



Water Quality and Industrial Surveillance Environmental Assessment Group March 2025

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Introduction

In 2024, the Northeast Ohio Regional Sewer District (NEORSD) monitored environmental and biological conditions at Big Creek and selected tributaries. Big Creek is a direct tributary to the Cuyahoga River at river mile (RM) 7.2 that drains the communities of Parma, Parma Heights, Brookpark, Linndale, Brooklyn, and Cleveland, Ohio. This monitoring was performed as part of the NEORSD general watershed monitoring program where ambient water quality assessments were conducted to determine attainment status and appropriateness of existing aquatic life use (ALU) designations in Big Creek. The intent of the general watershed monitoring program is to periodically assess all major watersheds in the NEORSD service area. Surveys at Big Creek RM 9.80, 2.40, and Stickney Creek RM 1.15 were also conducted as part of NEORSD post-restoration monitoring. Details of the stream restorations are mentioned below. Site surveys were conducted by the Environmental Assessment (EA) group of the NEORSD Water Quality and Industrial Surveillance (WQIS) Division.

Sampling was conducted by NEORSD Level 3 Qualified Data Collectors (QDCs) certified by the Ohio Environmental Protection Agency (EPA) in Fish Community Biology, Benthic Macroinvertebrate Biology, Chemical Water Quality, and Stream Habitat as explained in the NEORSD project study plan 2024 Cuyahoga River and Northern Tributaries Environmental Monitoring. All sampling and environmental assessments occurred between June 15, 2024 and September 30, 2024 (through October 15 for fish sampling assessments), as required in the Ohio EPA Biological Criteria for the Protection of Aquatic Life Volume III (1987b). The results gathered 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), Invertebrate Community Index (ICI), and the NEORSD Macroinvertebrate Threshold Model. Water chemistry data was validated by methods outlined in the Ohio EPA Surface Water Field Sampling Manual for water quality parameters and flows (2023a) and compared to the Ohio Water Quality Standards for their designated use to determine attainment (Ohio EPA, 2024). An examination of the individual metrics that comprise the IBI, MIwb, ICI, and NEORSD's Macroinvertebrate Threshold Model were used in conjunction with the water chemistry data and QHEI scores to assess the health of the stream.

Figure 1 shows a map of the sampling location, and Table 1 indicates the sampling location with respect to RM, latitude/longitude, description, and surveys conducted. A digital photo catalog of the sampling location is available upon request by contacting the WQIS Division.



Figure 1. Sampling Locations Map

Table 1. 2024 Big Creek Sampling Locations									
Location	River Mile	Station ID	Code	Latitude	Longitude	Drainage Area (mi ²)	Sampling Conducted		
Big Creek (19-005-000)									
Downstream of Pearl Road	9.80 ^H	303734	BGMB9.80	41.3884	-81.7664	5.60	F, M, C		
Memphis Picnic Area	4.40 ^H	301193	BGMB4.40	41.4460	-81.7540	19.30	F, M*, C		
Downstream of John Nagy Drop Structure	2.40 ^w	F01S20	BGMB2.40	41.4509	-81.7265	33.80	F, M, C		
Downstream of Jennings Road	0.15 ^B	502120	BGMB0.15	41.4461	-81.6853	37.10	F, M*, C		
Big Creek West	Big Creek West Branch (Ford Branch) (19-005-001)								
Downstream of Memphis Avenue	0.02 ^H	200072	BGWB0.02	41.4461	-81.7543	11.90	F, M*, C		
Stickney Creek	(19-005-0	02)			•		•		
Upstream of Ridge Road	1.15 ^H	303948	SKMB1.15	41.4335	-81.7351	3.17	F, M, C		
Downstream of Roadoan Road	0.50 ^H	200073	SKMB0.50	41.4384	-81.5216	4.41	F, M, C		
Big Creek Tribut	tary at RM	7.78 (Snow	& Pearl Branc	h) (19-005	-003)		ſ		
Upstream of Big Creek Parkway	0.20 ^H	302642	BGSP0.20	41.4089	-81.7511	2.50	F, M*, C		
^H - Headwater site (draining ≤20 miles ²) ^W - Wading site (non-boat site draining >20 miles ²) ^B - Boat site F = Fish community biology (includes habitat assessment) M = Macroinvertebrate community biology (* qualitative survey only) C = Water chemistry									

The Ohio EPA assigns designated uses to establish minimum water quality requirements for surface waters. These requirements represent measurable criteria for assessing the chemical, physical, and biological integrity of Ohio's surface waters consistent with Clean Water Act requirements. The beneficial use designations for Big Creek and its selected tributaries are listed below in Table 2 (Ohio EPA, 2024).

Table 2. Beneficial Use Designations for Big Creek													
	Beneficial Use Designation												
		Aqı	uatic	Life	Hab	oitat		Water		Recreation			
Water Body Segment			(ALU)			S	upply	y			
water Body Segment	S	W	Е	м	S	С	L	Р	А	I	D	Р	S
	R	W	W	W	S	W	R	W	W	W		С	С
	W	Н	Н	Н	Н	Н	W	S	S	S	vv	R	R
Big Creek- within boundaries of	*												
Cleveland Metroparks		Ŧ							т	т		т	
-all other segments		+							+	+		+	
Ford branch (Big Creek RM 4.40)							+		+	+			+
SRW = state resource water; WWH = warr	nwa	ter ha	abitat	; EW	H = e	xcep	tiona	al war	rmwa	ter h	abita	t;	
MWH = modified warmwater habitat; SSH = seasonal salmonid habitat; CWH = coldwater habitat;													
LRW = limited resource water; PWS = public water supply; AWS = agricultural water supply; IWS =													
industrial water supply; BW = bathing wat	er; P	PCR =	prim	ary c	onta	ct rec	reat	ion; S	SCR =	seco	ondar	y con	tact
recreation.													

* Designated use based on the 1978 water quality standards.

+ Designated use based on results of a biological field assessment performed by the Ohio EPA (OAC 3745-1-26).

Watershed Land Use Analysis

A land cover analysis of the Big Creek watershed was performed using land cover data obtained from the United States Geologic Survey's 2021 National Land Cover Database (CONUS) (Dewitz, J., 2024) downloaded from the Multi-Resolution Land Characteristics Consortium (mrlc.gov.data). Figure 2 illustrates the land cover types within the Big Creek watershed. Figure 3 below breaks down the percentages of each land use type within the Big Creek watershed. The Big Creek watershed is heavily developed with the predominant land cover type being developed, medium intensity representing 44.2% of the watershed. Developed, low intensity and developed, high intensity are the second and third most represented land cover types represent much of the land cover in the watershed; whereas more open green-space land types such as deciduous forest, open water, mixed forest, and woody wetlands represent less than four percent of total land cover combined. The land cover type breakdown confirms developed urban landscapes comprise a significant proportion of the land use in the watershed.



Figure 2. 2024 Big Creek Watershed Land Use



Figure 3. Big Creek Land Use Type and Percentages

Stream Restoration Monitoring

Two restoration projects have occurred at the main branch of Big Creek. One restoration project was completed at Big Creek RM 9.80 and one at RM 2.40. In November 2019, a stream restoration at Big Creek RM 9.80 improved stream function and halted erosion that was threatening public sanitary sewer infrastructure along Big Creek in Parama Heights adjacent to Colombo Park. The stream restoration included approximately 400-foot of stream realignment, widening, and stabilization of new floodplain areas in effort to reduce in-channel velocities and reduce streambank and streambed erosion.

The second restoration occurred at the main branch of Big Creek (RM 2.40). In November 2019, the Big Creek Stabilization project rehabilitated approximately 1,200 linear feet of the concrete-lined channel, which included removing a 30-foot-high vertical concrete spillway. The project consisted of two major actions which included the construction of a rock cascade to replace the failing spillway structure along with repairing the streambanks with riprap. The gently sloped rock cascade replaced the failing spillway with large rock to provide energy dissipation. It was expected that the completion of this project would allow for fish passage upstream.

Lastly, two separate stream restoration projects have been completed near Stickney Creek RM 1.15. The Stickney Creek Stream Relocation and Utility Repair Project was completed on November 8, 2019. The project restored more than 1,000 feet of urban stream channel between RMs 0.60 and 1.45, where bank erosion exposed and threatened the integrity of a NEORSD sanitary sewer. Additionally, the restoration expanded existing floodplain storage, slowed stream velocities, and created more in-stream habitat. The second project, *Stickney Creek Stream Stabilization and Floodplain Restoration Project in Veterans Memorial Park*, located just downstream at RM 1.10, was completed in 2021. This project generated more than 1,500 linear feet of natural stream system, including six acres of associated floodplain. The restoration design features included boulder toe, toe wood, buried soil riprap protection, and soil lifts with live branch layerings (Biohabitats, 2020). Although the Stickney Creek sampling location is upstream of the restoration reach, this project contributes to the overall Stickney Creek habitat improvements and is worth noting.

