

NORTHEAST OHIO REGIONAL SEWER DISTRICT

2017 Brandywine Creek Environmental Monitoring



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

Introduction

In 2017, the Northeast Ohio Regional Sewer District (NEORS) conducted water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys on Brandywine Creek. Sampling was conducted by NEORS Level 3 Qualified Data Collectors certified by Ohio Environmental Protection Agency (EPA) in Fish Community and Benthic Macroinvertebrate Biology, and Chemical Water Quality and Stream Habitat Assessments as explained in the NEORS study plan *2017 Cuyahoga River Tributaries Environmental Monitoring* approved by Ohio EPA on May 12, 2017

The lower Cuyahoga River has been designated as one of the 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 of a Total Maximum Daily Load (TMDL) for the Lower Cuyahoga River (Ohio EPA, 2003). The causes of impairment to the river were classified as organic enrichment, toxicity, low dissolved oxygen, nutrients, and flow alteration. This study was completed to determine current conditions in the stream and to measure the magnitude of any impacts Brandywine Creek may have on the Cuyahoga River. Fish communities and benthic macroinvertebrate communities were surveyed at three sites on Brandywine Creek between river mile (RM) 7.85 and RM 0.45. The results from these surveys will help characterize the overall fish and macroinvertebrate community health in the stream.

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

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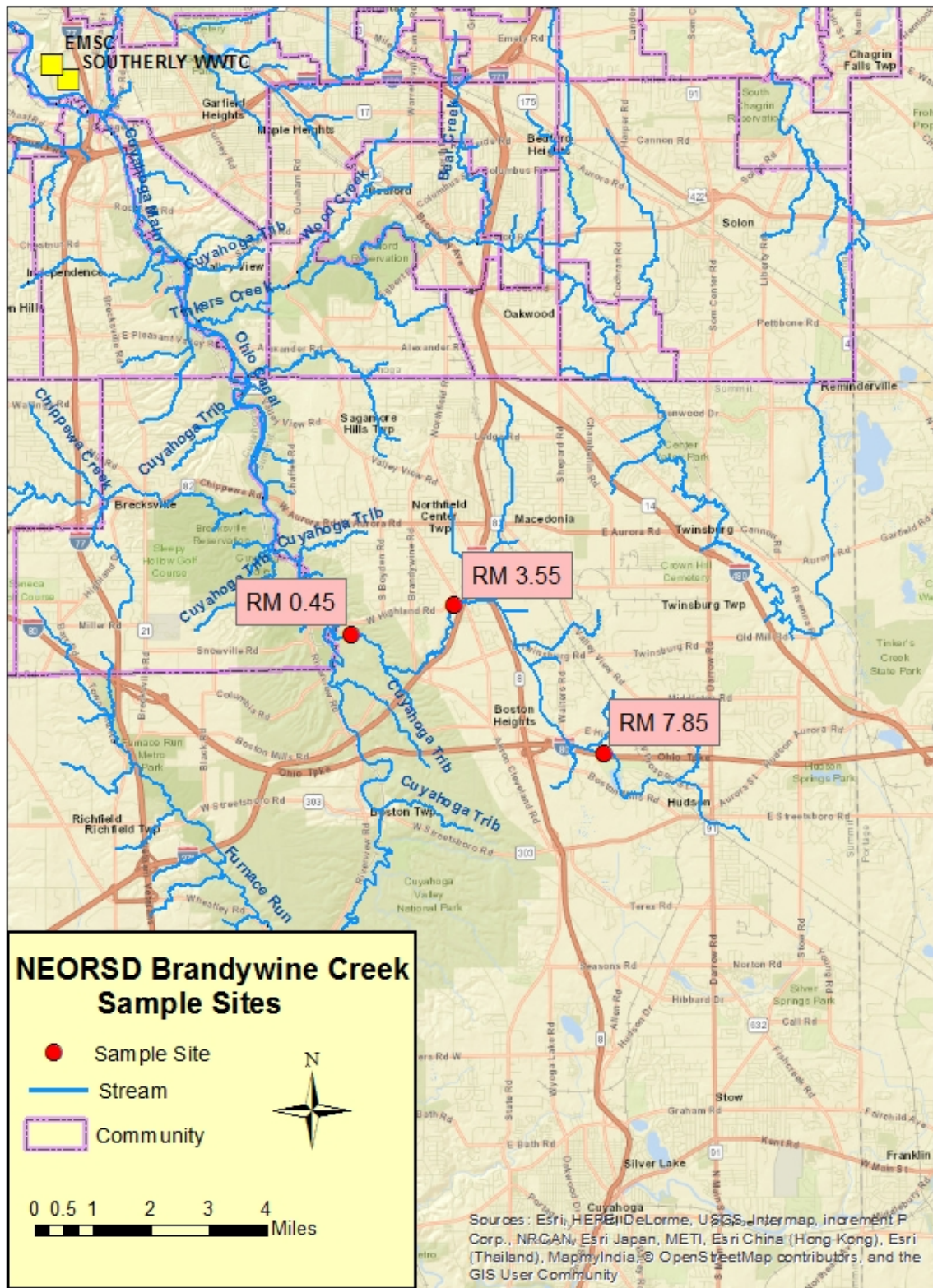


