

NORTHEAST OHIO REGIONAL SEWER DISTRICT

2018 Brandywine Creek Environmental Monitoring Biological, Water Quality and Habitat Survey Results



**Prepared by
Water Quality and Industrial Surveillance Division**

Introduction

The lower Cuyahoga River has been designated as one of 42 Great Lakes Areas of Concern (AOC) by the International Joint Commission. Past monitoring indicated impairment of aquatic biota in the river and was the basis for the establishment of Total Maximum Daily Loads (TMDLs) for the Lower Cuyahoga River. The causes of impairment to the river were classified as organic enrichment, toxicity, low dissolved oxygen, nutrients, and flow alteration (Ohio EPA, 2003). Recent monitoring by the Northeast Ohio Regional Sewer District (NEORSD), however, has shown recovery of the biological community in some reaches of the river. Further monitoring throughout the watershed is necessary to determine what areas may be still impaired.

In 2018, NEORSD conducted environmental assessments including water chemistry sampling, habitat assessments, and fish and macroinvertebrate community surveys on Brandywine Creek, a tributary to the Cuyahoga River. The objective of this study was to conduct environmental monitoring on Brandywine Creek in addition to five other tributaries to the Cuyahoga River as part of NEORSD's general watershed monitoring program. Portions of the tributary data collected will provide additional information to support the continued monitoring of the lower Cuyahoga AOC and the potential delisting of some beneficial use impairments.

Sampling was conducted by the NEORSD Environmental Assessment group of the Water Quality and Industrial Surveillance (WQIS) Division and occurred from June 15 through September 30, 2018 (through October 15 for fish sampling assessments), as required in the Ohio Environmental Protection Agency (EPA) *Biological Criteria for the Protection of Aquatic Life Volume III* (1987b). Sampling was conducted by NEORSD Level 3 Qualified Data Collectors certified by the Ohio EPA in Fish Community and Benthic Macroinvertebrate Biology, and Chemical Water Quality and Stream Habitat Assessments as explained in the NEORSD study plan *2018 Cuyahoga River Tributaries Environmental Monitoring* approved by Ohio EPA on April 18, 2018. The results obtained from these assessments were evaluated using the Ohio EPA's Qualitative Habitat Evaluation Index (QHEI), Index of Biotic Integrity (IBI), Modified Index of Well-Being (MIwb) and Invertebrate Community Index (ICI). Water chemistry data was validated per the methods outlined by the Ohio EPA (2018) and compared to the Ohio Water Quality Standards (Ohio EPA, 2018a) to determine attainment of applicable uses. An examination of the biological information was used in conjunction with the water quality data and QHEI results in order to assess the health of the stream and to show any temporal as well as spatial trends.

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Figure 1 is a study area map, noting the location of the sampling location evaluated during the 2018 study. Table 1 indicates the sampling locations for the study site on Brandywine Creek with respect to river mile, latitude/longitude, description, and the types of surveys conducted. A digital photo catalog of the sampling locations is available upon request by contacting the NEORSD WQIS Division.

