NORTHEAST OHIO REGIONAL SEWER DISTRICT

2018 Cuyahoga River Environmental Monitoring

Prepared by
Water Quality and Industrial Surveillance Division

Introduction

The Cuyahoga River watershed is located in Northeast Ohio, flowing through the major cities of Akron and Cleveland before its final confluence with Lake Erie. In 2018, the Northeast Ohio Regional Sewer District (NEORSD) conducted water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community assessments on the lower Cuyahoga River. The objective of this study was to evaluate water quality attainment and identify any spatial and temporal trends between present and historic data. During the 2018 sampling season, eight stream locations were evaluated from river mile (RM) 20.75 downstream to RM 7.00.

Sampling was conducted by NEORSD Level 3 Qualified Data Collectors (QDCs) certified by the Ohio Environmental Protection Agency (EPA) in Fish Community Biology, Benthic Macroinvertebrate Biology, Chemical Water Quality, and Stream Habitat Assessments as explained in the NEORSD study plan *2018 Cuyahoga River Environmental Monitoring* approved by Ohio EPA on April 13, 2018. All sampling and environmental assessments occurred between June 15, 2018 and September 30, 2018 (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* (2018a) and compared to the Ohio Water Quality Standards for their designated use to determine attainment (Ohio EPA, 2018c). 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.

The lower 46.5 miles of the Cuyahoga River was designated as one of the 42 Great Lakes Areas of Concern (AOC) in 1985 by the International Joint Commission. Past monitoring indicated impairment of the aquatic biota and recreational standards. The Ohio EPA listed the Cuyahoga River as an impaired water in 2018 according to the 2018 Integrated Water Quality Monitoring and Assessment Report (Ohio EPA, 2018b). In recent years, however, some sites have displayed full attainment of their respective biological criteria. Currently, there are four parameters included in the approved TMDL for the Cuyahoga River in NEORSD's service area. The major causes of impairment listed in the 2003 TMDL report were classified as organic enrichment, toxicity, low dissolved oxygen, nutrient enrichment, and flow alteration (Ohio EPA, 2003).

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.