Figure 1. Sampling Locations

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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

Water chemistry and bacteriological sampling was conducted five times, at three sites between July 25 and August 23, 2017, on Brandywine Creek between RMs 7.85 and 0.45. Techniques used for sampling and analyses followed the Ohio EPA *Surface Water Field Sampling Manual for water quality parameters and flows* (2015). 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 a 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- μ m 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, dissolved oxygen percent, pH, temperature, specific conductivity, 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).

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

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, 2015).

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

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.

Mercury analysis for all of 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 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 NEORSWQIS Division.

Results and Discussion

The sites sampled in 2017 are designated warmwater habitat (WWH), agricultural water supply, industrial water supply, and primary contact recreation. For the 2017 study, one duplicate sample and one field blank were collected for quality assurance and quality control (QA/QC) purposes. The duplicate sample was collected at RM 3.55 on August 16, 2017. There were no parameters rejected based on RPD values.

The field blank was collected at RM 0.45 on August 2, 2017. For the field blank, there were two parameters that showed possible contamination. It is unclear how the field blank became contaminated and may be due to inappropriate sample collection, handling, and/or contaminated blank water. Table 2 lists water quality parameters that were listed as

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estimated or downgraded from Level 3 to Level 2 data based on Ohio EPA data validation protocol.

Table 2. Parameters affected by possible blank contamination
Cr
TP

The final QA/QC check for the samples that were collected was for paired parameters, or those parameters in which one is a subset of the other. In 2017, there were zero instances in which the data for the paired parameters needed to be qualified because the sub-parameter was greater than the parent one.

Exceedances of the recreational bacteriological criteria occurred at RMs 3.55 and 0.45 during the 2017 sampling effort. 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. Both of these criteria were exceeded at RMs 3.55 and 0.45 for the 90-day periods beginning on July 25, 2017 (Table 3).

Both criteria were exceeded at all the sites for the 90-day periods beginning on July 25, 2017 (Table 3). These exceedances were not unusually high. Potential sources of bacteria to the river could include improper connections upstream of the study sites or simply fecal matter from animals such as raccoons.

Table 3. 2017 Brandywine Creek <i>E. coli</i> Densities (most-probable number/100mL)			
Date	RM 7.85	RM 3.55	RM 0.45
7/25/2017	146	516	166
8/2/2017	207	344	62
8/9/2017	78	286	328
8/16/2017	70	188	37
8/23/2017	90	1182	566

Exceeds geometric mean criterion for 90-day period starting on that date

Water chemistry sampling at RMs 7.85, 3.55, and 0.45 in 2017 revealed mercury concentrations that were below the method detection limit for EPA Method 245.1. It is expected, that the use of EPA Method 1631E, a low-level method, instead of EPA Method 245.1, would have resulted in exceedances of the criteria throughout the sampling period.

Mercury may be introduced into Brandywine Creek from urban stormwater runoff within the watershed.

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, 2015a).

While all the parameters necessary for SNAP were not assessed in 2017, nutrients were assessed for general watershed monitoring at the sites in 2017. Table 4 shows the results of the geometric mean concentration of all five sampling events in 2017 of dissolved inorganic nitrogen and total phosphorus. Table 2 of SNAP assesses a general ecological risk of nutrient enrichment based upon the dissolved inorganic nitrogen and total phosphorus concentrations.

