



# **Northeast Ohio Regional Sewer District**

## **2021 Stream Restoration Projects Biological, Water Quality, and Habitat Study**



**Water Quality and Industrial Surveillance**

**Environmental Assessment Group**

**May 2022**

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## **Introduction**

In 2021, the Northeast Ohio Regional Sewer District (NEORSD) monitored environmental conditions at seven sites to determine the effectiveness of recently completed and upcoming restoration projects in improving water quality conditions, habitat, and fish and macroinvertebrate communities. Sites on Big Creek, Rocky River East Branch, and Stickney Creek were assessed as part of post-project monitoring. Sites on Chippewa Creek, Hemlock Creek and Mill Creek were assessed as part of pre-project monitoring to establish baseline conditions prior to the completion of proposed stream restoration activities. Surveys at these locations were conducted by the Environmental Assessment group of the NEORSD Water Quality and Industrial Surveillance (WQIS) Division.

The Big Creek Stabilization Project was completed in November of 2019 and addressed hydrological issues affecting Big Creek in Cleveland. This project improved erosion and habitat issues along more than 1,200 linear feet of stream by replacing concrete lined streambanks with riprap and developed a sloped cascade of large rocks on top of an existing spillway structure that acted as a barrier to fish migration. The purpose of monitoring at a historical site upstream of the restoration project was to determine if the changes to the fish migration barrier resulted in an increase in the number of species.

The Colombo Park Stream Restoration was also completed in 2019 and addressed erosion and improved stream function along 400 feet of Big Creek in Parma Heights. The project halted stream-bank erosion that threatened public sanitary sewer infrastructure, and realigned, widened, and stabilized a section of the stream to establish new floodplain areas and slow in-channel velocities. Pre-construction monitoring at this location was completed in 2015 and 2016.

The Chippewa Creek Stream Stabilization near Broadview Road project is in the preconstruction phase and aims to improve stream bed and bank stability where an unnamed tributary to Chippewa Creek is eroding its right streambank in Broadview Heights, Ohio. The eroding stream bank is within twelve feet of the Chippewa Creek Condominiums and approximately six feet from a parallel local sanitary sewer. The erosion has also exposed storm sewer pipe and headwalls. The project will stabilize the eroding stream bank and protect sewer infrastructure assets with construction that began in 2021.

WQIS preconstruction environmental monitoring also supported the Hemlock Creek Bank Stabilization project. The purpose of the project is to provide riparian floodplain restoration adjacent to Hemlock Creek by creating a new floodplain or achieving floodplain reconnection. The project will also focus on reducing the existing and potential bank erosion from failing hardened bank stabilization practices to lessen loading of sediment and associated nutrients into Hemlock Creek. These actions are intended to restore and enhance stream and riparian ecological functions as well as minimize risk and long-term maintenance costs to adjacent infrastructure by reducing flooding on surrounding residential properties and within the road network. This sampling site was not included in the 2021 Stream Restoration Projects level 3 credible data study plan, but all water chemistry, habitat, and biological surveys were conducted by a level 3 qualified data collector in accordance with Ohio Environmental Protection Agency (EPA) sampling methods.

WQIS preconstruction environmental monitoring will support the Mill Creek Stream Stabilization in Warrensville Heights project. The project concept plan expands and reconnects floodplains and addresses erosion by stabilizing banks and protecting an exposed sanitary sewer line. The goal of the project is to eliminate the threats to numerous properties along Mill Creek and restore the stream by improving access to its floodplain to better handle high-volume flow and improve overall urban hydrology.

In 2017, the Cleveland Metroparks was awarded a grant to improve water quality and habitat along Rocky River East Branch and to restore adjacent areas within Bonnie Park in Strongsville, Ohio. The primary focus of the Bonnie Park Restoration project was the removal of a low-head dam that acted as a fish barrier and was affecting upstream water quality and attainment of Warmwater Habitat status. The project also improved the area surrounding this section of Rocky River East Branch with floodplain and wetland restoration. By the request of the Cleveland Metroparks, the NEORSD completed a preconstruction limited environmental survey upstream of the Bonnie Park Dam in July of 2017. In 2019, fish, macroinvertebrate, and water chemistry sampling were conducted at the same site under the yearly general watershed monitoring. The project's initial restorative actions were completed in Spring/Summer 2020, with the first post-construction fish survey conducted by WQIS in October 2020.

In Brooklyn, Ohio, the Stickney Creek Restoration project was completed on November 29, 2019. This project restored more than 1,000 feet of urban stream where erosion exposed and threatened the integrity of sanitary sewer infrastructure. Additionally, restoration efforts reestablished floodplain storage, slowed stream velocities, and created more in-stream habitat. Preconstruction monitoring at this location was completed in 2017.

Sampling was conducted by NEORSD Level 3 Qualified Data Collectors (QDCs) certified by the Ohio EPA in Fish Community Biology, Benthic Macroinvertebrate Biology, Chemical Water Quality, and Stream Habitat Assessments as explained in the NEORSD study plan *2021 Stream Restoration Projects Pre- & Post- construction Monitoring* approved by Ohio EPA on June 15, 2021. All sampling and environmental assessments occurred between June 15, 2021 and September 30, 2021 (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), and the Invertebrate Community Index (ICI). Water chemistry data was validated per methods outlined by the Ohio EPA *Surface Water Field Sampling Manual for water quality parameters and flows* (2021) and compared to the Ohio Water Quality Standards for their designated use to determine attainment (Ohio EPA, 2020). An examination of the individual metrics that comprise the IBI, MIwb, and ICI was used in conjunction with the water chemistry data and QHEI scores to assess the health of the stream.

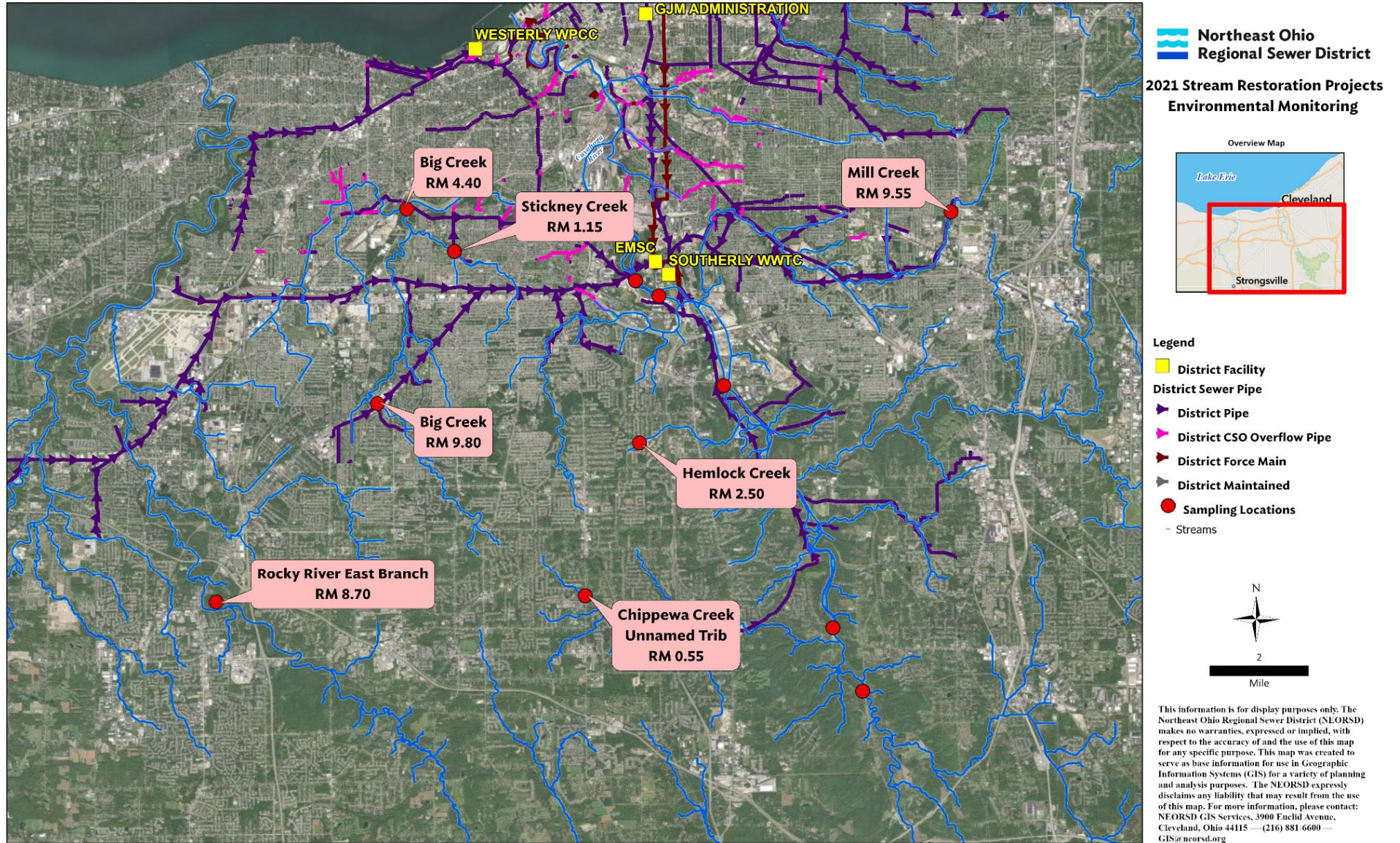
Figure 1 shows a map of the sampling locations, and Table 1 indicates the sampling locations with respect to RM, latitude/longitude, description, and surveys conducted. A digital photo catalog of the sampling locations is available upon request by contacting the NEORSD's Water Quality and Industrial Surveillance (WQIS) Division.

