIKE	87	18	16	17	7.5	12	6.5	10
Little Darby Creek	3.95	170	AT END OF ROBERTS RD.	92.5	18	19	18	9.5	12	6	10
Little Darby Creek	0.07	178	AT GEORGESVILLE @ ALKIRE RD.	79.25	16.5	16	12.5	9.25	10	5	10
Clover Run	0.6	1.9	AT ROAD TO MAPLE GROVE CEMETERY	65	13	13	15.5	6	10	3.5	4
Jumping Run	0.27	1.8	AT ST. RT. 559	70.25	12	16	14	5.75	10	2.5	10
Lake Run	0.95	5.7	AT ST. RT. 4	77	19	14	15	7	5.5	6.5	10
Proctor Run	4.9	8.8	SW OF WOODSTOCK @ PARK RD.	64	13.5	15	11.5	5	11	4	4
Proctor Run	1.6	9.9	SE OF WOODSTOCK @ MCMAHILL RD.	76.5	15.5	17	11.5	5	12	5.5	10
Treacle Creek	11.77	6.9	NNW OF MECHANICSBURG @ PARKVIEW RD.	71.25	13	15	13	6.75	10	3.5	10
Treacle Creek	6	12.9	NE OF MECHANICSBURG @ ST. RT. 161	62.5	13	15	12	3	7	2.5	10
Treacle Creek	0.78	36	AT WINGET RD. COVERED BRIDGE	40.5	4.5	11	7.5	2.5	9	0	6

Stream	River Mile	Drain. Area (Mi ²)	Location	QHEI	Substrate	Cover	Channel	Bank	Pool	Riffle	Gradient
Barron Creek	0.2	8.2	E OF ROSEDALE @ ST. RT. 38	65.25	12.5	15	13.5	5.25	7	4	8
Wamp Ditch	0.1	5.5	AT FINLEY GUY RD.	54.5	12	8	10	5.5	6	5	8
Spring Fork	15.9	4.8	S OF MECHANICSBURG @ WREN RD.	75	17	15	14.5	5	8	5.5	10
Spring Fork	10.08	15	SW OF ROSEDALE @ GUY CEMETERY RD.	57.5	11.5	12	11.5	5.5	8	3	6
Spring Fork	7.8	19.5	SE OF ROSEDALE @ ROSEDALE-MILFORD CENTER RD.	57.75	12.5	12	12.5	5.75	5.5	3.5	6
Smith Ditch	0.2	7.8	NW OF DARBYDALE @ BIGGERT RD.	77	14.5	12	16.5	9.5	11	5.5	8
Hellbranch Run	9.4	23.1	NW OF GALLOWAY, 0.6 MILES DST. ALTON RD.	70	15	16	11.5	7	10	4.5	6
Hellbranch Run	7.29	27.8	S OF GALLOWAY @ KUNZ RD.	72.75	13.5	15	14	6.25	9	5	10
Hellbranch Run	5.8	32	DST. OAKHURST KNOLLS WWTP	91.5	19	20	16.5	7	12	7	10
Hellbranch Run	0.98	37.4	N OF HARRISBURG @ LAMBERT RD.	77.5	14.5	15	15	6	12	5	10
Hellbranch Run	0.9	37.4	DST. TIMBERLAKE WWTP	75.5	14.5	13	16	7.5	11	3.5	10
Hamilton Run	3.4	3.6	S OF HILLIARD @ WALKER RD.	43.5	10.5	10	8	4.5	5	1.5	4
Hamilton Run	0.8	6.6	NEAR ALTON, UPST. MCCOY DITCH	47.5	9.5	9	8.5	6	7	1.5	6
Hamilton Run	0.41	9.7	NEAR ALTON @ U.S. RT. 40	58.25	13	13	8.5	5.25	6	2.5	10
McCoy Run	0.1	3.1	NEAR ALTON AT MOUTH	44	3.5	13	9.5	5	5	2	6
Clover Groff Run	5	4.6	AT PARK ADJ. FRAZELL RD.	39	2.5	10	11.5	4	7	0	4
Clover Groff Run	3.6	5.7	AT TIMBERBROOK WTP, HICKORY HILL DRIVE	56.5	15.5	13	9.5	4.5	6	4	4
Clover Groff Run	0.14	9.9	NEAR ALTON @ ALTON RD.	47.25	10.5	10	7	4.75	5	0	10
Springwater Run	0.8	1.8	AT HARRISBURG-GEORGESVILLE RD.	50.25	13.5	7	11.5	6.25	4.5	3.5	4
Trib. to Big Darby Creek (23.77)	0.10	0.60	S OF HARRISBURG @ MOUTH	44.75	13.5	8	11	3.75	3	1.5	4

General narrative ranges assigned to QHEI scores.				
Narrative Rating		QHEI Range		
		Headwaters (≤ 20 sq mi)	Larger Streams	Lacustrary
Excellent		≥ 70	≥ 75	≥ 80
Good		55 to 69	60 to 74	60 to 80
Fair		43 to 54	45 to 59	45 to 59
Poor		30 to 42	30 to 44	30 to 44
Very Poor		< 30	< 30	< 30

Recreation Use

Water quality criteria for determining attainment of recreation uses are established in the Ohio Water Quality Standards (Table 7-13 in OAC 3745-1-07) based upon the presence or absence of bacteria indicators (*Escherichia coli*) in the water column. New revisions to the recreation use rules in Ohio became effective on January 4, 2016. However, as sampling to assess the recreation use for the Big Darby Creek study area was designed and carried out when the previous rules were in effect, the assessment of data and determination of recreation use attainment status provided in this section were based on the prior rules.

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

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

Streams in the Big Darby Creek watershed evaluated during this survey are assigned the Primary Contact Recreation (PCR) use in OAC Rule 3745-1-24. Water bodies with a designated recreational use of PCR "...are waters that, during the recreation season, are suitable for one or more full-body contact recreation activities such as, but not limited to, wading, swimming, boating, water skiing, canoeing, kayaking and SCUBA diving" [OAC 3745-1-07 (B)(4)(b)]. At the time of the survey in the Big Darby Creek watershed, the Ohio Water Quality Standards specified three classes of PCR use to reflect differences in the potential frequency and intensity of use. Streams designated PCR Class A typically have identified public access points and support primary contact recreation. Streams designated PCR Class B support, or potentially support, occasional primary contact recreation activities. Streams designated PCR Class C support, or potentially support, infrequent primary contact recreation activities. The Big Darby Creek mainstem is designated PCR Class A waters from RM 74.30 (near North Lewisburg) to the mouth; all other streams assessed during this survey are designated PCR Class B waters. All values are expressed in colony forming units (cfu) per 100 ml of water. The *E. coli* criteria that apply to PCR Class A and B streams include a geometric mean of 126 and 161 cfu/100 ml, and a maximum value of 298 and 523 cfu/100 ml, respectively. The geometric mean is based on two or more samples and is used as the basis for determining attainment status when more than one sample is collected (Table 29). New revisions to the recreation use rules in Ohio became effective on January 4, 2016. However, as sampling to assess the

recreation use for the Big Darby Creek study area was designed and carried out when the previous rules were in effect, the assessment of data and determination of recreation use attainment status provided in this section were based on the prior rules.

Summarized bacteria results are listed in Table 29. Thirty locations in the Big Darby Creek watershed were sampled for *E. coli* bacteria on average five times, from July–September 2014. Included were 16 sites on the Big Darby Creek mainstem and 14 sites on tributary streams, including Little Darby Creek, Spain Creek, Buck Run, Sugar Run, Robinson Run, Hellbranch Run, and Gay Run.

Evaluation of *E. coli* bacteria results revealed that 26 locations failed to attain the applicable geometric mean criterion, and thus were in *non-attainment* of the designated recreation use. Four locations, including three consecutive sites on the lower portion of Big Darby Creek were in full attainment of the recreation use criteria (Figure 96). Sources of elevated bacteria concentrations were ubiquitous and most likely due to a variety of inputs and land use conditions within the watershed.

Agricultural activities and home sewage treatment systems (HSTS) are the most probable sources of bacteria to streams in the survey area. Agricultural activities include land application of manure and biosolids, as well as livestock production. Livestock impacts were observed at several sampling locations in the watershed, including the upper reaches of Little Darby Creek, Treacle Creek, Spring Fork, and Sugar Run. As might be expected, these streams recorded some of the highest *E. coli* concentrations found during the study.

Bacterial contamination in most streams was present during both wet and dry weather events. This indicates that strategies to reduce bacteria levels in streams should include both point and nonpoint source measures. Some of the potential sources of bacterial contamination throughout the study area are listed in Table 29. Sources listed are those which are prevalent in the watershed and which have been implicated throughout Ohio as contributing to recreation use impairment. However, these sources may not be exclusive and other possible sources cannot be ruled out.

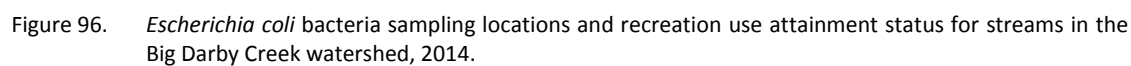


Table 29. Summary of recreation beneficial use assessments conducted at 30 sampling locations from the Big Darby Creek watershed, May 1 through October 31, 2014. Recreation use attainment is based on comparing the geometric mean of sampling results to Primary Contact Recreation (PCR) criteria (OAC 3745-1-07), underlined values indicate non-attainment. All values are expressed in colony forming units (cfu) per 100 ml of water. Water Quality Standards criteria: Class A streams, *E. coli* geometric mean < 126 cfu/100 ml and single sample max. < 298 cfu/100 ml; Class B streams, *E. coli* geometric mean < 161 cfu/100 ml and single sample max. < 523 cfu/100 ml. New revisions to the recreation use rules in Ohio became effective on January 4, 2016. However, as sampling to assess the recreation use for the Big Darby Creek study area was designed and carried out when the previous rules were in effect, the assessment of data and determination of recreation use attainment status provided in this section were based on the prior rules.

Location	Station Code	River Mile	# Samples	Class	Geometric Mean	Maximum Value	Attainment Status	HUC 12: 05060001-	Possible Source(s) ¹ of Bacteria
Big Darby Creek Mainstem and Tributaries									
Big Darby Creek N. Lewisburg Rd	V07P59	76.53	5	B	<u>313</u>	470	NON	19 02	AG, HSTS
Big Darby Creek Collins Rd	V06K03	69.5	5	A	<u>313</u>	<u>500</u>	NON	19 02	AG, HSTS
Big Darby Creek SR-38	V07S12	62.5	5	A	<u>176</u>	<u>380</u>	NON	19 05	AG, HSTS. WWTPs
Big Darby Creek UPST US-42	V06W04	54.1	5	A	<u>214</u>	<u>360</u>	NON	19 05	AG, HSTS
Big Darby Creek Cemetery Pike	V07S09	51.1	7	A	<u>132</u>	250	NON	19 05	AG, WWTP, Urban
Big Darby Creek Amity Pike	V06W08	49.46	5	A	<u>408</u>	<u>3100</u>	NON	21 01	AG, HSTS, WWTP
Big Darby Creek Hubbard Rd	603100	41.75	6	A	<u>225</u>	<u>440</u>	NON	21 02	AG, HSTS
Big Darby Creek DST Darbycrest	V06W19	38.33	5	A	<u>258</u>	<u>950</u>	NON	21 02	AG, HSTS, WWTPs
Big Darby Creek Alkire Rd	601140	34.15	4	A	<u>144</u>	240	NON	21 02	AG
Big Darby Creek Darbydale	V07S05	29.2	5	A	<u>610</u>	<u>5200</u>	NON	22 02	AG, WWTP
Big Darby Creek Harrisburg-G'ville	V07G73	26.8	6	A	<u>187</u>	<u>710</u>	NON	22 02	AG, WWTPs
Big Darby Creek SR-762	V07S03	23.75	6	A	<u>154</u>	<u>1100</u>	NON	22 03	AG, HSTS

Location	Station Code	River Mile	# Samples	Class	Geometric Mean	Maximum Value	Attainment Status	HUC 12: 05060001-	Possible Source(s) ¹ of Bacteria
Big Darby Creek Scioto-Darby Rd	V07P41	19.1	6	A	<u>161</u>	<u>580</u>	NON	22 03	AG, HSTS
Big Darby Creek SR-316	601300	13.36	7	A	95	140	FULL	22 04	
Big Darby Creek SE Darbyville	203274	7.40	4	A	87	160	FULL	22 04	
Big Darby Creek SR-104	600970	3.20	5	A	100	120	FULL	22 04	
Flat Branch nr US-33	V07P60	0.9	7	B	<u>291</u>	<u>2800</u>	NON	19 01	AG
Spain Creek at mouth	V07P58	0.01	8	B	<u>267</u>	<u>630</u>	NON	19 02	AG, HSTS, WWTP
Buck Run Sam Reed Rd	V06P07	2.16	7	B	<u>223</u>	<u>650</u>	NON	19 03	AG, HSTS
Sugar Run Cemetery Pike	V07S13	0.43	7	B	<u>403</u>	<u>5200</u>	NON	19 04	AG, HSTS, Livestock
Robinson Run US-42	V06W05	0.73	7	B	<u>298</u>	<u>1500</u>	NON	19 05	AG, HSTS
Hellbranch Run Lambert Rd	V07P11	0.98	5	B	<u>451</u>	<u>1300</u>	NON	22 01	AG, HSTS
Gay Run Boyd Rd	203265	2.20	5	B	<u>1445</u>	<u>5300</u>	NON	22 02	HSTS
Little Darby Creek Mainstem and Tributaries									
Little Darby Creek Wing Rd	V06S10	38.78	7	B	<u>1659</u>	<u>14000</u>	NON	20 03	AG, Livestock, WWTP, HSTS
Little Darby Creek Axe Handle Rd	V06S04	29.46	5	B	<u>328</u>	<u>1400</u>	NON	20 05	AG, HSTS
Little Darby Creek Middle Pike	V06G28	7.35	6	B	121	400	FULL	20 06	
Little Darby Creek Alkire Rd	601130	0.07	5	B	<u>234</u>	480	NON	20 06	AG, HSTS

Location	Station Code	River Mile	# Samples	Class	Geometric Mean	Maximum Value	Attainment Status	HUC 12: 05060001-	Possible Source(s) ¹ of Bacteria
Treacle Creek SR-161	V06G20	6.0	5	B	<u>1073</u>	<u>3600</u>	NON	20 01	AG, Livestock, HSTS
Treacle Creek Winget Rd	V06S11	0.78	7	B	<u>1040</u>	<u>1700</u>	NON	20 02	AG, Livestock, HSTS
Spring Fork Guy Cemetery Rd	V06G15	10.08	7	B	<u>202</u>	<u>730</u>	NON	20 04	AG, Livestock, HSTS
¹ - Possible Sources: 1AG – Agriculture CAFO – Concentrated Animal Feeding Operation HSTS – Home Sewage Treatment Systems WWTP – Wastewater Treatment Plants CSOs – Combined Sewer Overflows SSOs – Sanitary Sewer Overflows Urban – Urban runoff									

NPDES Permitted Facilities

A total of 41 National Pollutant Discharge Elimination System (NPDES) individual permitted facilities discharge sanitary wastewater, industrial process water and/or industrial storm water into streams within the Big Darby Creek watershed (Table 30). The locations of the NPDES dischargers are shown in Figure 97, Figure 98, and Figure 99.

One major municipal discharger, Ohio Department of Rehabilitation and Corrections (ODRC) Pickaway Correctional Institute (PCI) Wastewater Treatment Plant (WWTP), is located in the watershed. “Major” NPDES permitted facilities are typically those that have a design flow of 1.0 million gallons per day (MGD) or more. Other municipal dischargers include West Jefferson, Plain City, Lake Darby Estates, Mechanicsburg, North Lewisburg and Flat Branch. Together with PCI, these dischargers account for 86% of the municipal NPDES individual permitted flow in the Big Darby watershed. There are also eight (8) mobile home parks and five (5) schools that operate small wastewater package plants and discharge treated effluent in the watershed. These and several other smaller dischargers make up about 14% of the municipal NPDES permitted flow in the watershed. Industrial NPDES discharge facilities include Honda of America, Ranco, Battelle Memorial Institute, and Tuffco Sand and Gravel. Comparatively, permitted design flow for municipal dischargers is 6.36 MGD, while permitted industrial dischargers account for only 0.06 MGD design flow. Thus, municipal discharges far outweigh industrial discharges in the watershed. Flow data for selected NPDES dischargers are shown in Figure 100 and Figure 101.

Each facility is required to monitor their discharges according to sampling and monitoring conditions specified in the individual NPDES permit and report results to Ohio EPA in a Discharge Monitoring Report (DMR). Each permit includes a detailed list of each parameter to be monitored and the specific limits for both concentration and loading rate. They also include monthly average limits and daily or weekly limits, depending on monitoring requirements. The DMR data can be used to track compliance as well as to evaluate historic trends. A summary of 2014 effluent quality from reported DMR data for selected NPDES facilities is provided in Table 31. Permit violations (2012-2014) for selected facilities can be found in Appendix I.

Descriptions for notable NPDES permitted facilities in the Big Darby Creek watershed are provided below, along with brief compliance summaries and pollutant loading data. Additional facilities regulated by an Ohio EPA general NPDES permit are also found in the study area. 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. Information on Ohio EPA’s general permit program may be found at: <http://epa.ohio.gov/dsw/permits/gpfact.aspx>.

Table 30. Facilities regulated by an individual NPDES permit in the Big Darby Creek watershed.