Water Chemistry and Bacteriological Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times between July 23, 2024 and August 20, 2024, at the site listed in Table 1. Techniques used for sampling and analyses followed the Ohio EPA *Surface Water Field Sampling Manual for water quality parameters and flows* (Ohio EPA, 2023a). Chemical water quality samples from the site were collected with a 4-liter disposable polyethylene cubitainer with a disposable polypropylene lid, three 473-mL plastic bottles and one 125-mL plastic bottle. The first 473-mL plastic bottle was field preserved with trace nitric acid, the second was field preserved with trace sulfuric acid, and the third bottle received no preservative. The sample collected in the 125-mL plastic bottle (dissolved reactive)

phosphorus) was filtered using a $0.45-\mu m$ PVDF syringe filter. All water quality samples were collected as grab samples. Bacteriological samples were collected in sterilized plastic bottles and preserved with sodium thiosulfate. At the time of sampling, measurements for dissolved oxygen (DO), DO percent, pH, temperature, conductivity, and specific conductance were collected using a YSI EXO1 sonde. Duplicate/replicate samples and field blanks were each collected at randomly selected sites, at a frequency of not less than 5% of the total samples collected in NEORSD's 2024 *Cuyahoga River and Northern Tributaries Environmental Monitoring.* Relative percent difference (RPD) was used to determine the degree of discrepancy between the primary and duplicate/replicate sample (Formula 1).

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

X= is the concentration of the parameter in the primary sample Y= is the concentration of the parameter in the duplicate/replicate sample

The acceptable percent RPD is based on the ratio of the sample concentration and detection limit (Formula 2) (Ohio EPA, 2019).

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

X = sample/detection limit ratio

Those RPDs that were 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 Big Creek and tributaries are available upon request from the NEORSD WQIS Division. Dates of water chemistry sampling compared to rain gauge data from NEORSD's James Rhodes High School gauge are shown below in Figure 4.





Figure 4. 2024 Rainfall Data at NEORSD's James Rhodes High School Gauge with NEORSD Water Chemistry Sampling Dates. Red points are dates when samples were collected.

Results and Discussion

Data Validation QA/QC Checks

Over the course of the five sampling events in 2024, one field duplicate (field split), two replicates, and three field blank samples were collected and analyzed for all parameters. Parameters from three sampling events were qualified as rejected due to high relative percent differences (RPD) between duplicate/replicate samples (Table 3). The replicate sample collected on July 23, 2024, at Big Creek RM 4.40 contained qualified results for dissolved reactive phosphorus (DRP). Additionally, the replicate sample from August 6, 2024, at Big Creek RM 2.40 had qualified results for the parameters biochemical oxygen demand (BOD) and chemical oxygen demand (COD). Lastly, the duplicate sample collected at Big Creek RM 0.15 on August 13, 2024, contained qualified results for COD. Potential reasons for these discrepancies include lack of precision and consistency in sample collection and/or analytical procedures, environmental heterogeneity, and/or improper handling of samples.

Table 3. Duplicate/Replicate Samples with RPDs Greater than Acceptable									
River Mile	Date	Parameter	Result (Duplicate Result)*	Acceptable RPD	Actual RPD				
Big Creek (19	Big Creek (19-005-000)								
4.40	7/23/24	DRP	0.1 (0.3)	39.1	94.9				
2.40	8/6/24	BOD	2.0 (9.4)	99.7	129.8				
2.40		COD	8.2 (20)	80.1	83.3				
0.15	8/13/24	COD	4.2 (17.8)	99.7	123.6				
* Results in mg/L									

Paired parameters, wherein one parameter is a subset of another, were also evaluated in accordance with QA/QC protocols for all samples collected at Big Creek and its tributaries. There were three instances where data for the paired parameters was qualified due to the sub parameter value being greater than the parent value (Table 4). Total phosphorus (TP) and DRP were rejected for the sample collected at Big Creek RM 4.40 on July 23, 2024, due to DRP concentration exceeding TP concentrations. Similarly, DRP concentrations exceeded TP concentrations at Big Creek RM 0.15 on August 20, 2024; therefore, the sample was qualified as rejected. Additionally, for the sample collected on August 20, 2024, at Big Creek RM 0.15, results for total solids (TS) and total dissolved solids (TDS) were qualified as estimated due to the TDS concentration exceeding the TS concentration.

Table 4. Paired Parameter Qualifiers									
River	Date	Parent Parameter	Sub Parameter	RPD	Acceptable	Oualifier			
Mile		(Result*)	(Result*)		RPD				
Big Creek	Big Creek (19-005-000)								
4.40	7/23/24	TP (0.124)	DRP (0.2073)	75.1	45.2	Rejected			
0.15	9/20/24	TP (0.056)	DRP (0.513)	160.6	57.9	Rejected			
0.15	0/20/24	TS (350)	TDS (356)	1.7	30.20	Estimated (J)			
* Results	* Results in mg/L								

Over the course of the five sampling events, three field blanks were collected. Field blank samples were collected for the trips on July 30, August 13, and August 20, 2024, at Big Creek RM 9.80, Big Creek RM 2.40, and Stickney Creek RM 0.50, respectively. There was a single instance where the data was qualified based on field blank contamination (Table 5). The parameter that showed possible contamination in the field blank was BOD from the sample collected at Big Creek RM 0.15 on August 20, 2024. It is unclear how the field blanks become contaminated and may be due to inappropriate sample collection, handling, and/or contamination in the blank water. The results for the listed BOD were rejected because they were insufficiently different than the field blank results.

Table 5. Parameters with Field Blank Concentrations Showing Possible Contamination									
River Mile	River Mile Date Parame		Result/Blank Result	Qualifier					
Big Creek (19-005-000)									
0.15	8/20/24	BOD	0.96	Rejected					

Bacteriological Exceedances

Big Creek mainstem is designated primary contact recreation (PCR) and the West Branch is designated secondary contact recreation (SCR). Attainment of the recreation designated use is determined using *Escherichia coli* (*E. coli*), a fecal-indicator bacteria commonly found in the intestinal tract and feces of warm-blooded animals (USEPA, 2012). The PCR criteria include an *E. coli* criterion not to exceed a Statistical Threshold Value (STV) of 410 colony counts or mostprobable number (MPN) per 100mL in more than ten percent of the samples taken during any 90day period and a 90-day geometric mean criterion of 126 colony counts or MPN per 100mL. The SCR criteria include an *E. coli* criterion not to exceed a STV and 90-day geomean of 1030 MPN/100mL (Ohio EPA, 2023a). In accordance with Ohio EPA procedure and practice to qualify *E. coli* exceedances for the recreation criteria, the geometric mean and STV are only calculated and compared when a minimum of five bacteriological samples have been collected.

Table 6 and Figure 5 below detail *E. coli* densities for all samples collected, as well as exceedances of the recreation season geometric mean criterion which occurred for all the sites at Big Creek. The 90-day period started with the collection of the first sample. All sites at Big Creek were in non-attainment of both criteria in 2024, indicating bacteriological contamination in the watershed. *E. coli* exceedances may also have been a result of domestic and/or wild animal waste and improper sanitary sewage connections to stormwater outfalls upstream of the sampling location.

Table 6. E. coli Densities (MPN/100mL)										
Date	BGMB9.80	BGMB4.40	BGMB2.40	BGMB0.15	BGSP0.200	BGWB0.02**	SKMB1.15	SKMB0.50		
7/23/24	687	464	152	461	816	3,170	980	1,733		
7/29/24*	8,945	16,275	28,970	27,375	9,675	25,060	24,420	23,055		
8/6/24*	3,050	3,050	1,378	2,420	1,120	1,733	6,200	20,460		
8/13/24	365	816	1,986	1,300	517	727	2,130	5,040		
8/20/24*	1,986	2,560	980	3,640	866	2,130	2,420	7,760		
90-day STV Exceedance (%)	80	100	80	100	100	80	100	100		
90-day Geomean	1,685	2,170	1,6389	2,704	1,317	2,923	3,773	7,961		

Exceeds statistical threshold value of 410 MPN/100mL.

Exceeds 90-day STV criterion of 10%.

Exceeds 90-day geometric mean criterion of 126 MPN/100mL.

*Wet-weather Event: greater than 0.10 inches of rain, but less than 0.205 inches, samples collected that day and the following day are considered wet-weather samples; greater than 0.205 inches, the samples collected that day and the following two days are considered wet-weather samples.

**Compared to SCR STV and 90-day geomean of 1030 MPN/100mL



Figure 5. E. coli Densities at Big Creek (Log₁₀)

Every sample collected, except for two (95 percent), exceeded the STV of 410 colony counts/100mL, resulting in PCR impairment at Big Creek in 2024. Additionally, each site exceeded the 90-day geometric mean criterion of 126 colony counts/100mL (Table 6). Three of the five samples were collected during wet-weather events, which can lead to elevated *E. coli* densities due to urban runoff and potential sanitary sewer overflows

Additionally, gray water with strong sanitary odor was observed while conducting an electrofishing survey at Stickney Creek RM 0.50. The WQIS Pollution Prevention Group (PPG) has been tracking illicit discharges at the site. On September 6, 2024, a dry-weather flow sample was collected at the outfall in the upper section of the electrofishing zone and the results showed an *E. coli* density of >241,960 MPN/100mL, confirming the presence of sanitary wastewater entering the stream. Furthermore, a flow measurement was collected resulting in a daily flow volume of approximately 924 gallons per day (GPD). The findings of the PPG investigation suggest potential improper connections to the storm sewer.