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**Table 1.** 2021 Stream Restoration Projects Sampling Locations

Water Body	Latitude	Longitude	River Mile	Station ID	Location Information	Project Name	Sampling Conducted (Phase)
Big Creek	41.3884	-81.7664	9.80	303734	Downstream of Pearl Road/Colombo Park	Colombo Park Stream Restoration	F, M, C, (Post)
Big Creek	41.4460	-81.7540	4.40	301193	Memphis Picnic Area	Big Creek Stabilization	F, M, C, (Post)
Rocky River East Branch	41.3301	-81.8357	8.70	T01W29	Upstream of Former Bonnie Park Dam	Bonnie Park Restoration	F, M, C, (Post)
Stickney Creek	41.4334	-81.7351	1.15	303948	Upstream of Ridge Road	Stickney Creek Restoration	F, M, C, (Post)
Chippewa Creek Unnamed Tributary	41.3309	-81.6848	0.55	304248	Upstream of Broadview Road	Chippewa Creek Stream Stabilization Near Broadview Road	F, M, C, (Pre)
Hemlock Creek	41.3762	-81.6629	2.55	303700	Upstream of Donna Rae Drive	Hemlock Creek Bank Stabilization	F, M, C, (Pre)
Mill Creek	41.4437	-81.5392	9.55	304247	Upstream of Longbrook Road	Mill Creek Stream Stabilization in Warrensville Heights	M, C (Pre)
F = Fish community biology (includes habitat assessment) M = Macroinvertebrate community biology C = Water column chemistry Post = post-construction monitoring Pre = pre-construction monitoring							





**Figure 1.** 2021 Stream Restoration Project Sampling Locations

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 the 2021 Restoration Projects waterbodies are listed below in Table 2 (Ohio EPA 2020a).

<b>Table 2. Stream Restoration Projects Beneficial Use Designations</b>													
Stream	<b>Beneficial Use Designation</b>												
	Aquatic Life Habitat (ALU)							Water Supply			Recreation		
	S R W	W W H	E W H	M W H	S S H	C W H	L R W	P W S	A W S	I W S	B W	P C R	S C R
Big Creek – within Cleveland Metro Park - RM 9.80	*	+							+	+		+	
Rocky River East Branch		+							+	+		+	
Stickney Creek		+							+	+		+	
Chippewa Creek Unnamed Tributary		+							+	+		+	
Hemlock Creek		+							+	+		+	
Mill Creek		+							+	+		+	

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

## Water Chemistry and Bacteriological Sampling

### Methods

Water chemistry and bacteriological sampling was conducted five times between June 16, and July 14, 2021, at the sites 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* (2021). Chemical water quality samples from each 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-µm 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, dissolved oxygen percent, pH, temperature, specific conductance, and conductivity were collected using either a



YSI 600XL or EXO1 sonde. Duplicate samples and field blanks were each 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).

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

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

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

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

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

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 each site are available upon request from the NEORS D WQIS Division.

### Results and Discussion

Two duplicate samples and two field blanks were collected in support of quality assurance and quality control (QA/QC) guidelines for field sampling. The first duplicate sample was collected at Rocky River East Branch RM 8.70 on June 16, 2021. No chemical parameters assessed were rejected due to discrepancies between the sample and duplicate sample. The second duplicate sample was collected at the Chippewa Creek Unnamed Tributary RM 0.55 on June 30, 2021. The chemical parameter ammonia (NH<sub>3</sub>) was rejected based on RPD values outside of the acceptable RPD range for this sample (Table 3).

<b>Table 3. Duplicate Samples with RPDs Greater than Acceptable</b>				
Site Location	Date	Parameter	Acceptable RPD	Actual RPD
Chippewa Creek Unnamed Tributary RM 0.55	6/30/2021	Ammonia	73.1%	89.2%

The first field blank sample was collected on June 23, 2021, at Mill Creek RM 9.55. When comparing the field blank to all samples collected on this day, results indicate that no data

qualification was needed due to sample concentrations exceeding field blank concentrations tenfold. The second field blank was collected on July 14, 2021, at Big Creek RM 4.40. Results from the July 14, 2021, sampling indicate that biochemical oxygen demand (BOD) data from all the samples collected that day were calculated to have a sample result/field blank result ratio less than three times that of the sample result. These BOD results were rejected due to blank concentrations being within the “Result  $\leq$  3x Blank” data quality objective range. It is unclear how the field blank became contaminated and may be due to inappropriate sample collection, handling, contaminated blank water and/or interference during analysis. Table 4 below shows the parameters possibly affected by field blank contamination.

<b>Table 4. Parameters Affected by Possible Field Blank Contamination</b>				
Site Location	Date	Parameter	Qualifier	Reason
All	7/14/2021	BOD	R	Result $\leq$ 3x Blank
R = Data rejected				

Paired parameters, wherein one parameter is a subset of another, was also evaluated in accordance with QA/QC protocols for all samples collected at each Stream Restoration Projects site. Some of the total solids (TS) and total dissolved solids (TDS) samples from June 23, 2021, needed to be either rejected or qualified as estimated based on the TDS results being higher than the corresponding TS results (Table 5). Because there were no exceedances associated with these parameters, qualification of these results did not significantly change the overall water chemistry assessment of these streams.

<b>Table 5. Paired Parameter Qualifiers</b>					
Site Location	Date	Paired Parameter	Acceptable RPD (%)	Actual RPD (%)	Qualifier
Big Creek RM 9.80	6/23/21	TS/TDS	27.2	9.6	J
Big Creek RM 4.40	6/23/21	TS/TDS	28.9	33.1	R
Chippewa Creek RM 0.55	6/23/21	TS/TDS	28.2	14.3	J
Rocky River East Branch RM 8.70	6/23/21	TS/TDS	26.3	0.4	J
Stickney Creek RM 1.15	7/14/21	TS/TDS	25.2	4.5	J
J = Data estimated R = Data rejected					

Attainment of the PCR 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 includes an *E. coli* criterion not to exceed a Statistical Threshold Value (STV) of 410 colony counts or most-probable number (MPN) per 100mL in more than ten

percent of the samples taken during any 90-day period, and a 90-day geometric mean criterion of 126 colony counts or MPN per 100mL (Ohio EPA, 2019c). In accordance with Ohio EPA procedure and practice to qualify *E. coli* exceedances for the PCR criteria, the geometric mean and STV are only calculated and compared when a minimum of five bacteriological samples have been collected.

The STV of 410 colony counts/100mL in more than ten percent of the samples taken was exceeded at all sampling sites in 2021. Additionally, all sites exceeded the ninety-day geometric mean criterion of 126 colony counts/100mL (Table 6). Three of the five sampling dates were conducted during wet-weather events, which may lead to elevated *E. coli* densities due to sanitary sewer overflows, and urban runoff. *E. coli* exceedances may also have been a result of domestic and/or wild animal waste, improper sanitary sewage connections to stormwater outfalls, or failing household sewage treatment systems (HSTs) upstream of the sampling locations.

Although both the *E. coli* criteria were exceeded at RM 9.80, of note is the reduction in densities measured there compared to when sampling was last completed at that location in 2016. For that year, the 90-day geomean was 66,593 MPN/100mL, significantly greater than the 1,783 MPN/100mL measured in 2021. In 2017, an illicit discharge was found just upstream of that site and was remediated in 2018. By remediating this improper connection, more than 1,000 gallons per day of sanitary sewage was stopped from entering Big Creek and led to the observed reduction in *E. coli* densities.

**Table 6. *E. coli* Densities (MPN/100mL)**

Date	Big Creek RM 9.80	Big Creek RM 4.40	Chippewa Creek RM 0.55	Hemlock Creek RM 2.55	Mill Creek RM 9.55	Rocky River East Branch RM 8.70	Stickney Creek RM 1.15
6/16/2021	328	727	81	72,700	365	1,484	2,420
6/23/2021*	517	2,420	225	2,420	20,140	921	4,710
6/30/2021*	36,540	2,850	633	2,420	2,130	3,450	9,900
7/7/2021	1,203	488	141	1,733	2,280	308	1,986
7/14/2021*	2,420	12,230	2,420	4,350	3,990	2,460	4,880
90-day Geomean	1,783	1,973	330	5,027	2,696	1,290	4,053
<div style="display: flex; align-items: center;"> <div style="width: 20px; height: 20px; background-color: #f4a460; border: 1px solid black; margin-right: 5px;"></div> <p>Exceeds statistical threshold value of 410 MPN/100mL</p> </div>							
<div style="display: flex; align-items: center;"> <div style="width: 20px; height: 20px; background-color: #ffff00; border: 1px solid black; margin-right: 5px;"></div> <p>Exceeds geometric mean criterion for 90-day period of 126 MPN/100mL</p> </div>							
<p>*Wet-weather Event: 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.</p>							

Water chemistry sampling for the 2021 Stream Restoration Projects resulted in mercury concentrations that were below the method detection limit at all sites. Mercury analysis for all the sampling events was done 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 sites were 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.

Based on the sampling that was conducted, no exceedances of water quality standards were found for the other parameters that were monitored at these sites in 2021.

### *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 quality of surface waters based on factors including dissolved oxygen (DO) swings, benthic chlorophyll *a*, total phosphorous, and dissolved inorganic nitrogen (Ohio EPA, 2015). NEORSR did not assess DO swings or benthic chlorophyll *a* in 2021; however, nutrients were assessed.

Table 7 shows the 2021 nutrient concentrations for the Stream Restoration Projects sampling sites. The results of dissolved inorganic nitrogen (DIN) and total phosphorous (TP) were compared to Table 2 listed in the SNAP document (Figure 2) and applicable nutrient concentrations and narrative level can be seen in Table 8. Stickney Creek was the only site that showed an enriched condition. There are numerous illicit discharges upstream of this site that may be contributing to the elevated nutrient load.