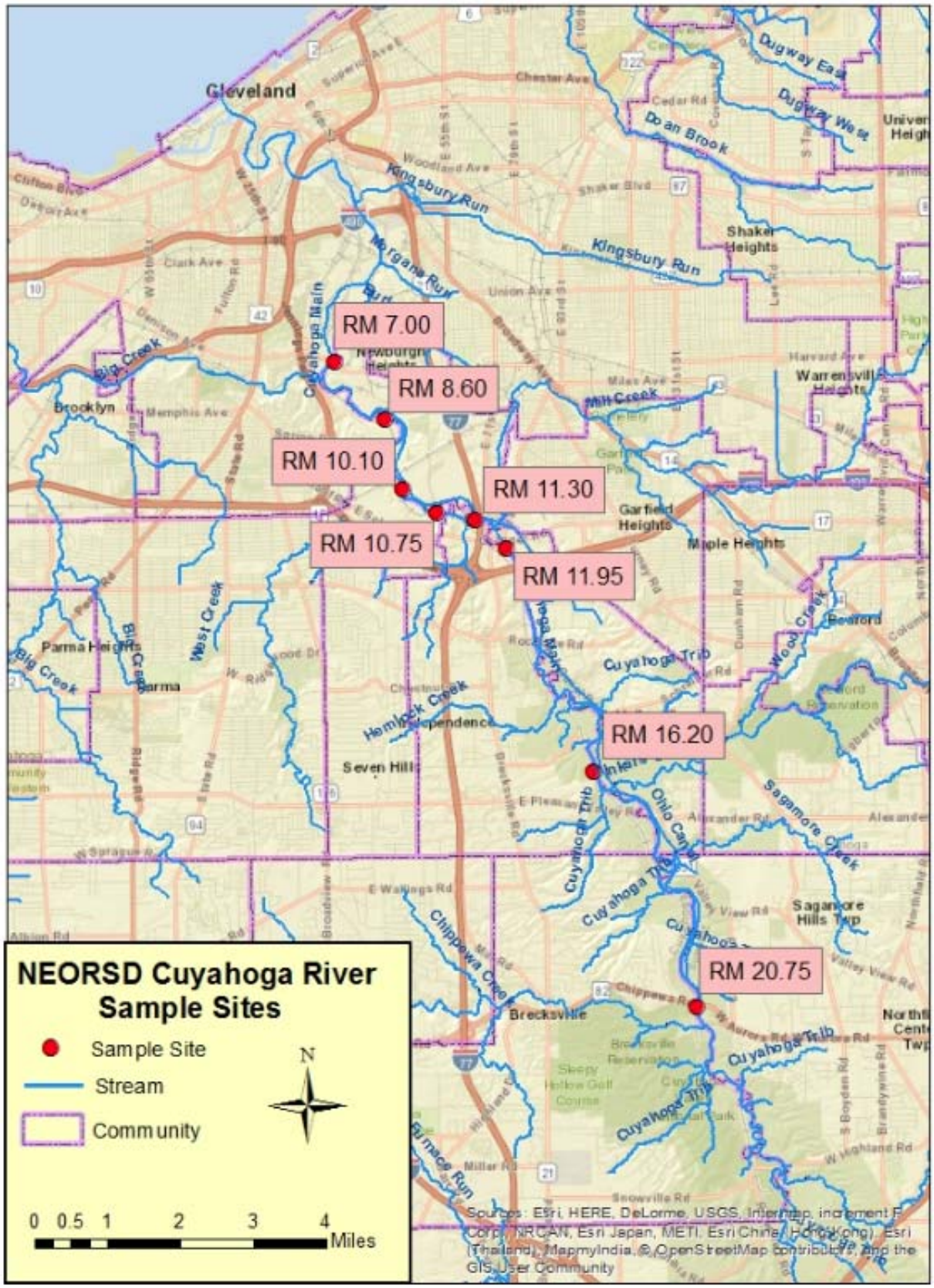


Figure 1. Sampling Locations

Table 1. Sample Locations

Location	Latitude	Longitude	River Mile	Description	Purpose
Upstream of State Route 82	41.3207	-81.5875	20.75	Upstream of the State Route 82 dam	Evaluate macroinvertebrate community and water chemistry upstream of Route 82 dam prior to potential removal
Downstream of Tinkers Creek	41.3678	-81.6139	16.20	Downstream of the confluence with Tinkers Creek near Old Riverview Road	Evaluate Tinkers Creek discharge on macroinvertebrate community and water chemistry
Upstream of Mill Creek	41.4123 41.4101	-81.6364 -81.6346	12.10[a] 11.95	Upstream of the confluence with Mill Creek (I-480)	Evaluate Mill Creek discharge on macroinvertebrate community and water chemistry
Downstream of Mill Creek	41.4179	-81.6446	11.30	Downstream of the confluence with Mill Creek	Evaluate Mill and West Creek discharges on macroinvertebrate community and water chemistry
Upstream of Southerly WWTC	41.4196	-81.6547	10.75	Upstream of Southerly WWTC effluent discharge	Evaluate West Creek and Southerly WWTC discharges on fish community, habitat macroinvertebrate community, and water chemistry
Downstream of Southerly WWTC	41.4242	-81.6638	10.10	Downstream of Southerly WWTC effluent discharge	Evaluate Southerly WWTC discharge on fish community, habitat, macroinvertebrates community, and water chemistry
Upstream of Big Creek	41.4381	-81.6680	8.60	Upstream of the confluence with Big Creek	Evaluate Big Creek discharge on fish community, habitat, macroinvertebrate, community, and water chemistry
Downstream of Big Creek	41.4497	-81.6815	7.00	Downstream of the confluence with Big Creek	Evaluate Big Creek discharge fish community, habitat, macroinvertebrate, community, and water chemistry

[a] HD and Water Chemistry Collection Site

Water Chemistry Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times on the Cuyahoga River between July 24 and August 21, 2018, at the eight 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* (2018a). 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 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).

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

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, 2018a).

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 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 Cuyahoga River 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 river.

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

Results and Discussion

The Cuyahoga River sites sampled in 2018 are designated as a warmwater habitat (WWH) and exhibit primary contact recreation criteria according to the Ohio EPA Water Quality Standards (2018c). Over the course of five sampling events in 2018, three field blanks and three duplicate samples were collected as part of this study. Two parameters (Al and TKN) showed possible contamination in the field blanks. It is unclear how the field blanks became contaminated and may be due to inappropriate sample collection, handling, and/or contaminated blank water. These parameters were listed as an estimate or downgraded from Level 3 to Level 2 data based on Ohio EPA data validation protocol.

Of the three duplicate samples collected, three instances occurred in which the acceptable RPD was exceeded (Table 2). Potential reasons for this discrepancy include lack of precision and consistency in sample collection and/or analytical procedures, environmental heterogeneity, and/or improper handling of samples.

Table 2. Duplicate Samples with RPDs Greater than Acceptable

Location	Date	Parameter	Acceptable RPD	Actual RPD
RM 8.60	7/31/2018	TKN	61.5	65.0
RM 20.75	8/21/2018	Al	17.4	20.0
		Ti	28.8	52.1

The final QA/QC check was for paired parameters, or those parameters in which one is a subset of the other. There were no instances in which the data for the paired parameters needed to be qualified because the sub-parameter value was greater than the parent value.

Exceedances of the recreational bacteriological criteria occurred at all eight sites during the 2018 sampling season. The recreational 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 streams designated as 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. These calculations are formulated when there are at least five samples collected within a rolling 90-day period. Both criteria were exceeded at all eight

sites for the 90-day periods beginning on July 24, 2018 (Table 3). These exceedances may be due to significant wet-weather events* which occurred on four of the five sampling dates. Potential sources of bacteria inputs may include stormwater runoff, illicit discharges, combined sewer overflows (CSOs), and failing household sewage treatment systems (HSTS).

