

NORTHEAST OHIO REGIONAL SEWER DISTRICT

2015 and 2016 Big Creek Environmental Monitoring: Biological, Water Quality, and Habitat Survey Results



**Prepared by
The Water Quality and Industrial Surveillance Department**

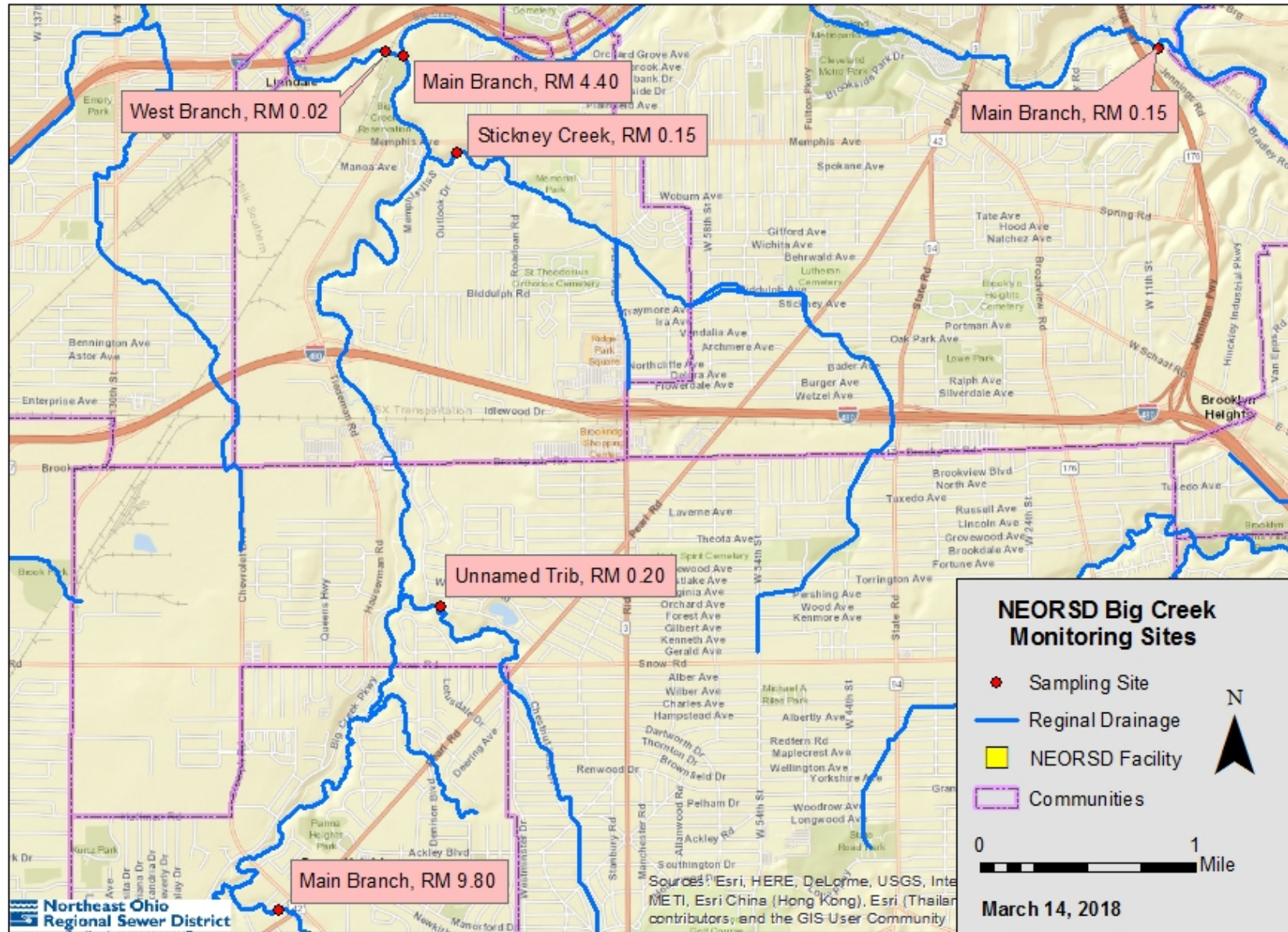
Introduction

In 2015 and 2016, the Northeast Ohio Regional Sewer District (NEORS) conducted stream monitoring activities at river miles (RM) 0.15 and 4.40 on Big Creek, an urbanized tributary to the Cuyahoga River. RM 0.15 is located downstream of Jennings Road on the Big Creek Main Branch and is downstream of NEORS-owned combined sewer overflows (CSOs). RM 4.40 is located at Memphis Tiedeman Park and is upstream of NEORS CSOs. NEORS assessed stream habitat, water chemistry, and fish and benthic macroinvertebrate community health to evaluate the impact of CSOs and other environmental factors on the creek. Habitat data, fish, macroinvertebrate and water chemistry sampling at RMs 0.15 and 4.40 are required by Ohio Environmental Protection Agency (Ohio EPA) National Pollutant Discharge Elimination System (NPDES) Permit No. 3PA0002*HD. Additional sites that were monitored in Big Creek were at Memphis Tiedeman Park on the Ford Branch at RM 0.02, Stickney Creek at RM 0.15, Big Creek unnamed tributary at RM 0.20, and Big Creek Main Branch at RM 9.80.

Stream monitoring activities were conducted by NEORS Level 3 Qualified Data Collectors certified by Ohio EPA in Fish Community Biology, Benthic Macroinvertebrate Biology, Chemical Water Quality, and Stream Habitat Assessment as explained in the NEORS Study Plans *2015 Big Creek Environmental Monitoring* and *2016 Big Creek Environmental Monitoring*, approved by Ohio EPA on June 17, 2015, and May 17, 2016, respectively. The results obtained from these assessments were evaluated using the Ohio EPA's Qualitative Habitat Evaluation Index (QHEI), Index of Biotic Integrity (IBI), Modified Index of Well-Being (MIwb), and Invertebrate Community Index (ICI). Water chemistry data was compared to the Ohio Water Quality Standards (Ohio EPA, 2017) to determine attainment of designated uses. An examination of the individual metrics that comprise the IBI and ICI was used in conjunction with the water quality data, NEORS Macroinvertebrate Field Sheet, and QHEI results to identify impacts to the fish and benthic macroinvertebrate communities. Results were also compared to historic data to show temporal trends.

Figure 1 is a map of the sampling locations on Big Creek, and Table 1 lists the sampling locations and the respective river mile, latitude/longitude, site description, and surveys conducted for each site. A digital photo catalog of the sampling locations is available upon request by contacting the NEORS Water Quality and Industrial Surveillance (WQIS) Division.

Figure 1. Big Creek Monitoring Sites



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Table 1. Sampling Locations						
Water Body	Latitude	Longitude	River Mile	Location Information	USGS HUC 8 Number - Name	Purpose
Big Creek, Main Branch	41.4460	-81.6865	0.15	Downstream of Jennings Road	04110002 Cuyahoga	Evaluate water chemistry, habitat, fish and macroinvertebrates as required by Ohio EPA Permit #3PA00002*HD
Big Creek, Main Branch	41.4455	-81.7537	4.40	Memphis Avenue Memphis Tiedeman Park	04110002 Cuyahoga	Evaluate water chemistry, habitat, fish and macroinvertebrates as required by Ohio EPA Permit #3PA00002*HD
Big Creek, Ford Branch	41.4459	-81.7545	0.02	Memphis Avenue Memphis Tiedeman Park	04110002 Cuyahoga	Evaluate water chemistry, macroinvertebrates and evaluate the fish community and instream habitat
Stickney Creek	41.4394	-81.7494	0.15	South of Memphis Ave. & north of Memphis Villas Blvd.	04110002 Cuyahoga	Evaluate water chemistry, macroinvertebrates and evaluate the fish community and instream habitat
Big Creek, Unnamed tributary	41.4089	-81.7511	0.20	Upstream of Big Creek Parkway, Snow Rd. & Pearl Rd. Branch	04110002 Cuyahoga	Evaluate water chemistry, macroinvertebrates and evaluate the fish community and instream habitat
Big Creek, Main Branch	41.3885	-81.7659	9.80	Downstream of Pearl Road	04110002 Cuyahoga	Evaluate water chemistry, macroinvertebrates and evaluate the fish community and instream habitat