Table 4. 2017 Brandywine Creek Nutrient Concentrations		
River Mile	Total Phosphorus Geometric Mean (mg/L)	Dissolved Inorganic Nitrogen Geometric Mean (mg/L)
7.85	0.022	0.565
3.55	0.040	0.161
0.45	0.015	0.016

The results of using Table 2 of SNAP reveal a narrative of “levels typical of developed lands; little or no risk to beneficial uses” for RM 7.85 and RM 3.55. This indicates that phosphorous and nitrogen levels resemble those of a developed area; however, they are not of concern as a source of impairment. A narrative of “background levels typical of least disturbed conditions” was determined for RM 0.45. This indicates that neither phosphorus 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 2017 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 QHEI score at RM 7.85 exceeded the Ohio EPA's target of 55 for headwater streams. The other two sites had scores that met or exceeded Ohio EPA's target of 60 for wading sites and, therefore all three sites, should be capable of supporting WWH fish communities. The highest score was RM 0.45, at 79.5 and an *Excellent* narrative range.

A QHEI scoring 57.5, *Good*, was conducted on July 30, 2017, on Brandywine Creek at RM 7.85. The site substrate was dominated by sand throughout the reach. Sparse to moderate amounts of cover included overhanging vegetation, pools greater than 70 cm, and aquatic macrophytes. Pool/riffle/run development was considered poor throughout the reach, with only one low quality riffle present. The one riffle was less than 5 centimeters deep, unstable, and had moderate embeddedness. These traits did not benefit the overall QHEI score. Erosion is of little to no concern through this stream segment.

A QHEI scoring 63.5, *Good*, was conducted on July 27, 2017, on Brandywine Creek at RM 3.55. The site substrate was dominated by bedrock throughout the stream sampling area. Rootwads, rootmats, pools greater than 70 centimeters, undercut banks, shallows, and overhanging vegetation were all present in sparse to moderate amounts throughout the reach. High stability, good development, and moderate sinuosity all benefited the overall QHEI score. Although the bedrock in the area was moderately eroded, areas of dirt and topsoil had little to no erosion. High scoring pool/glide quality characteristics all helped contribute positively towards the QHEI score as well.

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A QHEI scoring 79.5, *Excellent*, was conducted on July 27, 2017, on Brandywine Creek at RM 0.45. The site was dominated by a sand and cobble substrate with a variety of other substrate types present as well. A moderate amount of high quality instream cover was present throughout the reach. Pools greater than 70 centimeters, backwaters, oxbows, and logs/woody debris were common through the sampling zone. Additionally, rootwads, rootmats, boulders, shallows, and undercut banks were present in good amounts. RM 0.45 has a wide riparian width with a dominating forest/shrub flood plain that scores well in the “Bank Erosion and Riparian Zone” section of the QHEI. The QHEI section, “Pool/Glide Quality”, scored a perfect twelve out of twelve. Top scores were given due to pool depths greater than one meter, a variety of current velocities, and pool widths greater than riffle widths throughout the reach. RM 0.45 should be able to support a healthy fish community with no issues, based on habitat characteristics in the stream.

Individual components of the QHEI can also be used to evaluate whether a site can meet the WWH designated use. 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 of 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).

All three sites had the WWH attributes of maximum depths greater than 40 cm and had never been channelized or had recovered from it (Table 5). RM 0.45 met all WWH attributes. Additionally, all three sites had zero “High Influence” MWH attributes associated with them. RM 7.85 had five “Moderate Influence” MWH attributes associated with the site. Based on the lack of the MWH attributes at RMs 0.45 and 3.55, it would be expected that these sites would be able to support WWH fish communities without issue. With the presence of more than four moderate influence characteristics at RM 7.85, it would be expected that this site may not be able to support WWH fish communities without issue.