Water Column Chemistry Results and Discussion

Mercury analysis for all the sampling events was analyzed using EPA Method 245.1. Because the detection limit for this method is above the criteria for the Human Health Nondrinking and Protection of Wildlife Outside Mixing Zone Averages (OMZA), it generally cannot be determined if the site 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 stream. Mercury was not detected above the detection limit in any of the samples collected.

No additional water quality exceedances were observed in the data set.

Stream Nutrient Assessment

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 the quality of surface waters based on factors including DO swings, benthic chlorophyll *a*, TP, and dissolved inorganic nitrogen (DIN) (Ohio EPA, 2015). NEORSD did not assess benthic chlorophyll *a* in 2024; however, nutrients were assessed at all sites and DO swings were assessed at both Stickney Creek Sites.

Table 7 shows the nutrient concentrations at the sites within the Big Creek watershed. The results of DIN and TP were compared to Table 2 listed in the SNAP document (Figure 6) and applicable nutrient concentrations and narrative levels can be seen in Table 8. According to the SNAP table, Big Creek RM 0.15 and both Stickney Creek sites were classified as being modestly enriched or in an enriched condition with "low risk to beneficial use if allied responses are within normal range". Increased TP was the primary driver for nutrient enrichment at all three sites. There is a statistical relationship between mean TP concentrations in headwater streams greater than 0.12 mg/L and decreases in IBI and ICI scores (Ohio EPA, 1999). Figure 7 below shows both Stickney Creek sites, which are classified as headwater sites due to drainage area, had TP concentrations greater than 0.12 mg/L during each sampling event, confirming that TP was a primary driver for nutrient enrichment at the sites.

Table 7. Nutrient Analysis (Geometric Means*)										
River Mile DIN (mg/L) NO3-NO2 (mg/L) DRP (mg/L) TP (mg/L)										
Big Creek (1	Big Creek (19-005-000)									
9.80	0.209	0.204	0.015	0.034						
4.40	0.355	0.318	0.036**	0.071						
2.40	0.369	0.327	0.041	0.072						
0.15	0.438	0.350	0.047**	0.085*						
Big Creek West Branch (Ford Branch) (19-005-001)										
0.02	0.478	0.410	0.067	0.109						
Stickney Cre	eek (19-005-002)									
1.15	0.847	0.800	0.144	0.201						
0.50	0.784	0.709	0.155	0.179						
Big Creek Tr	ibutary at RM 7.7	'8 (Snow & Pearl Brar	nch) (19-005-00)3)						
0.20	0.538	0.506	0.050	0.079						
Data used in Table 2 of SNAP (Ohio EPA 2015) *n=5, unless otherwise noted										
**n= 4 due to	rejected data base	d on replicate comparis	son							

		← DECREASING RISK								
	TP Conc.	DIN Concentration (mg/l)								
	(mg/l)	<0.44	0.44 < 1.10	1.10 < 3.60	3.60 < 6.70	≥6.70				
DECREASING RISK	<0.040	background levels typical of least disturbed conditions	levels typical of developed lands; little or no risk to beneficial uses	levels typical of modestly enriched condition in phosphorus limited systems; low risk to beneficial use if allied responses are within normal ranges	levels typical of enriched condition in phosphorus limited systems; moderate risk to beneficial use if allied responses are elevated	characteristic of tile-drained lands; otherwise atypical condition with moderate risk to beneficial use if allied responses are elevated (1.1% of observations)				
	0.040- <0.080	levels typical of developed lands; little or no risk to beneficial uses	levels typical of developed lands; little or no risk to beneficial uses	levels typical of working landscapes; low risk to beneficial use if allied responses are within normal ranges	levels typical of enriched condition in phosphorus limited systems; moderate risk to beneficial use if allied responses are elevated	characteristic of tile-drained lands; moderate risk to beneficial use if allied responses are elevated (1.1% of observations)				
	0.080- <0.131	levels typical of modestly enriched condition in nitrogen limited systems; low risk to beneficial use if allied responses are within normal ranges	levels typical of working landscapes; low risk to beneficial use if allied responses are within normal ranges	levels typical of working landscapes; low risk to beneficial use if allied responses are within normal ranges	characteristic of tile-drained lands; moderate risk to beneficial use if allied responses are elevated; increased risk with poor habitat	characteristic of tile-drained lands; moderate risk to beneficial use if allied responses are elevated (1.0% of observations)				
	0.131- <0.400	levels typical of modestly enriched condition in nitrogen limited systems; low risk to beneficial use if allied responses are within normal ranges	levels typical of enriched condition; low risk to beneficial use if allied responses are within normal ranges	levels typical of enriched condition; low risk to beneficial use if allied responses are within normal ranges; increased risk with poor habitat	enriched condition; generally high risk to beneficial uses; often co-occurring with multiple stressors; increased risk with poor habitat	enriched condition; generally high risk to beneficial uses; often co- occurring with multiple stressors				
	≥0.400	atypical condition (1.3% of observations)	atypical condition (1% of observations);	enriched condition; generally high risk to beneficial uses; often co-occurring with multiple stressors; increased risk with poor habitat	enriched condition; generally high risk to beneficial uses; often co-occurring with multiple stressors; increased risk with poor habitat	enriched condition; generally high risk to beneficial uses; often co- occurring with multiple stressors				

"allied responses" = allied response indicators (24-hour DO swing, benthic chlorophyll)

Figure 6. Table 2 of the Stream Nutrient Assessment Procedure (Ohio EPA, 2015b)



Figure 7. Total Phosphorus Concentrations at Each Site

Table 8 below provides the applicable SNAP analysis along with the narrative level. Table 8 shows that Big Creek at RM 9.80 nutrient levels were typical of least disturbed conditions. Big Creek at RM 4.40 and 2.40, along with the site at RM 0.20 on the Big Creek Tributary at RM 7.78, were categorized as "levels typical of developed lands; little or no risk to beneficial use. Lastly, nutrient levels at the Big Creek West Branch were categorized as "levels typical of working landscapes; low risk to beneficial use if allied responses are within normal ranges". The SNAP analysis indicated that there is some level of nutrient enrichment associated with certain locations within the Big Creek watershed, particularly near the Big Creek-Cuyahoga River confluence and within Stickney Creek.

Table 8. /	Table 8. Applicable SNAP Analysis with Narrative Level (Geometric Means)									
River Mile	DIN Range	TP Range	Narrative Level							
Big Creek (19	-005-000)									
9.80	9.80 <0.44 <0.040		Background levels typical of least disturbed conditions							
4.40 <0.44 0.040<0.080		0.040<0.080	Levels typical of developed lands; little or no risk to beneficial use							
2.40 <0.44 0.040<0.080 Levels typical of developed land no risk to beneficial us										
0.15 <0.44 0.080<0.131		0.080<0.131	Levels typical of modestly enriched condition n nitrogen limited systems; low Risk to beneficial use if allied responses are within normal ranges							
Big Creek We	st Branch (Fo	rd Branch) (19-	005-001)							
0.02	0.44 <1.10	0.080<0.131	Levels typical of working landscapes; low risk to beneficial use if allied responses are within normal ranges							
Stickney Cree	ek (19-005-00)2)								
1.15	0.44 <1.10	0.131<0.400	Levels typical of enriched condition; low risk to beneficial use if allied responses are within normal range							
0.50 0.44 <1.10 0.131 < 0.400		0.131<0.400	Levels typical of enriched condition; low risk to beneficial use if allied responses are withing normal range							
Big Creek Tril	outary at RM	7.78 (Snow & Pe	arl Branch) (19-005-003)							
0.20 0.44 <1.10 0.040 < 0.080		0.040<0.080	Levels typical of developed lands; little or no risk to beneficial uses							

DO swings are an indication of nutrient enrichment used in the SNAP. One YSI EXO2 sonde was installed at both Stickney Creek sites for the purpose of determining if the algae growth on the substrate at the upstream restoration site (RM 1.15) was impacting DO concentrations. The data sonde collected DO measurements every 15 minutes for eight days. The 24-hour DO swings were determined by calculating the difference between the maximum and minimum daily concentrations of DO and compared to the threshold value established in the SNAP

recommendation guidance (OEPA, 2015). A low to normal DO swing value is \leq 6.5 mg/L and a wide DO swing is >6.5 mg/L.