<b>Table 7. Nutrient Analysis (Geometric Means)</b>					
Waterbody	River Mile	DIN (mg/L)*	NO <sub>3</sub> -NO <sub>2</sub> (mg/L)	DRP (mg/L)	TP (mg/L)*
Big Creek	9.80	0.365	0.340	0.040	0.067
	4.40	0.783	0.735	0.093	0.124
Chippewa Creek Unnamed Tributary	0.55	0.260	0.220	0.023	0.045
Hemlock Creek	2.55	1.222	1.163	0.054	0.082
Mill Creek	9.55	0.292	0.251	0.034	0.064
Rocky River East Branch	8.70	3.108	3.043	0.043	0.107
Stickney Creek	1.15	2.086	1.048	0.356	0.411
* Data used in Table 2 of SNAP (Ohio EPA 2015)					



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		← DECREASING RISK				
TP Conc. (mg/l)	DIN Concentration (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 2.** Table 2 of the Stream Nutrient Assessment Procedure (Ohio EPA, 2015b)

Table 8. Applicable SNAP Analysis with Narrative Level (Geometric Means)				
Waterbody	River Mile	DIN Range	TP Range	Narrative Level
Big Creek	9.80	<0.44	0.040<0.080	Levels typical of developed lands; little or no risk to beneficial uses
	4.40	0.44<1.10	0.080<0.131	Levels typical of working landscapes; low risk to beneficial uses if allied responses are within normal ranges
Chippewa Creek Unnamed Tributary	0.55	<0.44	0.040<0.080	Levels typical of developed lands; little or no risk to beneficial uses
Hemlock Creek	2.55	1.10<3.60	0.080<0.131	Levels typical of working landscapes; low risk to beneficial uses if allied responses are within normal ranges
Mill Creek	9.55	<0.44	0.040<0.080	Levels typical of developed lands; little or no risk to beneficial uses
Rocky River East Branch	8.70	1.10<3.60	0.080<0.131	Levels typical of working landscapes; low risk to beneficial uses if allied responses are within normal ranges
Stickney Creek	1.15	1.10<3.60	≥0.400	Enriched condition; generally high risk to beneficial uses; often co-occurring with multiple stressors; increased risk with poor habitat

## Habitat Assessment

### Methods

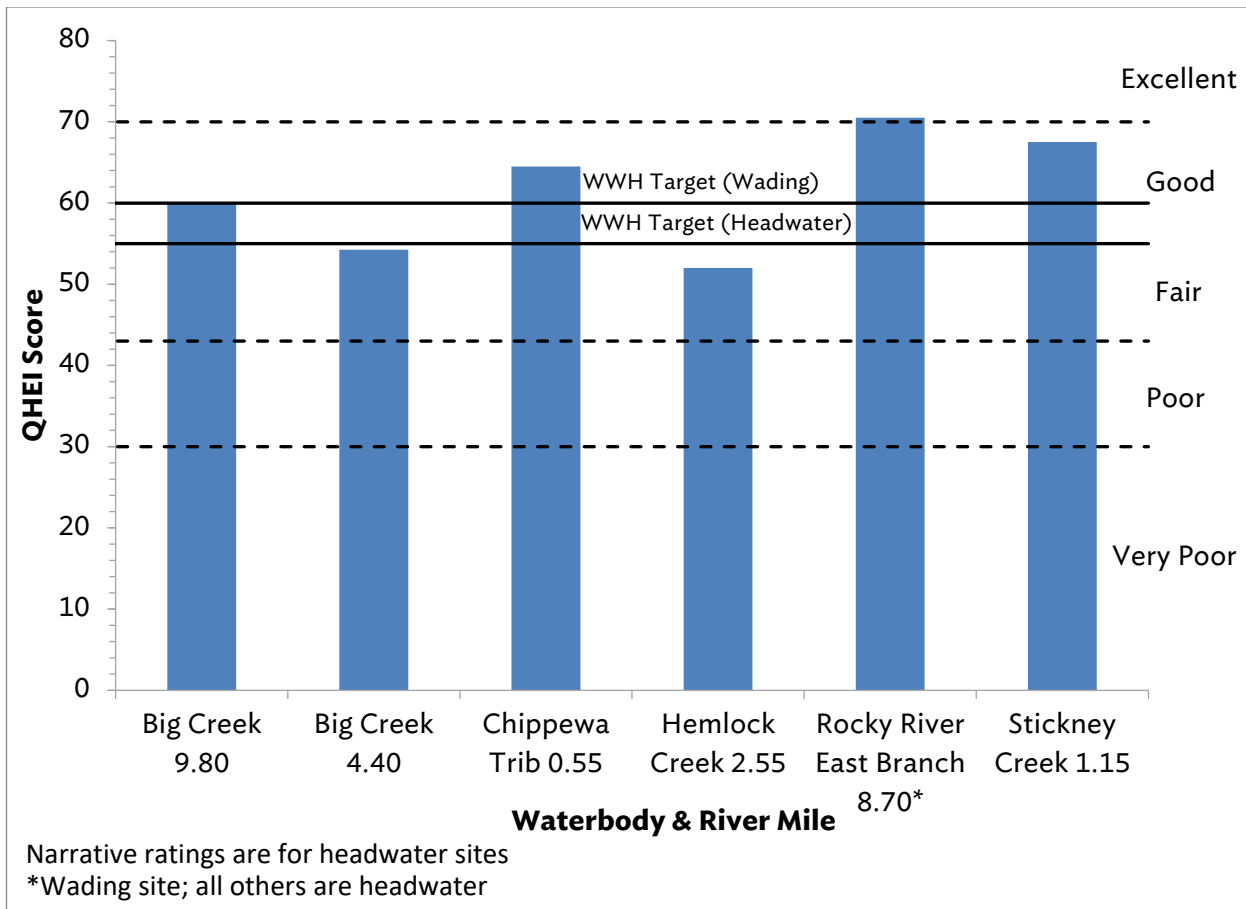
Instream habitat assessments were conducted using the Qualitative Habitat Evaluation Index (QHEI) at each site in 2021 except for Mill Creek RM 9.55, where access permission was unable to be obtained from all the landowners. The QHEI was developed by the Ohio EPA to assess aquatic habitat conditions 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 greater than 60 on streams greater than 20 square miles (mi<sup>2</sup>) and 55 for streams less than 20 mi<sup>2</sup>, suggests that sufficient habitat exists to support a fish community that attains the warmwater habitat criterion (Ohio EPA, 2006). Scores greater than 75 frequently demonstrate habitat conditions that have the ability to 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). QHEI field sheets for each site are available upon request from the NEORSD WQIS Division.

### Results and Discussion

All but two of the 2021 Stream Restoration Projects sampling sites achieved the Ohio EPA Warmwater QHEI target score of 60 for wading sites and 55 for headwater streams. Figure 3 shows an overview of each stream location assessed during the 2021 field season.

#### *Big Creek RM 9.80 and 4.40*

The habitat for the stream segment at Big Creek RM 9.80 was assessed on July 23, 2021. A QHEI score of 60 was calculated with a narrative rating of *Good*, exceeding the target QHEI score. This score, however, was lower than the score of 69 that was found there when it was last assessed back in 2016. The dominant substrates consisted of cobble and boulder, with four or more best types included, which positively contributed to segment scoring. This was a shift from the gravel and bedrock substrates that were the dominant types in 2016. A moderate amount of instream cover was of marginal quality and limited in type diversity, with only some boulders and few pools available. Factors that negatively impacted the score were the lack of sinuosity, shallow pools that did not exceed riffle width, and a diminished riparian corridor comprised of urban and industrial development. Elimination of deeper pools was one of the factors that led to the lower overall QHEI score in 2021. As the stream reach continues to recover in other areas following the restoration work, however, it is expected that the QHEI score will improve.



**Figure 3.** 2021 Stream Restoration Projects QHEI Scores

The habitat for the stream segment at Big Creek RM 4.40 was assessed on June 23, 2021. At this location, a QHEI score of 54.25 was calculated with a narrative rating of *Fair*, failing to meet the target score of 55 for WWH. The quality of the riffle habitat and the predominant substrates of boulder and cobble, with four or more best types being present, were factors that helped improve the site score. A high-influence MWH attribute that affected this score was the lack of instream cover. While a few types were present in the reach, including shallows (in slow water), rootmats, and boulders, the overall quality and quantity of cover was diminished, which can inhibit the establishment of fish communities. Additionally, the stream reach was characterized by poor riffle/pool complexes and devoid of sinuosity. The highly channelized reach also lacked sufficient development of pools which provide important refugia during dry periods. Because Big Creek RM 4.40 failed to meet the target score for QHEI, it could be expected that the reach may not be able to sustain a healthy biological community.

*Chippewa Creek Unnamed Tributary RM 0.55*

The QHEI assessment at the Chippewa Creek Unnamed Tributary RM 0.55 was scored at 64.5 and exceeded the headwater target of 55, with a *Good* narrative rating. The predominant substrates of cobble and gravel were characterized by normal silt and embeddedness narratives,

with four or more best types of substrate present. Channel morphology features included moderate sinuosity, fair development, and moderate to high stability with no channelization present in the sampling zone. Moderate to severe erosion was present with a narrow riparian zone consisting of residential, park, or new field floodplain that are comprised of impervious surfaces. Pool and riffle complexes were shallow and of fair quality with slow current velocity throughout the reach.

#### *Hemlock Creek RM 2.55*

The habitat assessment at Hemlock creek RM 2.55 was calculated to have a QHEI score of 52, falling short of the targeted score of 55 to support a healthy biological community. Gravel and bedrock of shale origin were the dominant substrates present in the sampling zone. Instream cover was sparse with only two habitat types present, boulders and pools, to provide refugia for the fish community. Channel morphology was characterized by moderate sinuosity, fair development, and moderate to high stability on the non-channelized section of stream. Pool/riffle complexes were also fair quality with moderately shallow pools and riffles that lacked fast current velocities. The sampling zone at Hemlock Creek also had moderate erosion on river right and heavy/severe erosion on river left, with a very narrow riparian width comprised of residential areas. In an urban residential flood plain like that surrounding Hemlock Creek, a greater percentage of impervious surface can lead to excessive flow to the stream, which may magnify erosion issues and lead to greater sediment deposition in the stream. The stream reach's inherent stability and lack of channelization may be key in maintaining positive channel morphology features and preventing additional erosion under elevated flow conditions.

#### *Rocky River East Branch RM 8.70*

Rocky River East Branch RM 8.70, a wading site, was surveyed on June 17, 2021. A QHEI score of 70.50 was calculated, which resulted in a narrative rating of *Good*. This was significantly higher than the score of 48 that was calculated in the reach prior to the dam removal and restoration project. This area is within the Cleveland Metroparks with a wide to moderate riparian width that consisted of park or new field on river right and urban riparian zone on river left. The predominant types of substrates were cobble and boulder, with four or more best types present in the reach. The riffle/pool complex quality was excellent with riffles and runs exhibiting good stability with moderate embeddedness. Channel morphology showed little to no sinuosity with good development and high stability. Instream cover included moderate amounts of boulders and pools with a depth greater than seventy centimeters.