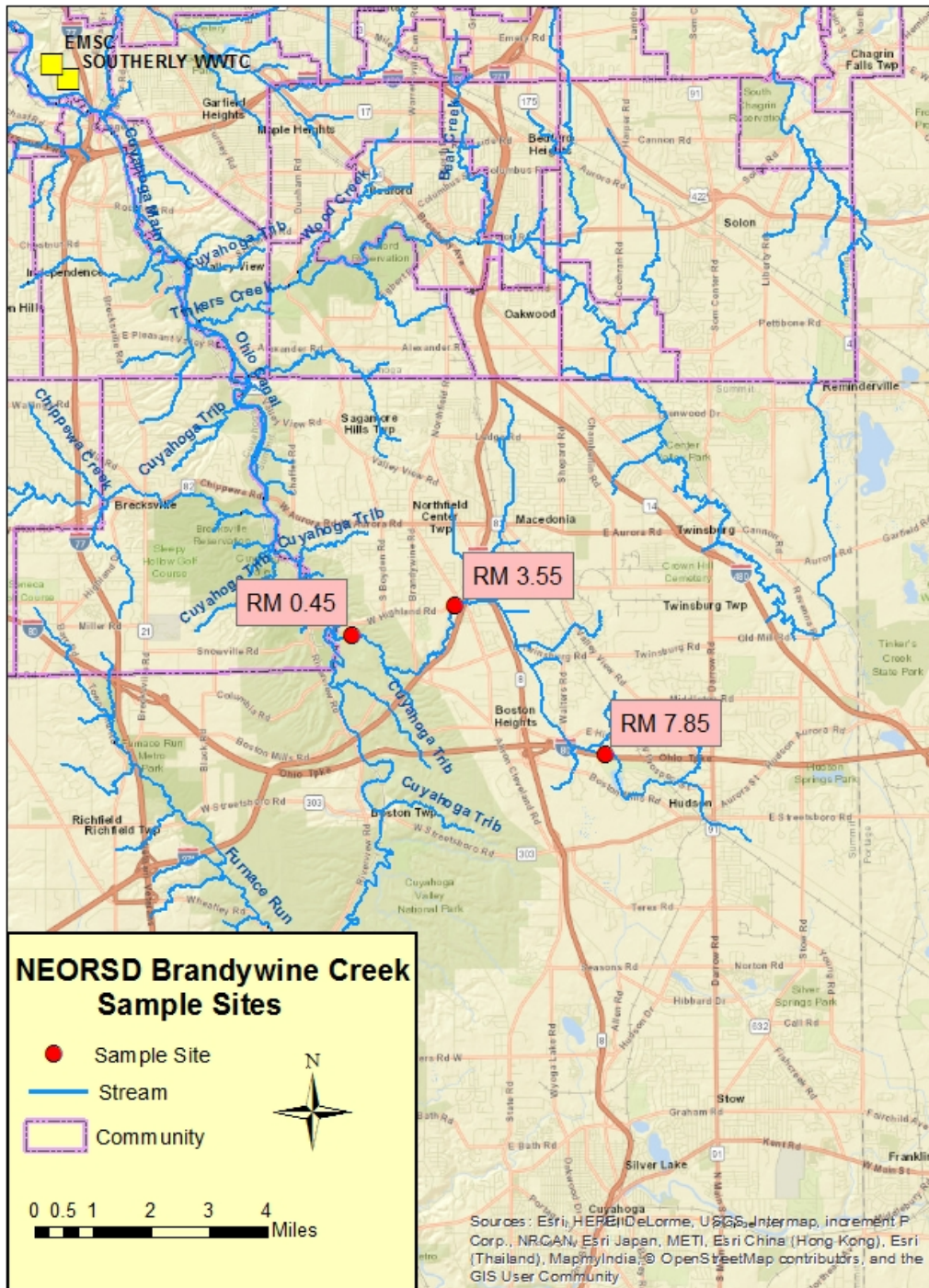


Figure 1. Sampling Locations

Table 1. Sample Locations					
Location	Latitude	Longitude	River Mile	Description	Purpose
Brandywine Creek	41.25603	-81.47547	7.85	Downstream of former Hudson WWTP	General watershed monitoring. Determine improvements following decommissioning of WWTP.
Brandywine Creek	41.2936	-81.52473	3.55	Upstream of East Highland Road	Background data for water chemistry and chlorophyll <i>a</i>
Brandywine Creek	41.28647	-81.55887	0.45	Brandywine Ski Resort	Background data for water chemistry and chlorophyll <i>a</i>

Water Chemistry Sampling

Methods

Five separate water chemistry and bacteriological sampling events were conducted between July 25 and August 22, 2018. Techniques used for sampling and analyses were conducted according to methods found in *Surface Water Field Sampling Manual for water quality parameters and flows* (Ohio EPA, 2018b). 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 preserved with sodium thiosulfate. At the time of sampling, measurements for dissolved oxygen, pH, temperature, and conductivity were collected using either a YSI 600XL sonde or YSI EXO1 sonde. Duplicate samples and field blanks were each collected 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).

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

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

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

The acceptable percent RPD is based on the ratio of the sample concentration and detection limit (Formula 2) (Ohio EPA, 2015b).

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

x = sample/detection limit ratio

Those RPDs that are higher than acceptable may indicate potential problems with sample collection and, as a result, the data was not used for comparison to the water quality standards.

Mercury analysis for all of the sampling events was completed 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 Average (OMZA), it generally cannot be determined if Brandywine Creek was in attainment of those criteria. Instead, this type of mercury sampling was used as a screening tool to determine whether contamination was present above those levels typically found in the stream.

Water chemistry analysis sheets for each site are available upon request from the NEORSW WQIS Division.

Results and Discussion

Brandywine Creek is designated Warmwater Habitat (WWH), Agricultural Water Supply, Industrial Water Supply, and Primary Contact Recreation. For the 2018 study, one duplicate sample and one field blank were collected for quality assurance and quality control (QA/QC) purposes (Ohio EPA, 2012). The duplicate was collected at RM 3.55 on August 15, 2018, and the field blank was collected at RM 3.55 on August 1, 2018. For the duplicate sample, there were no parameters rejected based on RPD values. For the field blank, there were no parameters that showed possible contamination.

Paired parameters for all samples collected were evaluated for QA/QC purposes. In 2018, five instances occurred in which the data for the paired parameters needed to be qualified because the sub-parameter was greater than the parent one (Table 2). The reason for the Total Dissolved Solids (TDS) and Dissolved Reactive Phosphorus (DRP) being greater than their parent parameters is unknown, but may be due to the fact that there are separate methods for analyzing the individual parameters.

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River Mile	Date	Paired Parameters	Acceptable RPD (%)	Actual RPD (%)	Qualifier
7.85	8/15/2018	TS/TDS	15.1	5.0	J
3.55	8/15/2018	TS/TDS	15.0	9.1	J
		TS/TDS	15.0	9.8	J
0.45	8/1/2018	TP/DRP	102.8	18.2	J
	8/15/2018	TS/TDS	15.1	8.0	J

J=Result is estimated.