Water Chemistry Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times at the six sites listed in Table 1 between July 22, 2015 and August 19, 2015, and another five times between July 26, 2016 and August 23, 2016. Techniques used for sampling and analyses followed the Ohio EPA *Surface Water Field Sampling Manual* (2015). Chemical water quality samples from each site were collected with two 4-liter disposable polyethylene

cubitainers with disposable polypropylene lids and two 473-mL plastic bottles. One of the plastic bottles was field preserved with trace nitric acid and the other was field preserved with trace sulfuric acid. All water quality samples were collected as grab samples. Bacteriological samples were collected in sterilized plastic bottles. At the time of sampling, measurements for dissolved oxygen, pH, temperature, and conductivity were collected using either a YSI EXO1 or 600XL sonde. Duplicate samples and field blanks were collected at randomly selected sites, at a frequency not less than 5% of the total samples collected. Relative percent difference (RPD) was used to determine the degree of discrepancy between the primary and duplicate sample (Formula 1).

$$\text{Formula 1: } \text{RPD} = \left(\frac{|X-Y|}{((X+Y)/2)} \right) * 100$$

X= is the concentration of the parameter in the primary sample

Y= is the concentration of the parameter in the duplicate sample

The acceptable percent RPD is based on the ratio of the sample concentration and detection limit (Formula 2) (Ohio EPA, 2013).

$$\text{Formula 2: } \text{Acceptable \% RPD} = [(0.9465X^{-0.344}) * 100] + 5$$

X = sample/detection limit ratio

Those RPDs that are higher than acceptable may indicate potential problems with sample collection and, as a result, the data was not used for comparison to the water quality standards. Water chemistry analysis sheets for each site are available upon request from the NEORSD WQIS Division.

Results and Discussion

QA/QC samples were collected during both 2015 and 2016. Two field blanks and two duplicate samples were collected as part of this study in 2015. Four field blanks and two duplicate samples were collected as part of this study in 2016. For the field blanks, there were four parameters that showed possible contamination. It is unclear how the field blanks became contaminated and may be due to inappropriate sample collection, handling, and/or contaminated blank water. Table 2 lists water quality parameters that were listed as estimated, downgraded from Level 3 to Level 2 data, or rejected based on Ohio EPA data validation protocol.

Table 2. Parameters affected by possible blank contamination	
2015	2016
DRP	Cr
NH ₃	-
Zn	-

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During the study, there were duplicate samples that were collected and resulted in a rejection of data because their RPD was greater than an acceptable limit (Table 3). Potential reasons for this discrepancy include lack of precision and consistency in sample collection and/or analytical procedures, environmental heterogeneity and/or improper handling of samples. One duplicate sample was collected on August 5, 2015, at RM 4.40. The tin (Sn) and thallium (Tl) results were rejected because of the RPDs. Another duplicate sample was collected on August 12, 2015, at Stickney Creek, RM 0.15. Parameters chromium (Cr), ammonia (NH₃), and vanadium (V) results were rejected. In 2016, one duplicate sample was collected during the study on August 16, 2016, at RM 9.80. All RPD results were acceptable. On August 23, 2016, another duplicate sample was collected at Stickney Creek, RM 0.15. The RPD for total suspended solids (TSS) was greater than the acceptable limit and resulted in rejection of the data.

Table 3. Duplicate Parameter Analysis					
River Mile	Date	Parameter	Acceptable RPD (%)	Actual RPD (%)	Qualifier
4.40	8/5/2015	Sn	99.7	133.9	Rejected
	8/5/2015	Tl	58.6	135.6	Rejected
0.15S	8/12/2015	Cr	60.2	73.3	Rejected
	8/12/2015	NH ₃	53.5	101.8	Rejected
	8/12/2015	V	73.1	89.0	Rejected
	8/23/2016	TSS	85.5	134.7	Rejected

The final QA/QC check for the samples was a comparison of paired parameters (Table 4). This comparison showed that total solids and total dissolved solids results for the samples listed below needed to be listed as estimated. The reason for these parameters not meeting Ohio EPA's requirements may include differences in sampling and analysis methods. Because there were no exceedances associated with these parameters, qualification of these results did not significantly change the overall water chemistry assessment of Big Creek.

Table 4. Paired Data Parameter Analysis						
River Mile	Date	Parameter	Data Pair	Acceptable RPD (%)	Actual RPD (%)	Qualifier
0.15	7/22/2015	TS	TDS	14.2	3.3	Estimated
	8/5/2015	TS	TDS	14.9	1.7	Estimated
	7/26/2016	TS	TDS	15.2	3.0	Estimated
	8/23/2016	TS	TDS	15.3	3.4	Estimated
4.40	8/12/2015	TS	TDS	15.8	1.1	Estimated
	8/16/2016	TS	TDS	15.9	2.6	Estimated
0.02	7/22/2015	TS	TDS	14.9	1.9	Estimated
	8/5/2015	TS	TDS	15.5	3.3	Estimated

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Table 4. Paired Data Parameter Analysis						
River Mile	Date	Parameter	Data Pair	Acceptable RPD (%)	Actual RPD (%)	Qualifier
	8/16/2016	TS	TDS	15.0	0.6	Estimated
0.15S	8/5/2015	TS	TDS	16.3	2.3	Estimated
	8/12/2015	TS	TDS	16.2	0.4	Estimated
	8/23/2016	TS	TDS	17.6	6.1	Estimated
	8/23/2016	TS	TDS	17.4	2.2	Estimated
0.20	8/16/2015	TS	TDS	17.1	0.5	Estimated
	8/16/2016	TS	TDS	17.1	0.5	Estimated
9.80	8/16/2015	TS	TDS	15.5	4.6	Estimated
	8/16/2016	TS	TDS	15.5	4.6	Estimated

The Ohio EPA has designated Big Creek warmwater habitat (WWH), agricultural water supply, industrial water supply, and primary contact recreation, with the exception of Big Creek Ford Branch RM 0.02, which is designated limited resource and secondary contact recreation.

The bacteriological criteria for *E. coli* consist of two components: a 90-day geometric mean during all weather conditions and a value not to be exceeded in more than 10% of the samples collected during a 90-day period (statistical threshold value) (Tables 5 and 6). For those streams designated primary contact recreation, these criteria were 126 colony counts/100mL and 410 colony counts/100mL, respectively. For streams designated secondary contact recreation, these criteria are increased to 1,030 colony counts/100 mL for both the 90-day geometric mean and the statistical threshold value. In 2015 and 2016, the geomean criterion and the statistical threshold value were exceeded for all samples with the exception of RM 0.02 on three occasions due to its higher bacteriological criteria. Therefore, Big Creek is not in attainment of water quality standards for primary contact recreation.

Table 5. Big Creek <i>E. coli</i> Densities (most probable number/100mL)						
Statistical Threshold Value						
Date	RM 0.15	RM. 4.40	RM 0.02	RM0.15S	RM 0.20	RM 9.80
7/22/2015	1,619	476	285**	1,313	501	120,980
7/29/2015	1,318	459	174**	4,660	1,639	49,020
8/5/2015	1,805	317	1,000	10,490	570	12,405
8/15/2015	6,860	3,963	6,460	24,540	6,340	8,280
8/19/2015	26,258	13,015	27,375	20,530	5,460	1,140
7/26/2016	898	793	308**	496	627	34,335
8/2/2016	1,903	830	1,399	798	743	86,645
8/9/2016*	3,285	626	440	1,082	307	120,980
8/16/2016*	1,1814	1,050	3,065	1,594	360	64,985

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Table 5. Big Creek <i>E. coli</i> Densities (most probable number/100mL) Statistical Threshold Value						
Date	RM 0.15	RM. 4.40	RM 0.02	RM0.15S	RM 0.20	RM 9.80
8/23/2016	3,642	2,918	1,138	3,225	1,549	55,995

*Wet-weather event

**Meets statistical threshold value criterion for secondary (RM 0.02) contact recreation use for 90-day geomean starting on that day.