Table 5. Brandywine Creek Qualitative Habitat Evaluation Index Score and Physical Attributes																															
River Mile	QHEI Score	Habitat Rating	WWH Attributes											MWH Attributes																	
			WWH Attributes											High Influence						Moderate Influence											
			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
7.85	57.5	Good	x	x							x		3							x		x	x			x		x			5
3.55	63.5	Good	x		x	x			x	x	x		6																	0	
0.45	79.5	Excellent	x	x	x	x	x	x	x	x	x	x	10																	0	

Fish Community Assessment

Methods

Two quantitative electrofishing passes were conducted at each site in 2017. 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 upstream site (RM 7.85). The sampling zone for RMs 3.55 and 0.45 was 0.20 kilometers. The methods that were used followed Ohio EPA protocol methods as detailed in *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987a) and *III* (1987b). Fish collected during the surveys were identified, weighed, and examined for the presence of anomalies, including DELTs (deformities, eroded fins, lesions, and tumors). All fish were then released to the waters from which they were collected, except for vouchers and those that could not be easily identified in the field.

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

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

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

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

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

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

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

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

n_i = Relative numbers or weight of species

N = Total number or weight of the sample

Table 6. Index of Biotic Integrity (IBI) Metrics	
Headwater	Wading
Total Number of Native Species	Total Number of Native Species
Number of Darters & Sculpins	Number of Darters & Sculpins
Number of Headwater Species	Number of Sunfish Species
Number of Minnow Species	Number of Sucker Species
Number of Sensitive Species	Number of Intolerant Species
Percent Tolerant Species	Percent Tolerant Species
Percent Pioneering Species	Percent Top Carnivores
Percent Omnivores	Percent Omnivores
Percent Insectivores	Percent Insectivores
Number of Simple Lithophils	Percent Simple Lithophils
Percent DELT Anomalies	Percent DELT Anomalies
Number of Individuals	Number of Individuals

Lists of the species, numbers, weights, 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.

Results and Discussion

Brandywine Creek, RM 7.85 had IBI scores that did not meet, but were within non-significant departure from the WWH criterion. Brandywine Creek, RM 3.55 had IBI and MIwb scores that did not meet, nor were they within non-significant departure from the WWH criterion. Brandywine Creek, RM 0.45, had IBI and MIwb scores that met the WWH criterion (Table 7). 2017 surveys were the first that WQIS staff have conducted on Brandywine Creek at RM 3.55 and RM 0.45. This data will be used for comparison with future surveys that are conducted on the stream. Surveys will be conducted again in 2018.

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Table 7. 2017 Brandywine Creek IBI and MIwb Results

		1st Pass		2nd Pass		Average	
Location	River Mile	IBI	MIwb	IBI	MIwb	IBI	MIwb
Downstream of former Hudson WWTP	7.85	36	---	36	---	36	---
Upstream of East Highland Road	3.55	28	6.0	28	6.4	28	6.2
Brandywine Ski Resort	0.45	46	8.8	46	8.7	46	8.8

Bold = meets WWH criterion [Headwater- IBI ≥40, Wading- IBI ≥38; MIwb ≥ 7.9]
Italics = non-significant departure from WWH criterion [Headwater- IBI ≥36, Wading- IBI ≥34; MIwb ≥7.4]

For the 2017 electrofishing surveys, the fish community within Brandywine Creek, RM 7.85 sampling reach averaged an IBI score of 36, narratively *Marginally Good*. This puts the site within non-significant departure from WWH criterion. When comparing the metric scores of each electrofishing pass, they were similar on each survey. “Proportion of Tolerant Species” and “Proportion of Insectivores” were the only differences in scores between the two passes at RM 7.85. Of all the fish collected during both passes on both surveys, there were no DELT anomalies reported. Total number of fish collected and proportions of species collected were similar between passes. Collectively, between the two passes, twelve native species were collected at RM 7.85. 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.