Exceedances of the recreational bacteriological criteria occurred at all three sites during the 2018 sampling season. The criteria for *Escherichia coli* (*E. coli*) consist of two components: a 90-day geometric mean and a value not to be exceeded in more than 10% of the samples collected during a 90-day period (statistical threshold value). For those streams designated primary contact recreation, these criteria are 126 colony counts/100mL or most-probable number (MPN)/100mL and 410 colony counts/100mL or MPN/100mL, respectively. RM 3.55 and RM 0.45 had *E. coli* densities that exceeded the statistical threshold value criterion for the 90-day periods beginning on July 25, 2018 (Table 3). These exceedances are likely due to wet-weather events before the sampling. Exceedances of the 90-day geometric mean occurred at all three of the sites based on the 2018 sampling period (Table 3). Potential sources of bacteria to the creek could include stormwater runoff, illicit discharges, and home sewage treatment systems.

Date	RM 7.85	RM 3.55	RM 0.45
7/25/2018*	260	2303	490
8/1/2018*	214	818	133
8/8/2018*	108	2050	1160
8/15/2018	71	262.5	41
8/22/2018*	116	912	1203
90-day Geomean	137.7	984.4	326.8

Exceeds statistical threshold value
 Exceeds geometric mean criterion for 90-day period

*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.

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). NEORSD did not assess DO swings or benthic chlorophyll *a* in 2018; however, nutrients were assessed (Table 4).

Site	Total Phosphorus Geometric Mean (mg/L)	Dissolved Inorganic Nitrogen Geometric Mean (mg/L)
RM 7.85	0.086	0.32
RM 3.55	0.060	0.23
RM 0.45	0.024	0.08

The results of using Table 2 of SNAP reveal a narrative of “levels typical of modestly enriched condition in nitrogen limited systems; low risk to beneficial use if allied responses are within normal ranges” for RM 7.85. A narrative of “levels typical of developed lands; little or no risk to beneficial uses” was determined for RM 3.55. The narratives for RM 7.85 and RM 3.55 indicate that phosphorous and nitrogen levels resemble those of a developed area; however, they are not of concern as a source of impairment. For RM 0.45, a narrative of “background levels typical of least disturbed conditions” was determined. This indicates that neither phosphorous or nitrogen are of a significant concern as a primary source of impairment at this site.

Habitat Assessment

Methods

Instream habitat assessments were conducted once at each site from RM 7.85 to RM 0.45 in 2018 using the Qualitative Habitat Evaluation Index (QHEI). The QHEI was developed by the Ohio EPA to assess aquatic habitat conditions that may influence the presence or absence of fish species by evaluating the physical attributes of a stream. The index is based on six metrics: stream substrate, instream cover, channel morphology, riparian zone and bank condition, pool and riffle quality, and stream gradient. The QHEI has a maximum score of 100, and a score of 60 (55 in headwater streams) or more suggests that sufficient habitat exists to support a fish community that attains the warmwater habitat criterion (Ohio EPA, 2003). 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

The stream segment at Brandywine Creek RM 7.85 was assessed on July 13, 2018. A QHEI score of 48.25 was calculated, correlating to a narrative rating of “*Fair*” (Table 5). The QHEI score did not meet the Ohio EPA’s target of 55 for headwater sites. The dominant substrate found within the reach was sand. Gravel, hardpan, and silt were also found in the reach. The riffle contained small amounts of cobble, and artificial substrate was observed in the pool. The reach was lacking quality instream cover, providing only moderate to sparse amounts of undercut banks, pools, and overhanging vegetation. There was a moderate amount of high quality aquatic macrophytes present. The riffle was shallow and unstable with moderate embeddedness. This stream segment had no sinuosity and poor development, but there was little or no risk for erosion.

The stream segment at RM 3.55 was assessed on August 10, 2018. A QHEI score of 67.50 was calculated, correlating to a narrative rating of “*Good*”. The QHEI score meets the Ohio EPA’s target of 60 for wading sites. Bedrock was the dominating substrate found within the reach. Boulder/slabs, gravel, and sand were present in the pool. Moderate to sparse amounts of instream cover were present, including shallows, rootmats, and pools greater than 70 centimeters. There was no channelization, high stability, good/fair development, and moderate sinuosity within the reach, which positively contributed to the QHEI score. Well established and stable riffles within the reach also positively contributed to the score. The stream segment at RM 3.55 should be capable of supporting fish communities based on the habitat characteristics.

The stream segment at RM 0.45 was assessed on July 13, 2018. A QHEI score of 75.75 was calculated, correlating to a narrative rating of “*Excellent*”, which meets the Ohio EPA’s target of 60 for wading sites. The dominant substrate found within the reach was cobble. Gravel, sand, boulder, hardpan, and artificial substrate were also observed in the pool and riffle portions of the reach. A moderate amount of instream cover was present in the reach, including undercut banks, overhanging vegetation, shallows, pools greater than 70 centimeters, boulders, and logs/woody debris, positively contributed to the QHEI score. A wide riparian width consisting of primarily forest and shrubs contributed to the high score for the “Channel Morphology” section. Another section that positively contributed to the overall score was the “Pool/Glide and Riffle Run Quality” section. The depth of the pool/glide was greater than 1 meter and had a pool width greater than the riffle width. The stream segment showed moderate to heavy/severe signs of erosion. A QHEI score greater than 75 demonstrates habitat conditions that can support exceptional warmwater faunas (Ohio EPA, 2006). Based on the overall habitat characteristics and QHEI score of this stream segment, RM 0.45 should be able to support a healthy warmwater fish population including exceptional warmwater faunas.