The diel DO swings were analyzed for the time period of August 9, 2024 through August 16, 2024 (Figure 8). Table 9 provides minimum and maximum DO concentrations for both sonde locations for this time period. The average DO swings at Stickney Creek RM 1.15 and RM 0.50 were 5.2 mg/L and 5.1 mg/L, respectively. These averages were both in the normal range for DO swings of \leq 6.5 mg/L. However, on August 15, 2024, DO swings at both sites exceeded the 6.5 mg/L threshold during the analyzed period. DO saturation values are also a good indicator of over-enrichment when values exceed 120% (Ohio EPA, 2023b). The Stickney Creek sondes had maximum daily DO saturations greater than 120% for five out of eight days at both Stickney Creek RM 1.15 and Stickney Creek RM 0.50. Because DO swings exceeded the 6.5 mg/L threshold and both sites frequently exhibited DO saturation values greater than 120%, this could potentially be the result of nutrient enrichment at both sites at Stickney Creek.



Figure 8. Diel DO Swings Over Time in 15-Minute Intervals at Stickney Creek

	Table 9. Daily	y DO Swings at	t Stickney Cr	eek at RM 1.15 a	and RM 0.50			
		RM 1.15		RM 0.50				
Data	Maximum Minimum		DO Suring	Maximum	Minimum	DO		
Date	DO	DO	DO Swing	DO	DO	Swing		
8/9/24	7.8	4.7	3.1	8.6	4.8	3.8		
8/10/24	9.8	4.9	4.9	9.8	4.8	5.0		
8/11/24	10.4	6.3	4.1	10.4	5.8	4.6		
8/12/24	11.2	6.5	4.7	10.9	5.9	5.0		

Table 9. Daily DO Swings at Stickney Creek at RM 1.15 and RM 0.50									
		RM 1.15		RM 0.50					
Data	Maximum	Minimum		Maximum	Minimum	DO			
Date	DO	DO	DO Swing	DO	DO	Swing			
8/13/24	11.8	6.5	5.3	11.3	5.8	5.5			
8/14/24	12.7	6.3	6.4	11.9	5.9	6.0			
8/15/24	13.8	6.1	7.7	12.3	5.4	6.9			
8/16/24	11.0	6.0	5.0	8.5	5.1	3.4			
>6.5 mg	>6.5 mg/L threshold								

Habitat Assessment

Methods

Instream habitat assessments were conducted once at Big Creek and its tributaries in 2024 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, with slightly different narrative ranges for streams based on total drainage areas (Table 10). For headwater streams, a score greater than 55 (and for larger streams a score greater than 60) suggests that sufficient habitat exists to support a fish community that attains the warmwater habitat criterion (Ohio EPA, 2006). Scores greater than 70 for headwaters and 75 for larger streams frequently demonstrate habitat conditions that can support exceptional warmwater faunas. 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). The QHEI field sheet is available upon request from the NEORSD WQIS Division.

Table 10. Narrative Ranges Assigned to QHEI Scores									
	QHEI Range								
Narrative Rating	Headwaters	Larger Streams							
	(drainage \leq 20 sq miles)	(drainage > 20 sq miles)							
Excellent	≥70	≥75							
Good	55-69	60-74							
Fair	43-54	45-59							
Poor	30-42	30-44							
Very Poor	<30	<30							

Results and Discussion

All sites apart from Big Creek RM 0.15, Stickney Creek RM 1.15, and Stickney Creek RM 0.50 met the WWH QHEI target for their respective stream size indicating that the habitat should be of

high enough quality to support healthy fish assemblages (Figure 9). The three sites that did not meet the WWH target all received a narrative rating of *Fair*. At Big Creek RM 0.15, the absence of a riffle, poor development, heavy instream silt, and extensive embeddedness all contributed to the low score at the site. At Stickney Creek RM 1.15, having a very narrow riparian width, a sparse amount of instream cover, and low diversity in instream cover types contributed to the site's habitat not meeting the WWH target. Lastly, at Stickney Creek RM 0.50, a sparse amount of instream cover along with lack of instream cover types and shallow pools contributed to the site not meeting the WWH target. As previously mentioned, the Big Creek watershed is in a heavily urbanized and industrialized area throughout most of the reach; however, a portion of the mainstem is located within the Cleveland Metroparks, providing more riparian areas than is typical of most urban streams. The presence of these riparian areas contributed to the rest of the monitored sites meeting the WWH target with a narrative rating of *Good*.

The individual components of the QHEI can also be used to evaluate whether a site can meet its WWH designated use (Table 11). This is done by categorizing specific attributes as indicative of either WWH or modified warmwater habitat (MWH) (Rankin, 1995). Attributes that are considered characteristic of MWH are further classified as being a moderate or high influence on fish communities. The presence of one high or four moderate-influence characteristics has been found to result in lower IBI scores, with a greater prevalence of these characteristics usually preventing a site from meeting WWH attainment (Ohio EPA, 2006). Typically, as MWH/WWH ratios increase above 2:1, the potential for instream habitat-caused impairment increases. All sites in 2024 had a combination of at minimum one high and/or three moderate-influence characteristics, except for Big Creek at RM 9.80 and Big Creek Tributary (RM 7.78) RM 0.20, indicating that there was a greater prevalence of characteristics preventing these sites from meeting the fish WWH criterion.



Figure 9. QHEI Scores

									Т	able	11.	QHE	l Sco	ores	anc	l Phy	ysica	al At	tribu	utes													
																						M٧	VH A	ttrik	outes	5							
	1	I		1	1	W	WH A	\ttri	bute	s	1	1	T		Hi	gh Ir	nflue	nce			1		1	T	Mode	erate	Influ	lence	e	1			
River Mile	QHEI Score	Narrative Rating	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max. Depth >40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	Channelized or no Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW sites)	Total High Influence Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total Moderate Influence Attributes	(MWH-H.I.+1) / (WWH+1) Ratio	(MWH M.I.+1) / (WWH+1) Ratio
Big Cree	ek (19-00	5-000)	1	r	1	1	1	1		1	1		1	1	1	1	1	1	1	r –			1	1				-	1				
9.80	65.0	Good		х				Х		х	х		4						0	х			Х	х				х	Х		5	0.2	1.2
4.40	55.5	Good		х					х		х		3	х		х	х		3				х	х	х			х	Х		5	1	1.5
2.40	63.0	Good	х	х		x			х	х	х	х	7				х		1					x	х			х			3	0.3	0.5
0.15	54.75	Fair	х	х			x	х			х		5				х		1		х		х				х	х		х	5	0.3	1
Big Cree	ek West B	Branch (Ford I	Branch) (19-	005-0	01)																											
0.02	71.5	Excellent	х	х				x		х	х	х	6				х		1				х	х			х	х	х		5	0.3	0.9
Stickne	y Creek (2	19-005-002)				_														-													
1.15	53.0	Fair		x		х	х				х		4				х		1	х							х	х	х		4	0.4	1.0
0.50	51.5	Fair	х	х									2				х	х	2		х		х	х			х	х	х		6	1	2.3
Big Cree	ek Tributa	ary at RM 7.78	3 (Snov	v & Pe	arl Bra	anch)	(19-0	05-00	03)																								
0.20	64.5	Good	х	х		x	х	х			x		6						0		х		х				х	х	х		5	0.1	0.9

Fish Community Biology Assessment

Methods

Two quantitative electrofishing passes were conducted at each site listed in Table 1 in 2024. There are two United States Geological Survey (USGS) stations with flow data available in the Big Creek watershed. A list of the dates when the surveys were completed, along with the mean daily flow measurements (measurements in cubic feet per second (CFS)) from USGS gage station 04208502 (Big Creek Main Branch) and 042085017 (East Branch) are shown below in Table 12. Sampling for all sites, except for Big Creek RM 0.15, was conducted using longline electrofishing techniques and consisted of shocking all habitat types within a sampling zone while moving from downstream to upstream. Big Creek RM 0.15 was sampled using boat electrofishing methods despite having a relatively low drainage area due to the presence of deep channels that were unwadable. The sampling zone was either 0.15, 0.20, or 0.25 kilometers and followed the Ohio EPA 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 into the waters from which they were collected, except for vouchers and those that could not be easily identified in the field.

	Table 12. Fish Survey Dates and Stream Flows										
Date	Sites Sampled (RMs)	Main Branch Daily Mean Flow (CFS)	East Branch Daily Mean Flow (CFS)								
6/24/24	Big Creek RM 9.80	15.8	6.3								
6/25/24	Big Creek Trib (RM 7.78) RM 0.20	6.9	4.2								
6/28/24	Big Creek RM 4.40, Big Creek West Branch RM 0.02	6.8	4.1								
8/8/24	Stickney Creek RM 1.15, Stickney Creek RM 0.50	21.2	4.5								
8/15/24	Big Creek RM 0.15	12.6	3.0								
8/22/24	Big Creek RM 4.40, Big Creek West Branch RM 0.02	6.5	1.9								
9/6/24	Big Creek RM 2.40	9.2	44.1								
9/11/24	Big Creek RM 9.80, Big Creek Trib (RM 7.78) RM 0.20	6.3	1.5								
10/10/24	10/10/24 Stickney Creek RM 1.15, Stickney Creek RM 0.50		1.4								
10/11/24 Big Creek RM 0.15, Big Creek RM 2.40		0.4	1.4								

The electrofishing results were compiled and utilized to evaluate fish community health. The Index of Biotic Integrity (IBI) incorporates twelve community metrics representing structural and functional attributes (Table 13). The structural attributes are based upon fish community aspects such as fish abundance and diversity. The 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*.