#### *Stickney Creek RM 1.15*

The QHEI score at Stickney Creek RM 1.15 was calculated at 67.50, which correlates to a *Good* narrative rating. This value significantly exceeds the Ohio EPA's target score of 55 for headwater sites and suggests that sufficient habitat exists to support a warmwater fish community. The most prominent types of substrate present consisted of cobble and gravel with a "normal" silt narrative. The recovering reach was characterized by additional morphology



features of high sinuosity, good development, and moderate to high stability. Development of the riffle/pool complexes was of good quality and a distinct transition between pool and riffle habitats were observed. A moderate amount of instream cover only included three distinct habitat types, overhanging vegetation, pools, and logs or woody debris, which was a key factor in reducing the QHEI score for the reach. The sample site at RM 1.15 is one of the only non-culverted sections of Stickney Creek, as the upstream sections are almost completely culverted and void of habitat. The Stickney Creek restoration project improved habitat in the stream reach compared to pre-construction monitoring, in which a score of 59.75 was calculated for the previous assessment.

In addition to overall QHEI scores, individual components of the QHEI can also be used to evaluate whether a site is capable of meeting its WWH designated use (Table 9). This is done by categorizing specific attributes as indicative of either a 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, 1999). Of the sites that were assessed in 2021, Chippewa Creek Unnamed Tributary RM 0.55, Hemlock Creek RM 2.55, and Stickney Creek RM 1.15 met these targets. Big Creek RM 4.40 had the greatest number of MWH characteristics with four high-influence attributes and five moderate-influence ones.

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**Table 9. QHEI Scores and Physical Attributes**

				<b>MWH Attributes</b>																														
				<b>WWH Attributes</b>							<b>High Influence</b>			<b>Moderate Influence</b>																				
<b>Water Body</b>	<b>River Mile</b>	<b>QHEI Score</b>	<b>Narrative Rating</b>	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	<b>Total WWH Attributes</b>	Channelized or no Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW sites)	<b>Total High Influence Attributes</b>	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	<b>Total Moderate Influence Attributes</b>	<b>(MWH-H.I.+1) / (WWH+1) Ratio</b>	<b>(MWH M.I.+1) / (WWH+1) Ratio</b>
Big Creek	9.80	60.00	Good	X	X	X	X	X	X	X	X	X	X	5	X					1				X	X	X	X	X	X	X		7	0.3	1.3
Big Creek	4.40	54.25	Fair	X	X		X							2	X		X	X	X	4				X			X	X	X	X		5	1.7	2.0
Chippewa Ck. Unnamed Tributary	0.55	64.50	Good	X	X		X	X			X	X	X	7					0				X				X					2	0.1	0.4
Hemlock Creek	2.55	52.00	Fair	X	X		X				X	X	X	6				X	1				X		X		X					3	0.3	0.6
Rocky River East Branch	8.70	70.50	Good	X	X		X	X	X	X	X	X	X	5		X			1	X	X			X	X			X	X			6	0.3	1.2
Stickney Creek	1.15	67.50	Good	X	X		X	X	X	X	X	X	X	9					0	X								X				2	0.1	0.3

## Fish Community Biology Assessment

### Methods

Two quantitative electrofishing passes were conducted at each site in 2021, except for Mill Creek RM 9.55, where access permission was unable to be obtained from all the landowners. A list of the dates when the surveys were completed, along with approved flow measurements from the United States Geological Survey gage station at available locations are shown in Table 10. Sampling was conducted using longline electrofishing techniques and consisted of shocking all habitat types within a sampling zone while moving from downstream to upstream by slowly and steadily. The sampling zone was 0.20 or 0.15 kilometers for each site 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 to the waters from which they were collected, except for vouchers and those that could not be easily identified in the field.

<b>Table 10. Sampling Dates and River Flows</b>		
Date	Site sampled	Daily Mean Flow (CFS)
6/17/21	Rocky River EB RM 8.70	14.34
	Chippewa Creek Trib RM 0.55	---
6/23/21	Big Creek RM 4.40	2.28
	Stickney Creek RM 1.15	---
7/15/21	Hemlock Creek RM 2.55	---
7/22/21	Chippewa Creek Trib RM 0.55	---
7/23/21	Big Creek RM 9.80	5.88
7/26/21	Big Creek RM 4.40	2.13
	Stickney Creek RM 1.15	---
9/8/21	Rocky River EB RM 8.70	13.90
9/30/21	Big Creek RM 9.80	1.88
10/6/21	Hemlock Creek RM 2.55	---
--- No gage station on stream		

The electrofishing results were compiled and utilized to evaluate fish community health through the application of two Ohio EPA indices. The first index, the Index of Biotic Integrity (IBI), incorporates twelve community metrics representing structural and functional attributes (Table 11). 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*.

<b>Table 11. IBI Metrics</b>	
Wading sites	Headwater sites (<20 sq. miles)
Number of indigenous fish species	Number of indigenous fish species
Number of darter species	Number of darter species
Number of sunfish species	Number of headwater species
Number of sucker species	Number of minnow species
Number of intolerant species	Number of sensitive species
Percent tolerant species	Percent tolerant species
Percent omnivore species	Percent omnivore species
Percent insectivore species	Percent insectivore species
Percent of top carnivore species	Percent pioneering species
Number of individuals (minus tolerants)	Number of individuals (minus tolerants)
Percent of simple lithophilic spawners	Number of simple lithophilic species
Percent DELT anomalies	Percent DELT anomalies

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 ( $\bar{H}$ ) (Formula 2 below) based on sample numbers, and the Shannon Diversity Index ( $\bar{H}$ ) based on sample weights.

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



All Restoration Projects waterbodies are located completely within the Erie-Ontario Lake Plains (EOLP) ecoregion and follow the EOLP IBI metric scoring. The WWH IBI scoring criterion in the EOLP ecoregion is 40 for wading sites and 38 for headwater sites. A site is considered to be within nonsignificant departure if the score falls within 4 IBI units or 0.5 MIwb units of the criterion (Table 12). Lists of the species diversity, abundance, pollution tolerances, and incidence of DELT anomalies for fish collected during the electrofishing passes at each site are available upon request from the NEORSD WQIS Division.

<b>Table 12. Fish Community Biology Scores in the EOLP Ecoregion</b>							
Ohio EPA Narrative	Very Poor	Poor	Fair	Marginally Good	Good	Very Good	Exceptional
IBI Score - Headwater	12-17	18-27	28-35	36-39	40-45	46-49	50-60
IBI Score - Wading	12-17	18-27	28-33	34-37	38-45	46-49	50-60
MIwb Score (Wading only)	0-4.4	4.5-5.8	5.9-7.3	7.4-7.8	7.9-8.8	8.9-9.3	≥9.4
Ohio EPA Narrative	Non-Attainment			NSD	Attainment		
NSD – Non-Significant Departure of WWH attainment							

## Results and Discussion

### Big Creek RM 9.80 and 4.40

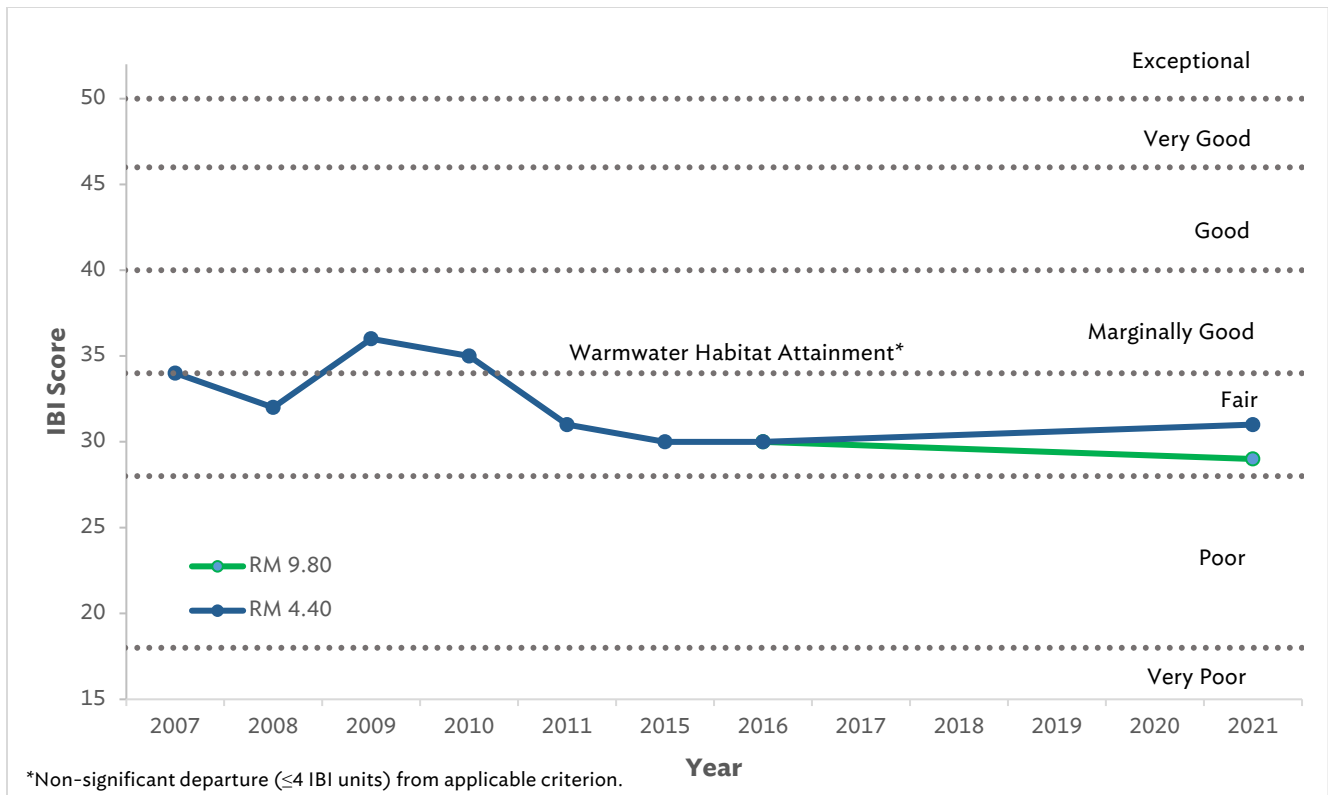
Electrofishing sampling surveys were conducted two times in each stream segment at RMs 9.80 and 4.40 of Big Creek in 2021. The sampling events for RM 9.80 were calculated to have an average IBI score of 29, narratively *Fair*, and therefore this stream segment was not in attainment of the IBI WWH designated use criterion. Results for the electrofishing surveys for both Big Creek sites can be seen in Table 13 below.