Table 5. Brandywine Creek Qualitative Habitat Evaluation Index Score and Physical Attributes

			MWH Attributes																													
			WWH Attributes											High Influence						Moderate Influence												
River Mile	QHEI Score	Habitat 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	Sand Substrates (Boat)	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 Attribute
7.85	48.25	Fair						x			x		2	x		x	x		3		x			x				x	x	x		5
3.55	67.50	Good	x		x	x	x	x	x	x	x		8				x		1					x								1
0.45	75.75	Excellent	x	x		x	x	x	x		x	x	8						0										x			1

Fish Community Assessment

Methods

Two quantitative electrofishing passes were conducted at each site in 2018. Sampling was conducted using longline electrofishing techniques and consisted of shocking all habitat types within a sampling zone while moving from downstream to upstream. The sampling zone was 0.15 kilometers for the headwater site (RM 7.85) and 0.20 kilometers for the wading sites (RMs 3.55 and 0.45). The methods that were used followed Ohio EPA protocol methods as detailed in *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987a) and *III* (1987b). Fish collected during the surveys were identified, weighed, and examined for the presence of anomalies, including DELTs (deformities, eroded fins, lesions, and tumors). All fish were then released to the waters from which they were collected, except for vouchers and those that could not be easily identified in the field.

The electrofishing results for each pass were compiled and utilized to evaluate fish community health through the application of the Ohio EPA Index of Biotic Integrity (IBI). The IBI incorporates 12 community metrics representing structural and functional attributes. The structural attributes are based upon fish community aspects such as fish numbers and diversity. Functional attributes are based upon fish community aspects such as feeding strategies, environmental tolerances, and disease symptoms. These metrics are individually scored by comparing the data collected at the survey site with values expected at reference sites located in a similar geographical region. The maximum possible IBI score is 60 and the minimum possible score is 12 (Table 6). The summation of the twelve individual metrics scores provides a single-value IBI score, which corresponds to a narrative rating of *Exceptional, Good, Marginally Good, Fair, Poor, or Very Poor*. The twelve metrics utilized for headwater sites and wading sites are listed in Table 7.

Table 6. Fish Community Biology Scores in the EOLP Ecoregion							
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	0.0-4.4	4.5-5.8	5.9-7.3	7.4-7.8	7.9-8.8	8.9-9.3	≥9.4
Ohio EPA Status	Non-Attainment			NSD	Attainment		
NSD – Non-Significant Departure of WWH attainment							

Table 7. Index of Biotic Integrity (IBI) Metrics	
Headwater	
Total Number of Native Species	Percent Pioneering Species
Number of Darters & Sculpins	Percent Omnivores
Number of Headwater Species	Percent Insectivores
Number of Minnow Species	Number of Simple Lithophils
Number of Sensitive Species	Percent DELT Anomalies
Percent Tolerant Species	Number of Fish
Wading	
Total Number of Native Species	Percent Omnivores
Number of Darter Species	Percent Insectivores
Number of Sunfish Species	Percent Top Carnivores
Number of Sucker Species	Percent Simple Lithophils
Number of Intolerant Species	Percent DELT Anomalies
Percent Tolerant Species	Number of Fish

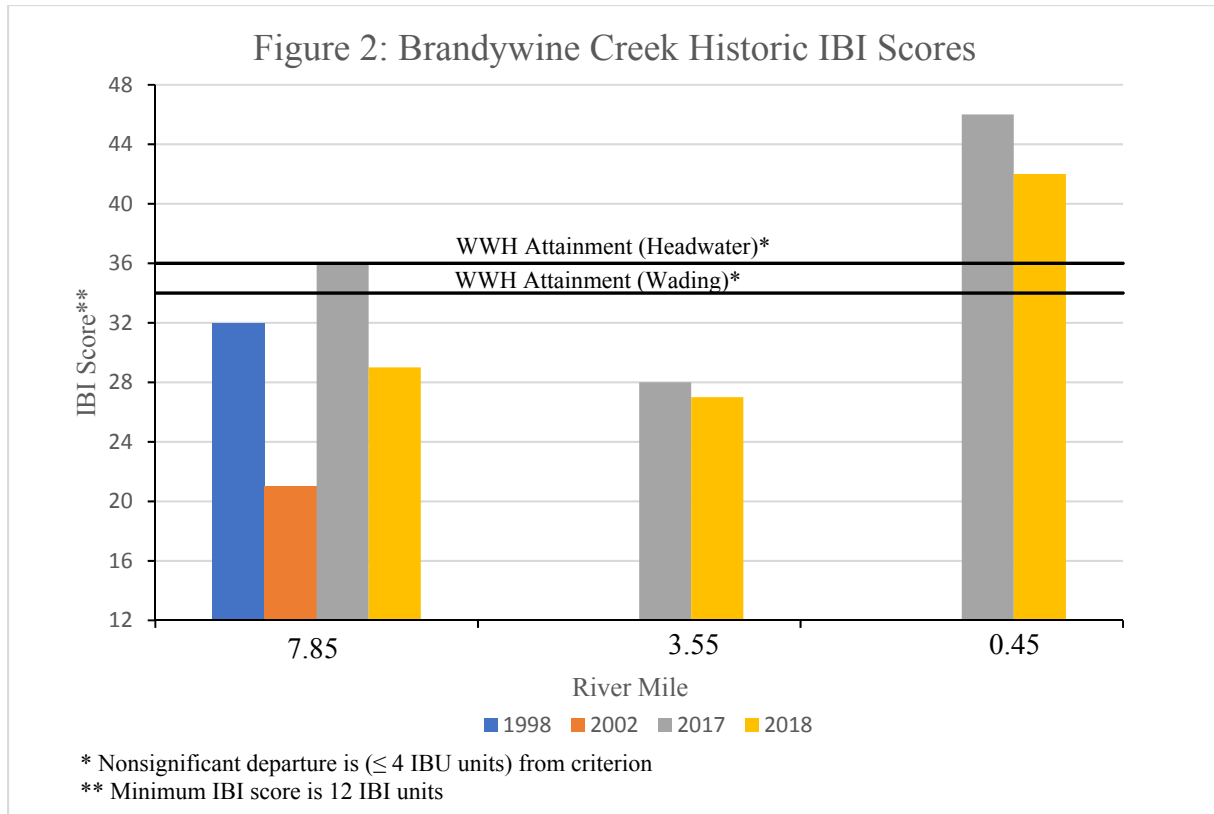
Lists of the species, numbers, pollution tolerances and incidence of DELT anomalies for fish collected during the electrofishing passes are available upon request from the NEORSW QWIS Division.