Table 6. Big Creek <i>E. coli</i> Densities (most probable number/100mL) 90-Day Geomean						
Date	RM 0.15	RM. 4.40	RM 0.02	RM0.15S	RM 0.20	RM 9.80
7/22/2015	3,700	1,290	1,544	7,979	1,746	14,734
7/29/2015	4,550	1,655	2,355	12,527	2,385	8,704
8/5/2015	6,876	2,538	5,613	17,419	2,702	4,892
8/15/2015	13,421	7,182	13,298	22,446	5,884	3,072
8/19/2015	26,258	13,015	27,375	20,530	5,460	1,140
7/26/2016	2,060	1,048	921**	1,171	603	66,593
8/2/2016	2,535	1,123	1,211	1,452	597	78,588
8/9/2016*	2,789	1,243	1,154	1,772	555	76,072
8/16/2016*	2,570	1,750	1,868	2,267	747	60,323
8/23/2016	3,642	2,918	1,138	3,225	1,549	55,995

*Wet-weather event

**Meets 90-day geometric mean criterion.

Samples collected on August 9, 2016, and on August 16, 2016, were collected as part of wet-weather events¹. In total, 16 recorded wet-weather overflows to Big Creek or its tributaries occurred from June 22 to August 19, 2015, for those CSOs with monitoring capabilities; eight overflows occurred during the 2015 sampling period (Table 7). These overflows contained a mixture of rainwater, urban and stormwater runoff, and raw sewage and were likely sources of elevated *E. coli* densities in the creek. Other possible contamination sources are known illicit discharges in the Big Creek watershed, especially at RM 9.80.

Table 7. Wet-Weather Overflows to Big Creek				
Date Range	Outfall Name	Location	Number of Overflows	Million Gallons (MG)
7/22/2015 – 8/19/2015	CSO 051	West 38th/Muriel	2	Unknown
	CSO 055	Bellaire/Kensington Dam	2	Unknown


¹ Wet-weather sampling events: greater than 0.10 inches of rain but less than 0.25 inches, samples collected that day and the following day are considered wet-weather samples; greater than 0.25 inches, the samples collected that day and the following two days are considered wet-weather samples.


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Table 7. Wet-Weather Overflows to Big Creek				
Date Range	Outfall Name	Location	Number of Overflows	Million Gallons (MG)
	CSO 056	Bellaire/Kensington Gate	2	0.872
	CSO 058	W. 145th/Puritas	2	5.256
7/26/2016 – 8/23/2016	CSO 051	W. 38th/Muriel	9	Unknown
	CSO 055	Bellaire/Kensington Dam	1	Unknown
	CSO 056	Bellaire/Kensington Gate	3	0.507
	CSO 058	W. 145th/Puritas	3	5.755

Mercury analysis for all of the sampling events was done using EPA Method 245.1. See Table 8 for results. Because the detection limit for this method is above the criteria for the Human Health Nondrinking Outside Mixing Zone Averages (OMZA) of 0.0031 µg/L and Protection of Wildlife OMZA of 0.0013 µg/L, it generally cannot be determined if Big Creek was in attainment of those criteria. Instead, this type of mercury sampling was used as a screening tool to determine whether contamination was present above those levels typically found in the creek. Based on the sampling that was completed, mercury was not present at levels above those normally found in the watershed (USEPA, 2004).

Table 8. Big Creek Mercury (Hg) Concentrations (ug/L)						
Date	RM 0.15	RM. 4.40	RM 0.02	RM0.15S	RM 0.20	RM 9.80
7/22/2015	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
7/29/2015	j 0.09	j 0.09	j 0.08	j 0.011	j 0.01	j 0.01
8/5/2015	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
8/15/2015	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
8/19/2015	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
7/26/2016	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
8/2/2016	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
8/9/2016*	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
8/16/2016*	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
8/23/2016	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005

 Exceedance of Human Health NonDrinking OZMA & Tier I OMZA (0.0031 ug/L) for 30-day period beginning with that date, assuming “j” values are actual values and concentrations below the MDL are zero.

 Exceedance of Wildlife OMZA (0.0013 ug/L) for 30-day period beginning with that date, assuming “j” values are actual values and concentrations below the MDL are zero.

*Wet-weather event

Benthic Chlorophyll *a* Sampling

In 2015, the Ohio EPA Nutrients Technical Advisory Group released a proposed Stream Nutrient Assessment Procedure (SNAP) designed to determine the degree of impairment in a stream due to nutrient enrichment. SNAP assigns designations for quality of surface waters based on factors including dissolved oxygen (DO) swings, benthic chlorophyll *a*, total phosphorous, and dissolved inorganic nitrogen (Ohio EPA, 2015).

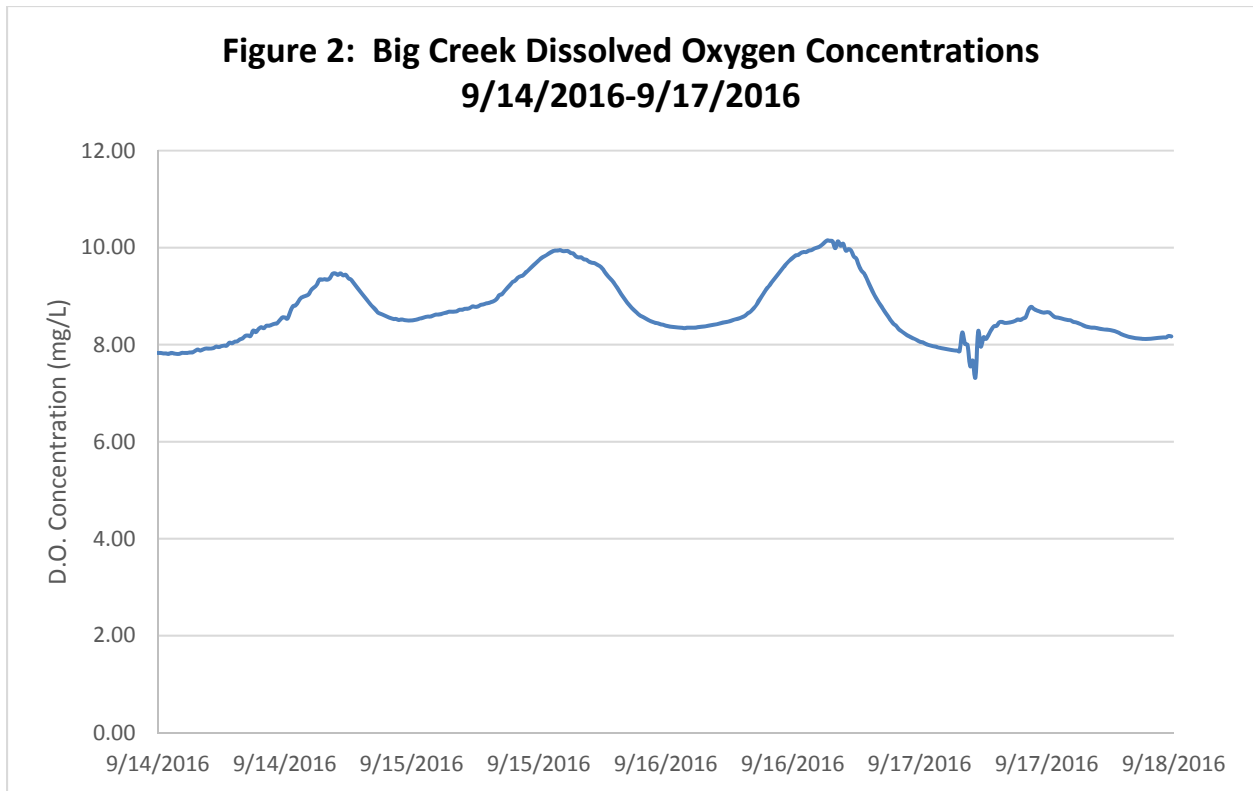
In 2016, chlorophyll *a* levels in Big Creek were measured at one location in the vicinity of a long-term data sonde station. The purpose of this sampling was to provide a more comprehensive understanding of the relationship among algal production, nutrient levels, and DO diel swings in the creek. While the primary purpose of the data sonde was to collect DO data, the data sonde also recorded measurements for specific conductance, pH, temperature, and turbidity in 15-minute increments. The data sonde, a YSI EXO2 sonde, is located at RM 0.15 on the downstream side of the Jennings Road bridge in Cleveland, OH (Lat: 41.4460, Lon: -81.6865). This location is approximately 50 meters upstream of the electrofishing zone. Data from RM 0.15 collected as part of 2016 Big Creek Environmental Project was also used during the SNAP analysis. The data sonde was calibrated at NEORSD Environmental and Maintenance Services Center per the manufacturer’s recommendations. Upon return from the field, data was downloaded and calibrations were checked for continued accuracy.