Ohio EPA NO.	FACILITY	DESIGN FLOW (GPD)	RECEIVING STREAM	COUNTY
1IW00270	Honda Mfg East Liberty Plant	NA	Trib. to Flat Branch	Logan
1PP00006	Flat Branch District WWTP	100,000	Big Darby Creek	Logan
1PB00037	Mechanicsburg WWTP	230,00	Little Darby Creek	Champaign
1PB00039	North Lewisburg WWTP	420,00	Spain Creek	Champaign
1PT00099	Triad Local Sch WWTP	20,000	Trib. to Brush Run	Champaign
1PX00047	Spring Meadows Care Center	15,000	Proctor Run	Champaign
4IC00008	Ranco North America	37,400	Big Darby Creek	Union
4IW00019	Honda Marysville (BRWP)	NA	Trib. to Flat Branch	Union
4PG00003	Crottinger Estates WWTP	7,000	Sugar Run	Union
4PG00005	Darby Meadows WWTP	10,000	Trib. to Robinson Run	Union
4PT00006	St John's Lutheran Church	3,500	Trib. to Robinson Run	Union
4PT00123	Fairbanks Middle & HS	20,000	Buck Run	Union
4PW00008	Reflections Sub.	2,000	Trib. to Buck Run	Union
4PX00017	Darby Creek Golf Course	7,600	Big Darby Creek	Union
4PV00004	Jefferson Lodge MHP	40,000	Little Darby Creek	Madison
4IJ00011	Tuffco Sand and Gravel	NA	Big Darby Creek	Madison
4IN00004	Battelle West Jefferson Site	NA	Big Darby Creek	Madison
4PB00016	Plain City WWTP	750,000	Big Darby Creek	Madison
4PB00024	West Jefferson WWTP	1.2 MGD	Little Darby Creek	Madison
4PG00048	Wissalohichan SSD	4,400	Big Darby Creek	Madison
4PR00031	Suburbans Community MHP	44,000	Ballenger-Jones Ditch	Madison
4PR00032	Canaan Community MHP	35,000	Fitzgerald Ditch	Madison
4PR00077	Countryside AKA Dutch Kitchen	8,000	Ballenger-Jones Ditch	Madison
4PT00104	Tolles Technical Center	20,000	Trib. to Big Darby Creek	Madison
4PT00119	Jonathan Alder Junior High	12,500	Ballenger-Jones Ditch	Madison
4PT00122	Monroe Elem School	7,000	Spring Fork	Madison
4PV00000	Green Meadows MHP	81,000	Spring Fork	Madison
4PV00107	B & B Lodge	2,200	Big Darby Creek	Madison
4PY00001	Green Tree MHP	23,700	Trib. to Big Darby Creek	Madison
4PH00000	Oakhurst Knolls WWTP	100,000	Hellbranch Run	Franklin
4PH00012	Darbydale WWTP	300,000	Trib. to Big Darby Creek	Franklin
4PR00000	Darby House WWTP	3,500	Big Darby Creek	Franklin
4PT00106	Pleasant View Middle School	20,000	Hellbranch Run	Franklin
4PU00001	Lake Darby Estates WWTP	500,000	Big Darby Creek	Franklin
4PV00008	Oak Hills MHP	69,000	Big Darby Creek	Franklin
4PV00101	Pleasant Acres MHP	39,000	Trib. to Big Darby Creek	Franklin
4PX00029	Thornapple Country Club	2,000	Clover Groff Run	Franklin
4PX00041	Alton RV Park	4,000	Trib. to Hamilton Ditch	Franklin
4PX00046	Hickory Hills Golf Club	3,000	Trib. to Big Darby Creek	Franklin
4PP00003	Pickaway Correctional Institute	2.3 MGD	Big Darby Creek	Pickaway
4PV00100	Whispering Pines MHP	9,000	Trib. to Big Darby Creek	Pickaway

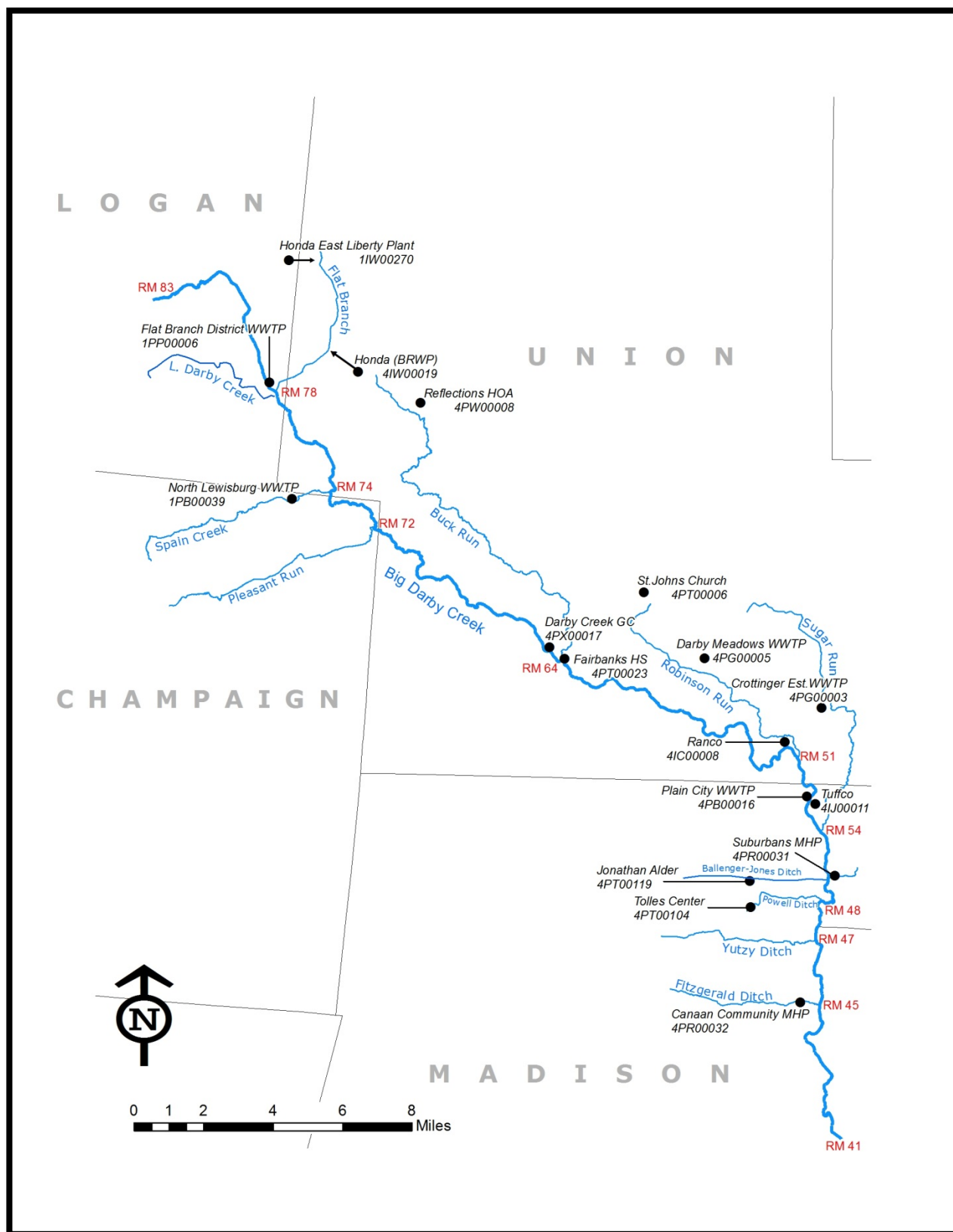


Figure 97. Locations of individual NPDES permitted discharges within the upper reaches of Big Darby Creek and tributaries, 2014.

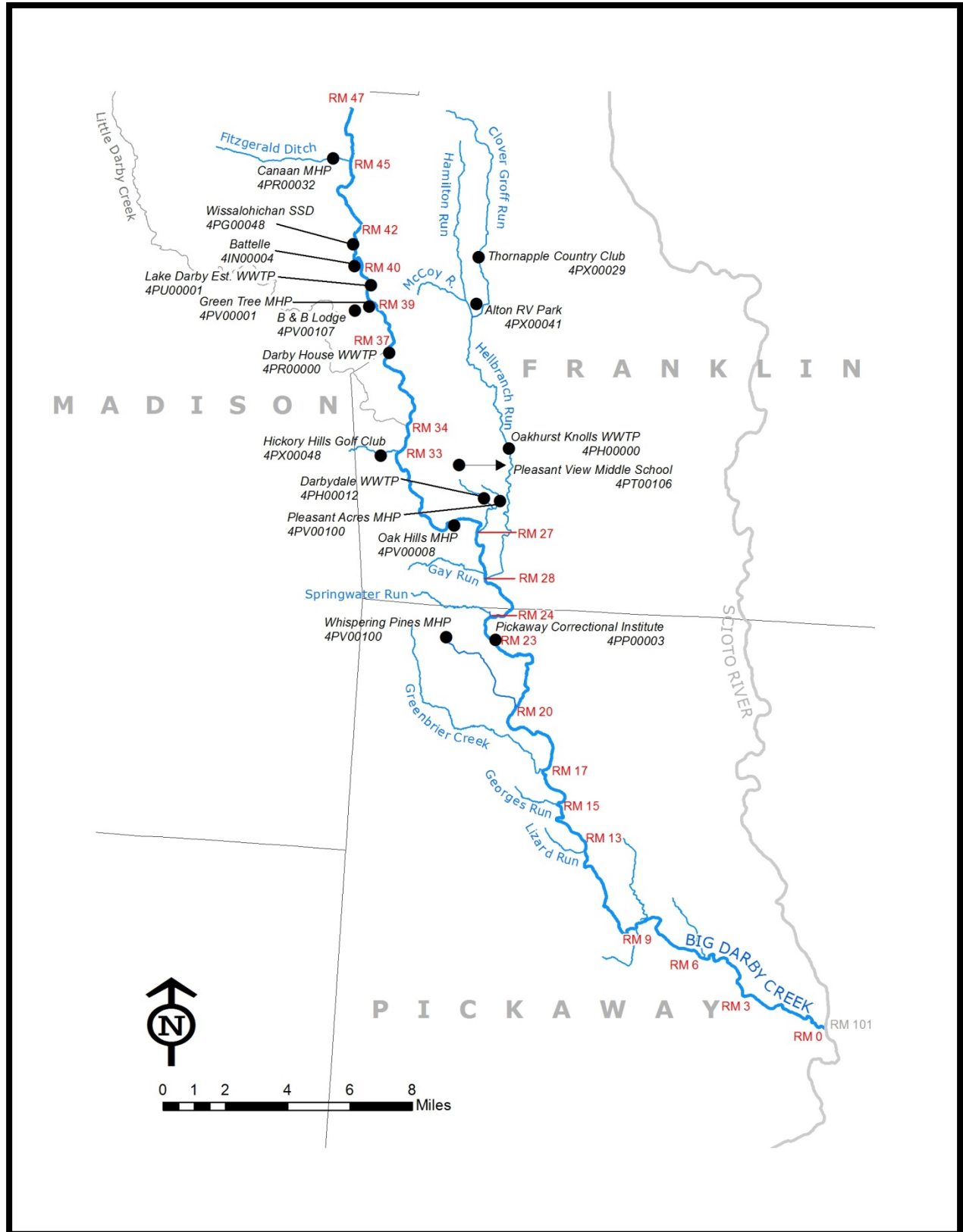


Figure 98. Locations of individual NPDES permitted discharges within the lower reaches of Big Darby Creek and tributaries, 2014.

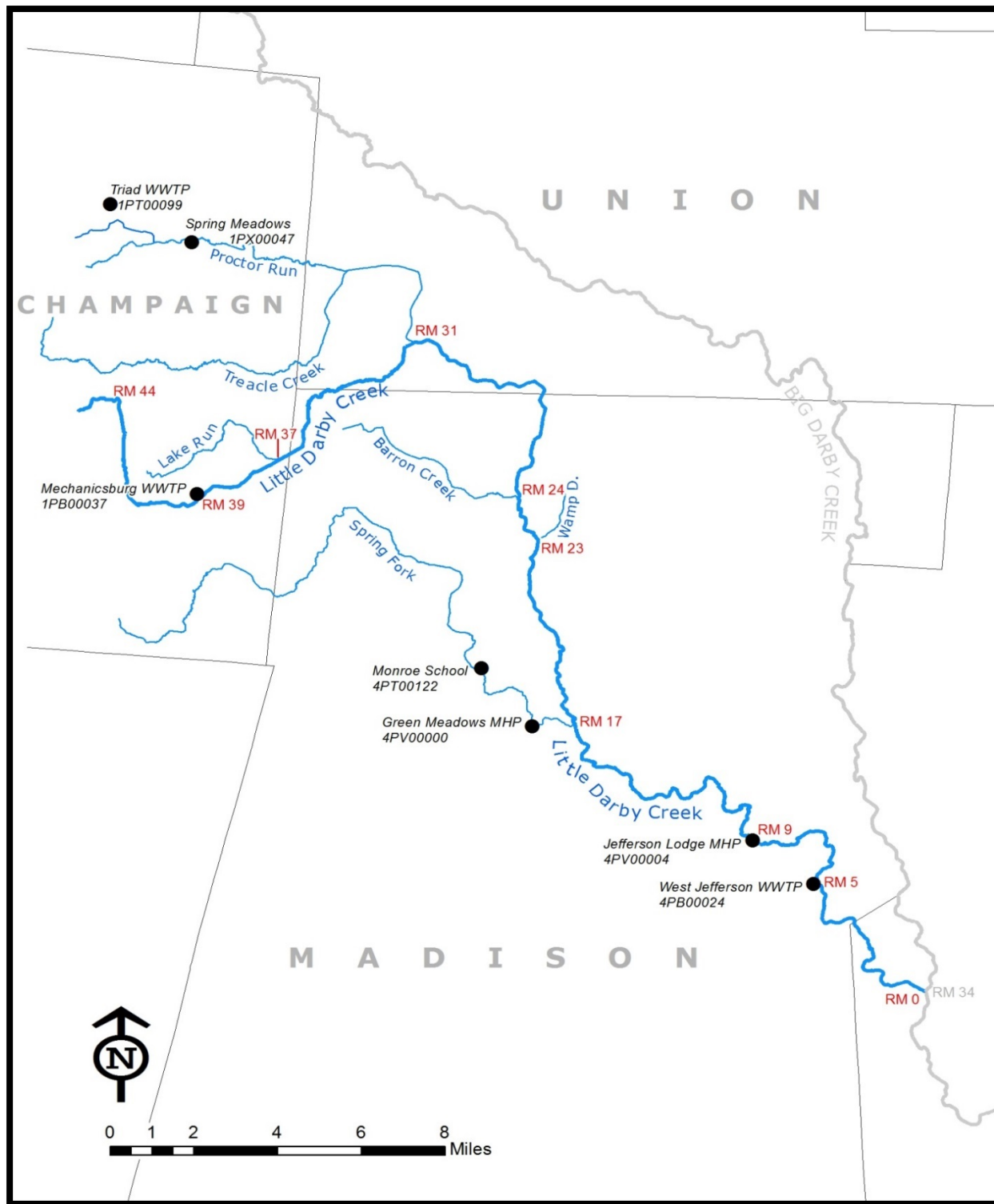


Figure 99. Locations of individual NPDES permitted discharges within Little Darby Creek and tributaries, 2014.

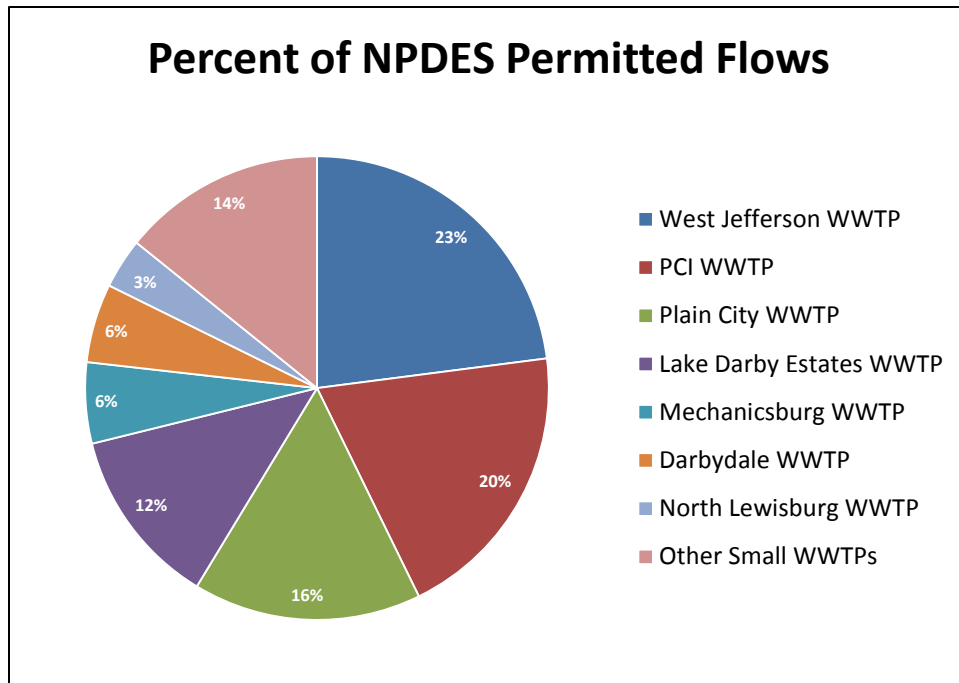


Figure 100. Percentage of permitted flows from NPDES discharges in the Big Darby Creek watershed, 2014. Percentages are based on median values from 2014.

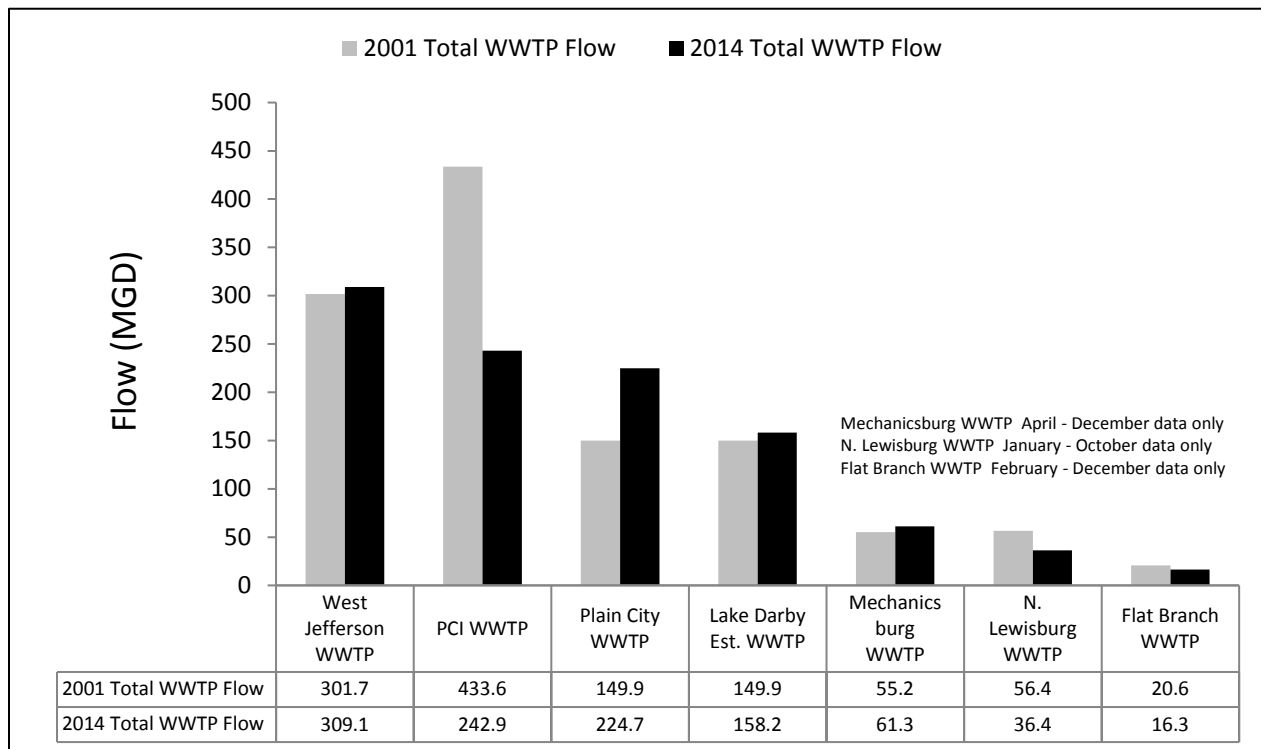


Figure 101. Total flow (MGD) for selected NPDES permitted dischargers in the Big Darby Creek basin, 2001 and 2014.

Table 31. Summary of the effluent quality for selected NPDES permitted facilities in the Big Darby Creek watershed, 2014. "AA" denotes that the specified parameter concentrations were below detection limit.