<b>Table 13. Big Creek IBI Results</b>					
River Mile	1 <sup>st</sup> Pass		2 <sup>nd</sup> Pass		Average
	Date	IBI	Date	IBI	IBI
9.80	7/23/2021	30 <sup>*H</sup>	9/30/2021	28 <sup>*H</sup>	29 <sup>*H</sup>
4.40	6/23/2021	34 <sup>*H</sup>	7/26/2021	28 <sup>*H</sup>	31 <sup>*H</sup>
*Significant departure from biocriterion (>4IBI; >0.5 MIwb units). Underlined scores are in the <i>Poor</i> or <i>Very Poor</i> narrative range <sup>ns</sup> non-significant departure from biocriterion (≤4IBI; ≤0.5 MIwb units) <sup>H</sup> Headwater scoring criteria					

The first electrofishing pass at Big Creek RM 9.80 was completed on July 23, 2021 and resulted in an IBI score of 30 (*Fair*). Multiple factors contributed to RM 9.80 scoring low in several metrics, including the absence of darters, sensitive species, headwater species, and insectivorous species. Only four species of fish were collected during this sampling event, most of which are considered tolerant to pollution. Blacknose dace were the predominantly collected species, with central stoneroller minnows (*Campostoma anomalum*) and creek chubs (*Semotilus atromaculatus*) comprising much of the remaining sample. Three green sunfish were also collected, with the presence of the species positively contributing to the IBI score. An absence of omnivorous taxa and no DELTs being observed in the sample population also provided for a positive contribution to the IBI score but did not ultimately influence attainment of the criterion.

The second electrofishing pass at RM 9.80 was completed on September 30, 2021. The survey resulted in a narrative rating of *Fair* for the IBI, and a failure to attain the WWH criterion with a score of 28. While overall metric scoring was relatively similar, a twenty-five percent decrease in the total density of individuals comprising the total sample number led to a reduction in scoring in one sample metric. Overall, there was the same number of taxa collected compared to the first sampling event, although an individual bluntnose minnow was collected with green sunfish being absent from the sample. The sample population was again dominated by tolerant species, drawing attention to potential issues with water quality in the area.

The habitat assessment of Big Creek RM 9.80 indicated that the stream reach would be suitable to support a quality fish community. However, the low IBI score calculated in 2021 contradicts this QHEI score. A decline in IBI score for RM 9.80 was seen compared to the last time the site was sampled in 2016, and the sample reach remains in non-attainment of the WWH criterion. Historical IBI scores for both RM 9.80 and RM 4.40 can be seen in Figure 4 below.



**Figure 4.** Big Creek Historical IBI Scores

The first electrofishing pass at Big Creek RM 4.40, conducted on June 23, 2021, resulted in an IBI score of 34 with a narrative rating of *Fair*, falling just short of the non-significant departure range of WWH status of the IBI criteria. Positively contributing to the IBI score was the presence of seven taxa of minnow species, including a significant number of sand shiners (*Notropis Stramineus*), which are categorized as moderately intolerant to pollution. Additional contributing factors to positive metric scoring was the low proportion of pioneering and omnivorous species, and total number of fish collected during the survey. A total of eight species were collected with central stoneroller minnows, creek chubs, and blacknose dace being the most common. Field sampling reported no DELTs present in the sample population. RM 4.40 exhibited a lack of key taxa including headwater, lithophilic, sensitive and darter species during the sampling event, providing a negative impact on the overall score.

The second electrofishing pass at RM 4.40 was calculated to have an IBI score of 28, which equates to a narrative rating of *Fair*. The July 26, 2021, sampling event had a species composition that was characterized by an abundance of tolerant taxa, comprising 53.3% of the fish collected. The most prevalent species collected was the central stoneroller minnow. Contained within the remaining sample were five species considered to be pollution tolerant: the creek chub, blacknose dace, bluntnose minnow, common white sucker, and yellow bullhead. Sampling also revealed the presence of the moderately pollution-intolerant sand shiners, but the total number of this species collected was reduced 42% from the first electrofishing pass. Overall, twice as many fish were collected during the second survey, with species composition remaining similar. The reduction of

overall score from the first pass was due to the absence of one less minnow species and an increase in the ratio of tolerant and pioneering species collected.

The purpose of monitoring of fish at this location was to determine if the Big Creek Stabilization project, which removed a fish migration barrier, had resulted in an increased number of fish species upstream of it. An evaluation of historic data collected from RM 4.40 showed that the species collected in 2021 were similar to those found previously. Therefore, at this time, removal of the migration barrier has not appeared to result in improvements in the upstream fish community.

*Chippewa Creek Unnamed Tributary RM 0.55*

For the 2021 electrofishing events, the Chippewa Creek Unnamed Tributary RM 0.55 stream segment averaged an IBI score of 44, narratively *Good*; therefore meeting the IBI WWH criterion (Table 14). The first electrofishing pass, completed on June 17, 2021, resulted in an IBI score of 42 (*Good*). Of all specimens assessed during the sampling event, no DELTs were reported. Three of the fish taxa collected belonged to the lithophilic species category, adding a strong positive contribution to the IBI score. However, only one taxon collected, the rainbow darter, is considered moderately intolerant to stream pollution and environmental stressors. This lack of balance is somewhat reflected in the percentage of pioneering species, which accounted for 23% of individuals in the sample population. The moderate density of these individuals is an indication that the stream may be slightly impacted by environmental or external stressors. Further, the lack of sensitive species in the sample population, one species in total, may be an indication of an external stressor impacting the fish population.

The second electrofishing pass was conducted on July 22, 2021 and achieved an IBI score of 46 (*Very Good*), which was an improvement to the score calculated from the first electrofishing event. Improvements in IBI scoring were seen in a reduction in percentage of tolerant species and the addition of a largemouth bass (*Micropterus salmoides*), which contributed an additional native species. Species composition was nearly identical with the addition of a green sunfish and bluegill sunfish hybrid. The total number of individuals collected during this sampling event was nearly five times the number of specimens collected during the June sampling event. The dominant species collected was the central stoneroller minnow, which comprised 68% of the sample population.

<b>Table 14. Chippewa Creek Unnamed Tributary IBI Results</b>					
River Mile	1 <sup>st</sup> Pass		2 <sup>nd</sup> Pass		Average
	Date	IBI	Date	IBI	IBI
0.55	6/17/2021	42 <sup>H</sup>	7/22/2021	46 <sup>H</sup>	44 <sup>H</sup>
*Significant departure from biocriterion (>4IBI; >0.5 MIwb units). Underlined scores are in the <i>Poor</i> or <i>Very Poor</i> narrative range <sup>ns</sup> non-significant departure from biocriterion (≤4IBI; ≤0.5 MIwb units) <sup>H</sup> Headwater scoring criteria					



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*Hemlock Creek RM 2.55*

On July 15, and October 6, 2021, electrofishing passes were performed at RM 2.55; both passes had an IBI score of 20 (Table 15), which is considered *Poor* and not in attainment of the WWH criterion. Only one type of species was found at this site, the creek chub, which is highly tolerant to pollution. This site is located immediately downstream of some failing home sewage treatment systems (HSTS), which as indicated by the elevated *E. coli* densities there, may have negatively impacted the water quality. The low fish diversity may also be because this site lacked quality runs, riffles, and pools. In 2015 and 2016, a fish biological community assessment was conducted at Hemlock Creek RM 2.50, with both surveys also producing an IBI score of 20. Elimination of those HSTS, along with improvements in habitat, may help to increase the IBI score in the future.

Table 15. Hemlock Creek IBI Results					
River Mile	1 <sup>st</sup> Pass		2 <sup>nd</sup> Pass		Average
	Date	IBI	Date	IBI	IBI
2.55	7/15/2021	20 <sup>*H</sup>	10/6/2021	20 <sup>*H</sup>	20 <sup>*H</sup>
<p>*Significant departure from biocriterion (&gt;4IBI units). Underlined scores are in the <i>Poor</i> or <i>Very Poor</i> narrative range  <sup>ns</sup> non-significant departure from biocriterion (≤4IBI units)  <sup>H</sup> Headwater scoring criteria</p>					

*Rocky River East Branch RM 8.70*

Two quantitative electrofishing passes were conducted at the Rocky River East Branch RM 8.70 in 2021. The outcome of this sampling shows this site achieved WWH attainment status (Table 16). The sampling zone was calculated to have an average IBI score of 40, which is considered to be *Good*. The average MIwb score of 9.4, though, was considered an *Exceptional* WWH under this metric.