Chlorophyll *a* samples along with nutrient samples were collected on September 14, 2016. Chlorophyll *a* was analyzed from both the benthos and water column following NEORSD SOP-EA001-01, Chlorophyll *a* Sampling and Field Filtering. For benthic chlorophyll *a* analysis, at least 15 rocks were sampled from a variety of habitats at the sample site. Water chemistry and chlorophyll *a* results are listed below in Table 9.

Table 9. Big Creek Benthic Chlorophyll <i>a</i> September 14, 2016 Results	
Parameter	Result
Chlorophyll <i>a</i> (Water Column)	2.678 µg/L
Chlorophyll <i>a</i> (Benthic)	87.2 mg/m ²
Dissolved Inorganic Nitrogen	0.639 mg/L
Dissolved Oxygen Swing	1.66 mg/L
DRP	0.063 mg/L
Total Phosphorus	0.095 mg/L
TSS	1.1 mg/L

DO diel swings were also evaluated from September 13, 2016 through September 17, 2016 (Figure 2). Daily maximum DO levels and daily minimum DO levels were calculated. The DO diel swing was calculated daily by subtracting the daily minimum from the daily maximum. DO diel swings used for SNAP evaluation were from the day of

sampling (September 14, 2016); however, each day was evaluated to ensure that the swing on the day of sampling was not atypical.



Biological sampling and habitat assessment results from 2016 were used in the assessment through SNAP (Table 10). Per the minimum data requirements of SNAP, biological data was collected at comparable baseflows, but may have experienced changing flow events between the biological collections and chlorophyll *a* collection events. Additionally, biological sampling and the habitat assessment were performed outside the suggested range of time from chlorophyll *a* sampling. However, all data collection occurred during the normal field season during 2016.

Table 10. Big Creek RM 0.15 Biological & Habitat Sampling Dates & Scores		
Sample	Date	Score
IBI	10/06/2016	30
MIwb	10/06/2016	7.2
Macroinvertebrate Qualitative Narrative	09/19/2016	Poor
QHEI	09/06/2016	69.5
Bold = Meets the WWH Biocriterion		

Nutrients were assessed during the chlorophyll *a* sampling. The minimum data requirements suggest at least three samples per location to be reported as a geometric mean.

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One set of nutrient data was collected at the same time as the chlorophyll *a* collection on September 14, 2016. Nutrients were also assessed at RM 0.15 for watershed monitoring. Table 11 shows the results of three dry-weather results and the calculated geometric mean and standard deviation as well as the results from September 14, 2016. The nutrient concentrations used in the SNAP analysis were done so by comparing the geometric mean to the single sampling event. If the single sampling event differed outside the standard deviation, the higher of the two concentrations was used.

Table 11. Big Creek Nutrient Results for SNAP Analysis						
Sample Date	8/2/2016	8/9/2016	8/23/2016	GeoMean	StdDev	9/14/2016
Total Phosphorus (mg/L)	0.106	0.096	0.078	0.093	0.014	0.095
DRP (mg/L)	0.063	0.061	0.039	0.053	0.013	0.063
Dissolved Inorganic Nitrogen (mg/L)	0.400	0.248	0.404	0.342	0.089	0.639
When questions arose using these numbers, the geometric mean and the measurements taken on 9/14/16 were considered. If the same result was not the output from the tables, the worst case of the two measurements was used.						

SNAP uses a variety of flow charts to determine the best course of action for a stream segment. The results of these flow charts are shown in Table 12. Some sections of the flow charts require the use of best professional judgment and the result could be disputed. However, in the case of a dispute, often the same answer was ultimately reached by both pathways through the flow chart.

Table 12. Big Creek SNAP Flow Chart Results	
Step/Question	Result/Answer
Step 1-Biological Criteria	Non-attaining (one or more indices below non-significant departure.
Step 2-DO Swing	Normal or low swings (≤ 6.5 mg/L)
Step 3-Benthic Chlorophyll <i>a</i>	Low to moderate (≤ 320 mg/m ²)
Step 4-Preliminary Assessment	Impaired, but causes(s) other than nutrients. See flow chart B.
Flow Chart B	
Are stressors unrelated to nutrients responsible for observed condition?	Yes (<i>E. coli</i>)
Document causal assessment and linkage to stressor(s)	

The results of SNAP at Big Creek determined that the best course of action with respect to nutrients is “attaining use or not threatened.” Thus, nutrients do not appear to be a contribution to any impairments at this time because other factors are most likely the cause for the biological non-attainment at that location.

Habitat Assessment

Methods

Instream habitats were conducted using the Qualitative Habitat Evaluation Index (QHEI). The QHEI was developed by the Ohio EPA to assess aquatic habitat conditions that may influence the presence or absence of fish species by evaluating the physical attributes of a stream. The index is based on six metrics: stream substrate, instream cover, channel morphology, riparian zone and bank condition, pool and riffle quality, and stream gradient. The QHEI has a maximum score of 100, and a score of 60 or more suggests that sufficient habitat exists to support a fish community that meets the warmwater habitat criterion for wading and boating sites (Ohio EPA, 2003). For headwater sites the target QHEI score is 55 or more. A more detailed description of the QHEI can be found in Ohio EPA's *Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)* (2006). QHEI field sheets for each site are available upon request from the NEORSW WQIS Division.

Results and Discussion

In 2015, an instream habitat assessment was conducted once at RMs 0.15, 4.40 (Big Creek), 0.02 (Ford Branch), 0.20 (Unnamed Tributary) and RM 0.15 (Stickney Creek) using the QHEI method. In 2016, an instream habitat assessment was again conducted at each site once in addition to RM 9.80 (Table 13) using the QHEI method.

Table 13. Big Creek QHEI Results			
River Mile	Year	QHEI Score	Narrative
0.15 Wading Site 2007-2014 Boat Site 2015-2016	2007	68.75	<i>Good</i>
	2008	64.00	<i>Good</i>
	2009	73.25	<i>Good</i>
	2010	70.50	<i>Good</i>
	2011	69.50	<i>Good</i>
	2012	71.50	<i>Good</i>
	2013	73.50	<i>Good</i>
	2014	68.00	<i>Good</i>
	2015	72.50	<i>Good</i>
	2016	69.50	<i>Good</i>
4.40 Headwater Site	2007	60.75	<i>Good</i>
	2008	66.50	<i>Good</i>
	2009	61.75	<i>Good</i>
	2010	60.50	<i>Good</i>
	2011	63.00	<i>Good</i>
	2015	62.50	<i>Good</i>
	2016	65.50	<i>Good</i>

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Table 13. Big Creek QHEI Results			
River Mile	Year	QHEI Score	Narrative
Ford Branch 0.02 Headwater Site	2015	68.50	<i>Good</i>
	2016	62.75	<i>Good</i>
Stickney Creek 0.15 Headwater Site	2015	63.00	<i>Good</i>
	2016	63.00	<i>Good</i>
Unnamed Trib 0.20 Headwater Site	2015	67.25	<i>Good</i>
	2016	67.00	<i>Good</i>
9.80 Headwater Site	2016	69.50	<i>Good</i>

River mile 0.15 was historically categorized as a wading site, but in 2015 and 2016, it was changed to a boating site due to a scouring of the substrate that resulted in it being too deep to wade in. The QHEI score was 72.50 for RM 0.15 in 2015 and 69.50 in 2016 (Table 13). For the past ten years, this site has exceeded the target QHEI score of 60 and therefore was rated “*Good*” for all ten years. The site has a predominantly gravel and sand substrate and features a large riffle, runs, and deep pools. Instream cover is moderate and consists of undercut banks, overhanging vegetation, slow shallows, boulders, rootwads and logs or woody debris. The creek has a very narrow riparian zone to buffer the surrounding urban and industrial land use, and the bank on river right has severe erosion. The sediments at this site appear to be prone to shifting, presumably during wet-weather events and high flows.