Results and Discussion

For the 2018 electrofishing events, the fish community within the Brandywine Creek RM 7.85 sampling reach averaged an IBI score of 29, correlating to a narrative score of *Fair* (Table 8). The site was not in attainment of the WWH criterion for headwater sites (Figure 2). The first electrofishing pass, completed on July 30, 2018, received an IBI score of 30 (*Fair*), and the second pass, completed on September 13, 2018, received an IBI score of 28 (*Fair*). When comparing the metric scores of each electrofishing pass, they were similar on each survey. The two metrics that contributed to the higher score on the first pass were “Proportion of Omnivores” and “Number of Individuals”. There were 710 individuals from 11 different species collected during the first pass and 420 species from 13 different species collected during the second pass. No sensitive or intolerant fish species were obtained in either of the passes. Several species were collected at RM 7.85 in 2018 that were not collected in 2017, including *Esox americanus* (grass pickerel), *Ictalurus melas* (black bullhead), and *Notemigonus crysoleucas* (golden shiner). Additionally, *Notropis chrysocephalus* (striped shiner) were not collected at RMs 7.85, 3.55, or 0.45 in 2017, but were obtained at all three of the sites in 2018. A fish barrier (Brandywine Falls), at approximately RM 1.95, prevents any migration of other fish species upstream. The barrier, in addition to habitat limitations, is likely why a greater diversity of species is not seen at RM 7.85.

Table 8. 2018 Brandywine Creek and IBI and MIwb Results

River Mile	1st Pass			2nd Pass			Average	
	Date	IBI (Narrative Rating)	MIwb (Narrative Rating)	Date	IBI (Narrative Rating)	MIwb (Narrative Rating)	IBI (Narrative Rating)	MIwb (Narrative Rating)
7.85	7/30/2018	30 (<i>Fair</i>)	---	9/13/2018	28 (<i>Fair</i>)	---	29 (<i>Fair</i>)	---
3.55	8/10/2018	28 (<i>Fair</i>)	6.1 (<i>Fair</i>)	9/13/2018	26 (<i>Poor</i>)	6.3 (<i>Fair</i>)	27 (<i>Poor</i>)	6.2 (<i>Fair</i>)
0.45/ 0.26*	7/30/2018	42 (<i>Good</i>)	7.9 (<i>Good</i>)	9/6/2018*	42 (<i>Good</i>)	9.6 (<i>Exceptional</i>)	42 (<i>Good</i>)	8.8 (<i>Good</i>)
* = Survey conducted at RM 0.26 by the Ohio EPA								
Bold = meets WWH criterion [Headwater Sites: IBI ≥40] [Wading Sites: IBI ≥38, MIwb ≥7.9]								
<i>Italics = non-significant departure from WWH criterion [Headwater Sites: IBI ≥ 36] [Wading Sites: IBI ≥34; MIwb ≥7.4]</i>								



The site at RM 7.85 is downstream of the decommissioned Hudson Wastewater Treatment Plant. NEORSD surveyed the reach in 1998 (prior to decommissioning), and again in 2002 (post-decommissioning). RM 7.85 received IBI scores of 32 (*Fair*) and 21 (*Poor*), respectively. The reach was not surveyed again until 2017, where an IBI score of 36 (*Marginally Good*) was assigned. 2017 was the highest scoring year and the only year where RM 7.85 was in non-significant departure from WWH criterion. The decrease in the IBI score of 29 in 2018 might be attributed to yearly variability.