	Table 13. IBI Metrics				
Headwater Sites (<20 sq. miles)	Wading Sites	Boat Sites			
Number of Indigenous Fish	Number of Indigenous Fish	Number of Ingenious Fish			
Species	Species	Species			
Number of Darter Species	Number of Darter Species	Percent of Roud-bodied			
Number of Darter species	Number of Darter species	Suckers			
Number of Headwater Species	Number of Sunfish Species	Number of Sunfish Species			
Number of Minnow Species	Number of Sucker Species	Number of Sucker Species			
Number of Sensitive Species	Number of Intolerant Species	Number of Intolerant Species			
Percent Tolerant Species	Percent Tolerant Species	Percent Tolerant Species			
Percent Omnivore Species	Percent Omnivore Species	Percent Omnivore Species			
Percent Insectivore Species	Percent Insectivore Species	Percent Insectivore Species			
Deveent Disperving Species	Percent of Top Carnivore	Percent of Top Carnivore			
Percent Ploneering Species	Species	Species			
Number of Individuals (minus	Number of Individuals (minus	Number of Individuals (minus			
tolerants)	tolerants)	tolerants)			
Number of Simple Lithophilic	Percent of Simple Lithophilic	Percent of Simple Lithophilic			
Spawners	Spawners	Spawners			
Percent of Individuals with	Percent of Individuals with	Percent of Individuals with			
DELTs	DELTs	DELTs			

The second fish index used by the Ohio EPA is the Modified Index of Well-Being (MIwb). The MIwb (calculated using Formula 1 below) incorporates four fish community measures: numbers of individuals, biomass, the Shannon Diversity Index (\overline{H}) (Formula 2 below) based on sample numbers, and the Shannon Diversity Index (\overline{H}) based on sample weights.

Formula 1:

 $MIwb = 0.5 InN + 0.5 InB + \overline{H}(No.) + \overline{H}(Wt.)$

- 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

 $\overline{H}(N0.) =$ Shannon Diversity Index based on numbers

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

Formula 2:

 $\overline{H} = -\sum \left[\left(\frac{n_i}{N} \right) \log_e \left(\frac{n_i}{N} \right) \right]$

 $n_i =$ Relative numbers or weight of species

N = Total number or weight of the sample

Big Creek and its tributaries are located completely within the Erie-Ontario Lake Plains (EOLP) ecoregion and follow the EOLP IBI and MIwb metric scoring. The WWH IBI scoring criterion in the EOLP ecoregion is 40 for headwater and boat sites, and 38 for wading sites. Sites are considered to be within non-significant departure if the score falls within 4 IBI units or 0.5 MIwb units of the criterion (Table 14). Lists of the species, diversity, abundance, pollution tolerances, and incidence of DELT anomalies for the fish collected during the electrofishing passes are available upon request from the NEORSD WQIS Division.

	Table 14. Fish Community Biology Scores in the EOLP Ecoregion								
Ohio EPA	Very	Deer	Fair	Marginally	Cood	Very	Exceptional		
Narrative	Poor	POOr	Fair	Good	Good	Good			
	Headwater								
IBI Score	12-17	18-27	28-35	36-39	40-45	46-49	50-60		
	Wading								
IBI Score	12-17	18-27	28-33	34-37	38-45	46-49	50-60		
MIwb Score	0-4.40	4.5-5.8	5.9-7.3	7.4-7.8	7.9-8.8 8.9-9.3		≥9.4		
				Boat					
IBI Score	12-15	16-25	26-35	36-39	40-43	44-47	48-60		
MIwb	0-0.49	5.0-6.3	6.4-8.1	8.2-8.6	8.7-9.0	9.1-9.5	≥9.6		
Ohio EPA	Ohio EPA								
Status	NO	n-Attainm	ent	NSD	Attainment				
NSD – Non-S	NSD – Non-Significant Departure of WWH attainment								

Results and Discussion

Fish assemblages throughout the Big Creek watershed failed to meet the WWH IBI designated use scoring criteria in 2024, expect for Stickney Creek at RM 1.15, which was in nonsignificant departure of the WWH criterion. Big Creek West Branch RM 0.02 is the only monitored site with an aquatic life use (ALU) not designated WWH. Attainment status for water bodies designated LRW is anything above *Very Poor*; therefore, West Branch RM 0.02 was in attainment for its designated use. However, the site was also evaluated using WWH biocriterion metrics for

comparison purposes. Table 15 and Figure 10 show the average IBI results between the two passes for all the sites. Average IBI scores ranged from 24 (*Poor*) to 36 (*Marginally Good*). For headwater sites, metrics that consistently performed poorly included number of darter, headwater, sensitive, and lithophilic species.

			Table 15. Fish Community /	Assessi	ment R	esults			
	Total #	Relative			IBI S	core		MIwb So	core
River	of	#/less	Prodominant Species (%)	1 st	2 nd	Average	1 st Pass	2 nd	Average
Big Cre	species	5-000	redominant Species (%)	rass	rass		r ass	rass	l
9.80	4	3008/ 1166	Central Stoneroller Minnow (38.7) Creek Chub (29.0) Blacknose Dace (28.6)	32*	28*	30* (Fair)			
4.40	10	2756/ 1436	Central Stoneroller Minnow (46.7) Creek Chub (24.1)	26*	<u>34*</u>	30* (Fair)			
2.40	9	4068/ 2678	Central Stoneroller Minnow (62.9) Creek Chub (12.9) Bluntnose Minnow (8.6)	<u>26*</u>	<u>26*</u>	<u>26*</u> <u>(</u> Poor)	6.9*	6.7*	6.8* (Fair)
0.15	22	827/375	Bluntnose Minnow (31.5) Common White Sucker (17.9) Round Goby (15.2)	<u>26*</u>	<u>24*</u>	<u>25*</u> <u>(</u> Poor)	6.9*	<u>5.2*</u>	6.1* (Fair)
Big Cre	ek West B	ranch (Ford	Branch) (19-005-001)			•			
0.02	10	2314/ 858	Central Stoneroller Minnow (36.0) Creek Chub (28.5)	<u>26</u>	<u>24</u>	<u>25</u> <u>(</u> Poor)			
Stickne	ey Creek (1	9-005-002)		-	-			- -	
1.15	6	7786/ 6120	Central Stoneroller Minnow (78.6) Bluntnose Minnow (7.5) Common White Sucker (6.8)	38 ^{ns}	34* ^s	36 ^{ns} (Marginally Good)			
0.50	5	2984/ 1486	Central Stoneroller Minnow (49.8) Bluntnose Minnow (16.3) Creek Chub (14.5)	<u>26*</u>	30*	28* (Fair)			
Big Cre	Big Creek Tributary at RM 7.78 (Snow & Pearl Branch) (19-005-003)								
0.20	10	2212/ 586	Creek Chub (44.2) Central Stoneroller Minnow (24.7) Blacknose Dace (14.1)	30*	34*	32* (Fair)			
*Significa Underlin ^{ns} non-si	*Significant departure from biocriterion (>4 IBI; >0.5 MIwb units). Underlined scores are in the Poor or Very Poor narrative range								

The wading site (Big Creek RM 2.40) received a narrative rating of *Poor* and performed poorly for the metrics of number of darter, sunfish, sucker, and intolerant species. Additionally, the site performed poorly for the percent insectivore and carnivore metrics; however, the site performed well in the percent omnivore metric and total number of individuals, achieving the highest possible metric score of 5 for both. The boat site (Big Creek RM 0.15) received a narrative rating of *Poor* and performed poorly for the metrics of round-bodied suckers, sunfish, and intolerant species. Furthermore, the site performed poorly for the metrics percent tolerant,

omnivore, and insectivore species. The only metric where the site obtained the highest possible score was for percent of individuals with DELTs. It is important to note that the full 0.5-kilometer zone could not be surveyed due to limited flow, which may have caused lower scores in categories where number of species are counted.



Figure 10. Average IBI Scores Between Two Passes Performed at Each Site in 2024 with Narrative Rating and WWH Criterion Comparisons

Most of the surveyed sites were dominated by the highly pollution-tolerant species Blacknose Dace (*Rhinicthys atratulus*) and Creek Chub (*Semotilus atromaculatus*) along with Central Stoneroller Minnow (*Campostoma anomalum*), which have an intermediate tolerance. The three most predominate species with the percentage per site are detailed below in Table 15. Although the watershed is dominated by pollution-tolerant species, it also supports the state-threatened Bigmouth Shiner (*Notropis dorsalis*), which was collected during surveys at Big Creek RM 4.40, RM 2.40, and West Branch RM 0.02. Most of the sites surveyed have sufficient habitat available which should support a healthy fish assemblage that has the capability of meeting WWH scoring criteria. This is an indication that habitat is not a limiting factor for the fish assemblage in the watershed.