The QHEI score for RM 4.40 was 62.50 in 2015 and increased to 65.50 in 2016. This site was rated “*Good*” for both years. The site has a predominately bedrock and gravel substrate and features two riffles, a run, and a pool 35cm deep. Instream cover is moderate with undercut banks, boulders, sparse rootwads, logs and aquatic macrophytes. There is heavy erosion on the right bank and moderate erosion on the left bank.

Big Creek’s Ford Branch RM 0.02 is located north of Memphis Avenue, Brooklyn, Ohio, and within the Cleveland Metroparks. The Ford Branch merges with Big Creek just upstream of RM 4.40. The QHEI score for RM 0.02 was 68.50 in 2015 and decreased to 62.75 in 2016, but still maintained the rating of “*Good*” for both years. The site has a predominately gravel and sand substrate and features a large gravel bar along the right bank and large boulders along the left bank. There is a moderate amount of instream cover with undercut banks, shallows, rootmats and two small areas of backwater. Both sides of the creek are experiencing moderate erosion.

Stickney Creek RM 0.15 had a QHEI score of 63.00 for both years and therefore was rated “*Good*”. Stickney Creek is a tributary of Big Creek. The confluence is at Big Creek’s RM 5.0, just south of Memphis Avenue in Brooklyn, Ohio. Stickney Creek’s substrate is predominately made up of bedrock and gravel. Instream cover is moderate

with undercut banks, shallows, rootmats, rootwads, and boulders. There is heavy erosion on both the right and left banks.

The QHEI score for Big Creek's unnamed tributary RM 0.20 was 67.25 in 2015 and decreased slightly to 67.00 in 2016. For both years, this site met the target score of 55, indicating that this site is "Good". Predominately sand and bedrock substrate was evident throughout the creek. The site has moderate instream cover with undercut banks, overhanging vegetation, shallows, rootmats, rootwads, deep pools, boulders, and woody debris. This site has little erosion on the left bank and moderate to heavy erosion on the right bank.

In 2016, Big Creek RM 9.80 had a QHEI score of 69.50 and was rated "Good". Bedrock and gravel were the predominate substrate types with normal silt and substrate embeddedness. Instream cover consisted of undercut banks, rootmats, rootwads, pools, boulders, and woody debris. The left and right banks are experiencing moderate erosion and have a narrow riparian width.

Fish Community Assessment

Methods

Quantitative electrofishing passes were conducted one or two times each at Big Creek in 2015 and 2016 by boat and longline electrofishing techniques and consisted of shocking all habitat types within a sampling zone while moving from either upstream to downstream (boat) or downstream to upstream (longline). RM 0.15 was conducted using boat method and the other sites were completed by longline. The sampling zones were 0.20 kilometers for the boat site and 0.15 kilometers for the longline sites. The methods that were used followed Ohio EPA protocol methods as detailed in *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987a) and *III* (1987b). Fish collected during the surveys were identified, weighed and examined for the presence of anomalies, including DELTs (deformities, eroded fins, lesions, and tumors). All fish were then released to the waters from which they were collected, except for vouchers and those that could not be easily identified in the field.

The electrofishing results for each pass were compiled and utilized to evaluate fish community health through the application of two Ohio EPA indices, the Index of Biotic Integrity (IBI) and the Modified Index of Well-Being (MIwb). The IBI incorporates 12 community metrics representing structural and functional attributes. The structural attributes are based upon fish community aspects such as fish numbers and diversity. Functional attributes are based upon fish community aspects such as feeding strategies, environmental tolerances, and disease symptoms. These metrics are individually scored by comparing the data collected at the survey site with values expected at reference sites located in a similar geographical region. The maximum possible IBI score is 60 and the

minimum possible score is 12. The summation of the 12 individual metrics scores provides a single-value IBI score, which corresponds to a narrative rating of *Exceptional*, *Good*, *Marginally Good*, *Fair*, *Poor* or *Very Poor*. The 12-metrics utilized for the monitoring sites are listed in Table 14.

Table 14. IBI Metrics		
	Headwater Sites	Boat Sites
1.	Total Number of Native Species	Total Number of Native Species
2.	Number of Darters & Sculpins	Percent Round-Bodied Suckers
3.	Number of Headwater Species	Number of Sunfish Species
4.	Number of Minnow Species	Number of Sucker Species
5.	Number of Sensitive Species	Number of Intolerant Species
6.	Percent Tolerant Species	Percent Tolerant Species
7.	Percent Pioneering Species	Percent Omnivores
8.	Percent Omnivores	Percent Insectivores
9.	Percent Insectivores	Percent Top Carnivores
10.	Number of Simple Lithophils	Percent Simple Lithophils
11.	Percent DELT Anomalies	Percent DELT Anomalies
12.	Number of Fish	Number of Fish

The second fish index utilized by Ohio EPA is the Modified Index of Well-being (MIwb). The MIwb, Formula 1 below incorporates four fish community measures: numbers of individuals, biomass, and the Shannon Diversity Index (H) (Formula 2 below) based on numbers and weight of fish. The MIwb is a result of a mathematical calculation based upon the formula.

Formula 1:
$$MIwb = 0.5 \ln N + 0.5 \ln B + \bar{H}(No.) + \bar{H}(Wt.)$$

N = Relative numbers of all species excluding species designated as highly tolerant, hybrids, or exotics

B = Relative weights of all species excluding species designated as highly tolerant, hybrids, or exotics

$\bar{H}(No.)$ = Shannon Diversity Index based on numbers

$\bar{H}(Wt.)$ = Shannon Diversity Index based on weight

Formula 2:
$$\bar{H} = -\sum \left[\left(\frac{n_i}{N} \right) \log_e \left(\frac{n_i}{N} \right) \right]$$

n_i = Relative numbers or weight of species

N = Total number or weight of the sample

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Lists of the species, numbers, weights, pollution tolerances and incidence of DELT anomalies for fish collected during the electrofishing pass are available upon request from the NEORSD WQIS Division.

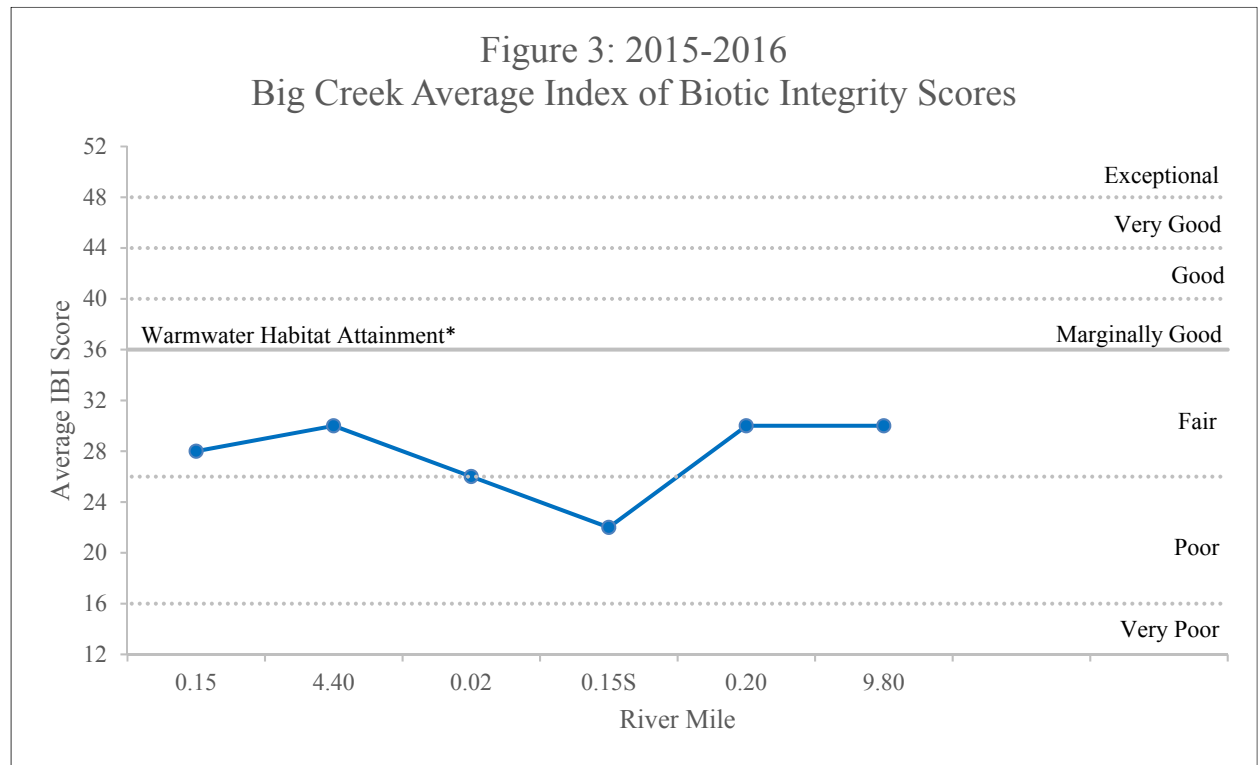
Results and Discussion

The WWH IBI criterion in the Erie-Ontario Lake Plain (EOLP) ecoregion is 40 for headwater and boat sites. A site is considered in non-significant departure if it is within 4 IBI units of the criterion. Therefore, an IBI score of 36 is considered to be in attainment. The MIwb criterion is 8.7 for boat sites; non-significant departure is within 0.5 units. Table 15 lists the IBI and MIwb scores where applicable and the average IBI scores are displayed in Figure 3.