At RM 3.55, the reach had an averaged IBI score of 27 (*Poor*) and MIwb score of 6.2 (*Fair*). The site was not in attainment of the WWH criterion for wading sites. The first pass, completed on August 10, 2018, received an IBI score of 28 (*Fair*), and a MIwb score of 6.1 (*Fair*). The second pass, completed on September 13, 2018, received an IBI score of 26 (*Poor*), and a MIwb score of 6.3 (*Fair*). The two passes resulted in similar scores for the 12 metrics, although, the first pass resulted in higher scores for the “Number of Native Species” and “Number of Sunfish Species” metrics. No intolerant species were obtained in either of the surveys. Potential reasons why there was not a greater diversity of fish species at RM 3.55 include the downstream fish migration barrier and a lack of suitable habitat due to the extensive amounts of bedrock. The 2017 IBI and MIwb scores for RM 3.55 were 28 (*Fair*) and 6.0 (*Fair*). Neither score is significantly different than the 2018 survey results for the river mile.

Because Ohio EPA was also conducting assessments in Cuyahoga River tributaries in 2018, NEORSD investigators collaborated with their field teams to complete electrofishing sampling events near the mouth of Brandywine Creek. An electrofishing pass at RM 0.45 was completed on July 30, 2018, by NEORSD. On September 6, 2018, a pass was completed by the Ohio EPA at RM 0.26. Data from the Ohio EPA survey at 0.26 was averaged with the data from the NEORSD RM 0.45 survey to determine attainment status in that reach of the creek. Both passes resulted in IBI scores of 42 (*Good*); therefore, RM 0.45 was in attainment of WWH criterion for wading sites. The survey performed by the Ohio EPA resulted in higher metric scores for “Number of Native Species” and “Proportion of Insectivores” than the pass performed by NEORSD; however, the pass performed by NEORSD resulted in higher metric scores for “Proportion of Top Carnivores” and “Proportion with DELTs”. The NEORSD survey on July 30 resulted in an MIwb score of 7.9 (*Good*), and the Ohio EPA pass on September 6 resulted in a score of 9.6 (*Exceptional*). The difference in MIwb can be attributed to the fact that a higher number of individuals were collected during the Ohio EPA pass, which resulted in a much higher biomass.

Macroinvertebrate Sampling

Methods

Macroinvertebrates were sampled quantitatively using modified Hester-Dendy (HD) samplers in conjunction with a qualitative assessment of Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly), also referred to as EPT taxa, inhabiting available habitats at the time of HD retrieval. Sampling was conducted at all of the locations listed in Table 1. Methods for sampling followed the Ohio EPA’s Biological Criteria for the Protection of Aquatic Life, Volume III (1987b). The recommended period for HDs to be installed is six weeks.

The macroinvertebrate samples were sent to Third Rock Consulting of Lexington, Kentucky, 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 WQIS.

The overall aquatic macroinvertebrate community in the stream was evaluated using either Ohio EPA’s Invertebrate Community Index (ICI) (Ohio EPA 1987a, Ohio EPA undated). The ICI consists of ten community metrics (Table 9), each with four scoring categories. Metrics 1-9 are based on the quantitative sample, while Metric 10 is based on the qualitative EPT taxa. The total of the individual metric scores result in the overall score (Table 10). This scoring evaluates the community against Ohio EPA’s reference sites for each specific eco-region.

Table 9. Metrics
ICI
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 10. Macroinvertebrate Community Biology Scores in the EOLP Ecoregion							
Ohio EPA Narrative	Very Poor	Poor	Fair	Marginally Good	Good	Very Good	Exceptional
IBI Score	≤6	8-12	14-28	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