One of the expectations for the restoration project at Big Creek RM 2.40 was the creation of a fish passage. As previously mentioned, the restoration project included the removal and replacement of a 30-foot-high vertical concrete spillway with a constructed rock cascade. It is difficult to quantify if the restoration has had a positive influence on the fish assemblage due to a variety of factors. First, RM 2.40 and the monitored upstream site, Big Creek RM 4.40, drainage areas fall under different surveying methodologies; therefore, they are scored by different metrics. Secondly, the Big Creek watershed does not have a particularly diverse fish assemblage and is

dominated by pollution-tolerant species. Similar species along with total number of species collected upstream and downstream of the drop structure were observed. As shown in Table 15 below, predominate species were similar and were species typically found in urban watersheds. It is likely the restoration has not had a positive impact on the fish assemblage upstream. At RM 4.40, no additional species have been collected after the project was completed when compared to historical surveys. More surveys in the future could provide more quantifiable data about any potential impacts.

Comparisons of historical IBI data for the headwaters and boat sites are shown in Figures 11 and 12. A historical graph was not created for the wading site due to 2024 being the first time the site was surveyed. All headwater sites besides Big Creek West Branch were assigned a narrative rating of *Fair* or *Marginally Good* during the 2024 sampling; however, Big Creek West Branch was assigned a narrative rating of *Poor*. The Big Creek West Branch site was surveyed in 2015 where it received an IBI score of 30 (*Fair*); however, in the 2016 and 2024 surveys the site scored *Poor*. Even though the narrative rating changed between the three surveys, the difference in IBI score in 2015 and 2024 was only three units. The presence of two DELTs and a higher abundance of omnivores were contributing factors to the decline in score since the 2015 survey.

Of all the headwater sites within Big Creek watershed surveyed, Big Creek RM 4.40 has been surveyed the most with a total of nine years of sampling data with a total of 13 surveys. Yearly averages for Big Creek RM 4.40 range from scores of 30 (*Fair*) in 2015, 2016, and 2024 to a score of 36 (*Marginally Good*) in 2009 with an average score of 32. The data indicates that the fish assemblage has shown minimal temporal changes since surveying began in 2007.



Figure 11. IBI Scores for Headwater Sites Over Time

Due to changes in the habitat and the inability to effectively wade the zone, surveys at Big Creek RM 0.15 were conducted using the boat methodology starting in 2014. Prior to that, it was surveyed as a wading site. Since the site has been surveyed as a boat site, there has been minimal change in the IBI scores, ranging from 25 (*Poor*) in 2024 to 28 (*Fair*) in 2015. The site demonstrated a similar level of consistency as when surveyed using wading methodology with the scores ranging from 26 (*Poor*) to 32 (*Fair*). A low percentage of round-bodied suckers, low number of intolerant species, and low numbers of simple lithophilic spawners were the primary drivers for low IBI scores at the site. However, there has been a level of variance in the number of sunfish species and number of suckers species along with the percentage of omnivores, insectivores, and carnivores across the seven boat surveys that have been completed since 2014. When Big Creek RM 0.15 was assessed as a wading site, the scores were slowly increasing from year to year; however, once the methodology changed the scores started trending downwardly. As previously mentioned, the QHEI did not meet the WWH target score indicating that limited habitat can be a limiting factor for the fish assemblage at this site.



Figure 12. IBI Scores for Big Creek RM 0.15

The WWH MIwb criterion only applies to the wading and boat sites. Table 15 above shows the average MIwb results between the two passes for all applicable sites. Big Creek RM 0.15 and RM 2.40 failed to meet attainment of the WWH criterion and were assigned a narrative rating of *Fair.* Figure 13 below compares historical MIwb scores over time for Big Creek at RM 0.15; a historical comparison is not available for RM 2.40 due to the site being surveyed for the first time in 2024. As previously mentioned, Big Creek RM 0.15 was surveyed as a wading site prior to 2014. The majority of the historical scores fall within the *Poor* to *Fair* narrative categories with a single exception of the 2014 survey, which received a narrative rating of *Marginally Good* and was in nonsignificant departure from the WWH criterion. Unlike IBI scores at the site, there was a little more

variance in the historical data; however, 2024 was the first time the site scored *Poor* when surveyed as a boat site.



Figure 13. MIwb Scores for Big Creek RM 0.15

Macroinvertebrate Community Biology Assessment

Methods

Macroinvertebrates were sampled quantitatively using modified Hester-Dendy (HD) and/or with a qualitative assessment of macroinvertebrates inhabiting available habitats at the time of HD Removal. Sampling was conducted at all locations listed below in Table 16. The recommended period for HDs to be installed is six weeks. The macroinvertebrate samples were sent to Third Rock Consultants, LLC for identification and enumeration. Specimens were identified to the lowest practical taxonomic level as defined by the Ohio EPA (1987b). Lists of the species collected during the quantitative and qualitative sampling are available upon request from the NEORSD WQIS Division.

Table 16. Macroin	vertebrate Sampling Dat	es
Site	HD Installation Date(s)	HD Retrieval and Qualitative Sample Dave
Big Creek RM 9.80	7/24/24	9/4/24
Big Creek RM 4.40*	7/24/24	9/4/24
Big Creek RM 2.40**	7/24/24 8/13/24	9/26/24

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Table 16. Macroinvertebrate Sampling Dates										
Site	HD Installation Date(s)	HD Retrieval and Qualitative Sample Dave								
Big Creek RM 0.15	Qualitative sample only	9/4/24								
Big Creek Trib (RM 7.78) RM 0.20	Qualitative sample only	9/4/24								
Big Creek West Branch RM 0.02	Qualitative sample only	9/5/24								
Stickney Creek RM 1.15	7/23/24	9/3/24								
Stickney Creek RM 0.50	7/23/24	9/3/24								
*HD was found missing, most likely due to being blown away or buried from siltation by elevated stream flows following significant wet-weather events.										

The macroinvertebrate sampling methods followed Ohio EPA protocols as detailed in *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987a) and *III* (1987b). The overall aquatic macroinvertebrate community in the stream was evaluated using Ohio EPA's Invertebrate Community Index (ICI). The ICI consists of ten community metrics (Table 17), each with four scoring categories. Metrics 1-9 are based on the quantitative sample, while metric 10 is based on the qualitative Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly), also referred to as EPT taxa, collected. The sum of the individual metric scores results in the overall ICI score. This scoring evaluates the macroinvertebrate community against Ohio EPA's reference sites for each specific eco-region. The WWH ICI criterion in the EOLP ecoregion is 34 (Table 18) and a site is within non-significant departure if the score falls within 4 ICI units of the criterion. As previously mentioned, Big Creek West Branch RM 0.02 is the only monitored site for which its ALU is not designated WWH; however, the site was also evaluated using WWH biocriterion metrics for comparison purposes.

Table 17. ICI Metrics
Total Number of Taxa
Number of Mayfly Taxa
Number of Caddisfly Taxa
Number of Dipteran Taxa
Percent Mayflies
Percent Caddisflies
Percent Tanytarsini Midges
Percent Other Diptera and Non-Insects
Percent Tolerant Organisms (as defined)
Number of Qualitative EPT Taxa

Table 18. ICI Range for EOLP Ecoregion								
Ohio EPA Narrative	Very Poor	Poor	Low Fair Fair		Marginally Good	Good	Very Good	Exceptional
ICI Score	0-6	8-12	14-20	22-28	30-32	34-40	42-44	46-60
Ohio EPA Status Non-Attainment NSD Attainment								
NSD – Non-Significant Departure of WWH attainment								

Results and Discussion

Table 19 provides a summary analysis of the macroinvertebrate sampling results in 2024. Figure 14 compares ICI scores and/or narrative rating results to the WWH criterion for macroinvertebrates. Big Creek RM 0.15, Big Creek West Branch RM 0.20, Big Creek Tributary (RM 7.78) RM 0.02, and both Stickney Creek Sites were in non-attainment of the WWH macroinvertebrate criterion. For the other sites, only qualitative samples were collected, and based on those, narrative ratings assigned. Macroinvertebrate community composition by site in 2024 is shown below in Figure 15. There were distinct shifts in the community compositions at the sites that scored poorly. The percentage of specimens that indicate good water quality, including mayflies and caddisflies, was greatly diminished at these sites.