Table 15. Big Creek IBI & MIwb Scores					
River Mile	Year	IBI		MIwb	
		Score	Narrative Rating	Score	Narrative Rating
0.15 Boat Site*	2007	28	<i>Fair</i>	5.3	<i>Poor</i>
	2008	32	<i>Fair</i>	6.6	<i>Fair</i>
	2009	26	<i>Poor</i>	5.6	<i>Poor</i>
	2010	29	<i>Fair</i>	6.1	<i>Fair</i>
	2011	30	<i>Fair</i>	6.1	<i>Fair</i>
	2012	31	<i>Fair</i>	7.0	<i>Fair</i>
	2013	32	<i>Fair</i>	5.4	<i>Poor</i>
	2014	28	<i>Fair</i>	8.6	<i>Marginally Good</i>
	2015	28	<i>Fair</i>	6.6	<i>Fair</i>
	2016	27	<i>Fair</i>	7.6	<i>Fair</i>
4.40 Headwater Site	2007	34	<i>Fair</i>	n/a	n/a
	2008	32	<i>Fair</i>	n/a	n/a
	2009	36	<i>Marginally Good</i>	n/a	n/a
	2010	35	<i>Fair</i>	n/a	n/a
	2011	31	<i>Fair</i>	n/a	n/a
	2015	30	<i>Fair</i>	n/a	n/a
	2016	30	<i>Fair</i>	n/a	n/a
Ford Branch 0.02 Headwater Site	2015	28	<i>Poor</i>	n/a	n/a
	2016	24	<i>Poor</i>	n/a	n/a
Stickney Creek 0.15 Headwater Site	2015	22	<i>Poor</i>	n/a	n/a
	2016	22	<i>Poor</i>	n/a	n/a
Unnamed Trib 0.20 Headwater Site	2015	30	<i>Fair</i>	n/a	n/a
	2016	30	<i>Fair</i>	n/a	n/a

Table 15. Big Creek IBI & MIwb Scores					
		IBI		MIwb	
River Mile	Year	Score	Narrative Rating	Score	Narrative Rating
9.80 Headwater Site	2015	n/a	n/a	n/a	n/a
	2016	30	<i>Fair</i>	n/a	n/a

*Prior to 2014, RM 0.15 was assessed as a wading site



*Non-significant departure (≤ 4 IBI units) from applicable criterion.

Prior to 2014, RM 0.15 was assessed as a wading site. In 2015 and 2016, two electrofishing passes took place by boat method. The fish community at RM 0.15 in 2015 had an average IBI score of 28 (*Fair*) and an average MIwb score of 6.6 (*Fair*), failing to meet the IBI WWH biocriterion and the MIwb biocriterion. In 2016, the RM 0.15 IBI score again failed to meet the IBI WWH biocriterion because the average score decreased to 27 (*Fair*) and also failed to meet the MIwb biocriterion with the score of 7.6 (*Fair*). Twenty-three species of fish were collected during the electrofishing passes, and about 40% of the total catch consisted of highly pollution-tolerant individuals such as common white sucker (*Catostomus commersonii*), yellow bullhead (*Ictalurus natalis*), green sunfish (*Lepomis cyanellus*) and goldfish (*Carassius auratus*). These types of fish are generally adaptive fish that are able to tolerate turbidity, siltation, and elevated temperatures. Just over 20% of the collected fish are moderately intolerant to pollution. These included northern hog suckers (*Hypentelium nigricans*), sand shiners (*Notropis stramineus*), brook

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silverside (*Labidesthes sicculus*), northern logperch darter (*Percina caprodes*), and smallmouth bass (*Micropterus dolomieu*).

In 2015 and 2016, new sites were added to the District's study of Big Creek. The new sites were the Ford Branch RM 0.02, Stickney Creek RM 0.15, an unnamed tributary at RM 0.20 and the most upstream point of the study, RM 9.80. The IBI at Big Creek RM 4.40 received a score of 30 (*Fair*) for both years, which is a slight decline from the average scores achieved in 2008 through 2011 sampling events which had an average score of 33 (*Fair*). Also in each year, eight species of fish were collected in one electrofishing pass. In 2015, 41% of the total catch consisted of pollution-tolerant individuals such as common white sucker and bluntnose minnow (*Pimephales promelas*). The creek chub (*Semotilus atromaculatus*) was the most dominant pollution-tolerant found. These types of fish are generally adaptive fish that are able to tolerate turbidity, siltation, and elevated temperatures. In 2016, 72% of the total catch consisted of pollution-tolerant individuals such as creek chub and blacknose dace (*Rhinichthys atratulus*). In both 2015 and 2016, only 2% of the collected fish were moderately intolerant to pollution. These were sand shiners. Other species collected that are moderately tolerant or of intermediate tolerance were central stoneroller minnows (*Campostoma anomalum*), northern bluegill sunfish (*Lepomis macrochirus*), and bigmouth shiners (*Notropis dorsalis*).

The Ford Branch RM 0.02 received an IBI score of 28 (*Poor*) in 2015 and 24 (*Poor*) in 2016. During the electrofishing pass in 2015, 62% of the fish collected were pollution-tolerant. There were common white suckers, blacknose dace, creek chub, and bluntnose minnow. Bigmouth shiner and central stoneroller minnows are of intermediate tolerance and made up 34% of the fish collected and sand shiners are moderately intolerant to pollution and made up about 4%. It should be noted that the bigmouth shiner is on the threatened species list for the state of Ohio (ODNR, 2016).

Stickney Creek RM 0.15 had one electrofishing pass in 2015 and again in 2016. In both years, RM 0.15 scored an IBI score of 22 (*Poor*) with four of the five species collected considered to be highly tolerant to polluted waters. Creek chub had the highest population collected at 59% in 2015 and 42% in 2016. Blacknose dace made up almost 8% in 2015 and increased to 25% in 2016. In 2015, bluntnose minnows made up only 3% and the common white sucker collected made up 11%. In 2016, each made up 10% of this highly pollution-tolerant collection. Central stoneroller minnows made up the remaining 20% in 2015 and 13% in 2016.

The unnamed Big Creek tributary at RM 0.20 had one electrofishing pass in 2015 and one in 2016. In 2015, RM 0.20 scored a *Fair* IBI score of 30. Seventy-one percent of the fish collected were pollution-tolerant. The pollution-tolerant species were common white sucker, blacknose dace, creek chub, bluntnose minnow, and green sunfish. Central stoneroller minnows made up the remaining 29%. In 2016, 80% of the fish collected were pollution-tolerant and included common white sucker, golden shiners, blacknose dace,

creek chub, bluntnose minnow, and green sunfish. Central stoneroller minnows made up the remaining 20%.

Electrofishing was not conducted in 2015 at RM 9.80, but it was completed in 2016. RM 9.80 had an IBI score of 30 (*Fair*), failing to meet the WWH biocriterion. About 50% of the total catch consisted of pollution-tolerant fish such as common white sucker, creek chub, green sunfish (*Lepomis cyanellus*), and blacknose dace. Only 5% of the fish collected are moderately tolerant or of intermediate tolerance to pollution: northern bluegill sunfish, pumpkinseed sunfish (*Lepomis gibbosus*) and largemouth bass (*Micropterus salmoides*).