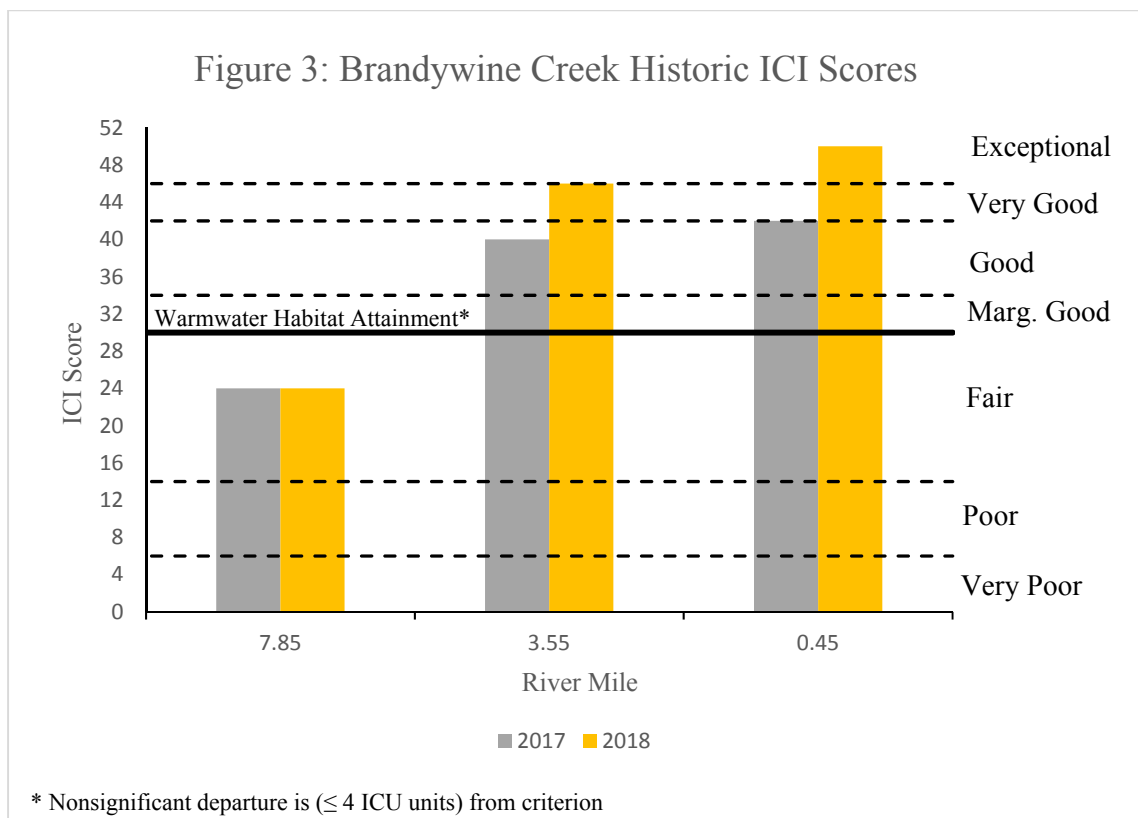
In 2018, the macroinvertebrate community at Brandywine Creek RM 7.85 received an ICI score of 24, correlating to a narrative rating of *Fair* (Table 11). This score does not meet the WWH criterion (Figure 3). Of the 36 total taxa collected, four EPT taxa were present. The EPT taxa collected from RM 7.85 included *Baetis flavistriga*, *Callibaetis sp*, *Caenis sp*, and *Oecetis cinerascens*. Collectively, the diptera and non-insects accounted for 84.7% of the macroinvertebrates collected. Approximately 33% of the sample population consisted of pollution-tolerant organisms. The lack of pollution-intolerant organisms and EPT taxa may have been due to water quality issues, such as exceedances of *E. coli*, as well as deficient habitat. The riffle was shallow, moderately embedded, dominated by sand, contained a moderate amount of silt, and had a moderate to slow current velocity. In 2017, the reach received the same score of 24 (*Fair*). While the reach received the same overall ICI score both years, there were differences in the composition

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of the samples. The number of caddisfly taxa and qualitative EPT taxa both increased in 2018. The percent tolerant organisms also increased from 8.1% in 2017 to 32.9% in 2018.

Table 11. 2018 Brandywine Creek Macroinvertebrate Results					
River Mile	ICI Score	Total Number of Taxa	Number of Qualitative EPT Taxa	% Tolerant (as defined)	Narrative Rating
7.85	24	36	4	32.9	<i>Fair</i>
3.55	46	39	9	4.02	<i>Exceptional</i>
0.45	50	41	11	2.93	<i>Exceptional</i>

Bold indicates attainment of WWH criterion
Italics indicates non-significant departure (≤ 4 ICI units) from criterion



As mentioned earlier, RM 7.85 was surveyed by NEORSD in 1998 (prior to Hudson WWTP decommissioning), 2002 (post-decommissioning), 2017, and 2018. Semi-quantitative kick samples were used in 1998 and 2002. The surveys in 2017 and 2018

consisted of both quantitative and qualitative sampling methods. Historically, semi-quantitative data was utilized to evaluate individual metrics ordinarily associated with the Ohio EPA’s Invertebrate Community Index. Since an ICI score cannot be derived from semi-quantitative data, a general comparison has been made between historical and 2017 and 2018 data. Between 1998 and 2002, the macroinvertebrate community improved at RM 7.85. Increases in taxa richness, percent tolerant organisms, total mayfly, caddisfly, and dipteran taxa during this timeframe were all signs that improvements to the stream reach had occurred (Table 12). Macroinvertebrate data from 2017 and 2018 suggest that the decommissioning of the Hudson WWTP has not had a significant impact on the benthic macroinvertebrate community at RM 7.85. Although there has been a steady increase in number of organisms each year, the taxa richness has declined each year since September 2002. The percent tolerant organisms has also increased since 2002. Based on this information and historical data, there may be influences other than the Hudson WWTP that impact the macroinvertebrate community in Brandywine Creek at RM 7.85.

Table 12. Brandywine Creek RM 7.85 Macroinvertebrate Data							
Date	Number of Organisms	Taxa Richness	Total Mayfly Taxa	Total Caddisfly Taxa	Total Dipteran Taxa	Percent other Dipterans and non-insects	Percent Tolerant Organisms
10/98	200	28	2	0	9	36.5%	1.5%
7/02	338	55	2	5	26	37.3%	11.0%
9/02	592	56	4	5	21	37.0%	6.8%
9/17	766	39	0	4	15	89.3%	8.1%
9/18	924	36	2	5	13	84.7%	32.9%

The macroinvertebrate community at RM 3.55 received an ICI score of 46, correlating to narrative rating of *Exceptional* and was in attainment of the WWH criterion for the 2018 sampling season. Of the 39 total taxa collected in the sampling events, nine EPT taxa were collected; consisting of four Ephemeroptera taxa, five Trichoptera taxa, and zero Plecoptera taxa. Six caddisfly taxa, comprising 18.8% of the total macroinvertebrate population, contributed significantly to the total ICI score. Additionally, only 5.51% of the sample consisted of tolerant organisms, which also positively contributed to the score at this site. In 2017, RM 3.55 received an ICI score of 40 (*Good*). The most significant change in the composition of the sample from 2017 to 2018 was the percent mayflies, which increased from 7.8% in 2017 to 37.9% in 2018. The increased ICI score may be due yearly variability and water quality improvements.