Facility	Parameter	Number of Measurements	Percentiles 50 TH / 95 th
Flat Branch WWTP 1PP00006 Outfall 001	Flow MGD TSS mg/l Ammonia-N mg/l Total Phosphorus mg/l	365 48 48 13	0.044 / 0.091 AA / AA AA / AA 0.6 / 1.224
Mechanicsburg WWTP 1PB00037 Outfall 001	Flow MGD CBOD mg/l TSS mg/l Nitrate+Nitrite Ammonia-N mg/l Total Phosphorus	365 105 105 12 105 13	0.207 / 0.4858 3 / 7 3 / 5.8 6.3 / 9.145 AA / 0.3 1.01 / 2.766
North Lewisburg WWTP 1PB00039 Outfall 001	Flow MGD CBOD mg/l TSS mg/l Ammonia-N mg/l Nitrate+Nitrite Total Phosphorus mg/l	364 104 50 104 10 28	0.106 / 0.1836 AA / 4.2 5 / 27 AA / 0.711 13.8 / 24.16 0.645 / 2.43
Ranco North America 4IC00008 Outfall 001 Outfall 601	Flow MGD Ammonia-N mg/l Copper ug/l Chromium+6 Dis. ug/l Total Toxic Organics (TTO)	261 53 53 12 4	0.007 / 0.065 AA / AA AA / 11.68 AA / AA AA / AA
Jefferson Lodge MHP 4PV00004 Outfall 001	Flow MGD CBOD mg/l Ammonia-N mg/l Total Phosphorus mg/l	356 47 24 4	0.053 / 0.1148 2.1 / 3.91 0.01 / 2.726 1.36 / 1.821
Plain City WWTP 4PB00016 Outfall 001	Flow MGD CBOD mg/l TSS mg/l Ammonia-N mg/l Nitrate+Nitrite Total Phosphorus mg/l	364 94 95 94 12 24	0.5108 / 1.147 2.35 / 10.15 5.4 / 18.9 AA / 0.6 17.5 / 22.21 0.365 / 0.6055
West Jefferson WWTP 4PB00024 Outfall 001	Flow MGD CBOD mg/l TSS mg/l TDS mg/l Ammonia-N mg/l Nitrate+Nitrite Total Phosphorus mg/l	365 144 144 57 144 12 48	0.75 / 1.451 1.7 / 2.955 3.4 / 6.0 949 / 1044 AA / 0.085 17.5 / 22.75 0.81 / 1.183
Suburbans MHP WWTP 4PR00031	Flow MGD CBOD mg/l TSS mg/l Ammonia-N mg/l Total Phosphorus mg/l	365 48 48 24 4	0.044 / 0.044 5 / 24.8 3 / 13.3 1.5 / 12.86 2.065 / 4.947

Facility	Parameter	Number of Measurements	Percentiles 50 TH / 95 th
Canaan MHP WWTP 4PR00032 Outfall 001	Flow MGD	364	0.042 / 0.113
	CBOD mg/l	48	2.75 / 10.55
	TSS mg/l	48	2.5 / 10.65
	Ammonia-N mg/l	24	0.025 / 0.9625
	Total Phosphorus mg/l	4	3.105 / 3.519
Green Meadows MHP 4PV00000 Outfall 001	Flow mgd	365	0.037 / .1244
	CBOD mg/l	48	2.2 / 3.53
	TSS mg/l	48	1 / 3
	Ammonia-N mg/l	24	0.01 / 0.427
	Total Phosphorus mg/l	24	0.59 / 0.808
Oakhurst Knolls WWTP 4PH00000 Outfall 001	Flow MGD	365	0.024 / 0.0998
	CBOD mg/l	101	3 / 9
	TSS mg/l	101	3 / 10
	Ammonia-N mg/l	28	AA / 0.495
	Nitrate+Nitrite	12	17.05 / 34.38
	Total Phosphorus mg/l	12	1.455 / 2.92
Darbydale WWTP 4PH00012 Outfall 001	Flow MGD	365	0.166 / 0.3164
	CBOD mg/l	101	4 / 9
	TSS mg/l	100	3 / 8
	Ammonia-N mg/l	101	AA / 0.9
	Nitrate+Nitrite	12	20.6 / 31.25
	Total Phosphorus mg/l	14	1.404 / 0.4047
Lake Darby Est. WWTP 4PU00001 Outfall 001	Flow MGD	365	0.408 / 0.6916
	CBOD mg/l	95	2.15 / 4.16
	TSS mg/l	95	1.9 / 4
	TDS mg/l	24	3024 / 3902
	Ammonia-N mg/l	95	0.11 / 0.629
	Nitrate+Nitrite	12	17.35 / 24.66
	Total Phosphorus mg/l	26	0.37 / 1.153
Oak Hills MHP 4PV00008 Outfall 001	Flow MGD	365	0.06567 / 0.1085
	CBOD mg/l	48	1.7 / 32.24
	TSS mg/l	48	7 / 23.25
	Ammonia-N mg/l	26	0.5305 / 19.45
Pleasant Acres MHP 4PV00101 Outfall 001	Flow MGD	365	0.025 / 0.0308
	CBOD mg/l	48	AA / 10.95
	TSS mg/l	48	1 / 6
	Ammonia-N mg/l	24	AA / 13.67
ODRC-PCI 4PP00003 Outfall 001	Flow MGD	365	0.647 / 0.8936
	CBOD mg/l	178	1.1 / 2.16
	TSS mg/l	179	2.8 / 5.93
	TDS mg/l	42	898 / 1076
	Ammonia-N mg/l	160	AA / 1
	Nitrate+Nitrite	12	6.9 / 13.32
	Total Phosphorus mg/l	96	0.485 / 2.248

Ohio Dept. of Rehabilitation and Correction - Pickaway Correctional Institute (PCI) WWTP (Ohio EPA Permit # 4PP00003)

The PCI WWTP, located at 11781 State Route 62, Orient, Ohio, discharges to Big Darby Creek at RM 22.92 in Pickaway County. The PCI has an average design flow of 2.3 MGD. Wet stream processes include screening and grit removal, influent pumping, activated sludge aeration using oxidation ditches, final clarification, ultraviolet disinfection, and post-aeration. The plant has recently added chemical feed for phosphorus removal. Solid stream processes include sludge thickening followed by aerated digestion and beneficial reuse by land application. The PCI WWTP provides service to all parts of the correctional facility, the village of Orient and parts of Pickaway County. The WWTP service area is a 100% separate sanitary sewer system.

Bioassay testing

Ohio EPA effluent toxicity screening conducted in 2010, 2011 and 2015 indicated effluent was not acutely toxic. Whole effluent toxicity testing performed by PCI in accordance with the NPDES permit was below detection for the period 2012-2014.

Compliance summary

A review of DMR data for 2012–2014 revealed numerous total phosphorus violations of both the 7-day and 30-day permit limits. These violations are summarized in Appendix I. Ohio EPA has been working with PCI to meet permit limits for total phosphorus. PCI continues to improve the chemical feed system to lower phosphorus in the effluent.

Pollutant loadings

PCI WWTP annual loadings (kg/day) of selected pollutants are presented in Figure 103. Annual median WWTP flow decreased from 1.3 MGD in 2000 to 0.65 MGD in 2014. Annual flow data are summarized in Figure 102. Improved flow monitoring, infiltration and inflow improvements, and water conservation efforts are responsible for this flow reduction. Most notably, total phosphorus loadings significantly decreased in 2008 and total suspended solids (TSS) loadings have steadily declined since 2000. Nitrate and total dissolved solids (TDS) mostly remained steady over the past several years.

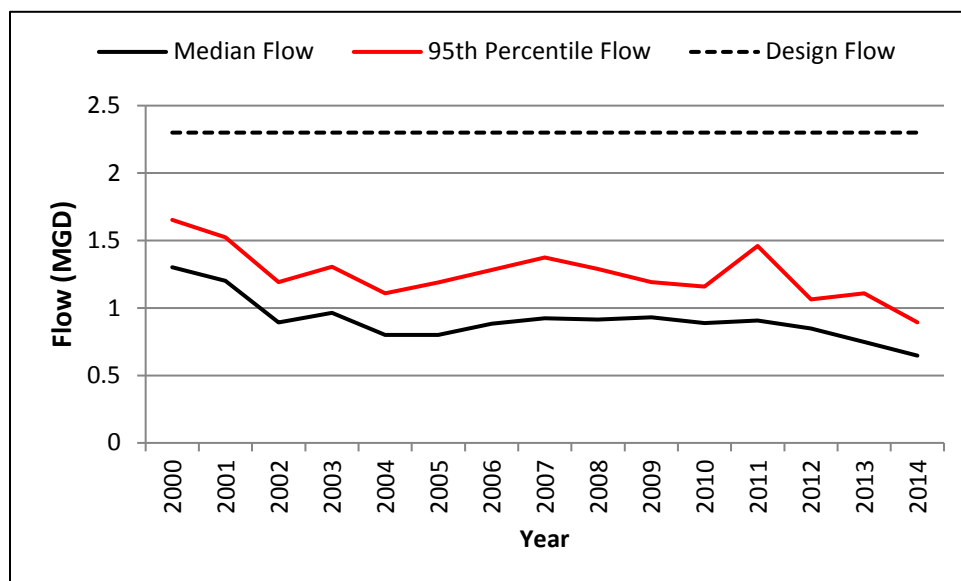


Figure 102. Annual 50th and 95th percentile flow values for the PCI WWTP, 2000-2014.

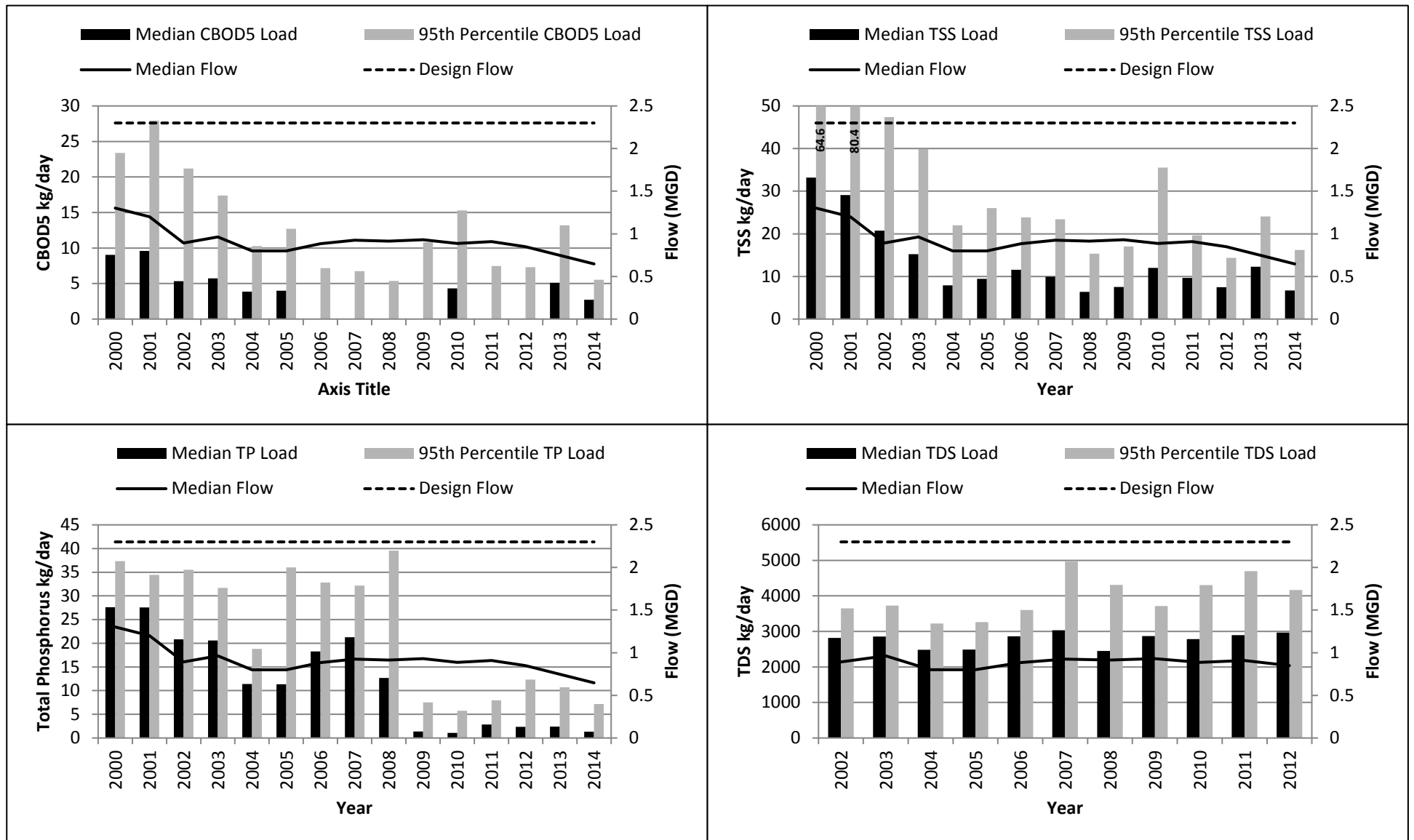


Figure 103a. Annual loading data from the PCI WWTP for selected parameters, 2000-2014.

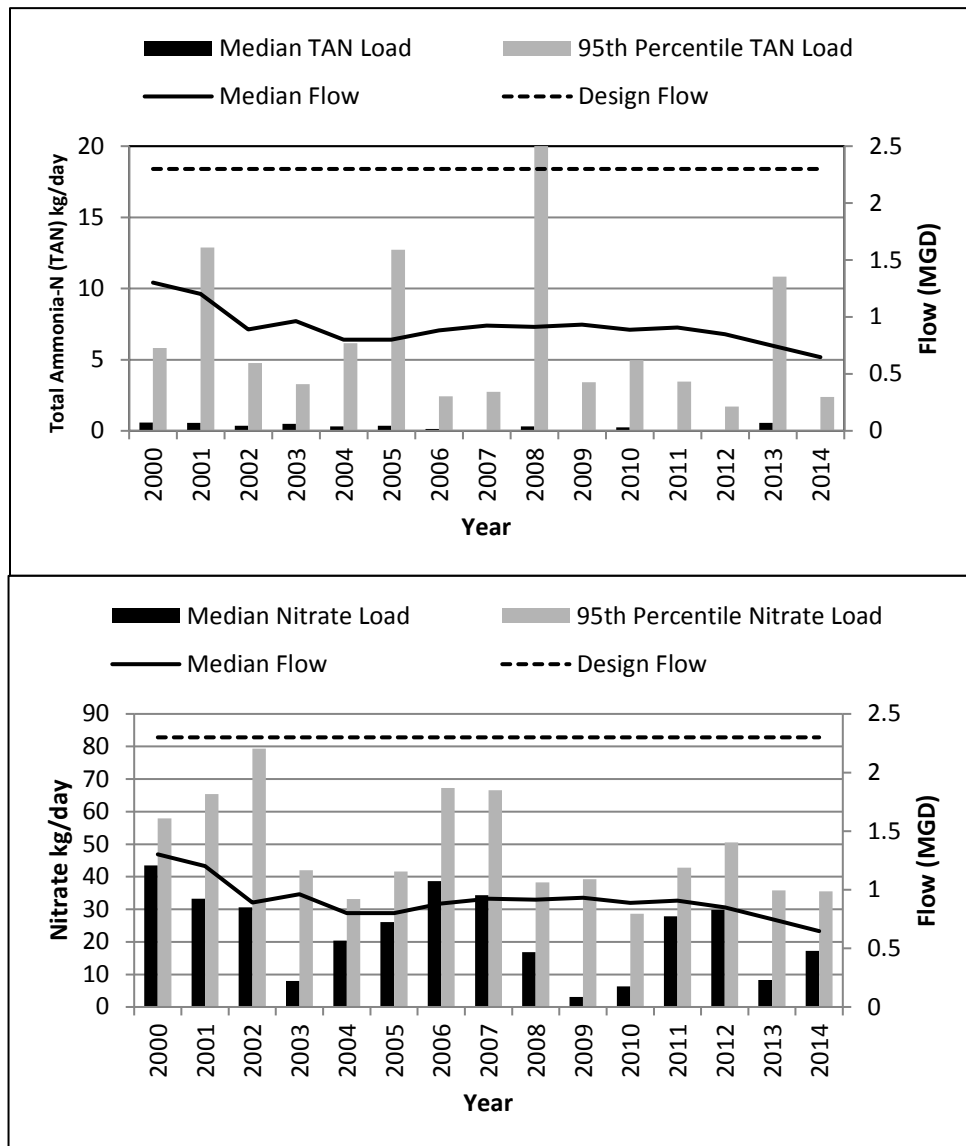


Figure 103b. Annual loading data from the PCI WWTP for selected parameters, 2000-2014.

West Jefferson WWTP (Ohio EPA Permit # 4PB00024)

The West Jefferson WWTP, located at 450 Cemetery Road, West Jefferson, Ohio, discharges to Little Darby Creek at RM 5.25 in Madison County. West Jefferson has a design flow of 1.20 MGD but is not yet considered a “major” NPDES facility; this facility has a sustained flow (reported DMR flow data) of less than 1 MGD and is, thus, still considered a minor discharger. Treatment units include flow equalization, two oval oxidation ditches, two secondary clarifiers, chlorine disinfection, chemical feed to reduce total phosphorus, and cascade post-aeration. Solids handling includes aerated digestion with land application of biosolids. The WWTP serves a 100% separate sanitary sewer system.

Compliance summary

West Jefferson has generally been in compliance with permit limits. Five violations were recorded for total phosphorus (30-day limit) in 2012 and 2014. These violations occurred while fine tuning their chemical feed system and this facility is back in compliance with permit limits. These violations are summarized in Appendix I.

Pollutant loadings

West Jefferson WWTP annual loadings (kg/day) of selected pollutants are presented in Figure 105. Annual flow for West Jefferson has remained steady over the past ten years with a median flow of 0.75 MGD in 2014 (Figure 104). Annual median total phosphorus loadings have declined sharply since 2012 with improved phosphorus treatment. Median nitrate loads have more than doubled from 20.54 kg/day in 2003 to 49.92 kg/day in 2014.

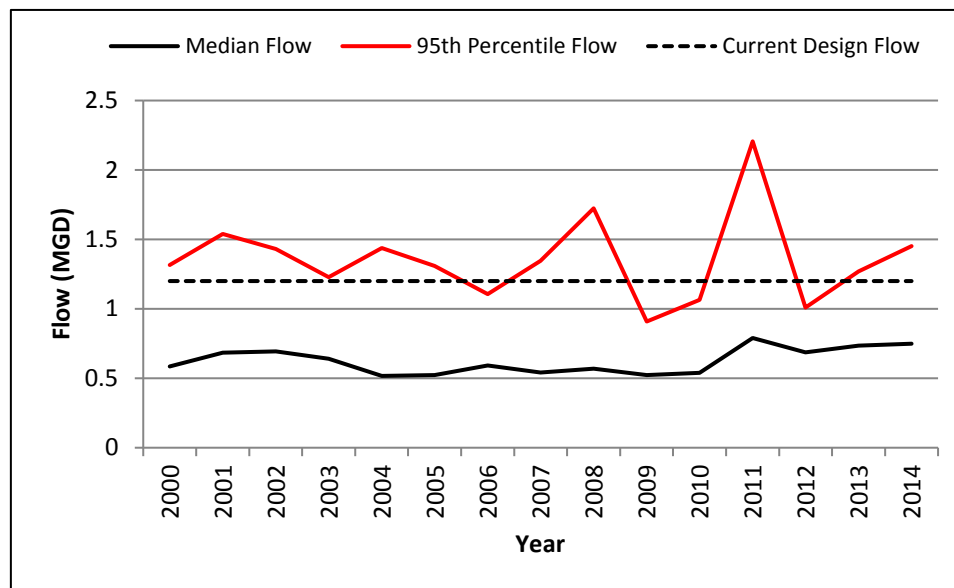


Figure 104. Annual 50th and 95th percentile flow values for the West Jefferson WWTP, 2000-2014.