During the two years of sampling of Big Creek, over twelve million gallons of combined sewage flowed into Big Creek (Table 7). These overflows may detract from a movement of more desirable pollution-sensitive species from inhabiting the creek. CSO 051 and CSO 055 do not currently have regulators that quantify the amount of combined sewage discharged. There are also a number of illicit discharges located upstream of the sampling area. The fish community would likely improve with the reduction/removal of overflow events and illicit discharges, as the habitat should be capable of supporting a more diverse population of fish. However, there are also fish migration barriers present in the creek that prevent the movement of additional species into the upper section of the watershed.

Macroinvertebrate Sampling

Methods

Macroinvertebrates were sampled quantitatively using modified Hester-Dendy (HD) samplers in conjunction with a qualitative assessment of Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly), also referred to as EPT taxa, inhabiting available habitats at the time of HD retrieval. Methods for sampling followed the Ohio EPA's Biological Criteria for the Protection of Aquatic Life, Volume III (1987b). The recommended period for HDs to be installed is six weeks.

The macroinvertebrate qualitative samples were sent to Third Rock Consulting of Lexington, Kentucky, for identification and enumeration. Specimens were identified to the lowest practical taxonomic level as recommended in Ohio EPA's *Biological Criteria for the Protection of Aquatic Life, Volume III* (1987, updated September 30, 1989; November 8, 2006; and August 26, 2008). The taxa list and enumerations are available upon request from NEORSD's WQIS Department.

The overall aquatic macroinvertebrate community in the stream was evaluated using Ohio EPA's Invertebrate Community Index (ICI) (Ohio EPA 1987a). The ICI consists of ten community metrics (Table 18), each with four scoring categories. Metrics 1-9 are based

on the quantitative sample, while Metric 10 is based on the qualitative *Ephemeroptera*, *Plecoptera*, and *Trichoptera* (EPT) taxa. Each ICI metric can receive a score of 6, 4, 2, or 0 depending on the undisturbed site comparison, therefore the total of the individual metric scores result in the overall score can contain a range between 0 as the lowest score to 60 as the highest score. This scoring evaluates the community against Ohio EPA's reference sites for each specific eco-region.

Table 18. ICI Metrics	
1.	Total number of taxa
2.	Number of mayfly taxa
3.	Number of caddisfly taxa
4.	Number of dipteran taxa
5.	Percent mayflies
6.	Percent caddisflies
7.	Percent Tanytarsini midges
8.	Percent other diptera and non-insects
9.	Percent tolerant organisms (as defined)
10.	Number of qualitative EPT taxa

Results and Discussion

For Big Creek RMs 4.40, 0.02, and 0.20, an HD sampler was unable to be recovered during the 2015 and 2016 sampling seasons. Therefore, a narrative assessment was designated for these sample sites based on data from qualitative sampling, and by utilizing the best professional judgment of the leading macroinvertebrate biologists and Qualified Data Collectors (QDCs). Factors considered in the assignment of narrative ratings included, but was not limited to: historical data from the site; total site drainage area; macroinvertebrate population composition in the qualitative sample with respect to the number of total taxa, EPT (Ephemeroptera, Plecoptera, and Trichoptera) taxa, pollution sensitive taxa, and pollution tolerant taxa; and organism abundance within individual families or groups noted during sample collection. Table 18 summarizes the sampling results from 2007-2016.

Big Creek RM 0.15 was assigned a narrative rating of *Poor* in 2016. According to data collected from the qualitative sample, the site has degraded from the previous year with respect to the macroinvertebrate population. In 2015, the site received an ICI score of 18, narratively *Fair*. In 2016, there were fewer overall taxa in the qualitative sample (16 qualitative taxa) compared to 2015 (23 qualitative taxa). Seven of the 16 total taxa present in the 2016 sample were either classified as tolerant or moderately tolerant to pollution according to the 2016 Ohio EPA Macroinvertebrate Taxa List. The remaining

nine taxa were classified as facultative. Only three EPT taxa were found to be present at this site in 2016, all of which were classified as facultative. Ephemeropteran taxa present in the qualitative sample were *Baetis flavistriga* and *Baetis intercalaris*. The single Trichopteran taxon present was *Hydropsyche depravata group*. The most abundant organisms observed during qualitative sampling included facultative Baetidae, pollution tolerant *Caecidotea sp.*, and facultative to tolerant Chironomidae. The narrative rating assignment of *Poor* was assigned primarily due to the low number of EPT taxa, decrease in overall taxa compared to the previous year, and the complete lack of sensitive taxa at the site.

Over the past ten years of monitoring Big Creek RM 0.15, this site has averaged an ICI score of 24 with a narrative assessment of *Fair*. Two years, 2012 and 2014, reached scores of 32 and 30, which are considered *Marginally Good* as the narrative assessment. In 2015, the stream's ICI score drastically declined, hitting its lowest ICI score of 18, followed by a narrative assessment in 2016 as *Poor*.

Big Creek RM 4.40 was assigned a narrative rating of *Marginally Good* in both 2015 and 2016. In 2015, a total of 24 taxa with pollution tolerance values ranging from tolerant to moderately intolerant were collected in the qualitative sample. Six EPT taxa ranging from facultative to moderately intolerant were present in 2015 including Ephemeropteran taxa, *Baetis flavistriga* and *Baetis intercalaris*; and Trichopteran taxa, *Cheumatopsyche sp.*, *Ceratopsyche morosa*, *Ceratopsyche sparna*, and *Hydropsyche depravata group*. Two sensitive taxa with pollution tolerance classifications of moderately intolerant were found to be present at this site in 2015, *Ceratopsyche morosa* and *Antocha sp.* The macroinvertebrate families recorded as most common during the qualitative sampling included Baetidae, Hydropsychidae and Chironomidae. The pollution tolerant taxon *Caecidotea sp.* was also found to be common at this site. While the level of species diversity, and number and abundance of EPT taxa were found to be greater than what would be observed for a site with a narrative rating of *Fair*, the limited number of sensitive taxa collected indicates that this site does not meet WWH expectations. Therefore, this site was designated with the narrative rating of *Marginally Good* in 2015.

The qualitative sampling performed at Big Creek RM 4.40 in 2016 yielded very similar results to the sampling performed in 2015. In 2016, a total of 28 taxa with pollution tolerance values ranging from tolerant to moderately intolerant were collected. Compared to the data from 2015, one additional EPT taxa from the group Trichoptera, *Chimarra aterrima*, was found to be present at the site. While the sensitive Dipteran taxa *Antocha sp.* was not found to be present in 2016, two additional sensitive taxa were collected for a total of three moderately intolerant taxa, Trichopteran species *Chimarra aterrima* and *Ceratopsyche morosa*; and the Chironomidae *Polypedilum aviceps*. Because there were negligible changes observed between 2015 and 2016, the site was again designated with the narrative rating of *Marginally Good* in 2016. Since 2008, Big Creek RM 4.40 has

fluctuated from being rated between *Fair* and *Good*, with *Marginally Good* as the rating the last two years.

Big Creek Ford Branch RM 0.02 was assigned a narrative rating of *Poor* for both 2015 and 2016. The number of total taxa collected in the qualitative sample was low in both years, at 14 taxa and 16 taxa in 2015 and 2016, respectively. In both years, *Baetis flavistriga* was the only EPT taxa collected at the site. Approximately half of the collected taxa had pollution tolerance value classifications of either tolerant or moderately tolerant (according to the Ohio EPA Taxa List). The remaining taxa were classified as facultative. The most abundant groups observed during qualitative sample collection were noted as Baetidae and Amphipoda in 2015; and Baetidae, Turbellaria, Oligochaeta and Hirudinea in 2016.

Big Creek Stickney Creek Branch RM 0.15 was assigned a narrative rating of *Good* in 2015 and an ICI score of 36, reaching attainment of WWH criterion. The total taxa for the qualitative sample was 31 taxa, which contained 4 EPT taxa, including *Baetis flavistriga* and *Hydropsyche depravata group*. RM 0.15 score reduced to *Fair* in 2016. There were fewer taxa in the qualitative sample although there were a higher number of EPT taxa in comparison to the previous year. The sampling event in 2016 also included the collection of *Cardiocladius obscurus*, *Antocha*, and the caddisfly *Ceratopsyche morosa*. These species are classified as moderately intolerant of pollution. The collection was dominated by *Tanytarsus glabrescens* group that is listed as facultative.