Table 16. Rocky River East Branch IBI and MIwb Results								
River Mile	1 <sup>st</sup> Pass			2 <sup>nd</sup> Pass			Average	
	Date	IBI	MIwb	Date	IBI	MIwb	IBI	MIwb
8.70	6/17/2021	42	9.1	9/8/2021	38	9.7 <sup>E</sup>	40	9.4 <sup>E</sup>
<p>*Significant departure from biocriterion (&gt;4IBI; &gt;0.5 MIwb units). Underlined scores are in the <i>Poor</i> or <i>Very Poor</i> narrative range  <sup>ns</sup> non-significant departure from biocriterion (≤4IBI; ≤0.5 MIwb units)  <sup>E</sup> Exceptional WWH score</p>								

The first electrofishing pass on June 17, 2021, produced IBI and MIwb scores of 42 (*Good*) and 9.1 (*Very Good*), respectively. The most significant IBI metric scoring was provided by the low percentage of tolerant and omnivorous fish collected, the presence of four sunfish taxa, and the total number of fish collected during the survey. Other significant contributing factors to IBI scoring included the presence of three darter and three sucker taxa, percentage of simple lithophilic species, and ratio of fish collected that were considered insectivores (46.7%). The

presence of these insectivorous species is an indicator of a healthy benthic macroinvertebrate community. Only three top carnivore individuals were collected (0.3% of the population) and no intolerant species were present in the reach, which negatively impacted IBI scoring. Five moderately intolerant taxa were collected, which contributed to 22% of the sample population, and included golden redhorse (*Moxostoma erythrurum*), northern hogsuckers (*Hypentelium nigricans*), sand shiners, greenside darters (*Etheostoma blenniodes*), and rainbow darters (*Etheostoma caeruleum*). The presence of these taxa represents the good overall water quality present in the sample reach at RM 8.70.

The second electrofishing survey at RM 8.70 was completed on September 8, 2021, resulting in scores of 38 and 9.7 for the IBI and MIwb, respectively. Species composition was similar to the first pass, but the IBI score was reduced by four points when compared to this year’s previous fish community assessment. This was due to an increased collection of tolerant and omnivore species. One additional top predator species, largemouth bass, was collected but this did not increase the overall IBI score. However, the MIwb score on the second pass was increased by 0.6, giving the stream reach a narrative rating of *Exceptional*. This was due to the overall relative weights and numbers of fish collected during the survey. This increase in abundance gave RM 8.70 an average MIwb score of 9.4, achieving Exceptional WWH criterion based on this metric.

Historical IBI and MIwb scores can be viewed in Table 17 below. The scores after the dam removal and restoration project were completed show an improved fish community. The increase in scores was due to an overall increase in the number of species and total individuals that were collected. The number of darter species also increased.

<b>Table 17. Rocky River East Branch Historical IBI and MIwb Results</b>				
	IBI		MIwb	
Year	RM 9.00	RM 8.70	RM 9.00	RM 8.70
2017	32*	-	7.4 <sup>ns</sup>	-
2019	37 <sup>ns</sup>	-	7.5 <sup>ns</sup>	-
2020	-	44	-	-
2021	-	40	-	9.4 <sup>E</sup>
*Significant departure from biocriterion (>4IBI; >0.5 MIwb units). Underlined scores are in the <i>Poor</i> or <i>Very Poor</i> narrative range				
<sup>ns</sup> non-significant departure from biocriterion (≤4IBI; ≤0.5 MIwb units)				
<sup>E</sup> Exceptional WWH score				

### Stickney Creek RM 1.15

In 2021, Stickney Creek RM 1.15 obtained an IBI score of 32 (*Fair*) for both electrofishing passes conducted during the field season (Table 18). This is in the significant departure range of the IBI criterion for WWH attainment status.

The first electrofishing pass on RM 1.15 was conducted on June 23, 2021. The fish assemblage collected consisted of five species, four of which are listed as pollution tolerant. No

pollution-intolerant species or darter species were collected. The central stoneroller minnow was the most abundant of the fish collected, contributing to nearly 60% of the sample population and is not considered pollution tolerant; this allowed for the percent tolerant metric to positively contribute to the overall IBI. Additional positive scoring came from the low percentage of pioneering and omnivorous species and total number of fish collected. One DELT was found to be present on the fish collected, but the occurrence of the anomaly did not impact the scoring metric.

<b>Table 18. Stickney Creek IBI Results</b>					
River Mile	1 <sup>st</sup> Pass		2 <sup>nd</sup> Pass		Average
	Date	IBI	Date	IBI	IBI
1.15	6/23/2021	32* <sup>H</sup>	7/26/2021	32* <sup>H</sup>	32* <sup>H</sup>
*Significant departure from biocriterion (>4IBI units). Underlined scores are in the <i>Poor</i> or <i>Very Poor</i> narrative range <sup>ns</sup> non-significant departure from biocriterion (≤4IBI units) <sup>H</sup> Headwater scoring criteria					

The second electrofishing pass occurred on July 26, 2021. The taxa collected were identical and a larger ratio of central stoneroller minnows characterized the sample population (66.6%). The total number of fish collected during this survey was increased by 27% with IBI scoring of the individual metrics remaining identical. No DELT anomalies observed were observed during the second survey.

From the results of the habitat assessment, the QHEI score of 70.50 suggests that sufficient habitat exists to support a warmwater fauna. However, there may be other factors contributing to the non-attainment IBI score. The Stickney Creek watershed is highly developed and was greatly altered from its naturally free flowing state prior to restoration. Degraded water quality indicated by high *E. coli* and low dissolved oxygen levels at RM 1.15 may be contributing to the abundance of pollution-tolerant fish species and the lack of pollution-intolerant species. The SNAP assessment for Stickney Creek was also the only site in the Stream Restoration projects assessment to be labeled as “enriched” and have a high risk to beneficial uses. Connectivity from Stickney Creek to the lower Big Creek and the Cuyahoga River was once lost due to the John Nagy drop structure that acted as a fish barrier at Big Creek RM 2.10 but was only recently reestablished through the Big Creek Stabilization project. Additionally, Stickney Creek is extensively culverted upstream of RM 1.15 and provides little to no habitat to support aquatic life beyond this reach. The sampling zone at RM 1.15 did not show an improvement from the previous fish community assessment conducted in 2017 prior to restoration (Table 19).

<b>Table 19. Stickney Creek RM 1.15 Historical IBI Results</b>	
Year	Score
2017	35*
2021	32*
*Significant departure from biocriterion (>4IBI units). Underlined scores are in the <i>Poor</i> or <i>Very Poor</i> narrative range <sup>ns</sup> non-significant departure from biocriterion (≤4IBI units)	

## Macroinvertebrate Community Biology Assessment

### 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. Sampling was conducted at all locations listed in Table 1. 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 at each site are available upon request from NEORSW WQIS Department.

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 20), each with four scoring categories. Metrics 1-9 are based on the quantitative sample, while metric 10 is based on the qualitative 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 21) and a site is within non-significant departure if the score falls within 4 ICI units of the criterion.

<b>Table 20. ICI Metrics</b>
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

<b>Table 21. ICI Range for EOLP Ecoregion</b>								
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								

For sites where an HD sampler could not be deployed and/or retrieved, a narrative rating was assigned to the site by a Level 3 QDC certified benthic macroinvertebrate biologist. In 2021, the NEORSD developed expectation thresholds for three qualitative metrics to assist with the assignment of macroinvertebrate narrative ratings. These metrics include qualitative total taxa, qualitative EPT taxa, and qualitative sensitive taxa. These expectations were developed using Level 3 QDC data provided from the Ohio EPA from the EOLP ecoregion from the time period between 2005-2014 provided by the Ohio EPA. The data were divided into drainage area categories. Expectations were optimized for accuracy, sensitivity, and specificity using a threshold limit model predictive for ICI score. Qualitative sampling results were compared to these expectation thresholds summarized in Table 22. Narrative ratings were assigned using best professional judgement taking into consideration field observations, comparisons to historical site data, and comparisons with the NEORSD developed expectations for qualitative total, EPT, and sensitive taxa.

<b>Table 22. NEORSD Recommended Expectation Threshold Limits for Narrative Rating Assignments in the EOLP</b>				
Drainage Category	Designation	Qualitative Total Taxa	Qualitative EPT Taxa	Qualitative Sensitive Taxa
Headwater (0-20 miles <sup>2</sup> )	EWH	38	12	6
	WWH	27	7	2
	Fair	23	4	1
Wadable (20-200 miles <sup>2</sup> )	EWH	51	18	12
	WWH	41	11	6
	Fair	33	8	2

## Results and Discussion

### *Big Creek RM 9.80 & 4.40*

In 2021, HDs were installed at Big Creek RM 9.80 and 4.40 with qualitative sampling performed at both sites. Table 23 provides a summary of 2021 Big Creek macroinvertebrate data. The benthic macroinvertebrate communities at RMs 9.80 and 4.40 were both in attainment of the WWH Biological Criterion with ICI scores of 40 (*Good*) and 34 (*Good*), respectively.



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Table 23. Big Creek Macroinvertebrate Results							
Stream RM	Density Qt. (ft <sup>2</sup> )/Ql.	Ql./Total Taxa	Ql. EPT/Sensitive Taxa	Qt. % Tolerant/Sensitive taxa	Predominant orgs. on natural substrates	ICI	Narrative Evaluation
<b>Big Creek (19-005-000)</b>							
9.80	558/M-L	19/41	5/1	8.8/2.43	Baetidae, Turbellaria, Chironomidae	40	Good
4.40	405/M-L	18/35	7/2	17.0/5.9	Baetidae, Turbellaria, Isopoda, Amphipoda	34	Good
Qt. Quantitative sample collected on Hester-Dendy artificial substrates Ql. 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 <i>Moderately Intolerant</i> , no <i>Intolerant</i> taxa were collected							

Table 24 provides historical ICI scores with additional data summaries. There was a significant improvement in the macroinvertebrate community at RM 9.80 in 2021 compared to the previous record in 2016, from a narrative rating of *Poor* to an ICI score of 40 (*Good*). This site showed improvements in the number of quantitative taxa and qualitative EPT taxa in 2021 indicating continued improvements in biodiversity and overall health of the macroinvertebrate community. Some of these improvements may have resulted from the stream restoration project, but it is thought that most of them likely came from the elimination of the illicit discharge just upstream of the site.

At RM 4.40, the macroinvertebrate community scored similarly in 2021 compared to previous years. It was not expected that the downstream restoration project would have a significant impact on the macroinvertebrate community. Slight increases in the number of taxa collected on the HD sampler and EPT taxa in the qualitative sample indicate a general improvement of water quality in the stream.