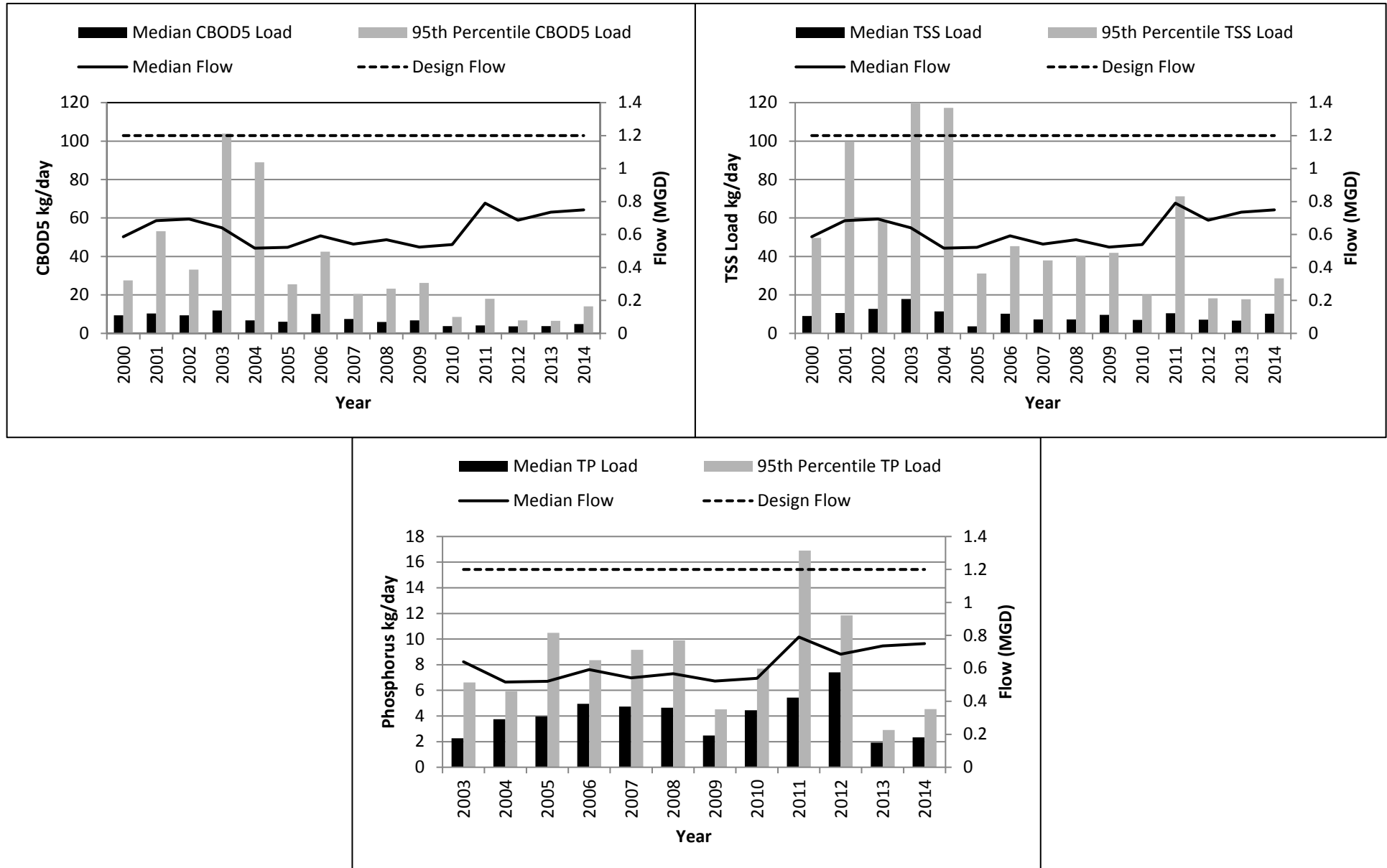


Figure 105a. Annual loading data from the West Jefferson WWTP for selected parameters, 2000-2014.

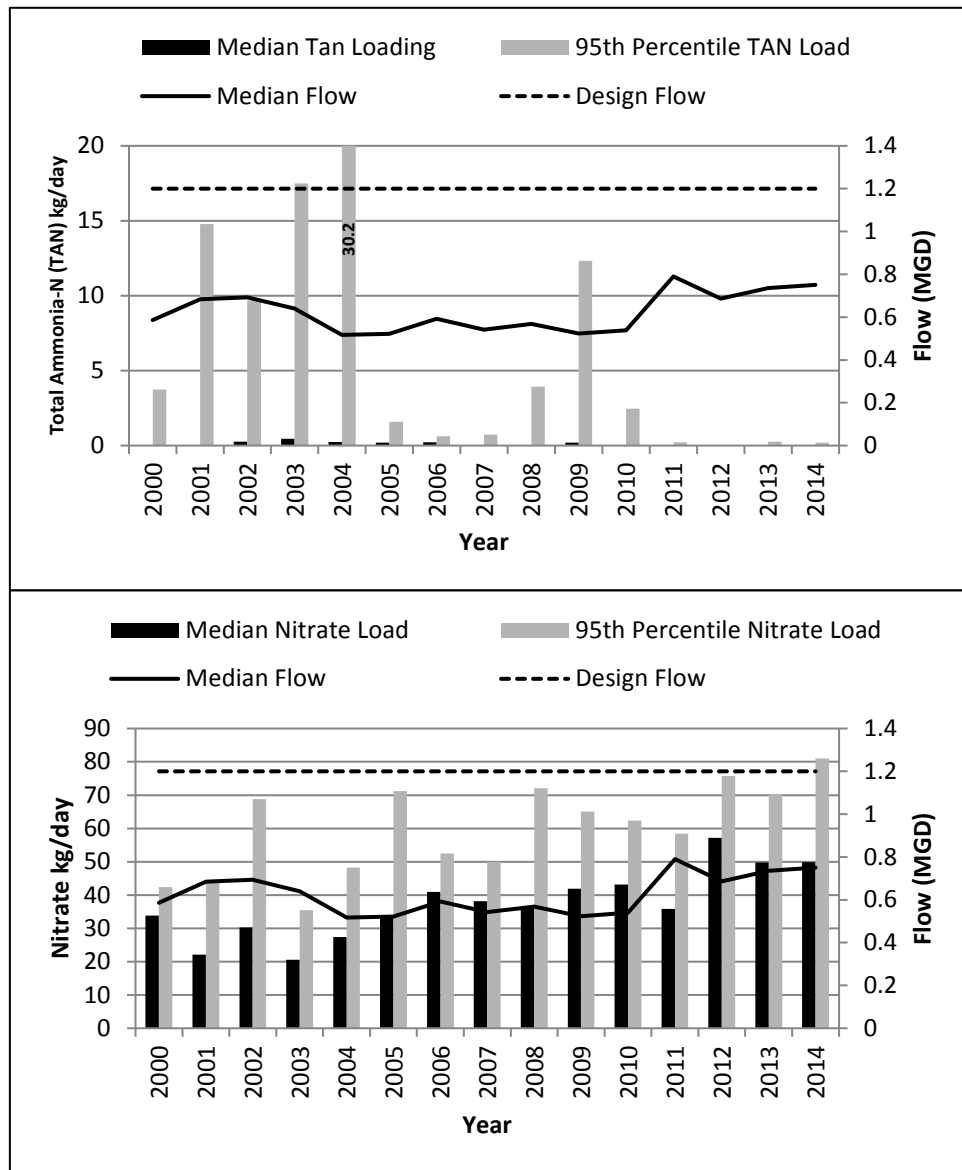


Figure 105b. Annual loading data from the West Jefferson WWTP for selected parameters, 2000-2014.

Plain City WWTP (Ohio EPA Permit # 4PB00016)

The Plain City WWTP is located at 225 Central Avenue, Plain City, Ohio, and discharges into Big Darby Creek at RM 52.1 in northern Madison County. Plain City WWTP has a design flow of 0.75 MGD. After screen/grit removal, Plain City WWTP has two treatment trains using oxidation ditch technology. The older unit utilizes two race track oxidation ditches with rotors followed by two small clarifiers. The newer train is an orbital oxidation ditch with rotors and a single clarifier. Ultraviolet disinfection follows clarification with chemical feed addition to reduce total phosphorus. A cascade post-aeration system is utilized prior to effluent discharge to Big Darby Creek. Solids are managed through aerated digesters with land application. The WWTP serves a 100% separate sanitary sewer system.

Compliance summary

According to 2012-2014 DMR data, Plain City WWTP has experienced numerous total suspended solids (TSS) violations. Included are violations recorded in May and July 2014 for both 7-day and 30-day TSS limits. Also, in May 2014, four CBOD⁵ violations were recorded. The facility has been listed in significant non-compliance (SNC) during this period for total suspended solids violations. These violations are summarized in Appendix I.

Pollutant loadings

Plain City WWTP annual loadings (kg/day) of selected pollutants are presented in Figure 107. Median annual WWTP flows have increased steadily from 2000 (0.26 MGD) to 2014 (0.51 MGD) (Figure 106). Notably, median annual nitrate loads have significantly increased from a low of 2.35 kg/day in 2005 to 31.76 kg/day in 2014, which likely reflected more efficient nitrification of ammonia (Figure 107). Total phosphorus loads have been declining since 2007 from 3.94 kg/day to 0.8 kg/day in 2014; a chemical feed system was placed into service in August 2012 and is likely responsible for reduced total phosphorus loadings. CBOD⁵ median annual loads have remained steady from 2000-2014.

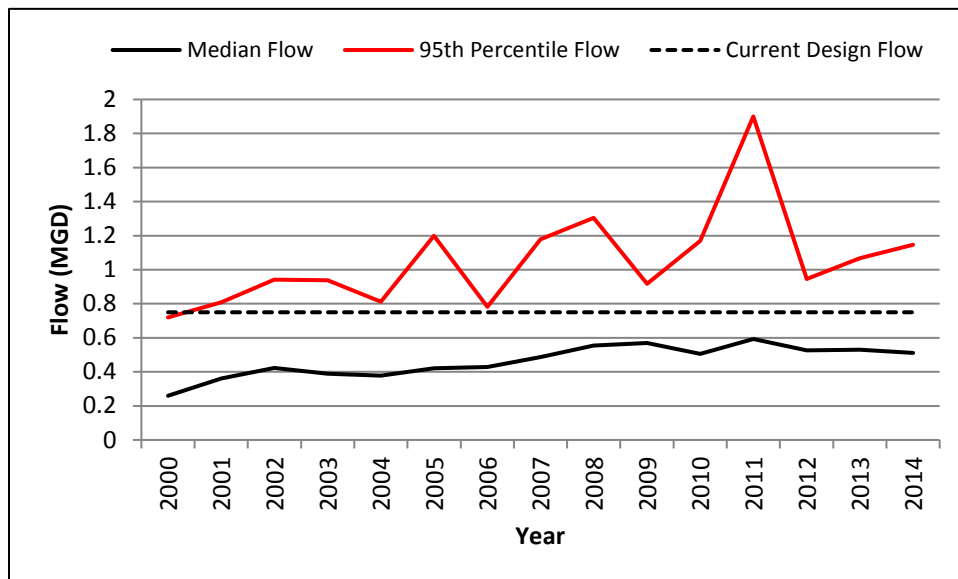


Figure 106. Annual 50th and 95th percentile flow values for the Plain City WWTP, 2000-2014.

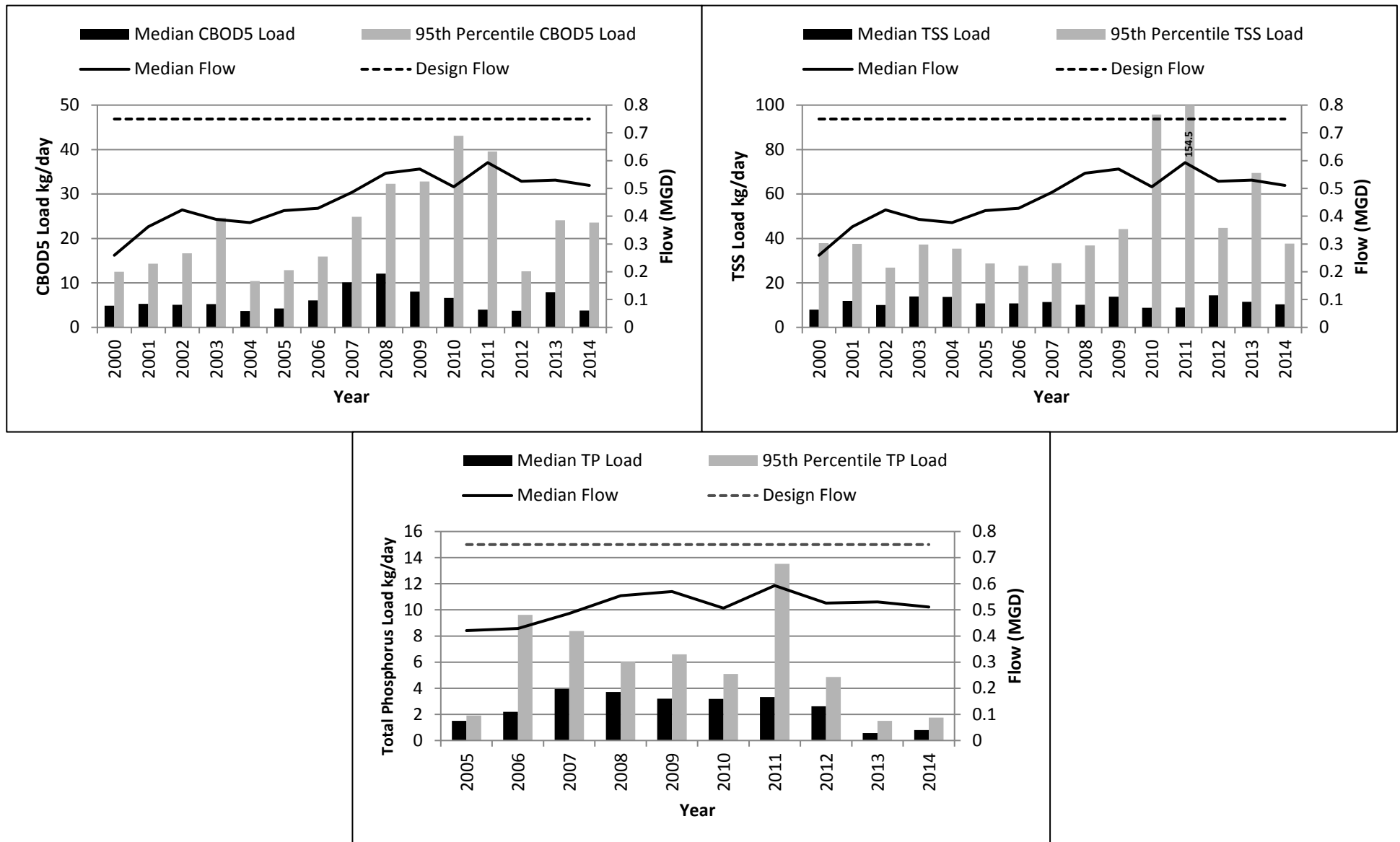


Figure 107a. Annual loading data from the Plain City WWTP for selected parameters, 2000-2014.

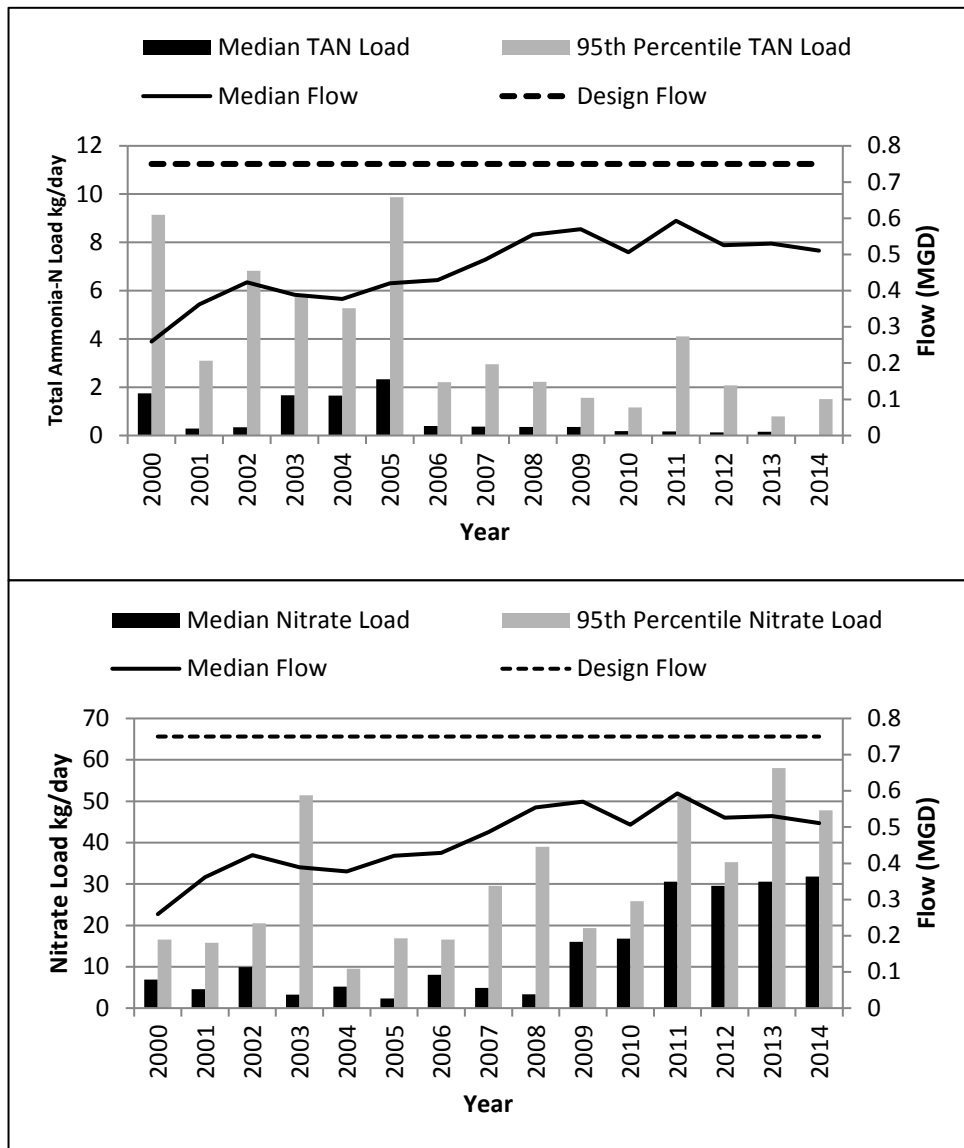


Figure 107b. Annual loading data from the Plain City WWTP for selected parameters, 2000-2014.