In 2018, the macroinvertebrate community at Brandywine Creek, RM 0.45 received an ICI score of 50, correlating to a narrative rating of *Exceptional*. RM 0.45 was in attainment of WWH criterion for 2018. Of the 41 total taxa collected from the site, 11 were EPT taxa (five Ephemeroptera taxa, six Trichoptera taxa, and zero Plecoptera taxa). The high percentage of caddisflies and Tanytarsini midges significantly contributed to the overall ICI score. Moreover, a low percent of the total population consisted of tolerant organisms and diptera and non-insects. The dominant proportion of the sample population collected was classified as facultative or better for pollution tolerance, which supports the high ICI score. The 2018 ICI score of 50 (*Exceptional*) increased from the 2017 score of 42 (*Very Good*). The most significant change in the composition of the sample from 2017 to 2018 was the total number of taxa; increasing from 20 in 2017 to 41 in 2018. The improvement in the ICI score can also be attributed to an increase in the numbers of mayfly and dipteran taxa. Similar to RM 3.55, potential causes of the improved ICI score in 2018 may be due to season variability and water quality improvements.

Conclusions

In 2018, the biological assessments that were conducted indicate that Brandywine Creek at RM 7.85 and 3.55 were in non-attainment of the WWH biological criteria (Table 13). The ICI score for RM 3.55 was in attainment of WWH criteria; however, the IBI score was not in attainment or within non-significant departure of the criterion. In 2018, RM 0.45 was in full attainment of the WWH biological criteria. All criteria scores were met or exceeded at this site for the IBI, MIwb, and ICI.

Table 13. 2018 Brandywine Creek Survey Results

River Mile	Aquatic Life Use Attainment Status	Average IBI Score (Narrative Rating)	ICI Score (Narrative Rating)	QHEI Score (Narrative Rating)	Water Quality Exceedances
RM 7.85	NON	29 (Fair)	24 (Fair)	48.25 (Fair)	<i>E. coli</i>
RM 3.55	NON	27 (Poor)	46 (Exceptional)	67.50 (Good)	<i>E. coli</i>
RM 0.45	FULL	42 (Good)	50 (Exceptional)	75.70 (Excellent)	<i>E. coli</i>
WWH biocriterion attainment: IBI score of 40; MIwb score of 8.2; ICI score of 34 Non-significant departure: ≤4 IBI units; ≤0.5 MIwb units; ≤4 ICI units					

Habitat conditions within some of the sampling sites may have limited the potential for healthy biological communities. Sparse amounts of instream cover and shallow and unstable riffle habitat containing a moderate amount of silt did not provide adequate habitat for diverse macroinvertebrate and fish communities at RM 7.85. Additionally, the natural barrier at RM 1.95 could have reduced the diversity of fish at RM 7.85 and RM 3.55. Water

quality impairments, such as exceedances of *E. coli*, may be preventing establishment of healthier biological communities. Exceedances of the water quality standards for *E. coli* indicate the presence of some sanitary sewage in the river. Potential sources of pollution include illicit discharges, failing septic systems, stormwater runoff, wildlife fecal material, and flow from upstream tributaries. Addressing these potential sources could potentially improve the overall quality of the in-stream biological community.

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References

- Ohio Environmental Protection Agency. (1987a). *Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters* (Updated January 1988; September 1989; November 2006; August 2008). Columbus, OH: Division of Water Quality Monitoring and Assessment.
- Ohio Environmental Protection Agency. (1987b). *Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities* (Updated September 1989; March 2001; November 2006; and August 2008). Columbus, OH: Division of Water Quality Monitoring and Assessment.

Ohio Environmental Protection Agency. (2003). Total Maximum Daily Loads for the Lower Cuyahoga River. Ohio EPA, Division of Surface Water. Water Standards and Technical Support Section.

Ohio Environmental Protection Agency. (2006). *Methods for assessing habitat in flowing waters: using the Qualitative Habitat Evaluation Index (QHEI)*. (Ohio EPA Technical Bulletin EAS/2006-06-1). Columbus, OH: Division of Surface Water; Division of Ecological Assessment Section.

Ohio Environmental Protection Agency. (2015). *Proposed Stream Nutrient Assessment Procedure*. Columbus, OH: Division of Surface Water, Ohio EPA Nutrients Technical Advisory Group.

Ohio Environmental Protection Agency. (2012). *Manual of Ohio EPA Surveillance Methods and Quality Assurance Practice*. Columbus, OH: Division of Surface Water; Division of Environmental Services.

Ohio Environmental Protection Agency. (2018a). *State of Ohio Water Quality Standards Ohio Administrative Code Chapter 3745-1* (Revision: February 6, 2017). Columbus, OH: Division of Surface Water; Standards and Technical Support Section.

Ohio Environmental Protection Agency. (2018b). *Surface Water Field Sampling Manual for water quality parameters and flow*. Columbus, Ohio: Division of Surface Water.