The site at RM 7.85 is downstream of the decommissioned Hudson Wastewater Treatment Plant. River mile 7.85 was surveyed by NEORSD in 1998 (prior to decommissioning), 2002 (post-decommissioning), and 2017. In 1998, RM 7.85 had an average IBI score of 32, narratively *Fair*. 2002 sampling efforts showed a decrease in average IBI score. The site at RM 7.85 had an average IBI score of 21, narratively *Poor*. 2017 sampling efforts had the highest average IBI score of 36, with a narrative of *Marginally Good*. This increase in IBI score may be due to an improvement in water quality at the site. After more than sixteen years since Hudson WWTP closed, any legacy materials that were discharged from the treatment plant have likely been washed away and are no longer having an impact on the fish community in that reach. Additionally, there were no DELT anomalies reported in 2017 during either of the two passes conducted. This could also be a sign of improvement to water quality. Although 2017 sampling efforts showed an improvement to the stream reach, it is still not meeting WWH criterion. This indicates that there may be influences other than the Hudson WWTP that might impact the fish community in Brandywine Creek

At Brandywine Creek, RM 3.55, the sampling zone averaged an IBI score of 28 and MIwb score of 6.2. Both scores are narratively considered *Fair*. River mile 3.55

does not meet WWH criterion, nor does it fall within non-significant departure of WWH criterion. Metric scores were identical on the two passes. Although there was not an impact to the metric score, the number of fish species collected during each sampling pass was different. The first pass yielded three more species (silverjaw minnow, largemouth bass, and rainbow darter) than the second. Only one or two of each of these species were collected during the first survey. Because none of these species were found during the second survey, this could indicate that they are not common species in this stretch of Brandywine creek. Additionally, a lack of suitable habitat due to the extensive amounts of bedrock hinders all fish species within the stream reach. This, in addition to the downstream fish migration barrier, is likely why a greater diversity of species is not seen at RM 3.55.

The Brandywine Creek, RM 0.45 fish community averaged an IBI score of 46 and an MIwb score of 8.8. The average IBI score is narratively considered *Very Good*. The average MIwb score is narratively considered *Good*. Average IBI and MIwb scores at RM 0.45 both exceed minimum WWH criteria. An average of twenty native species were collected during each pass. Metric scores were identical between the two electrofishing surveys. The first pass yielded two more species (spotfin shiner and sand shiner) than the second pass; however, there was no increase in metric scoring due to the additional species. Unlike sites upstream, lack of habitat for fish species is not of concern at RM 0.45. The stream resides within the boundaries of the Cuyahoga Valley National Park system. The park maintains the area in a natural state and in return, this results in little to no human impact to the stream and surrounding habitat. Without a fish barrier impeding upstream movement of fish, an increase of total fish species collected during both surveys was also evident.

The metric for number of pollution-intolerant fish scored poorly at RMs 3.55 and 0.45 as none of these fish were collected. The metric for number of sensitive species scored also poorly at RM 7.85 as, once again, none of these fish were collected. Water quality conditions could be one reason for why these fish may be absent. Exceedances of the bacteriological criteria indicate that there may be some sanitary sewage present in the river. This could be due to improper connections and/or malfunctioning septic systems. The stress to fish associated with such pollutants could therefore be a hindrance to the establishment of those species.

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 8), 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. This scoring evaluates the community against Ohio EPA's reference sites for each specific eco-region.

Table 8. 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

Results and Discussion

The HD samplers were successfully removed from all three sampling sites on Brandywine Creek during the 2017 field season. Combined with qualitative macroinvertebrate sampling on the day of HD retrieval, this allowed for a calculated ICI score to assess each of the three sampling sites.

The macroinvertebrate community at Brandywine Creek, RM 7.85 received an ICI score of 24 with a narrative rating of *Fair* for 2017 (Table 9). This score does not meet WWH criterion, nor does it fall within non-significant departure of the WWH criterion. Of the 39 total taxa collected in both the qualitative and quantitative sampling events, only one representative from the EPT (Ephemeroptera, Plecoptera, and Trichoptera) was present. *Baetis flavistriga* was the only EPT taxa collected during the sampling event. Collectively, the diptera and non-insects accounted for 89.30% of the macroinvertebrates collected at RM 0.10. These macroinvertebrates are all at least somewhat tolerant of pollution. The lack of pollution intolerant macroinvertebrates indicates that water quality issues, such as exceedances of *E. coli*, may be having an impact on the reach.