Table 24. Historical Big Creek Invertebrate Community Index (ICI) Results						
RM	Date	ICI Score	Narrative Rating	Quantitative Taxa	Qualitative Taxa	Qualitative EPT Taxa
9.80	2015	20	<i>Fair</i>	22	18	3
	2016	--	<i>Poor</i>	--	12	4
	2021	<b>40</b>	<i>Good</i>	34	19	5
4.40	2007	8	<i>Poor</i>	13	19	4
	2008	<b>36</b>	<i>Good</i>	23	28	5
	2010	<b>38</b>	<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
	2021	<b>34</b>	<i>Good</i>	28	18	7
<b>Bold indicates attainment of WWH criterion</b>						
-- HD was not collected						

*Chippewa Creek Unnamed Tributary RM 0.55*

In 2021, qualitative sampling only was performed at the unnamed tributary to Chippewa Creek RM 0.55 for stream restoration pre-construction monitoring. This site is a headwater stream with insufficient depth and/or streamflow velocity for Hester-Dendy installation. Table 25 provides a summary of the macroinvertebrate pre-construction monitoring data. The site was assigned a narrative rating of *Marginally Good*. A total of 31 qualitative taxa were collected at the site. Five EPT taxa were collected including one Baetidae: *Baetis flavistriga*, one Polycentropodidae: *Cheumatopsyche sp.*, and three Hydropsychidae: *Ceratopsyche morosa group*, *Hydropsyche depravata group*, and *Hydropsyche simulans*. Three sensitive taxa of the moderately intolerant category were collected at the site including two of the forementioned EPT taxa and one Chironomidae midge *Tvetenia bavarica group*.

The unnamed tributary to Chippewa Creek RM 0.55 has a drainage area of only 1.4 square miles, placing the site on the low end of the “headwater” drainage area category. WWH expectations for the number of total qualitative taxa, qualitative EPT taxa, and qualitative sensitive taxa for headwater sites are 27, 7, and 2, respectively. This site met the WWH expectations for qualitative total and sensitive taxa, but not qualitative EPT taxa. The site fell between WWH and fair expectations for the qualitative EPT metric. Therefore, expectations for EPT taxa of an average size headwater stream may be less likely to occur at this site. Field observations indicated that the most abundant groups present were Turbellaria and *Caecidotea sp.*, which fall under pollution tolerance categories of facultative and tolerant, respectively. The site was assigned a field narrative rating of *Fair* at the time of sample collection. These observations together indicate that the site was typical of similar sites with an ICI score in the narrative rating category of *Marginally Good*.

Table 25. Chippewa Creek Unnamed Tributary Macroinvertebrate Results							
Stream RM	Density Ql.	Ql. Taxa	Ql. EPT/ sensitive Taxa	Qt. % Tolerant/ Sensitive taxa	Predominant orgs. on natural substrates	ICI	Narrative Evaluation
<b>Chippewa Creek Unnamed Tributary (19-009-000)</b>							
0.55	L	31	5 / 3	NA	Isopoda, Chironomidae	NA	<i>Marginally Good*</i>
Qt. Quantitative sample collected on Hester-Dendy artificial substrates Ql. 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 <i>Moderately Intolerant</i> , no <i>Intolerant</i> taxa were collected * Based on qualitative sample and best professional judgement.							

*Hemlock Creek RM 2.55*

In 2021, qualitative sampling only was performed at Hemlock Creek RM 2.55 for stream restoration pre-construction monitoring. This site is a headwater stream with insufficient depth and/or streamflow velocity for Hester-Dendy installation. Table 26 provides a summary of the

macroinvertebrate pre-construction monitoring data. Hemlock Creek RM 2.55 was assigned a narrative rating of *Good*. A total of 27 qualitative taxa were collected at the site. Nine EPT taxa were collected including two Baetidae: *Baetis Tricaudatus*, and *Baetis flavistriga*, one Heptageniidae: *Stenonema femoratum*, one Caenidae: *Caenis sp*, two Philopotamidae: *Chimarra aterrma* and *Cheumatopsyche sp*, and three Hydropsychidae: *Diplectrone modesta*, *Ceratopsyche morosa group*, and *Hydropsyche depravata group*. Four sensitive taxa of the moderately intolerant category were collected at the site including three of the forementioned EPT taxa and one Chironomidae midge *Tvetenia bavarica group*.

Hemlock Creek RM 2.55 has a drainage area of only 0.6 square miles, placing the site on the low end of the “headwater” drainage area category. WWH expectations for the number of total qualitative taxa, qualitative EPT taxa, and qualitative sensitive taxa for headwater sites are 27, 7, and 2, respectively. This site met all three of these metrics. Field observations indicated that the most abundant taxa present was *Simulium sp*, followed by Baetidae, Hydropsychidae and Chironomidae. The site was assigned a field narrative rating of *Good* at the time of sample collection. These observations together indicate that the site was typical of similar sites with an ICI score in the narrative rating category of *Good*.

Table 26. Hemlock Creek Macroinvertebrate Results							
Stream RM	Density Ql.	Ql. Total Taxa	Ql. EPT/ sensitive Taxa	Qt. % Tolerant/ Sensitive taxa	Predominant orgs. on natural substrates	ICI	Narrative Evaluation
<b>Hemlock Creek (19-001-000)</b>							
2.55	M-L	27	9 / 4	NA	Simuliidae, Baetidae, Chironomidae	NA	<i>Good*</i>
Qt. Quantitative sample collected on Hester-Dendy artificial substrates Ql. 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 <i>Moderately Intolerant</i> , no <i>Intolerant</i> taxa were collected * Based on qualitative sample and best professional judgement.							

*Mill Creek RM 9.55*

In 2021, an HD was installed at Mill Creek RM 9.55 for stream restoration pre-construction monitoring. The macroinvertebrate community at this site was in non-attainment of the biological criterion with an ICI score of 26 (*Fair*). Only one sensitive taxon was present at the site and was found in the qualitative sample. High percentages of tolerant organisms (30.1%), non-tanytarsini diptera and non-insects (81%), and low numbers of mayfly taxa (1) resulted in the low ICI score.

Table 27. Mill Creek Macroinvertebrate Results							
Stream RM	Density Qt. (ft <sup>2</sup> ) /Qt.	Ql./ Total Taxa	Ql. EPT/ sensitive Taxa	Qt. % Tolerant/ Sensitive taxa	Predominant orgs. on natural substrates	ICI	Narrative Evaluation
<b>Mill Creek (19-006-000)</b>							
9.55	354/L	32/50	5 / 1	25 / 0	Baetidae, Chironomidae, Physella	26	Fair
Qt. Quantitative sample collected on Hester-Dendy artificial substrates Ql. 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 <i>Moderately Intolerant</i> , no <i>Intolerant</i> taxa were collected							

### Rocky River East Branch

The Hester-Dendy sampler at Rocky River East Branch (RREB) RM 8.70 was washed out following a heavy rain event. The qualitative sample data was compared to expectations developed by NEORSD in 2021 using threshold limit models as described above. Table 28 provides a comparative summary of the macroinvertebrate pre-construction and post-construction monitoring data. RREB RM 8.70 was assigned a narrative rating of *Good*. A total of 45 qualitative taxa were collected at this site. Fourteen EPT taxa were collected including two Baetidae: *Baetis flavistriga* and *Baetis intercalaris*, three Heptageniidae: *Stenacron sp.*, *Stenonema femoratum*, and *Maccaffertium pulchellum*, one Philopotamidae: *Chimarra obscura*, one Polycentropodidae: *Cheumatopsyche sp.*, four Hydropsychidae: *Ceratopsyche morosa group*, *Ceratopsyche sparna*, *Hydropsyche depravata group*, and *Hydropsyche dicantha*, and one Hydroptilidae: *Hydroptila sp.* Six sensitive taxa of the moderately intolerant category were collected at the site including five of the forementioned EPT taxa and one Chironomidae midge *Cardiocladius obscurus*.

RREB RM 8.70 has a drainage area of 59.0 square miles, placing the site in the “wadable” drainage area category. WWH expectations for the number of total qualitative taxa, qualitative EPT taxa, and qualitative sensitive taxa for wadable sites are 41, 11, and 6, respectively. The site met all three WWH expectations. Field observations indicated that the most abundant groups present were Baetidae, Hydropsychidae and Chironomidae. The site was assigned a field narrative rating of *Good* at the time of sample collection. These observations together indicate that the site was typical of similar sites with an ICI score in the narrative rating category of *Good*.

The macroinvertebrate community improved rapidly following completion of the dam removal and stream restoration project. In 2019, the site had an ICI score of 18 (*Low Fair*) in the area upstream of the dam pool. The site was converted from a deep run and dam pool to primarily riffle/run habitat. The NEORSD also performed monitoring of additional sites along the RREB in 2019 including the upstream site at RM 17.50, which had an ICI score of 46 (*Exceptional*) (NEORSD, 2019). The connectivity to sites with high quality macroinvertebrate communities and the improved habitat at this site following the stream restoration project have resulted in rapid improvements at this site.

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Table 28. Rocky River East Branch Macroinvertebrate Results								
Stream RM	Year	Density Ql.	Ql. / Total Taxa	Ql. EPT/ sensitive Taxa	Qt. % Tolerant/ Sensitive taxa	Predominant orgs. on natural substrates	ICI	Narrative Evaluation
<b>Rocky River (13-100-000)</b>								
8.70	2019	153 / L	20	2 / 3	36 / 0.9	Chironomidae	18	Low Fair
	2021	NA / M	45 / NA	14 / 6	NA	Hydropsychidae, Chironomidae, Baetidae	NA	Good*
Qt. Quantitative sample collected on Hester-Dendy artificial substrates Ql. 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 <i>Moderately Intolerant</i> , no <i>Intolerant</i> taxa were collected * Based on qualitative sample and best professional judgement.								

Stickney Creek RM 1.15

In 2021, an HD was installed at Stickney Creek RM 1.15. Table 29 provides a comparative summary of the Stickney Creek macroinvertebrate pre-construction and post-construction monitoring data. No improvement was observed in the benthic macroinvertebrate community at this point following completion of the stream restoration project. The site remained in non-attainment of the biological criteria with an ICI score of 22 (*Fair*). While there was no improvement in the diversity of the macroinvertebrate community, there was a greater than 3-fold increase in macroinvertebrate density. The lack of improvement in macroinvertebrate diversity is likely due to water quality impairments that continue to negatively impact this site. No sensitive taxa were collected, with only one EPT taxa found in the qualitative sample. This is similar to what was found in 2017.