Darbydale WWTP (Ohio EPA Permit # 4PH00012)

The Darbydale WWTP is a newer facility placed on-line in 2005 serving the villages of Darbydale and Harrisburg as well as the Timberlake subdivision. The facility is located at 6262 London-Groveport Road, Grove City, Ohio, in western Franklin County and discharges to an unnamed tributary to Big Darby Creek at RM 27.93. Main treatment units include screening/grit removal, vertical loop reactor for biological treatment, secondary clarification, chemical feed for phosphorus removal, ultraviolet disinfection, and cascade post-aeration. Sludge is removed to a holding tank and sent to another NPDES WWTP (city of Columbus) for further use. The average design flow for the facility is currently 0.30 MGD. Recently, Ohio EPA has received and approved an NPDES permit modification to increase the ADDF of this WWTP; the upgrades will also allow this plant to accept from several smaller mobile home parks. More information about the Darbydale WWTP upgrades can be found at the following [link](#). The WWTP serves a 100% separate sanitary sewer system.

Compliance summary

Darbydale WWTP has experienced minor effluent violations for the period 2012-2014. During the Ohio EPA study in 2014, the plant had two dissolved oxygen violations (daily) and one total phosphorus (7-day) violation. Violations are summarized in Appendix I.

Pollutant loadings

The 2014 median annual flow for the Darbydale WWTP was reported at 0.17 MGD (Figure 108). Median annual nitrate loading from the plant has risen steadily since 2005 to its current level of 14.4 kg/day. Total phosphorus loads from the WWTP dropped significantly (close to 50%) in 2013 and 2014 from previously reported years; a chemical feed system was installed during the winter of 2012 and is likely responsible for decreases in reported total phosphorus loadings. Annual loadings (kg/day) are presented in Figure 109.

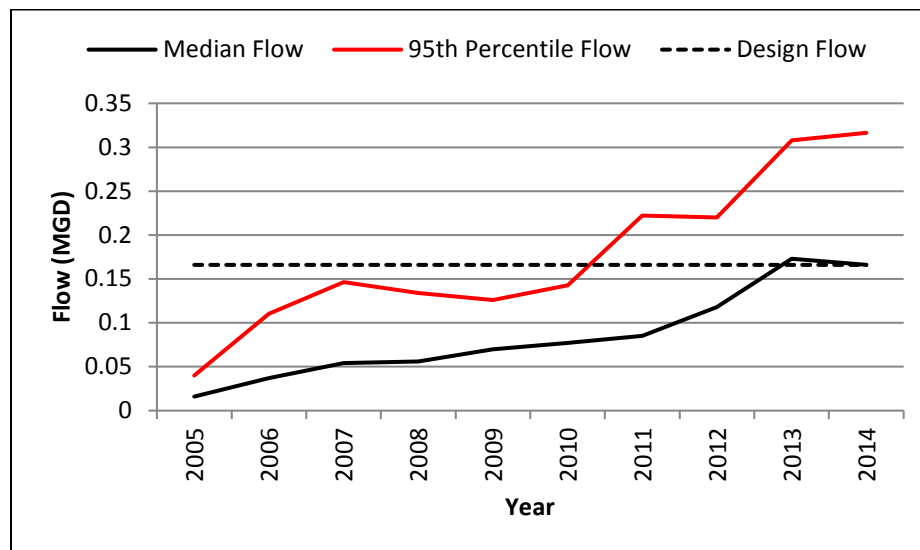


Figure 108. Annual 50th and 95th percentile flow values for the Darbydale WWTP, 2000-2014.

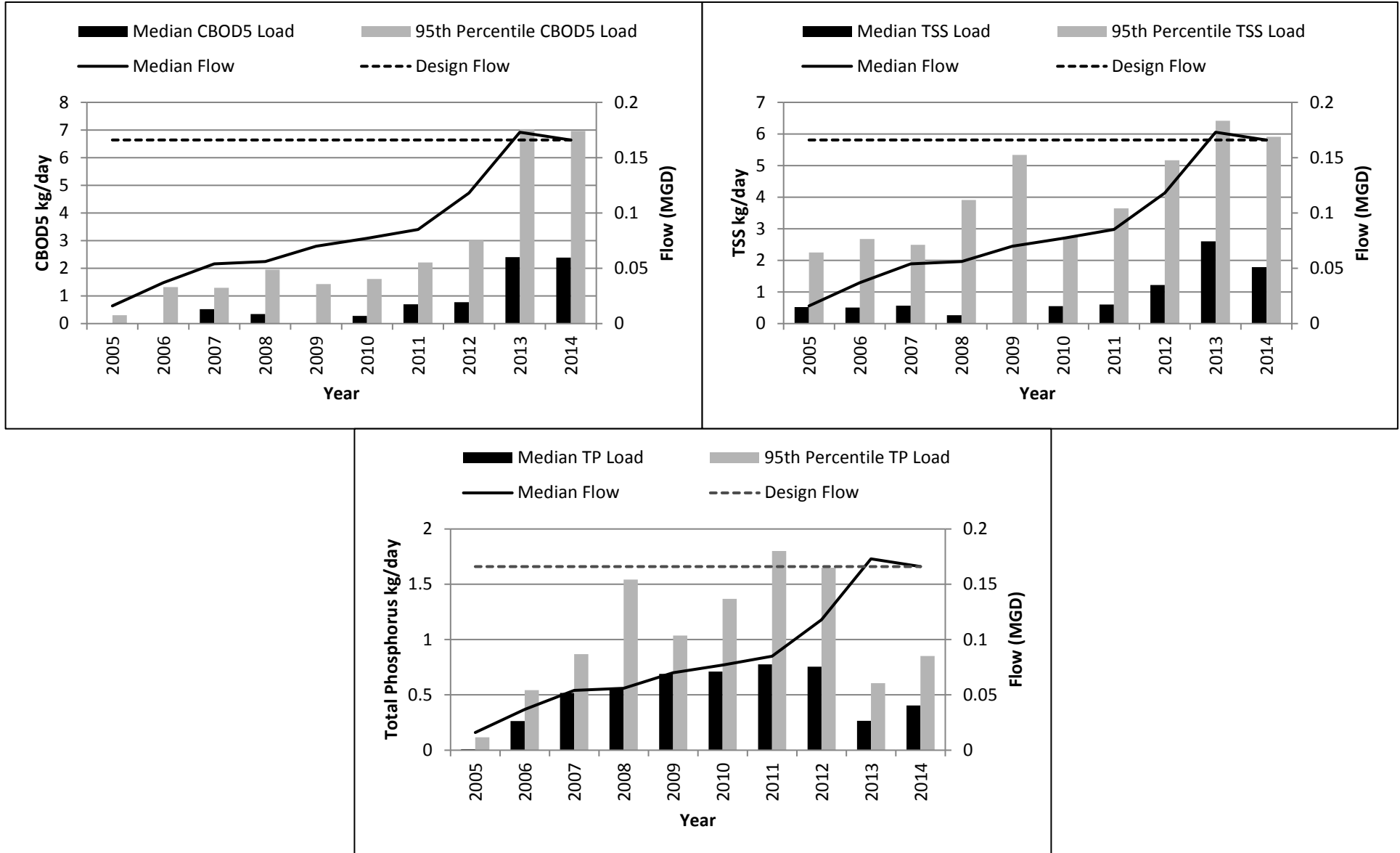


Figure 109a. Annual loading data from the Darbydale WWTP for selected parameters, 2005-2014.

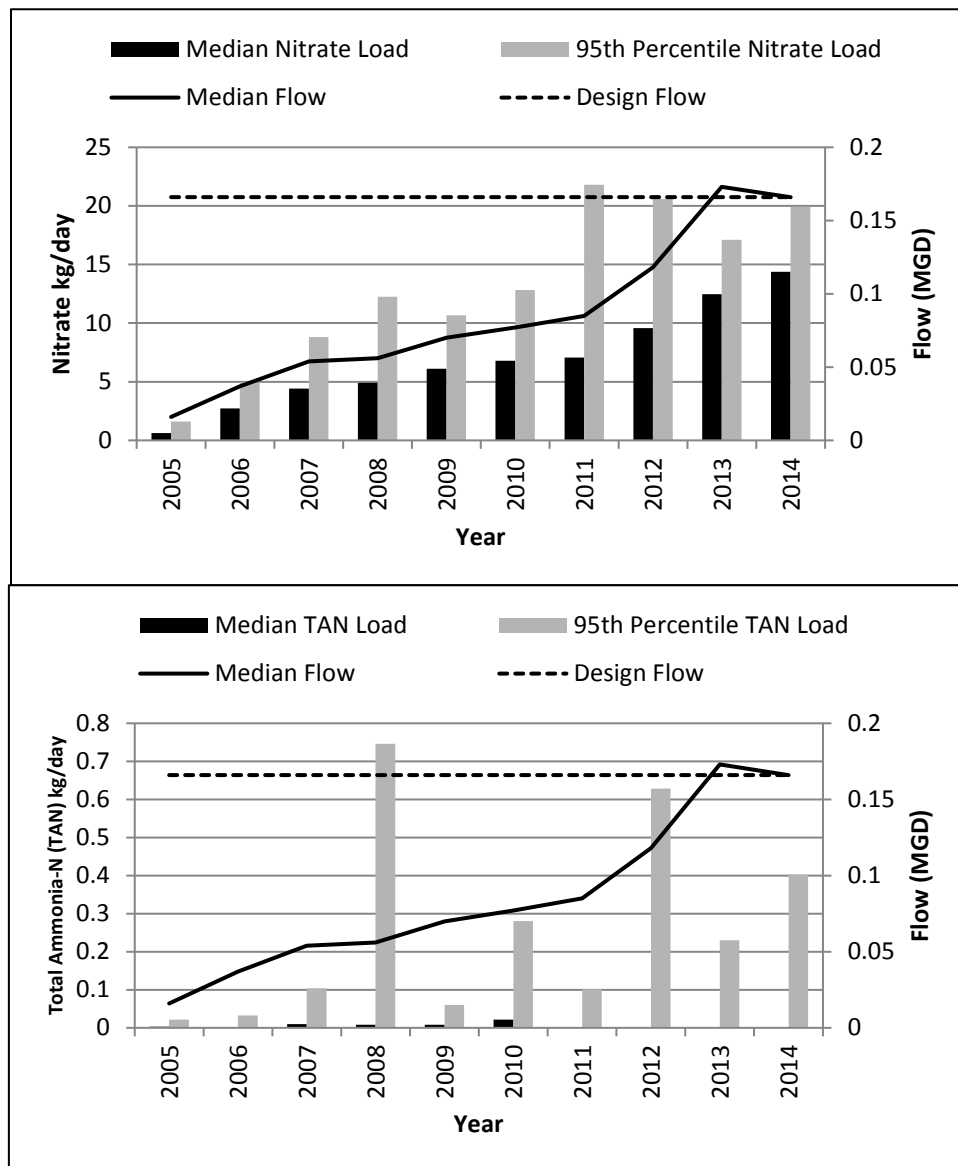


Figure 109b. Annual loading data from the Darbydale WWTP for selected parameters, 2005-2014.

Lake Darby Estates WWTP (Ohio EPA Permit # 4PU00001)

The Lake Darby Estates WWTP is located at 589 Hubbard Road, Galloway, Ohio, and discharges to Big Darby Creek at RM 39.75 in western Franklin County. The WWTP design flow is 0.5 MGD and is a 100% separate sanitary collection system. The treatment system includes two activated sludge aeration tanks with two secondary clarifiers followed by chlorine disinfection, chemical feed to reduce total phosphorus, and cascade post-aeration. Sludge is treated through two aerated sludge digesters with landfill disposal of biosolids.

Compliance summary

Lake Darby Estates reported discharge limit violations (CBOD⁵) in 2012. No limit violations were reported in 2013 or 2014. Overall, the facility has been in compliance with permit limits. Violations are summarized in Appendix I.

Pollutant loadings

Lake Darby Estates WWTP annual loadings (kg/day) of selected pollutants are presented in Figure 111. Effluent flow from Lake Darby Estates WWTP has remained relatively level with the median annual flow averaging about 0.37 MGD (Figure 110). Nitrate and TSS median annual loads have fluctuated for the 2000-2014 period. In 2014, total phosphorus loads were significantly reduced from previous years. For example, the median annual load for 2014 was 0.51 kg/day compared to 2.27 kg/day reported in 2013.

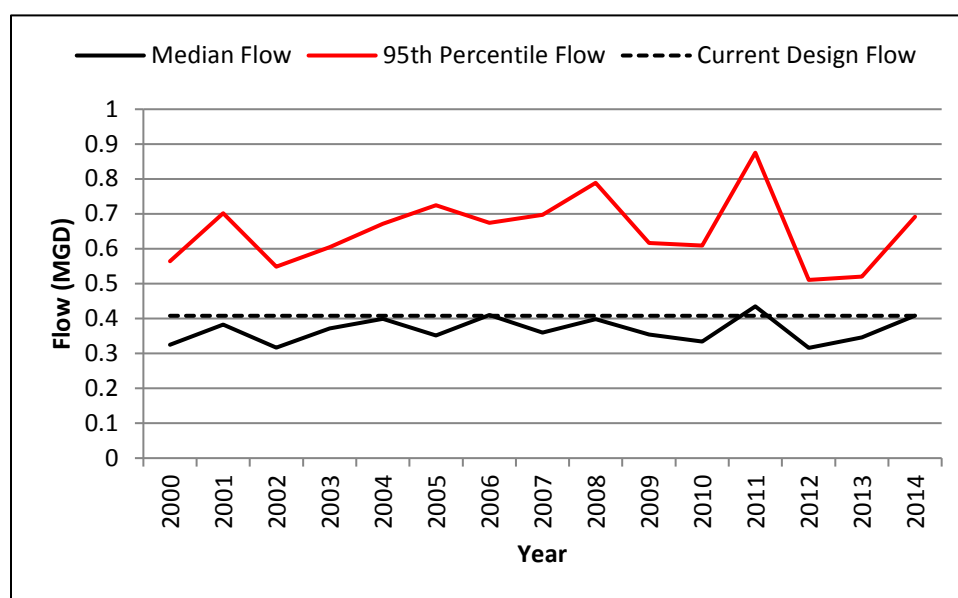


Figure 110. Annual 50th and 95th percentile flow values for the Lake Darby Estates WWTP, 2000-2014.

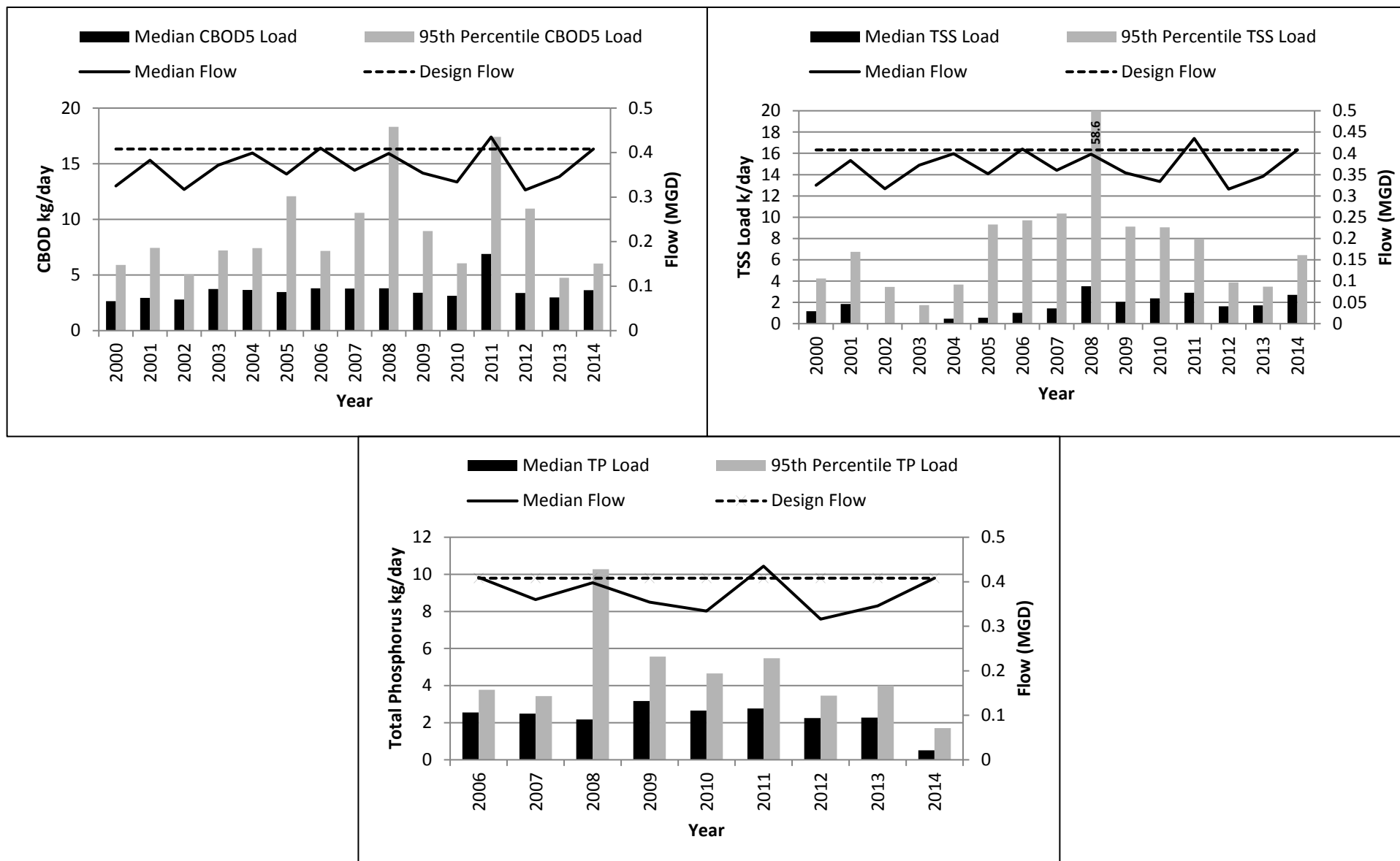


Figure 111a. Annual loading data from the Lake Darby Estates WWTP for selected parameters, 2000-2014.