In 2015, the unnamed Big Creek tributary RM 0.20 site was assigned a narrative rating of *Fair*. A total of 25 taxa were collected at this site. Of these taxa, three EPT taxa were present, one Ephemeroptera taxa, *Baetis flavistriga*, and two Trichoptera taxa, *Cheumatopsyche sp.* and *Hydropsyche depravata group*. Twenty-four of the 25 taxa were classified as tolerant to facultative with respect to pollution tolerance according to the Ohio EPA Macroinvertebrate taxa list. At the time of sample collection, macroinvertebrate density was noted as low and the most commonly observed groups included Baetidae and Turbellaria.

Big Creek RM 9.80 was assigned a narrative rating of *Poor* in 2016. According to data collected from the qualitative samples, the site had degraded from the previous year with respect to the macroinvertebrate population. In 2015, the site received an ICI score of 20, narratively *Fair*. In 2016, there were fewer overall taxa in the qualitative sample compared to 2015 (18 qualitative taxa in 2015, 12 qualitative taxa present in 2016). Five of the 12 taxa present in the sample were either listed as tolerant or moderately tolerant. The remaining seven taxa were listed as facultative. Four EPT taxa were found to be present at this site in 2016, all of which were listed as facultative. Of these, *Baetis flavistriga* was the only Ephemeropteran species found to be present. The Trichopteran taxa, *Cheumatopsyche sp.*, *Certartopsyche sparna*, and *Hydropsyche depravata group* made up the remainder of the EPT taxa present at the site. The narrative rating assignment

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of *Poor* was designated primarily due to the low number of EPT taxa, decrease in overall taxa compared to the previous year, and the complete lack of sensitive taxa at the site. This site suffers from high levels of sanitary sewage contamination, organic loading, and corresponding nuisance algae growth, resulting from nearby point source pollution from storm sewer outfalls with documented sanitary sewage cross connections. The sanitary sewage contamination, coupled with the low rainfall and corresponding decreased streamflow observed in 2016, were most likely the largest contributors to the poor quality of the macroinvertebrate population observed at this site.

Table 18. Big Creek Invertebrate Community Index (ICI) Results							
RM	Date	ICI Score	Narrative Rating	Quantitative Taxa	Qualitative Taxa	Qualitative EPT Taxa	% Tolerant (as defined)
0.15	2007	22	<i>Fair</i>	29	16	5	43.9
	2008	20	<i>Fair</i>	24	15	6	57.4
	2009	28	<i>Fair</i>	26	24	6	19.0
	2010	20	<i>Fair</i>	31	27	3	58.5
	2011	--	<i>Marginally Good</i>	--	25	7	--
	2012	32*	<i>Marginally Good</i>	31	25	6	18.2
	2013	24	<i>Fair</i>	36	27	3	45.8
	2014	30*	<i>Marginally Good</i>	28	25	4	16.22
	2015	18	<i>Fair</i>	25	23	3	87.53
2016	--	<i>Poor</i>	--	16	3	--	
4.40	2007	8	<i>Poor</i>	28	19	4	14.9
	2008	36*	<i>Good</i>	23	28	5	10.0
	2010	38*	<i>Good</i>	23	24	6	--
	2011	--	<i>Fair</i>	--	30	6	--
	2015	--	<i>Marginally Good</i>	--	24	6	--
	2016	--	<i>Marginally Good</i>	--	28	7	--
1.00	2014	28	<i>Fair</i>	24	20	8	20.97
0.02	2015	--	<i>Poor</i>	--	14	1	--
	2016	--	<i>Poor</i>	--	16	1	--
0.15S	2015	36*	<i>Good</i>	25	31	4	2.49
	2016	28	<i>Fair</i>	21	28	7	8.53
0.20	2015	--	<i>Fair</i>	--	25	3	--
	2016	30*	<i>Marginally Good</i>	32	20	6	22.62
9.80	2015	20	<i>Fair</i>	22	18	3	20.13
	2016	--	<i>Poor</i>	--	12	4	--
* Bold indicates attainment of WWH criterion							
-- HD was not collected							

Conclusions

The results of the water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys conducted by NEORS indicate that the Big Creek watershed may be impacted by a variety of environmental stressors and various aquatic habitat limitations, as mentioned previously. Biological assessments that were

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conducted at all six sites showed non or partial attainment of WWH biological criteria (Table 19). Sampling on Big Creek was conducted to determine point source and non-point source impairments. From the water chemistry portion of this sampling, it was found that exceedances of the applicable water quality standards occurred for bacteria (Table 5). Combined sewer overflows due to wet-weather events, along with illicit discharges, were most likely responsible for the elevated *E. coli* densities that were found in the creek.

The fish and macroinvertebrate communities in Big Creek indicated some impairment, and may be the result of these above-mentioned sources. The fish community mainly consisted of highly pollution-tolerant fish, such as white suckers, yellow bullheads and green sunfish. The macroinvertebrate communities scored in the *Poor* to *Marginally Good* ranges, respectively, for the 2015-2016 sampling season. The low ICI scores for several sites may be attributed to poor water quality conditions that continue to compromise Big Creek. *E. coli* densities above the acceptable levels may be preventing Big Creek from supporting a more robust and diverse macroinvertebrate population that would include pollutant-sensitive species. A good proportion of the macroinvertebrate community was comprised of *Oligochaeta*, a classification of organisms listed in the ICI metrics as extremely pollution tolerant. RM 4.40 continues to maintain a *Marginally Good* rating, which could be attributed to the variety of favorable instream habitats.

The water quality, fish and macroinvertebrate communities are expected to improve in Big Creek over time, if CSO overflows are reduced and or eliminated and illicit discharges from storm sewer outfalls are identified and remediated.

Table 19. 2015 and 2016 Big Creek Survey Results							
	River Mile	Aquatic Life Use Attainment Status	Water Quality Exceedances	QHEI Score (Narrative Rating)	IBI Score (Narrative Rating)	MIwb Score (Narrative Rating)	ICI Score (Narrative Rating)
2015	0.15	Non-Attainment	<i>E. coli</i>	72.50 (Good)	28 (Fair)	6.6 (Fair)	18 (Fair)
	4.40	Partial Attainment	<i>E. coli</i>	62.50 (Good)	30 (Fair)	--	(Marginally Good)
	0.02	Non-Attainment	<i>E. coli</i>	68.50 (Good)	28 (Fair)	--	(Poor)
	0.15S	Non-Attainment	<i>E. coli</i>	63.00 (Good)	22 (Poor)	--	36 (Marginally Good)
	0.20	Non-Attainment	<i>E. coli</i>	67.25 (Good)	30 (Fair)	--	(Fair)
	9.80	Non-Attainment	<i>E. coli</i>	--	--	--	20 (Fair)

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Table 19. 2015 and 2016 Big Creek Survey Results							
	River Mile	Aquatic Life Use Attainment Status	Water Quality Exceedances	QHEI Score (Narrative Rating)	IBI Score (Narrative Rating)	MIwb Score (Narrative Rating)	ICI Score (Narrative Rating)
2016	0.15	Non-Attainment	<i>E. coli</i>	69.50 (Good)	30 (Fair)	7.2 (Fair)	(Poor)
	4.40	Partial Attainment	<i>E. coli</i>	65.50 (Good)	30 (Fair)	--	(Marginally Good)
	0.02	Non-Attainment	<i>E. coli</i>	62.75 (Good)	24 (Poor)	--	(Poor)
	0.15S	Non-Attainment	<i>E. coli</i>	63.00 (Good)	22 (Poor)	--	28 (Fair)
	0.20	Partial Attainment	<i>E. coli</i>	67.00 (Good)	30 (Fair)	--	32 (Marginally Good)
	9.80	Non-Attainment	<i>E. coli</i>	69.50 (Good)	30 (Fair)	--	(Poor)
WWH Biocriteria attainment IBI score of 40; ICI Score of 34 Non-significant departure: ≤ 4 IBI units ≤ 0.5 MIwb units							

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2016 - Lindsay Baker, Sarah Foley, and Joseph Schiel

2015 - Julia Klepach, Sean Giblin, and Kyle Connelly

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