Table 29. Stickney Creek Macroinvertebrate Results								
Stream RM	Year	Density Qt. (ft <sup>2</sup> ) / Ql.	Ql. / Total Taxa	Ql. EPT/ sensitive Taxa	Qt. % Tolerant/ Sensitive taxa	Predominant orgs. on natural substrates	ICI	Narrative Evaluation
<b>Stickney Creek (19-005-000)</b>								
1.15	2017	300/M-L	13/31	1 / 0	38 / 0	Baetidae, Amphipoda	24	Fair
	2021	957/M-L	19/30	1 / 0	44 / 0	Turbellaria, Baetidae	22	Fair
Qt. Quantitative sample collected on Hester-Dendy artificial substrates Ql. 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 <i>Moderately Intolerant</i> , no <i>Intolerant</i> taxa were collected								

## Conclusions

The stream segments at each site in this study were assigned an aquatic life habitat use designation defined as WWH. According to the Ohio EPA (2020), 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 its respective ecoregion. The results of NEORSD’s 2021 Stream Restoration Projects water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys indicate limiting conditions at most sites despite the presence of functional habitat. Only two of the sites that were assessed were found to be in full attainment of the biological criteria (Table 30).

<b>Table 30. 2021 Survey Results</b>								
RM	DA (mi <sup>2</sup> )	Attainment Status	IBI Score	MIwb Score	ICI Score	QHEI Score	Cause(s)	Source(s)
<b>Big Creek (WWH Existing)</b>								
9.80 <sup>H</sup>	5.7	PARTIAL	29* <sup>H</sup>	--	40	65.0	Pollutants in urban stormwater	Urban runoff/storm sewers
4.40 <sup>H</sup>	19.3	PARTIAL	31* <sup>H</sup>	--	34	54.25	Pollutants in urban stormwater Natural (Habitat)	Urban runoff/storm sewers Natural Sources
<b>Chippewa Creek Unnamed Tributary (WWH Existing)</b>								
0.55	1.4	FULL	44 <sup>H</sup>	--	Marginally Good	64.50		
<b>Hemlock Creek (WWH Existing)</b>								
2.55	0.6	NON	<u>20</u> * <sup>H</sup>	--	Good	52.0	Pollutants in urban stormwater Organic enrichment Natural (Habitat)	Urban runoff/storm sewers On-site treatment systems (septic systems) Natural Sources
<b>Mill Creek (WWH Existing)</b>								
9.55	3.3	NON	--	--	28*	--	Pollutants in urban stormwater	Urban runoff/storm sewers
<b>Rocky River East Branch (WWH Existing)</b>								
8.70	59.0	FULL	40	9.4	Good	70.50		
<b>Stickney Creek (WWH Existing)</b>								
1.15	3.2	NON	32* <sup>H</sup>	--	22*	70.50	Pollutants in urban stormwater	Urban runoff/storm sewers Illicit Discharges
*Significant departure from biocriterion (> 4ICI; > 4IBI; > 0.5 MIwb units). Underlined scores are in the <i>Poor</i> or <i>Very Poor</i> narrative range <sup>H</sup> Headwater scoring criteria <sup>E</sup> Exceptional narrative range								



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*Big Creek RM 9.80 and 4.40*

The results of the water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys conducted by NEORS D indicated that the Big Creek watershed may be impacted by a variety of environmental stressors and various aquatic habitat limitations, as mentioned previously. From the water chemistry portion of this sampling, it was found that exceedances of the applicable water quality standards occurred for bacteria (Table 5). Illicit discharges, along with stormwater runoff, were most likely responsible for the elevated *E. coli* densities that were found in the creek.

The fish community in Big Creek RM 9.80 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 blacknose dace and creek chubs. However, this may also be due, in part, to an impaired fish community being present in the creek downstream of the restoration site and the absences of more pollution-sensitive fish being present to repopulate that area.

The macroinvertebrate community at this site scored in the *Good* range for the 2021 sampling season, which was a significant improvement from the *Poor* community that was found there in 2016. Improvements came from increases in both the number of overall and EPT taxa. These increases were most likely due to the elimination of an upstream illicit discharge that was found and remediated between 2017 and 2018 .

The purpose of monitoring at RM 4.40 was to determine if a downstream restoration project near John Nagy Boulevard that altered a fish migration barrier resulted in an increase in the number of fish species upstream of it. Based on the surveys that were completed, no additional species have migrated upstream in Big Creek. The results for both the fish and macroinvertebrate communities were similar to what was found previously, indicating no significant changes in the health of the stream since sampling was last conducted in 2016.

*Chippewa Creek Unnamed Tributary RM 0.55*

The site that was monitored on the Chippewa Creek Unnamed Tributary was found to be in full attainment of the WWH criteria in 2021. The fish community was found to be *Good*, while the macroinvertebrate community was *Marginally Good*. Although *E. coli* exceedances were found at this site, the densities were generally lower than those measured at the other sites in this study.

The QHEI score fell into the *Good* range but showed impacts from bank erosion. Completion of the restoration project will help to stabilize the stream bank and protect the integrity of the sanitary sewer infrastructure there. This may help to increase the overall QHEI score. In terms of the biological communities, however, the project may not result in significant improvements due to the current fish and macroinvertebrate populations already being relatively healthy. Monitoring will be conducted again post-construction to determine if that is the case.

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*Hemlock Creek RM 2.55*

The site at Hemlock Creek was in non-attainment of the WWH designation due to the presence of a *Poor* fish community. Although elevated *E. coli* densities were found, indicating impacts from urban stormwater and HSTs, the failure of the stream segment to reach full WWH attainment may also be due to habitat. This site lacked riffle/run complexes, significant instream cover, and only had slow to moderate stream velocity. Overall, it failed to meet Ohio EPA's target QHEI score for headwater streams.

Although the fish community was impaired, the macroinvertebrates were considered to be *Good*. In addition to a relatively high total number of taxa present based on the drainage area, there were also a relatively high number of EPT and sensitive taxa.

This site will also be monitored again once the bank stability and stream bed improvement activities are completed.

*Mill Creek RM 9.55*

Due to difficulties in obtaining property owner permissions, a full biological and habitat assessment could not be conducted on Mill Creek at RM 9.55. The macroinvertebrate assessment that was completed showed an impaired community that fell into the *Fair* range. This community was dominated by tolerant organisms and lacked the sensitive taxa groups present in healthy streams. Based on historical assessments at sites on Mill Creek downstream of this one, it is expected that any fish assessments completed would also have shown impairment.

Similar to the other sites that were monitored, Mill Creek had elevated *E. coli* densities, indicating that part of this impairment may be due to pollutants found in urban stormwater or illicit discharges. As any illicit discharges are identified and remediated, improvements to the biological communities may be expected. Completion of the restoration project there, which is intended to diversify stream habitat with woody debris, cobble riffles and additional pool habitat, may also result in improvements. Additional monitoring will be conducted at this site once the restoration project is completed to help document any changes that result.

*Rocky River East Branch RM 8.70*

The Rocky River East Branch was in full attainment of the WWH criteria. Based on the sampling that was completed, exceedances of the recreation *E. coli* criteria did occur, and possible sources are illicit discharges, HSTs, storm sewer runoff, and wild/domesticated animal waste. However, these exceedances did not appear to have a significant impact on the biological communities. The sample reach at Rocky River East Branch RM 8.70 exhibited high quality habitat found to be capable of supporting healthy fish and macroinvertebrate populations.

Both the fish and macroinvertebrate index scores fell into the *Good* range, while the MIwb score was considered to be *Exceptional*. These scores were an improvement from when pre-project assessments were completed upstream of the dam in 2017. Improvements in the fish community came from increases in overall numbers of species, individuals and darter species collected. The macroinvertebrate community showed a higher number of both overall taxa and EPT taxa collected in the qualitative sample. All of these improvements likely were the result of the elimination of the impounded area upstream of the dam and the creation of riffle and run habitat.

#### *Stickney Creek RM 1.15*

Stickney Creek did not meet the necessary standards for the designated aquatic life use and received non-attainment status at RM 1.15 during the 2021 sampling season (Table 14). The results of water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys conducted by NEORS D indicate that the Stickney Creek watershed may be impacted by a variety of environmental stressors, as mentioned previously. From water chemistry sampling, it was found that exceedances of the applicable water quality standards occurred for *E. coli* densities during all sampling events and the stream exhibited relatively low DO. Stormwater runoff during wet-weather events and illicit discharges are likely responsible for the elevated *E. coli* densities and low DO found in Stickney Creek.

With a QHEI score of 70.50, stream habitat in Stickney Creek was found to be exceptional, which suggests that sufficient habitat exists to support a warmwater fish community. Although the habitat received an *Excellent* narrative at RM 1.15, this narrative may not represent the entire Stickney Creek watershed as upstream reaches of the stream are completely culverted and void of habitat.

The fish and macroinvertebrate communities both received narrative ratings of *Fair* in 2021. Both assemblages were comprised of a high percentage of pollution-tolerant species. It should be noted that the recently removed John Nagy drop structure located downstream on Big Creek at RM 2.10 also acted as a fish barrier and eliminated connectivity of Stickney Creek to Big Creek and the Cuyahoga River. Fish assemblages in Big Creek from RM 4.40 and 9.80, also above the John Nagy drop structure, were also *Fair*. With similar fish assemblages observed in connected waterways, along with a predominately culverted stream, it is unlikely that the fish assemblage will greatly improve unless connectivity is restored and water quality improves. Monitoring at this site will continue to help document changes that result from elimination of illicit discharges and as the stream continues to recover from restoration activities.

## Acknowledgments

Field activities and report review completed by the following, except where otherwise noted:

Seth Hothem - Author  
John W. Rhoades  
Mark Matteson  
Eric Soehnlen  
Justin Telep  
Hannah Boesinger  
Joe Schiel  
Daniel Neelon  
Kevin Fitzgibbons – Author  
Michael Meaney  
Veronica Riedel

NEORSD Analytical Services Division – Completed analysis for all water chemistry sampling.

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