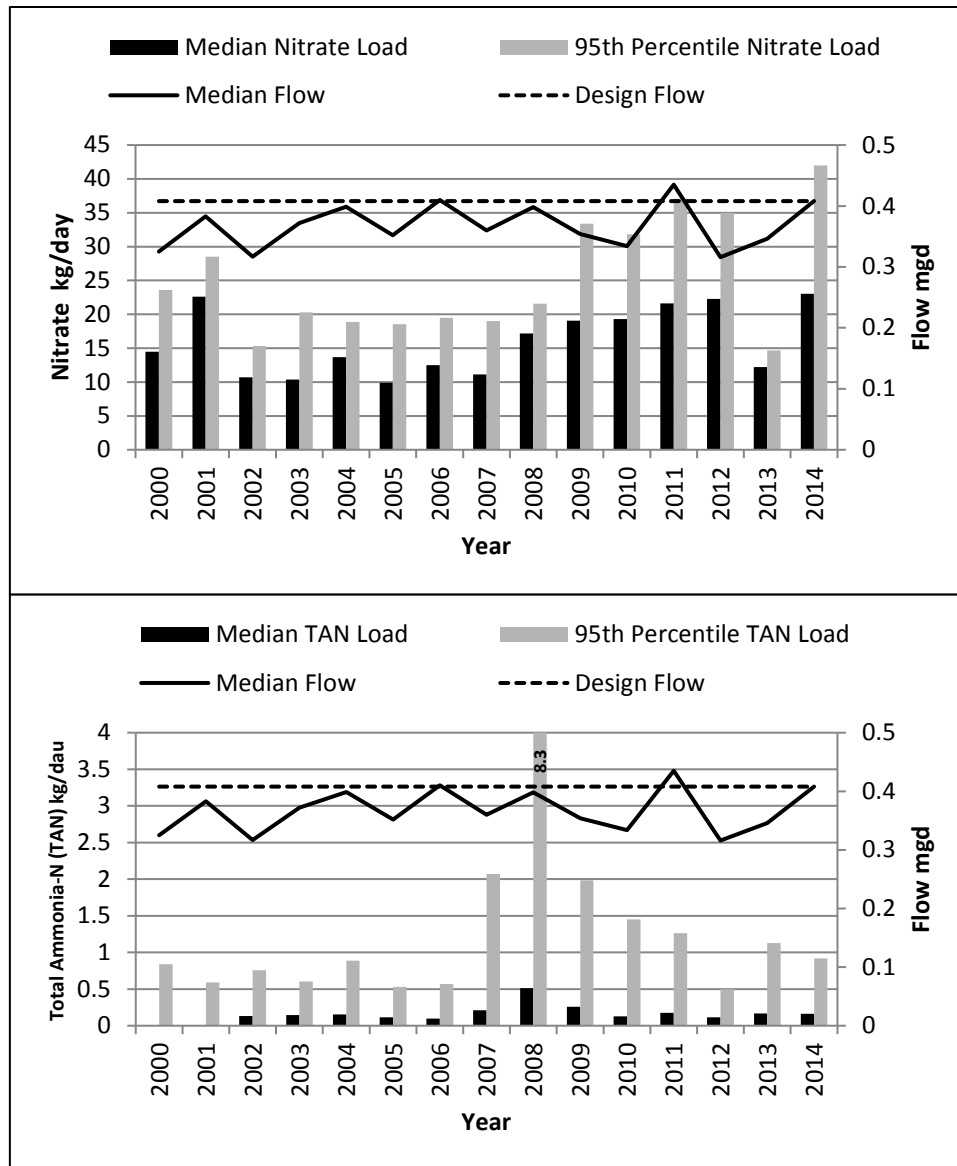


Figure 111b. Annual loading data from the Lake Darby Estates WWTP for selected parameters, 2000-2014.

Honda of America (Ohio EPA Permit # 1IW0027)

The Honda of America Manufacturing operates the automobile assembly facility known as the East Liberty Auto Plant located at 11000 State Route 347, east of the village of East Liberty, Ohio. This facility has a permitted discharge consisting of storm water and process water generated from the onsite treatment of ground water. The treated ground water is utilized for potable water in the plant and manufacturing. Generated site storm water is collected in a dedicated collection system that flows to an onsite storm water detention basin that ultimately discharges through the facility's primary outfall (Station 003) to an unnamed tributary of Flat Branch. Lime softening, sand filtration, pH adjustment via carbon dioxide, and chlorination are utilized in the treatment of ground water to produce potable water. Used lime (lime sludge) is discharged into a sedimentation pond complex for settling. Backwash from the sand filters and lime sedimentation pond(s) discharges flow thru permitted Station 602, prior to discharge thru Station 003. This facility has been in compliance with permit limits.

Triad Local (Ohio EPA Permit 1PT00099)

The Triad Local School is located at 7920 Brush Lake Rd., North Lewisburg, Ohio, in Champaign County. The WWTP has an average daily design flow of 20,000 GPD and serves the Triad Local Elementary School (1145 students). The WWTP has a trash trap, equalization, aeration, secondary clarification, sand filters, chlorination, de-chlorination, and a sludge holding tank. Effluent is discharged to an unnamed tributary of Brush Lake, then Proctor Run. Sludge is hauled to another POTW. Triad was last inspected in October of 2016 and there have been no recent effluent violations.

Flat Branch WWTP (Ohio EPA Permit 1PP00006)

The Flat Branch WWTP is located at 11046 Township Rd. 157 in East Liberty, Ohio. The WWTP serves a population of 750 in Perry Township, Logan County. The WWTP consists of an influent pump station, bar screen, equalization, aeration, secondary clarification, lamella polishing clarification, ultraviolet disinfection, and post-aeration with the discharge to Big Darby Creek. The average daily design flow is 0.1 MGD. Sludge can be disposed by either sanitary landfill or hauling to another publicly owned treatment works (POTW). Flat Branch's previous NPDES permit (1PP00006*GD) had a compliance schedule for evaluating its ability to comply with its new final effluent limit for low level mercury (12 µg /l).

Numerous numerical violations have been reported since 4/15/2011 and some code violations have been reported since 2011 as well. However, the performance of this WWTP improved substantially since the last survey and the number of overall violations decreased dramatically since the early 2000s (Figure 112 and Figure 113). Flat Branch's current NPDES permit (1PP00006*HD) had a compliance schedule for meeting its new final effluent limit for total phosphorus (1.0 mg/l) by 11/1/2014. An inspection was conducted at the facility in February 2016, and the facility was notified of several effluent violations, including phosphorus. The facility has since responded to address the reasons for the violations, as well as preventative measures in place going forward. The facility was issued a resolution of violation in May 2016. Annual loading data for selected parameters are displayed in Figure 113.

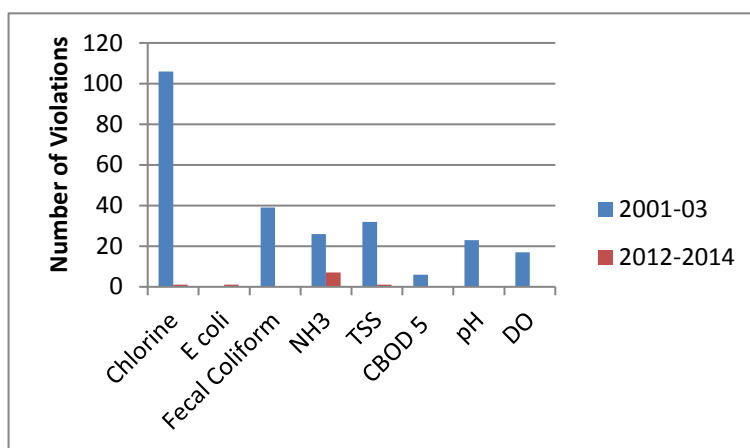


Figure 112. Aggregated number of all NPDES permit violations from the Flat Branch WWTP for the indicated time periods.

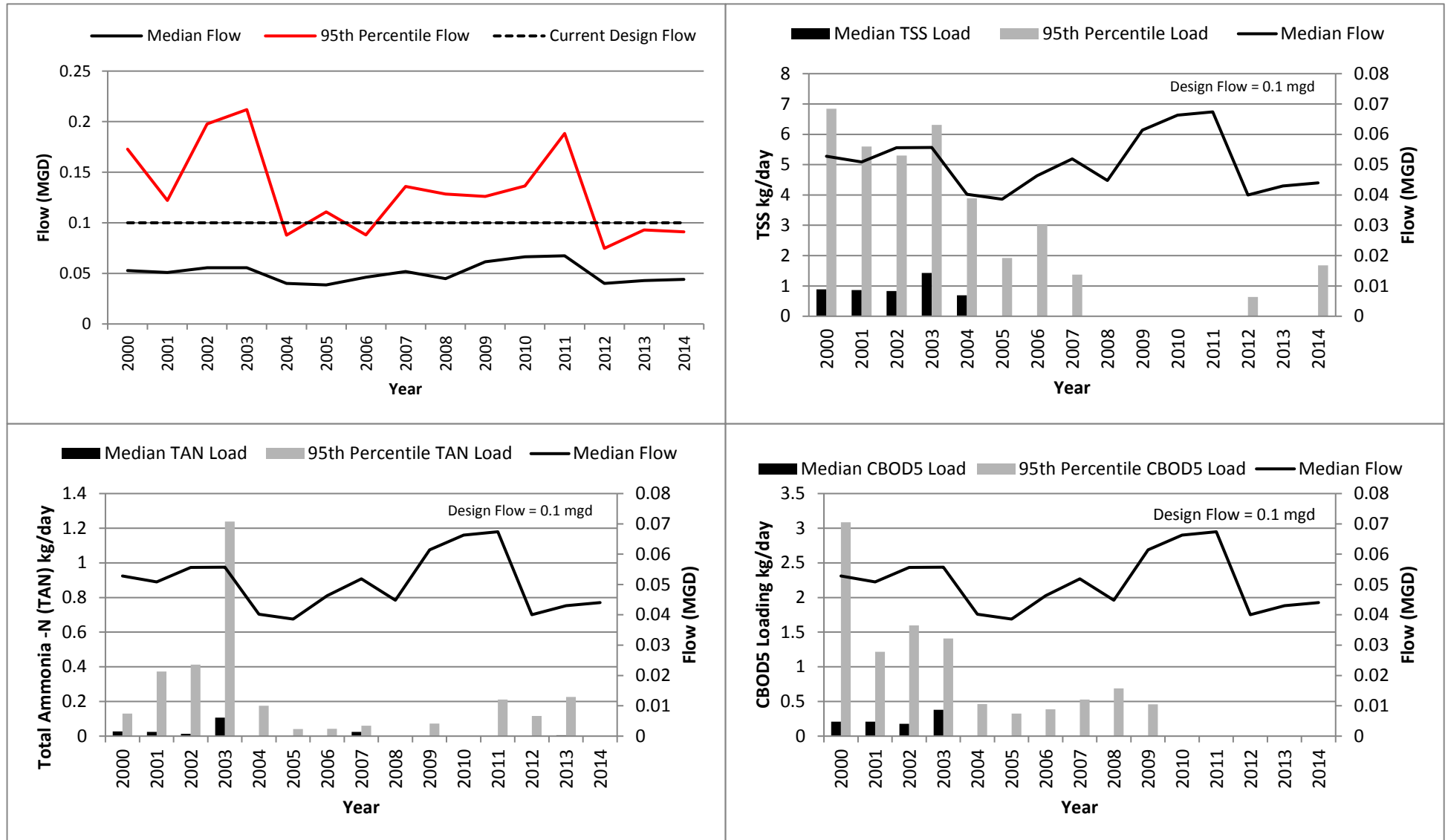


Figure 113. Annual loading data from the Flat Branch WWTP for selected parameters, 2000-2014.

Mechanicsburg WWTP (Ohio EPA Permit # 1PB00037)

The Mechanicsburg WWTP is located on Mill Street in the village of Mechanicsburg, Ohio, and discharges to Little Darby Creek at RM 39.27. The population of Mechanicsburg is about 1,800 persons. Current permit limits are based on a WWTP current design flow of 0.23 MGD.

Sanitary waste generated in the Village is collected and conveyed via a dedicated sanitary collection system that is impacted by inflow and infiltration (I&I). In 2013, rehabilitation of an existing sewer main and manholes occurred over about 85% of the collection system. Over 22,000 linear feet of sewer pipe was installed, providing a reduction (estimated at 50 to 60%) of clean water into the sanitary system. Private sanitary laterals were generally not included in this effort.

Treatment of wastewater is provided by mechanical fine screens, extended aeration and clarification in a dual compartment sequencing batch reactor (SBR), alum addition, tertiary disk filtration, disinfection via chlorination/de-chlorination, and post-aeration. Flow equalization is provided by the former wastewater lagoon system. Sludge is processed through aerobic digestion and disposed in a sanitary landfill. The most recent upgrade commenced in 2014 and included two tertiary disk filters, automated alum feed system, and a Supervisory Control and Data Acquisition (SCADA) system. In late 2015, the disk filters and alum feed system were placed in service. Since early 2016, the facility has been manually adding alum in place of the chemical feed system while the system is being optimized.

For the period 2012-2014, the Mechanicsburg WWTP experienced numerous effluent violations. Most notably were violations for total phosphorus and total suspended solids (TSS). The facility was placed in significant non-compliance (SNC) during this period. The recent plant upgrade has largely helped address the non-compliance. An inspection was conducted in early 2016 and the facility was notified of their ongoing total phosphorus and TSS violations. Since the inspection and introduction of the protocol for manual alum addition, the facility has been removed from the SNC list and all TSS and TP violations have ceased. A complete list of NPDES violations can be found in Appendix I.

Since 2003, the WWTP flow has remained under the plant design flow of 0.23 MGD. For 2014, the median annual flow was reported as 0.207 MGD (Figure 114). Since 2004, median annual total phosphorous loads have remained under 1 kg/day. The highest reported load for total phosphorus for the period 2000-2014 was 2.8 kg/day in 2003. Since 2007, both median and 95th percentile annual nitrate loading has risen steadily. Annual loadings (kg/day) for these and other pollutants are presented in Figure 114 and Figure 115.

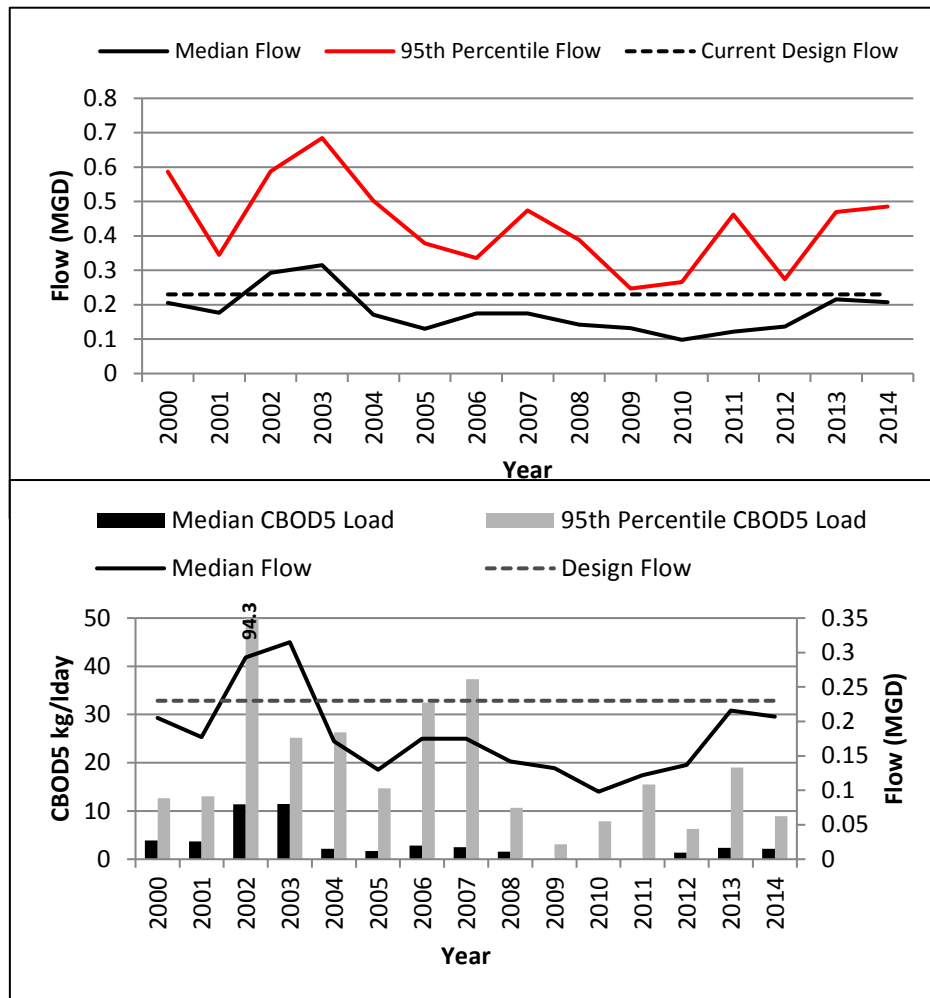


Figure 114. Annual 50th and 95th percentile flow values (top) and CBOD⁵ loadings data (bottom) for the Mechanicsburg WWTP, 2000-2014

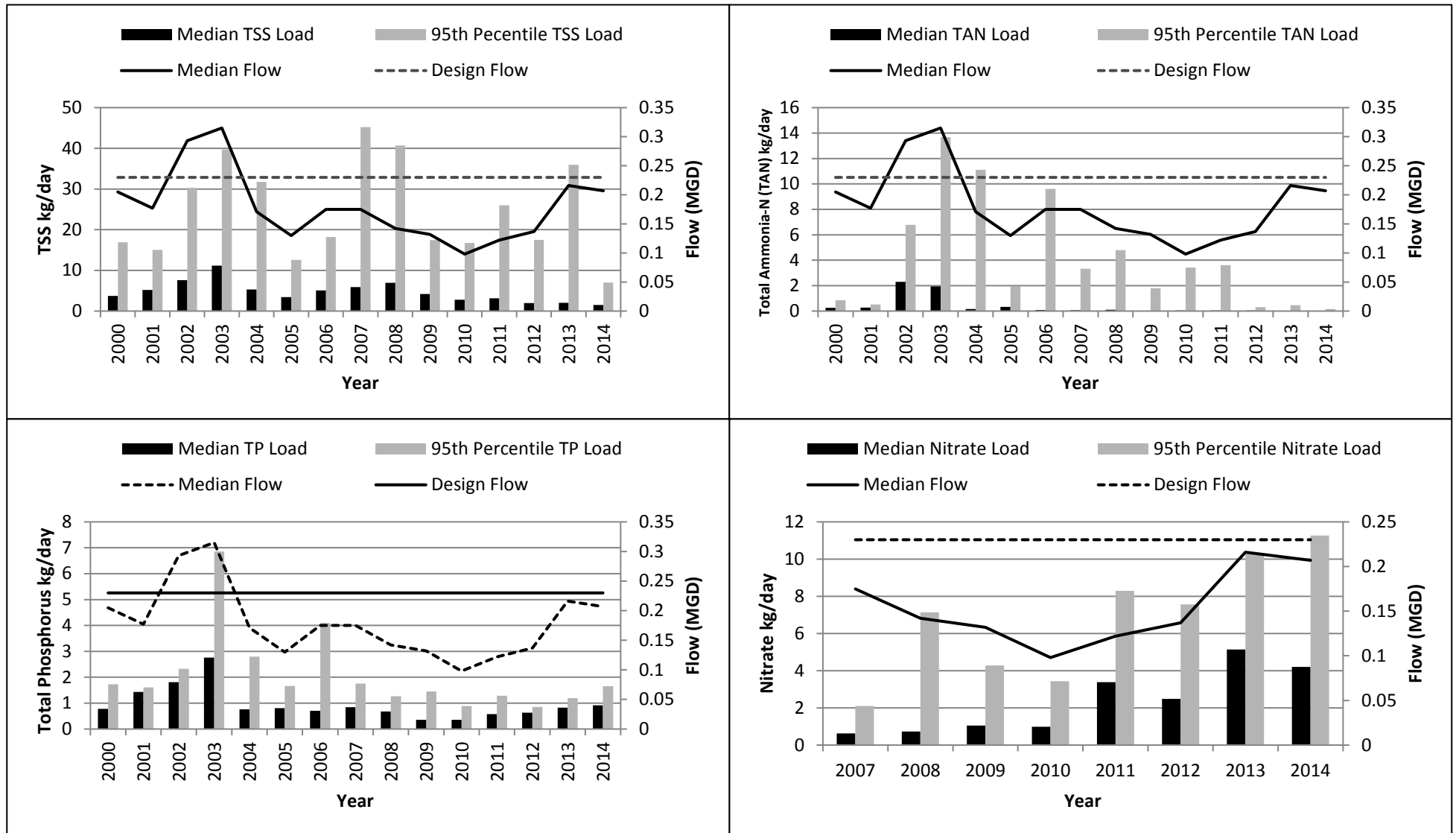


Figure 115. Annual loading data from the Mechanicsburg WWTP for selected parameters, 2000-2014.