Table 9. 2017 Brandywine Creek Macroinvertebrate Results

Location	River Mile	ICI Score	Total Number of Taxa	Number of Qualitative EPT Taxa	% Tolerant (as defined)	Narrative Rating
Downstream of former Hudson WWTP	7.85	24	39	1	8.09	<i>Fair</i>
Upstream of East Highland Road	3.55	40	47	7	5.51	<i>Good</i>
Brandywine Ski Resort	0.45	42	50	9	0.02	<i>Very Good</i>
Bold indicates attainment of WWH criterion						
<i>Italics indicates non-significant departure (≤ 4 ICI units) from criterion</i>						

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

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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 (See Table 10). 2017 macroinvertebrate data suggests that the decommissioning of the Hudson WWTP has not had a significant impact on the benthic macroinvertebrate community at RM 7.85. Although there was an initial improvement, 2017 data shows a reduction in a few parameters. In 2017, RM 7.85 saw a decrease in the total number of taxa collected when compared to the last sampling events in 2002. Additionally, a reduction in the number of qualitative EPT taxa collected (average of eight taxa in 2002 versus one taxon in 2017) also occurred. The sampling efforts in 2017 did result in the highest number of organisms collected per sampling event when compared to historical data as well as the highest percent of other dipterans and non-insects. In 2017, RM 7.85 received an IBI score of 24 with a narrative rating of fair. 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 10. 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%

The macroinvertebrate community at Brandywine Creek, RM 3.55 received an ICI score of 40 with a narrative rating of *Good* for 2017. River mile 3.55 was in attainment of the WWH criterion for the 2017 sampling season. Of the 47 total taxa collected in both the qualitative and quantitative sampling events, seven representatives from the EPT (Ephemeroptera, Plecoptera, and Trichoptera) were present, including: *Baetis flavistriga*, *Baetis intercalaris*, *Chimarra aterrima*, *Cheumatopsyche sp*, *Ceratopsyche morosa*, *Hydropsyche depravata group*, and *Hydroptila sp*. A significant portion of the ICI score can be attributed to the number of caddisfly taxa (six) and percent caddisflies with a 21.48% presence. Additionally, only 5.51% of the sample consisted of tolerant organisms, which also helped bring up the ICI score at this site.

The macroinvertebrate community at Brandywine Creek, RM 0.45 received an ICI score of 42 with a narrative rating of *Very Good* for 2017. Just like RM 3.55, RM 0.45 is in attainment of the WWH criterion for 2017. Of the 50 total taxa collected in both the qualitative and quantitative sampling events, nine representatives from the EPT (Ephemeroptera, Plecoptera, and Trichoptera) were present, including: *Baetis flavistriga*, *Baetis intercalaris*, *Stenacron sp*, *Stenonema femoratum*, *Caenis sp*, *Chimarra aterrima*, *Chimarra obscura*, *Cheumatopsyche sp*, and *Ceratopsyche morosa*. Due to high percentages of caddisflies and tanytarsini midges and a low percentage of other diptera/non-insects, these three metrics all scored well, which in turn assisted in the higher ICI score at this site.

Conclusions

In 2017, the sampling that was conducted indicated that Brandywine Creek, RM 7.85 was in partial attainment of the biological criteria (Table 11). The IBI score was within non-significant departure; however, the ICI score was not within attainment or non-significant departure. At RM 3.55, the ICI criteria was met, but the IBI and MIwb criteria fell short of attainment/non-significant departure. RM 0.45 was in full attainment of the biological criteria. All criteria scores were exceeded for the IBI, MIwb, and ICI.

Table 11. 2017 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	PARTIAL	36 (<i>Marginally Good</i>)	24 (<i>Fair</i>)	57.50 (<i>Fair</i>)	<i>E. coli</i>
RM 3.55	PARTIAL	28 (<i>Fair</i>)	40 (<i>Good</i>)	63.50 (<i>Good</i>)	<i>E. coli</i>
RM 0.45	FULL	46 (<i>Very Good</i>)	42 (<i>Very Good</i>)	79.50 (<i>Excellent</i>)	<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					

Environmental assessments in 2017 showed that for all three sampling sites on Brandywine Creek, some water quality impairments may be preventing establishment of healthier biological communities. Exceedances of the water quality standards occurred for *E. coli*, indicating 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. Future monitoring will allow for the collection and comparison of more data regarding Brandywine Creek. Monitoring will continue in 2018.

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