Table 19. Macroinvertebrate Community Assessment Results									
River Mile	Density Qt. (ft ²) /Ql.	QI./ Total Taxa	QI. EPT/ Sensitive Taxa	Qt. % Tolerant/ % Sensitive Taxa	Predominant Orgs. on Natural Substrates	ICI	Narrative Rating		
Big Creek (19-005-000)									
9.80	935/L	38/43	10/5	10.1/0.1	Turbellaria, Baetidae, Hydoptilidae, Diptera, Zygoptera	40	Good		
4.40	/M	34/	9/3		Baetidae, Chironomidea, Amphipoda, Zygoptera		Good		
2.40	764/L-M	37/42	9/4	29.2/0.01	Hydopsychidae, Baetidae, Turbellaria	30	Marginally Good		
0.15	/L	27/	2/0		Chironomidae, Isopoda		Poor		
Big Creek	West Branch ((Ford Branch)	(19-005-00	1)					
0.02	/L-M	25/	4/2		Baetidae, Isopda, Turbellaria, Amphipoda		Fair		
Stickney	Stickney Creek (19-005-002)								
1.15	742/L-M	19/34	0/0	16.9/0.02	Turbellaria, Zygoptera, Anisoptera	20	Low-Fair		

Table 19. Macroinvertebrate Community Assessment Results									
River Mile	Density Qt. (ft²) /Ql.	Ql./ Total Taxa	QI. EPT/ Sensitive Taxa	Qt. % Tolerant/ % Sensitive Taxa	Predominant Orgs. on Natural Substrates	ICI	Narrative Rating		
0.50	286/L-M	20/27	3/0	49.2/0	Baetidae, Turbellaria, Chironomidae, Zygoptera	14	Low-Fair		
Big Creek	Big Creek Tributary at RM 7.78 (Snow & Pearl Branch) (19-005-003)								
0.20/L-M 21/ 7/2 Hydropsychidae, Baetidae, Isopoda, Zygoptera, Leeches, Turbellaria									
Qt. Quantitative sample collected on Hester-Dendy artificial substrates									
QI. Qualitative sample collected from natural stream substrates									
Qualitative sample relative density: L=Low, M=Moderate, H=High									
Sensitive Taxa: Taxa listed on the Ohio EPA Macroinvertebrate Taxa List (2019) as Moderately Intolerant or Intolerant taxa									



Figure 14. ICI Scores and Narrative Rating from 2024 Compared to the WWH Criterion. Sites where an ICI score was not calculated were assigned a narrative rating.



Figure 15. Macroinvertebrate Community Composition by Site in 2024

Big Creek RM 9.80 had an ICI score of 40 (*Good*). The site had a total of 43 taxa collected with 38 taxa collected in the qualitative sample and 25 collected in the quantitative sample. Ten of the total taxa collected were EPT taxa and six were sensitive taxa. The HD was highly dominated by *Paratanytarsus sp.*, which made up 45 percent of the total organisms on HD. The site scored the same as the most recent historical assessment in 2021 with a score of 40 (*Good*); however, Turbellaria (flatworms) were the predominate species on the HD, comprising 32 percent of the sample. The number and percent of caddisfly taxa along with a high number of qualitative EPT taxa helped the site meet the WWH attainment criterion.

Big Creek RM 2.40 received a score of 30 and was assigned a narrative rating of *Marginally Good*, which is in non-significant departure of the WWH biocriterion. As previously mentioned, this was the first time the site has been monitored and was surveyed due to the reconstruction and restoration of the drop structure just upstream of the zone. A total of 42 taxa were collected with a total of 9 qualitative EPT taxa. Turbellaria were the predominate organisms on the HD comprising 29 percent of the sample. The number and percentage of caddisflies along with a high number of qualitative EPT taxa, total taxa, and dipteran taxa contributed to the site obtaining non-significant departure of the WWH biocriterion.

Stickney Creek RM 1.15 had a score of 20 and was assigned a narrative rating of *Low-Fair*. This site has been surveyed four times historically with scores ranging from 22 (*Fair*) in 2021 to 30 (*Marginally Good*) in 2023. The 2024 survey was the lowest score this site has received. This could be due to illicit discharges and improper sanitary connections upstream of the survey zone. A total of 34 taxa were present with zero EPT or sensitive taxa collected. The HD was highly dominated by Turbellaria (flatworms), which comprised 48 percent of the sample. No caddisflies or other EPT taxa were collected resulting in a lower score for this survey and the site not meeting attainment for WWH.

Stickney Creek at RM 0.50 had an ICI score of 14 and was assigned a narrative rating of *Low-Fair.* The site has never been previously surveyed. The 2024 survey contained 27 total taxa with 20 collected on the HD and 15 collected during the qualitative sample. Three EPT taxa, which included *Baetis flavistriga, Baetis intercalaris,* and *Hydrospyche,* were collected during the survey; however, no sensitive taxa were collected. A total of 1428 organisms were found on the HD with 48 percent of the observed organisms being *Oligochaeta.* A high percentage of tolerant species and a low number of mayflies were observed in the sample, leading to a lower ICI score and failure to meet WWH attainment.

Narrative rating assessments were assigned for Big Creek RMs 4.40 and 0.15, Big Creek West Branch RM 0.02, and Big Creek Tributary (RM 7.78) RM 0.20 based on the results of the qualitative sample only. An HD was installed at Big Creek RM 4.40, but became buried during the deployment period and no blocks were able to be collected. It was noted at the time of installation that no other suitable locations were present for the HD to be installed. HDs were not installed at Big Creek RM 0.15, Big Creek West Branch RM 0.02, and Big Creek Tributary (RM 7.78) RM 0.20 due to insufficient depth and/or streamflow velocity.

The qualitative sample data for each site was compared to expectations developed by NEORSD in 2021 using threshold limit models (NEORSD, 2023). These models were developed using QDC Level 3 macroinvertebrate data provided by the Ohio EPA from the Erie Ontario Lake Plain (EOLP) ecoregion from the ten-year period between 2005 and 2014 (threshold limit model analysis available upon request). Table 19 provides the expectation threshold limits for qualitative total taxa, qualitative EPT taxa, and qualitative sensitive taxa metrics, grouped by drainage area category. In addition to these threshold limits, field observations including, but not limited to, relative taxa abundance and field narrative rating as well as comparisons to historical data from this watershed were considered in the assignment of the narrative rating.

Table 20. NEORSD Recommended Expectation Threshold Limits for Narrative Rating										
	Assignments in the EOLP									
Drainage Category	DesignationQualitative Total TaxaQualitative EPT TaxaQualitative Taxa									
Headwater	EWH	38	12	6						
(0-20	WWH	27	7	2						
miles ²)	Fair	23	4	1						

Table 20 . NEORSD Recommended Expectation Threshold Limits for Narrative Rating Assignments in the EOLP								
Drainage Category	Designation	Qualitative Total Taxa	Qualitative EPT Taxa	Qualitative Sensitive Taxa				
Wadable	EWH	51	18	12				
(20-200 miles ²)	WWH	41	11	6				
	Fair	33	8	2				
Small River	EWH	44	16	10				
(200-1,000	WWH	36	11	7				
miles ²)	Fair	29	9	5				

Big Creek RM 4.40 was assigned a narrative rating of Good. This site has a drainage area of 19.3 square miles placing it in the headwater drainage area category. It had a total of 34 taxa in the qualitative sample with nine being EPT taxa. The EPT taxa included two Baetidae (*Baetis flavistriga* and *Baetis intercalaris*), one Heptageniidae (*Stenonema femoratum*), two Philopotamidae (*Chimarra aterrima* and *Chimarra obscura*), and four Hydropsychidae (*Cheumatopsyche sp., Hydropsyche morosa* group, *Hydropsyche sparna*, and *Hydropsyche depravata* group). Of the 34 total taxa, three were sensitive taxa. These numbers put the site just above the expectation threshold limits for WWH. Field observations indicated that the most predominant organisms collected were Baetidae mayflies and Chironomidae midges. Riffle and margin habitat were of fair quality; however, very little margin habitat was present and consisted of root mats and shallows. No pool was present at this site. The site was assigned a field narrative rating of *Moderately Good* to *Good* at the time of sample collection. Taking into consideration the above-listed data, the site was assigned a narrative rating of *Good* in 2024.

Big Creek RM 0.15 was assigned a narrative rating of *Poor*. This site has a drainage area of 37.1 square miles putting it on the lower end of the wadable drainage area category. This site had 27 total taxa in the qualitative sample and only two EPT taxa, one Baetidae mayfly (*Baetis intercalaris*) and one Heptageniidae mayfly. No sensitive taxa were collected in this qualitative sample. This site was below the fair expectation for all three metrics. Field observations indicated that the reach was channelized, habitat quality was poor, and evidence of eutrophication was observed. During the qualitative assessment, it was noted that Chironomidae midges and isopods were the predominant organisms present, while all other macroinvertebrates present were rare. This site received a field narrative rating of *Very Poor* at the time of sampling. This site was assigned a narrative rating of *Poor* in 2024 based on the above data and field observations.

Big Creek West Branch RM 0.02 was assigned a narrative rating of *Fair*, which is considered to be meeting the LRW ALU. This site has a drainage area of 11.9 square miles placing it in the headwater drainage category. This site had a total of 25 taxa collected in the qualitative sample. Four of these were EPT taxa including one Baetidae mayfly: (*Baetis flavistriga*) and three Hydropsychidae caddisflies (Cheumatatopsyche sp., *Hydropsyche depravata group*, and *Hydropsyche simulans*). The total number of qualitative taxa for this site fell between the WWH

and fair expectations for a headwater site. The number of EPT taxa for this site met the fair expectation for a headwater site. Two of the 25 taxa collected were sensitive taxa which meets the WWH expectation. At the time of sample collection, this site received a field narrative rating of *Fair* to *Poor*. Riffle quality was poor and the riffle was noted to be embedded. Predominant organisms collected were Baetidae mayflies, isopods, and leeches. Overall macroinvertebrate diversity at the site was low and the density was moderate to low. Field observations, along with the above-listed data from the qualitative sample, put this site below WWH expectations. The site was assigned a narrative rating of *Fair* in 2024.