Spring Meadows Care Center (Ohio EPA Permit # 1PX00047)

Spring Meadows Care Center provides physical rehabilitative services, and short term and long term health care needs. The facility has the ability to provide 42 beds for individual care purposes. The facility is located in northeastern Champaign County at 1649 Park Road, Woodstock, Ohio. Generated wastewater from this facility flows through a dedicated sanitary collection system that then flows to a permitted extended aeration package-type wastewater treatment plant. The treatment train for this facility consists of a trash tank, extended aeration, clarification, slow surface sand filters, and ultraviolet disinfection. Treated effluent discharges to a storm sewer which conveys water to Proctor Run. There have been no recent permit limit violations at this facility.

North Lewisburg WWTP (Ohio EPA permit 1PB00039)

The North Lewisburg WWTP is located at 9984 State Route 245 in North Lewisburg, Champaign County, Ohio. The WWTP serves 2,150 people in the villages of North Lewisburg and Woodstock. The average daily design flow for this plant is 0.42 MGD. Treatment consists of influent pumping, bar screen, grit removal, conventional activated sludge, pre-aeration, membrane bioreactor, post-aeration, and ultraviolet disinfection. Effluent is discharged to Spain Creek at RM 1.5. Sludge can be land applied or, as is more recently the case, hauled to a sanitary landfill.

Since the inspection on September 3, 2014, the WWTP had numerous violations and is currently in SNC. In 2014, the North Lewisburg WWTP experienced 20 total phosphorous violations. Other violations reported for the 2012-2014 period included D.O. and TSS. The latest inspection conducted on April 13, 2016 resulted in additional violations regarding operation and maintenance of the plant. In addition, the facility remains in SNC for effluent violations of phosphorus, ammonia, and *E. coli*. Interaction between Ohio EPA and the facility continues in efforts to address the ongoing noncompliance. In December 2016, the facility cleaned and refurbished the membranes and installed a new press, which has improved effluent quality. Other compliance items include constructing water quality management plans (storm water management, ground water recharge, etc.) and the assessment of existing lagoons in order to avoid bypass. Violations are summarized in Appendix I.

Annual flow and pollutant loadings data (2000-2014) for the North Lewisburg WWTP are shown in Figure 116 and Figure 117. Overall, current plant loadings appear to be lower than those reported during previous years. Median WWTP flow has also remained well below average design flow (0.42 MGD); the 2014 median flow was 0.106 MGD.

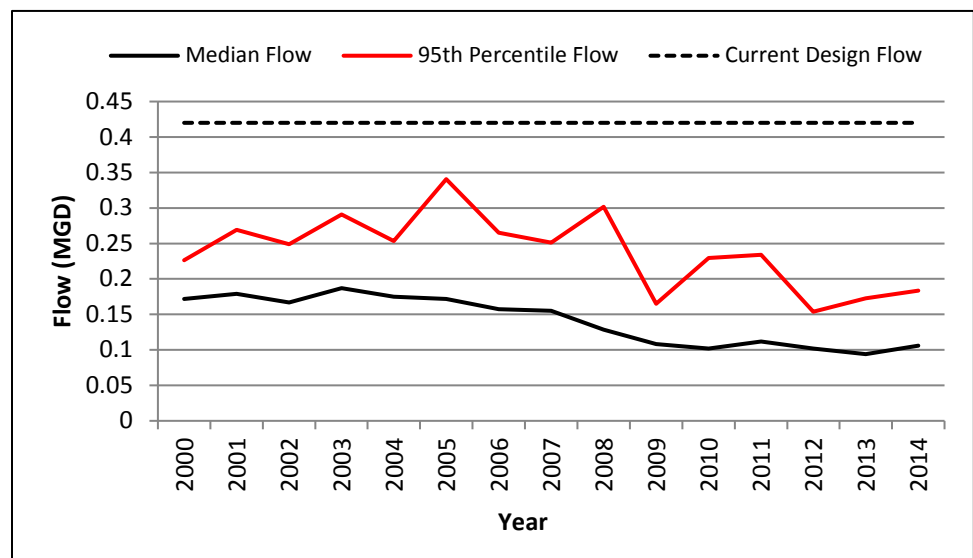


Figure 116. Annual 50th and 95th percentile flow values for the North Lewisburg WWTP, 2000-2014.

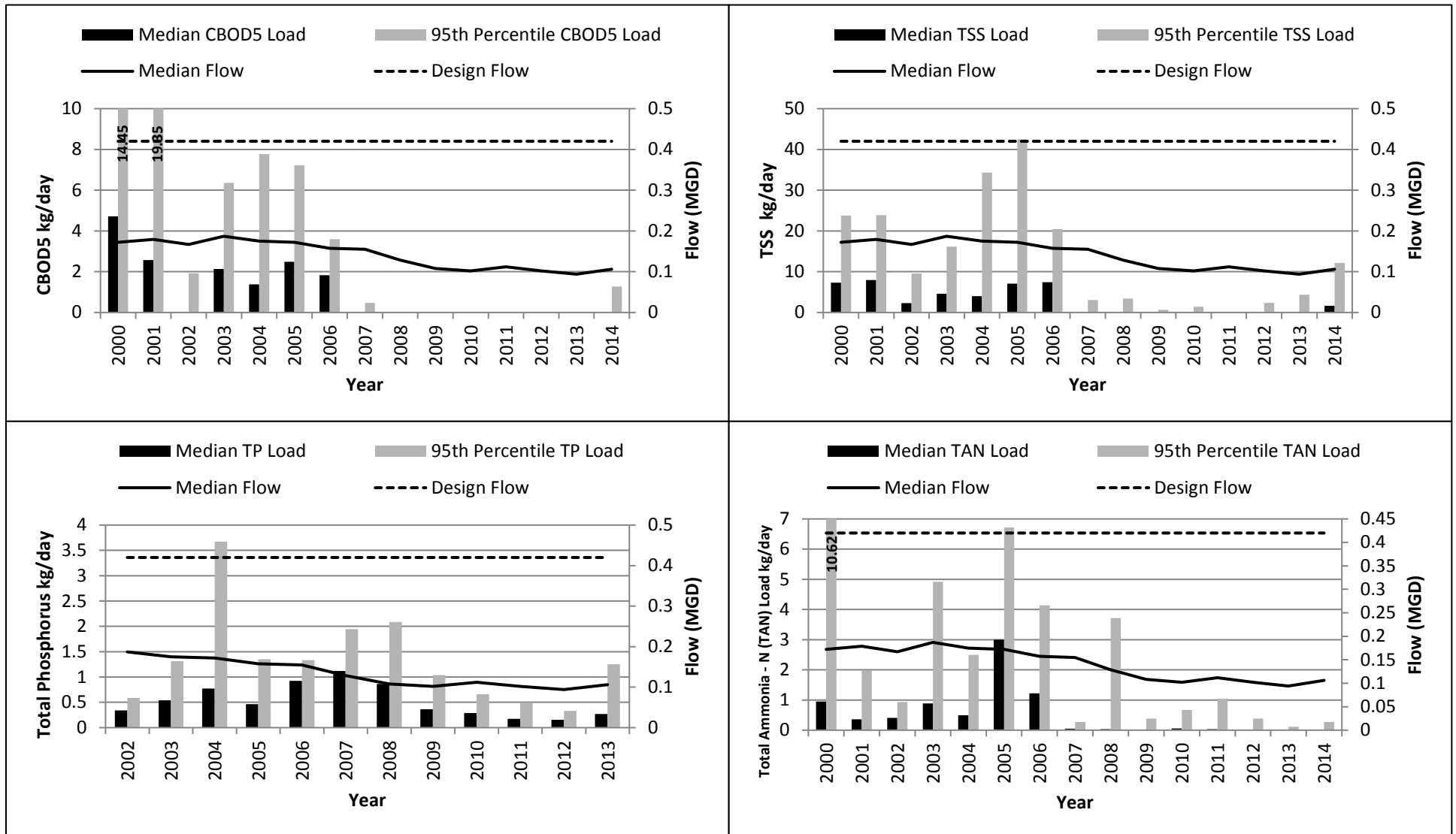


Figure 117. Annual loading data from the North Lewisburg WWTP for selected parameters, 2000-2014.

Sediment Chemistry

Sediment quality is of particular importance in a watershed such as Big Darby Creek, which is well known not only for its diversity and richness of fish and macroinvertebrate species, but is also renowned for its freshwater mussel species, which spend much of their life cycle in stream sediments. The Big Darby Creek watershed is home to more than 40 species of freshwater mussels, many of which are listed as threatened or endangered (Watters, 1998).

Sediment chemistry samples were collected from 17 sites in the Big Darby Creek watershed study area by Ohio EPA in late summer and early fall of 2014; data are summarized in Table 32 and Table 33. Samples were analyzed for metals, organics, nutrients, total organic carbon (TOC) and particle size. Sediment sample results were evaluated using published guidelines discussed below.

Sample collection focused on depositional areas of fine grain material (silts and clays), and one spatial composite sample was created for each location. Sampling staff walked a zone of each stream site within approximately 100 feet downstream and/or upstream from the bridge crossing or road access, collecting scoops of depositional material wherever it could be found and mixing all subsamples together in a stainless steel pan. The fine grained materials found in depositional areas of the stream were the focus of this sampling because contaminants typically adsorb to, or co-occur with, these sediment types compared to sands and gravels.

All sediment sampling took place within or directly adjacent to the wetted stream channel. Sampling locations were represented at times by sparse deposits of fine grained material. It should be noted that the proportion of depositional areas within a stream reach, or the volume of fine depositional material relative to larger substrates such as gravel or cobble, varied by sampling location. Clay and silt comprised a small proportion of the bottom substrates in some of the stream sites surveyed (*e.g.*, Big Darby Creek at RM 26.85, Little Darby Creek at RM 7.35). Bottom substrates at these locations were dominated by sand and larger substrates such as gravel or cobble. In fact, no sample was collected at Big Darby Creek RM 13.3 due to a lack of fine-grained depositional material smaller than gravel. Other sampling locations were more replete with fine-grained sediments (*e.g.*, Big Darby Creek at RM 51.1).

Sediment data were evaluated using Ohio Sediment Reference Values (SRVs) (Ohio EPA 2008) along with guidelines established in *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems* (MacDonald et. al. 2000). Ohio EPA SRVs represent ecoregion background conditions for metals based on data collected at Ohio reference sites. These values were developed for lotic (flowing) water bodies and are based on Ohio ecoregions. MacDonald guidelines define two levels of ecotoxic effects. A *Threshold Effect Concentration* (TEC) is a level of sediment chemical quality below which harmful effects are unlikely to be observed, and can be considered comparable to background conditions. A *Probable Effect Concentration* (PEC) indicates a level above which harmful effects are likely to be observed. These guidelines include both metals and organic parameters.

Finally, guidelines established by the Ontario Ministry of the Environment (Persuad et. al. 1993) were used to evaluate sediment sample results for total organic carbon (TOC) and total phosphorus. These guidelines include the Lowest Effect Level (LEL) and the Severe Effect Level (SEL). The LEL is a level of sediment concentration that can be tolerated by a majority of benthic organisms. The SEL is a concentration considered harmful to most benthic organisms.

Organic compounds were largely undetected in stream sediment samples collected from the Big Darby Creek watershed. Sediments were analyzed for 130 organic parameters including polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and pesticides. The only organics identified were dieldrin and pyrene (one detection each), flouranthene (two detections) and benzo(g,h,i)perylene (four detections). Detections were at or below concentrations expected to cause aquatic life impairment, with the exception of dieldrin (7 µg/kg) which was in excess of the 1.9 µg/kg TEC in Little Darby Creek at RM 38.78, downstream from Mechanicsburg at Wing Rd. None of the detected organic compounds exceeded PEC guidelines.

For five sites studied on Big Darby Creek and two sites studied on Little Darby Creek, most sediment results were below Ohio SRVs for metals. Exceptions were metals results from stream sediment collected from Big Darby Creek at RM 51.1 below Plain City, RM 41.75 upstream from West Jefferson, and RM 19.9 downstream from Clarks Lake tributary, and Little Darby RM 7.35 at West Jefferson. Most threshold exceedances were found at Big Darby Creek RM 51.1 downstream from Plain City. Urban storm water runoff and effluent from the Plain City WWTP likely contributed to the elevated metal sediment concentrations found here. None of these metal threshold exceedances at any site exceeded PEC guidelines.

Stream sediment sampling from 10 tributary streams were also mostly below Ohio SRVs for metals and PEC thresholds. The highest sediment metal concentrations were located in the urbanized portion of the Hellbranch Run subwatershed, in both Clover Groff and Hamilton runs. The sediment arsenic concentration (41 mg/kg) for Hamilton Run was the only tributary sampling location that exceeded the PEC (33 mg/kg).

Sediment nutrient concentrations were elevated in many locations throughout the Big Darby Creek watershed. A majority of the sites studied exceeded the Ontario LEL guidelines for total phosphorus (600 mg/kg) and total organic carbon (1%). For Big Darby Creek and Little Darby Creek, the median (n=7) sediment total phosphorus result was 773 mg/kg at Little Darby Creek RM 7.35; the minimum result was 516 mg/kg at Big Darby Creek RM 26.85 and the maximum result was 1740 mg/kg at RM 51.1 below the Plain City WWTP. For the 10 tributary sites studied, the median total phosphorus result was 646 mg/kg at Robinson Run RM 0.73; the minimum result was 323 mg/kg at Spain Creek (near mouth) and the maximum result was 1490 mg/kg at Hamilton Run (near mouth).

Stream sediment total ammonia concentrations ranged from 62 to 380 mg/kg at the five sites on Big Darby Creek and were 130 and 540 mg/kg at the two Little Darby Creek sampling locations. Concentrations of ammonia in the other 10 tributaries in the watershed ranged from 64 mg/kg in both Robinson Run and Spain Creek to 1100 mg/kg in Buck Run. Ohio EPA does not currently utilize a reference guideline, similar to the Ontario research-based values for phosphorous or total organic carbon, for ammonia concentrations in stream sediments. Freshwater mussels are sensitive to inorganic chemical toxicants such as ammonia (USEPA 2013) and when they are buried within sediments, can be exposed to pore-water concentrations of ammonia that are often greater than the concentrations found in the above water column (Augsburger, et al. 2003; Frazier et al. 1996). Potential linkages between pore water un-ionized ammonia concentrations and detrimental impacts to mussels have been demonstrated in a laboratory setting (Newton and Bartsch 2007); however, the relationship between pore water and sediment un-ionized ammonia concentrations are not well understood.

Table 32.

Selected results of chemical/physical sediment sampling at sites in Big Darby Creek and Little Darby Creek, 2014. Only parameters detected in concentrations greater than the analytical reporting level were included. Data in bold were in excess of the specific guideline indicated by footnote, and the guideline value is listed below in parentheses.

			Big Darby Creek	Big Darby Creek	Big Darby Creek	Big Darby Creek	Big Darby Creek	Little Darby Creek	Little Darby Creek
Parameter Units			RM 51.1	RM 41.75	RM 26.85	RM 21	RM 19.9	RM 38.78	RM 7.35
	% Solids	%	34.4	44.05	66.15	53.65	42.7	63.05	46.9
Organics	Benzo[g,h,i]perylene	mg/kg	< RL	< RL	< RL	< RL	< RL	0.87	< RL
	Dieldrin	ug/kg	< RL	< RL	< RL	< RL	< RL	7* (1.9)	< RL
	Fluoranthene	mg/kg	1.18	< RL	< RL	< RL	< RL	0.69	< RL
	Pyrene	mg/kg	0.93	< RL	< RL	< RL	< RL	< RL	< RL
Metals	Aluminum	mg/kg	23500	10000	3770	6700	9540	3860	6250
	Arsenic	mg/kg	19.3* (9.79)	9.56	6.2	6.26	10.8* (9.79)	8.68	8.41
	Barium	mg/kg	251† (240)	118	52.4	66.9	119	90.8	101
	Cadmium	mg/kg	1.48* (0.99)	0.676	0.335	0.423	0.693	0.356	0.516
	Calcium	mg/kg	143000†† (120000)	83800	77900	79600	65700	68800	104000
	Chromium	mg/kg	26.6	12.3	6.01	8.69	12.2	5.55	8.24
	Copper	mg/kg	42.3* (31.6)	18.8	7.92	10.1	19.3	8.15	11.8
	Iron	mg/kg	49800†† (33000)	24200	11100	14400	23900	12500	16300
	Lead	mg/kg	41.5* (35.8)	16.5	8.35	9.63	17.3	8.07	12.9
	Magnesium	mg/kg	50500†† (35000)	27700	26300	21800	21900	23500	35700†† (35000)
	Manganese	mg/kg	1000†† (780)	532	382	331	518	266	443
	Mercury	mg/kg	0.151	< RL	< RL	< RL	< RL	< RL	< RL
	Nickel	mg/kg	42.5* (22.7)	22.2	11.4	13.3	22	10.3	14.6

			Big Darby Creek	Big Darby Creek	Big Darby Creek	Big Darby Creek	Big Darby Creek	Little Darby Creek	Little Darby Creek
			RM 51.1	RM 41.75	RM 26.85	RM 21	RM 19.9	RM 38.78	RM 7.35
Parameter	Units								
	Potassium	mg/kg	3570	< RL	< RL	< RL	< RL	< RL	< RL
	Strontium	mg/kg	1490 ⁺⁺ (390)	653 ⁺⁺ (390)	277	325	503 ⁺⁺ (390)	265	531 ⁺⁺ (390)
	Zinc	mg/kg	249* (121)	95	47.6	56.4	99.9	43	69.6
Nutrients	Ammonia	mg/kg	380	200	62	77	230	130	540
	TOC	%	3.7 ⁺⁺ (1)	3.7 ⁺⁺ (1)	1.4 ⁺⁺ (1)	2.3 ⁺⁺ (1)	2.7 ⁺⁺ (1)	2.5 ⁺⁺ (1)	3.1 ⁺⁺ (1)
	Total Phosphorus	mg/kg	1740 ⁺⁺ (600)	851 ⁺⁺ (600)	516	760 ⁺⁺ (600)	913 ⁺⁺ (600)	594	773 ⁺⁺ (600)
Particle Size	Fine clay (<1 µm)	%	24	12	8.8	10	18	ns	12
	Medium clay (1-2 µm)	%	6	6.1	1.3	4	4	ns	4
	Coarse clay (2-4 µm)	%	8	4.1	2.5	4	4	ns	4
	Very fine silt (4-8 µm)	%	6	2	1.3	2	4	ns	2
	Fine silt (8-15 µm)	%	14	4.1	2.5	2	18	ns	2
	Medium silt (15-30 µm)	%	4	10	5	8.1	4	ns	12
	Coarse silt (30-60 µm)	%	38	4.1	2.5	6.1	4	ns	4
	Sand & larger (>60 µm)	%	0	57	76	64	44	ns	60

Table 33. Selected results of chemical/physical sediment sampling at tributary sites in the Big Darby and Little Darby watersheds, 2014. Only parameters detected in concentrations greater than the analytical reporting level were included. Data in bold were in excess of the specific guideline indicated by footnote, and the guideline value exceeded is listed in parentheses.