The site at Big Creek Tributary (RM 7.78) RM 0.20 was assigned a narrative rating of Fair. This site has a drainage area of 2.5 square miles putting it on the low end of the headwater drainage area category. This site had 21 total taxa in the qualitative sample. Seven of these were EPT taxa including two Baetidae (Baetis flavistriga and Baetis intercalaris), one Heptageniidae (Stenonema femoratum), one Philopotamidae (Chimarra obscura), and three Hydropsychidae (Cheumatopsyche sp., Hydropsyche morosa group, and Hydropsyche depravata group). Two out of the 21 total taxa were sensitive taxa. This site was below the fair expectation for qualitative total taxa; however, it met the WWH expectation for qualitative EPT taxa and sensitive taxa. Field observations indicated that the most predominant organisms collected were Hydropsychidae caddisflies, isopods, and leeches, followed by Baetidae mayflies, flatworms, and damselflies. Pool, riffle, run, and margin habitats were sampled. Riffle habitat was noted as embedded and fair quality. Margin habitat was good quality and comprised approximately 45 percent of the available habitat sampled. Field observations noted that overall macroinvertebrate density was moderate to low and diversity was low. At the time of sample collection, this site received a field narrative rating of Fair to Marginally Good. This site was assigned a narrative rating of Fair in 2024 based on the above-listed data from the qualitative assessment, along with the field observations.

Comparisons of ICI scores are shown in Figure 16 through 18 below. Figure 16 is a boxplot which displays the wide swing in scores for every survey completed in the watershed. Figures 17 and 18 break down temporal changes in the ICI scores for the main branch and the tributaries. Sites that have been assigned narrative ratings in the past, due to loss of HD or insufficient flow, have been assigned an estimated score based off narrative ratings as described in Ohio EPA's *Delisting Guidance and Restoration Targets for Ohio Areas of Concern* (Ohio EPA, 2020). Additionally, Big Creek RM 0.15 and Big Creek RM 4.40 have multiple yearly samples from 2006 through 2008; therefore, an average from the two scores was used in the graph.







Figure 17. Historical ICI Scores for the Main Branch



Figure 18. Historical ICI Scores for Big Creek Tributaries

The temporal trends observed at the main branch of Big Creek exhibit significant variability and lack consistency. Big Creek RM 0.15 has been trending downwardly since 2014. The highest score the site achieved was in 2012 where the site scored 32 and received a narrative rating of *Marginally Good*; whereas, the site has seen its lowest scores of 12 with a narrative rating of *Poor* in the last two surveys. Changes in habitat could be a contributing factor to the decrease in scores. Where Big RM 0.15 ICI scores are trending downwards, Big Creek RM 4.40 and RM 9.80 both are trending in an upward direction with both sites meeting the ICI WWH criterion in the 2024 sampling season.

All Big Creek tributary sites failed to meet WWH target scores in 2024. While there is fewer sampling data available for these sites, they have historically trended between *Fair* and *Marginally Good* with the exception of the West Branch RM 0.02 site, which has a LRW designated use and was rated *Poor* during previous assessments. It is typical for smaller headwater sites with small drainage areas to display temporal changes in biocriterion scoring due to sensitivity to environmental stressors such as changes in flow and runoff from point and nonpoint sources.

Conclusions

The aquatic life habitat use designation for most of the stream segments in this study is WWH. According to the Ohio EPA (2021), warmwater habitats are capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater organisms having a species composition, diversity, and functional organization comparable to the twenty-fifth percentile of

the identified reference sites within their respective ecoregion. The results of NEORSD's 2024 Big Creek Watershed study, which included water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys, indicated limiting conditions exist throughout the watershed. None of the sites monitored were found to be in full attainment of the biological criteria for WWH; however, Big Creek West Branch RM 0.20 was in attainment for LRW biological criteria since the IBI and ICI narrative ratings were above *Very Poor*.

A summary of the 2024 Big Creek Watershed survey results is provided in Table 20 below. All surveyed sites were in exceedance of both STV and geomean recreational criteria for *E. coli*. Nutrient concentrations at Big Creek RM 0.15, Stickney Creek RM 1.15, and Stickney Creek RM 0.50 were categorized as modestly enriched or enriched according to SNAP. The remaining sites were categorized as typical of developed land or working landscapes. Wide DO diel swings observed at both Stickney Creek sites indicated a state of nutrient enrichment at the sites according to the SNAP. The elevated levels of sanitary sewage contamination in the watershed, in combination with urban runoff, are most likely the greatest contributor to elevated nutrients, particularly TP, and wide DO diel swings in the watershed.

Habitat scores met WWH expectations at all sites with the exceptions of Big Creek RM 0.15, Stickney Creek RM 1.15, and Stickney Creek RM 0.50, which scored in the Fair narrative rating category. At Big Creek RM 0.15, the lack of riffle/pool/run sequence development and extensive embeddedness contributed to the low QHEI score. At both Stickney Creek sites, sparse amount of instream habitat along with a lack of diversity within the instream cover were contributing factors to the sites not meeting WWH expectations. Three sites were in non-attainment of the WWH biological criteria including Big Creek RM 0.15, Big Creek Tributary (RM 7.78) RM 0.20, and Stickney Creek RM 0.50. All remaining sites besides West Branch RM 0.02 were in partial attainment of WWH criteria. All sites with the exception of Stickney Creek RM 1.15 were in non-attainment of the fish IBI scoring criterion with average scores from two passes ranging from 25 (Poor) to 32 (Fair). Stickney Creek RM 1.15 was in non-significant departure for the WWH biocriterion. Big Creek RM 2.40 and RM 0.15 were in non-attainment of MIwb scoring criterion. Three of the eight sites were in attainment using macroinvertebrate ICI scoring criterion or NEORSD threshold expectation limits, with only Big Creek RM 9.80, RM 4.40, and RM 2.40 meeting the criterion. In conclusion, Big Creek RM 9.80, 4.40, and Stickney Creek were in partial attainment for WWH biological criteria. Big Creek West Branch at RM 0.02 was in attainment for LRW biocriteria, since the site scored above Very Poor. Although Big Creek RM 2.40 was in non-significant departure for the ICI scoring index, the site could not be in partial attainment due to its IBI narrative rating of Poor. The remaining sites were not in attainment for WWH biological criteria.

	Table 21. 2024 Big Creek Watershed ALU Attainment Status								
River Mile	DA (mi²)	Attainment Status	IBI Score	MIwb Score	ICI Score/ Narrative Rating	QHEI Score	Cause(s)	Source(s)	
Big Creek (19-005-000) - WWH									
9.80 ^H	5.6	PARTIAL	30*		40	65.0	Pollutants in urban stormwater	Urban runoff/ storm sewers	
4.40 ^H	19.3	PARTIAL	30*		Good	55.5	Pollutants in urban stormwater	Urban runoff/ storm sewers	
2.40 ^w	33.8	NON	<u>26*</u>	6.8*	30 ^{ns}	63.0	Pollutants in urban stormwater Habitat modification	Urban runoff/ storm sewers	
0.15 ^B	37.1	NON	<u>25*</u>	<u>6.1*</u>	Poor*	54.75	Organic enrichment Nutrient enrichment Siltation/sedimentation Flow alterations	Industrial and municipal point sources Natural sources (flow alterations)	
Big Creek Ford Branch (West Branch) (19-005-001) - LRW ^L									
0.02 ^H	11.9	FULL	<u>25</u>		Fair	71.5			
Stickney	Stickney Creek (19-005-002) - WWH								
1.15 ^H	3.17	PARTIAL	36 ^{ns}		20*	53.0	Organic enrichment Nutrient Enrichment Habitat modification	Urban runoff/ storm sewers Illicit Discharges	
0.50 ^H	4.405	NON	28*		14*	51.5	Organic enrichment Nutrient enrichment Siltation/sedimentation	Urban runoff/ storm sewers Illicit Discharges	
Big Cree	ek Tribut	ary at RM 7.78	(Snow &	Pearl Br	anch) (19-005-00	3) - WWH	1		
0.20 ^H	2.5	NON	32*		Fair*	64.5	Pollutants in urban stormwater Siltation/sedimentation	Urban runoff/ storm sewers	
 ^{ns} Non-significant departure from WWH biocriteria (≤4 ICI; ≤4 IBI; ≤0.5 MIwb units) *Significant departure from biocriterion (> 4 ICI; > 4IBI; > 0.5 MIwb units). Underlined scores are in the <i>Poor</i> or <i>Very Poor</i> narrative range ^H Headwater scoring criteria ^W Wading scoring criteria ^B Boat scoring criteria ^L Scores above <i>Very Poor</i> are considered to meet criteria 									

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