			Flat Branch	Spain Creek	Treacle Creek	Robinson Run	Buck Run	Spring Fork	Sugar Run	Clover Groff Run	Hamilton Run	Hellbranch Run
Parameter		Units	RM 0.9	RM 0.01	RM 0.78	RM 0.73	RM 2.16	RM 7.8	RM 0.43	RM 0.14	RM 0.1	RM 0.98
	% Solids	%	63.8	71.7	57.4	54.2	60.7	55.7	47	41.85	43.1	63.05
Organics	Benzo[g,h,i]perylene	mg/kg	0.73	0.67	<RL	<RL	0.77	<RL	<RL	<RL	<RL	<RL
Metals	Aluminum	mg/kg	8170	2800	4930	5560	5020	7030	8240	11200	12700	4140
	Arsenic	mg/kg	8.01	6.24	7.95	11.2* (9.8)	5.65	20.3* (9.8)	12.4* (9.8)	20.2* (9.8)	41** (33)	8.73
	Barium	mg/kg	71.1	44.9	61.7	87.2	42.1	92.4	92.4	170	252	51
	Cadmium	mg/kg	0.583	0.321	0.482	0.511	0.427	0.514	0.574	1.09* (0.99)	1.21* (0.99)	0.365
	Calcium	mg/kg	21900	109000	83600	144000† (120000)	113000	74400	47500	7600	58500	81000
	Chromium	mg/kg	10	4.76	6.45	7.8	6.84	8.29	10.3	13.9	15	6.61
	Copper	mg/kg	14.9	7.36	10.6	12.5	11.6	11.6	15	33.5* (31.6)	32.9* (31.6)	11.5
	Iron	mg/kg	21100	9830	11900	19200	12000	21800	25600	36200† (33000)	53600† (33000)	16900
	Lead	mg/kg	15.1	7.3	7.24	10.1	8.41	9.87	15.2	29.6	44.7* (35.8)	11.6
	Magnesium	mg/kg	8140	43200† (35000)	35800† (35000)	63400† (35000)	57900† (35000)	30200	22000	33200	22600	25800
	Manganese	mg/kg	393	272	284	382	262	447	562	1210† (780)	1190† (780)	375
	Mercury	mg/kg	<RL	<RL	<RL	<RL	<RL	<RL	<RL	0.073	0.085	<RL
	Nickel	mg/kg	19.5	10	12.4	17.2	14.8	15.7	18.8	31.5* (22.7)	34.3* (22.7)	14.5
	Potassium	mg/kg	1360	<RL	<RL	<RL	<RL	<RL	<RL	<RL	<RL	<RL
	Strontium	mg/kg	54	295	357	213	111	668† (390)	94	261	306	120
	Zinc	mg/kg	73.7	45.3	48.4	59	47	63	86.6	169*	173*	66.5

			Flat Branch	Spain Creek	Treadle Creek	Robinson Run	Buck Run	Spring Fork	Sugar Run	Clover Groff Run	Hamilton Run	Hellbranch Run
Parameter		Units	RM 0.9	RM 0.01	RM 0.78	RM 0.73	RM 2.16	RM 7.8	RM 0.43	RM 0.14	RM 0.1	RM 0.98
Nutrients										(121)	(121)	
	Ammonia	mg/kg	86	64	140	64	1100	130	160	250	210	280
	TOC	%	1.6† (1)	2.9† (1)	3.2† (1)	2.7† (1)	1.9† (1)	2.9† (1)	5.2† (1)	3† (1)	3.9† (1)	1.2† (1)
Particle Size	Total Phosphorus	mg/kg	805†† (600)	323	626†† (600)	646†† (600)	579	692†† (600)	794†† (600)	1220†† (600)	1490†† (600)	613†† (600)
	Fine clay (<1 µm)	%	ns	ns	ns	9.9	ns	ns	14	16	18	7.5
	Med. clay (1-2 µm)	%	ns	ns	ns	4	ns	ns	6.1	6.1	6.1	2.5
	Coarse clay (2-4 µm)	%	ns	ns	ns	4	ns	ns	6.1	4.1	4.1	1.3
	Very fine silt (4-8 µm)	%	ns	ns	ns	2	ns	ns	4	2	4.1	1.3
	Fine silt (8-15 µm)	%	ns	ns	ns	4	ns	ns	12	12	16	2.5
	Med. silt (15-30 µm)	%	ns	ns	ns	7.9	ns	ns	2	10	8.2	7.5
	Coarse silt (30-60 µm)	%	ns	ns	ns	2	ns	ns	2	2	43	2.5
	Sand & larger (>60 µm)	%	ns	ns	ns	66	ns	ns	53	47	0	75

* Value is greater than Threshold Effect Concentration (TEC), from MacDonald et. al. 2000

†Value is greater than Ohio EPA Sediment Reference Value (SRV)

††Nutrient value is greater than Lowest Effect Level (LEL), from Persaud et al. 1993

Fish Tissue Contamination

Ohio has been sampling streams annually for sport fish contamination since 1993. Fish are analyzed for contaminants that bioaccumulate in fish and that could pose a threat to human health if consumed in excessive amounts. Contaminants analyzed in Ohio sport fish include mercury, PCBs, DDT, mirex, hexachlorobenzene, lead, selenium, and several other metals and pesticides. 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 2010a) and the Fish Collection Guidance Manual (Ohio EPA 2012).

Fish contaminant data are primarily used for three purposes: 1) to determine fish advisories; 2) to determine attainment with Ohio Water Quality Standards human health criteria; and 3) to examine trends in fish contaminants over time. A complete list of tissue samples collected from the Big Darby Creek watershed for the current survey, along with tissue contamination results for mercury and total PCB concentrations are presented in Appendix J.

Fish advisories

Fish contaminant data are used to determine a meal frequency that is safe for people to consume (*e.g.*, two meals a week, one meal a month, do not eat), and a fish advisory is issued for applicable species and locations. Because mercury mostly comes from nonpoint sources, primarily aerial deposition, Ohio has had a statewide one meal 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 at the following website:

<http://www.epa.state.oh.us/dsw/fishadvisory/index.aspx> .

Current fish tissue consumption advisories and changes to these advisories based on 2014 data collected from Big Darby Creek are displayed in Table 34. Based on the 2014 data, the PCB advisory for common carp in the lower reach of Big Darby Creek was removed. Smallmouth bass in Big Darby Creek were added to the consumption advisory under the “one meal per month” limit due to mercury (avg. 0.279 ppm). Channel catfish and freshwater drum (20” and over) remain on the advisory list for Big Darby Creek with elevated mercury levels. PCB concentrations for these two species have decreased; however, confirming samples need to be collected before delisting this contaminant for these species.

Little Darby Creek does not have any fish consumption advisories for PCBs or mercury. Based on the new data received, there were no changes. All other species caught should follow the statewide advice of two meals per week for sunfish and yellow perch, one meal per month for flathead catfish 23” and over, and northern pike 23” and over, and one meal per week for all other species not otherwise listed.

Table 34. Current status and updates to the fish consumption advisory for Big Darby Creek based on data collected in 2014. Changes to existing advisories are listed in red.

Stream	Location	Species	Meal Frequency	Contaminant
Big Darby Creek	US Route 42 (Plain City) to Alkire Rd. (Georgesville) (Franklin, Madison and Union counties)	Channel Catfish	Month	Mercury, PCBs
		Smallmouth Bass	Month	Mercury
	Alkire Rd. (Georgesville) to mouth (Scioto River) (Franklin and Pickaway counties)	Channel Catfish	Month	Mercury, PCBs
		Common Carp	Month	PCBs
		Freshwater Drum over 20"	Month	Mercury
		Smallmouth Bass	Month	Mercury

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 Standards criteria pursuant to OAC Rules 3745-1-33 and 3745-1-34. The human health criteria are presented in water column concentrations of µg/Liter, and are then translated into fish tissue concentrations in mg/kg. [See [Ohio's 2010 Integrated Report, Section E](#) for further details of this conversion.]

In order to be considered in attainment of the Water Quality Standards human health criteria, the sport fish caught within a HUC-12 assessment unit must have a weighted average concentration of the geometric means for all species below 1.0 mg/kg for mercury, and below 0.054 mg/kg for PCBs.

Within the Big Darby Creek watershed, fish tissue data were adequate to determine attainment status for several HUC-12 assessment units which incorporate Big Darby Creek or Little Darby Creek mainstem reaches. The details of these assessments are displayed in Table 35 of this report. There were several historically impaired reaches that are now in full attainment based on the 2014 data. In general, most of the mainstem assessment units showed no impairment due to fish tissue contamination; however, the Big Darby mainstem included within two assessment units (Greenbrier Creek-Big Darby Creek and Lizard Run-Big Darby Creek) did show impairment for PCBs. These two HUC-12 assessment units incorporate the lower 26 miles of Big Darby Creek from the confluence of Hellbranch Run to the mouth. The Greenbrier Creek-Big Darby Creek mainstem reach was historically unimpaired, but is now listed as impaired based on this most recent data set. The Lizard Run-Big Darby Creek mainstem reach was historically impaired and the 2014 data confirmed the continued impaired status of this HUC-12. A small portion of sites in specific assessment units did not have a large enough sample size for any conclusion to be drawn.

Table 35. Updates to the attainment status of HUC-12 assessment units which incorporate Big Darby Creek and Little Darby Creek mainstem reaches based on data collected in 2014.

HUC 12	Results (Previous IR)	Results (Current IR)	Pass/Fail	Cause of Impairment	Assessment Unit Name	PCBs (ppm)	PCBs Threshold	Hg (ppm)	Hg Threshold	Trophic Level 3 Sample Size	Trophic Level 4 Sample Size
50600011902	5h	1	Pass		Spain Creek-Big Darby Creek	Non-detect	0.054	0.139	1.0	3	3
50600011905	5h	1	Pass		Robinson Run-Big Darby Creek	Non-detect	0.054	0.28	1.0	4	5
50600012002	5h	5h	Unknown		Proctor Run-Treacle Creek	Non-detect	0.054	0.158	1.0	2	1
50600012005	1h	1	Pass		Barron Creek-Little Darby Creek	Non-detect	0.054	Insufficient Sample Size	1.0	3	2
50600012006	1h	1	Pass		Thomas Ditch-Little Darby Creek	Non-detect	0.054	Insufficient Sample Size	1.0	8	7
50600012101	1h	1	Pass		Worthington Ditch-Big Darby Creek	Non-detect	0.054	Insufficient Sample Size	1.0	3	2
50600012102	1h	1	Pass		Silver Ditch-Big Darby Creek	Non-detect	0.054	Insufficient Sample Size	1.0	4	6
50600012202	5h	5h	Unknown		Gay Run-Big Darby Creek	Non-detect	0.054	Insufficient Sample Size	1.0	2	1
50600012203	1h	5	Fail	PCBs	Greenbrier Creek-Big Darby Creek	0.076	0.054	Insufficient Sample Size	1.0	4	6
50600012204	5h	5	Fail	PCBs	Lizard Run-Big Darby Creek	0.067	0.054	Insufficient Sample Size	1.0	15	10

Fish contaminant trends

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

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

Fish tissue data were collected from both Little Darby and Big Darby creeks across multiple years, dating back as far as 1974. Contaminants for the Big Darby Creek watershed have remained relatively low with no notable issues. PCB concentrations have shown a decrease across all species collected in comparison to previous years (Figure 118). Common carp are currently listed on the “one meal per month” advisory for PCBs, but according to the most recent data that advisory is proposed for removal. The average from the 2012 and 2014 data for total PCBs in common carp is now 0.074 ppm, which falls under the “one meal per week” advisory. Channel catfish are also listed under the “one meal per month” advisory due to PCBs and mercury. This consumption advisory should be maintained due to mercury levels, but not because of PCBs. The average from the 2012 and 2014 data shows channel catfish with an average total PCB concentration of 0.133 ppm, which falls into the “one meal per week” category. Mercury concentration trends have remained relatively similar through the years, with higher trophic level fish species generally showing higher contaminant concentrations (Figure 119). The lifting of PCB advisories for common carp and reduced concentrations in channel catfish denotes an improvement in fish tissue contamination in Big Darby Creek.

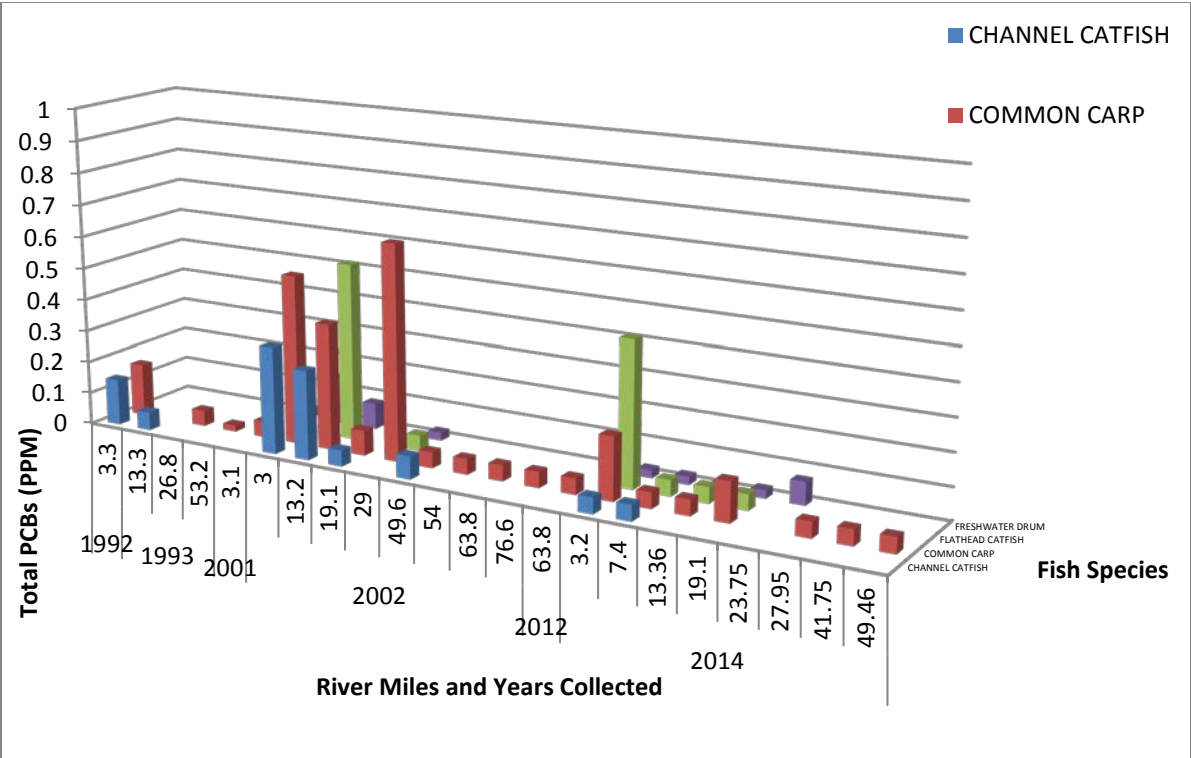


Figure 118. Average total PCBs for fish tissue samples collected from Big Darby Creek. Results are arranged by year collected then by river mile within the year. The trend shows a decrease of PCB contamination over time, with a higher contaminant concentration towards the river mouth.

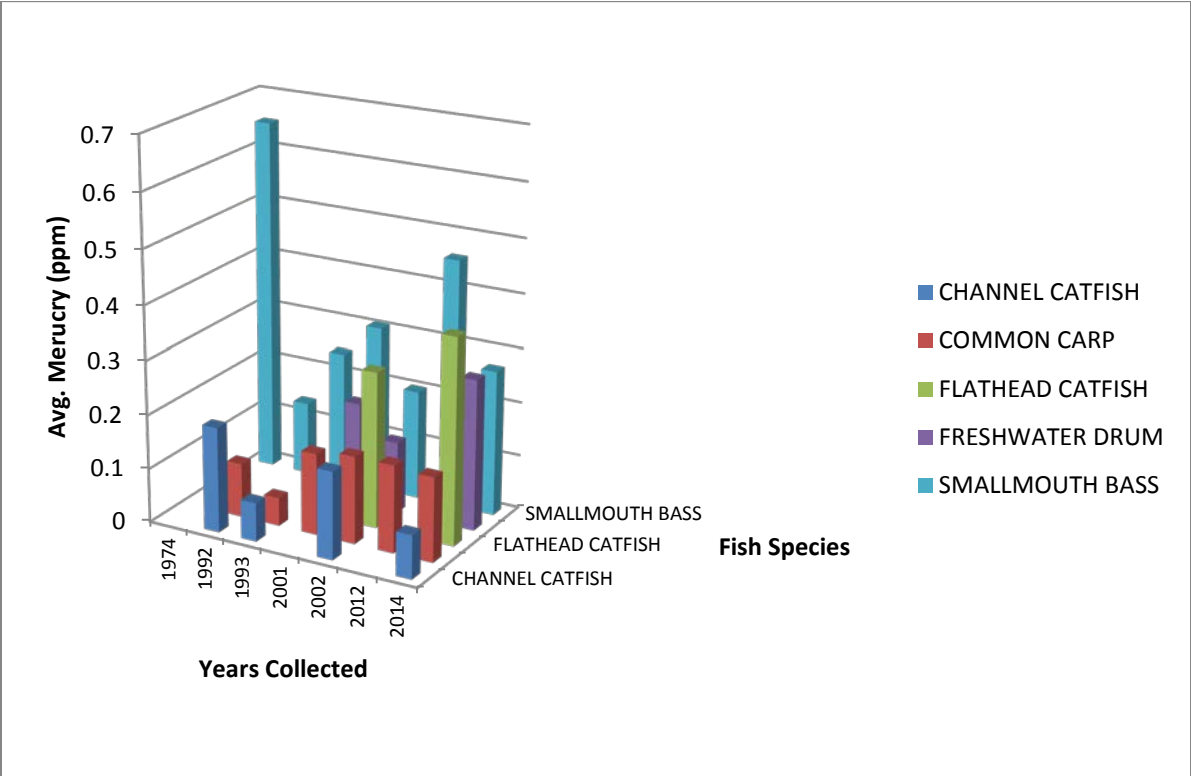


Figure 119. Average mercury concentration for fish tissue samples collected from Big Darby Creek. Results are arranged by species over time. Higher trophic level fish species (e.g., smallmouth bass) tend to accumulate higher concentrations of contaminants. No clear trends are observed.

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