Table 3. 2018 Cuyahoga River *E. coli* Densities (MPN/100mL)

Date	RM 20.75	RM 16.20	RM 12.10	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00
7/24/2018*	884	554	700	616	833	1,273	1,973	6,260
7/31/2018*	398	166	214	183	150	164	152	150
8/7/2018*	5,840	4,020	5,425	9,250	7,300	10,150	15,250	21,750
8/14/2018	616	1,015	330	474	668	406	314	200
8/21/2018*	4,985	2,680	3,120	8,280	14,860	17,720	8,520	97,680
90-day Geomean	1,445	1,001	965	1,326	1,554	1,724	1,650	3,313

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.

Mercury was another parameter that failed to meet the applicable criteria at some sites. Exceedances of the wildlife outside mixing zone average (OMZA) and the Human Health Non-Drinking OMZA occurred at RMs 11.30, 10.75, 10.10, 8.60, and 7.00 during the 2018 sampling (Table 4). All other sites had results that were below the method detection limit. It is expected that the use of a low-level mercury analysis like EPA Method 1631E, instead of EPA Method 245.1, may have resulted in exceedances of the criteria throughout the sampling period.

Table 4. 2018 Cuyahoga River Mercury Concentrations (µg/L)

Date	RM 20.75	RM 16.20	RM 12.10	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00
7/24/2018	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
7/31/2018	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
8/7/2018	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
8/14/2018	<0.025	<0.025	<0.025	<0.025	<0.025	j0.026	AE	<0.025
8/21/2018	<0.025	<0.025	<0.025	j0.026	j0.030	j0.029	j0.029	j0.038

Exceedance of Wildlife OMZA (0.0013 µg/L) and Human Health Non-Drinking OMZA (0.0031) for 30-day period beginning with that date, assuming "j" values are actual values and concentrations below the MDL are zero.

AE = data is not valid

In 2018, the Ohio EPA released an Early Stakeholder Outreach regarding Nutrient Water Quality Standards for Ohio's Large Rivers (≥500 mi^2 drainage area). The proposed eutrophication standard, shown in Table 5, will establish standards based on Sestonic Chlorophyll, 5-day Biological Oxygen Demand (BOD), 24-hour Dissolved Oxygen Range (DO), Total Kjeldahl Nitrogen (TKN), and use Total Suspended Solids (TSS) for sites where chlorophyll data are lacking (Ohio EPA, 2018d).

The Ohio EPA is also proposing a seasonal average, summer base-flow target level of total phosphorus at 0.130 mg/L as a management target for presently over-enriched waters (Miltner, 2017). The total phosphorus target of 0.130 mg/L has been proposed to reduce chlorophyll concentrations to less than 100 µg/L in large rivers. Chlorophyll concentrations greater than 100 µg/L contribute to elevated BOD, large daily DO swings, and a higher concentration of suspended solids; all of which display gross levels of enrichment and suggest a high likelihood of biological enrichment (Miltner, 2017).

Table 5. Ohio EPA Proposed Eutrophication Standards for Ohio's Large Rivers

	Acceptable	Enriched or Over Enriched	Over Enriched
Indicator		Chronic Condition	Acute Condition
Sestonic Chlorophyll	<30 ug/l as seasonal average	Magnitude 30 < 100 ug/l seasonal average with biological impairment; Frequency ≥ 30 < 100 ug/l as seasonal average in two of three years	Magnitude ≥ 100 ug/l anytime with biological impairment; Frequency ≥ 100 ug/l multiple observations at base flow
BOD5	<2.5 mg/l as seasonal average	Magnitude ≥ 2.5 < 6 mg/l seasonal average with biological impairment Frequency ≥ 2.5 < 6 mg/l as seasonal average in two of three years	Magnitude ≥ 6 mg/l anytime with biological impairment and seasonal average chlorophyll ≥ 30 ug/l Frequency ≥ 6 mg/l two or more times during the base flow period
24-Hour D.O. Range	<6.5 mg/l	≥7 mg/l – 9.0 mg/l (default to chlorophyll, BOD5 and biological indicators)	Magnitude and Frequency ≥9.0 mg/l anytime with biological impairment
TKN	NA	NA	≥0.75 mg/l May substitute for BOD5
TSS		~20 mg/l; general screening level for inspection of data sets lacking chlorophyll observations.	

Nutrient data was collected at eight sample locations during the five water chemistry sampling events in 2018. In addition, on September 4-6, 2018, YSI data sondes were installed at four locations in the Cuyahoga River (see Table 6 for locations). These data sondes recorded DO, pH, specific conductivity, conductivity, and temperature in 15-minute increments over a three-day period. The data sondes were calibrated at the NEORSD Environmental and Maintenance Services Center per the manufacturers' recommendations. Upon return from the field, the data was downloaded, and calibrations were checked for continued accuracy. TKN, dissolved reactive phosphorus (DRP), total phosphorus, TSS, and BOD were collected five times at each site during water chemistry sampling. In addition, a sixth sampling event occurred on RMs 16.20, 10.75, 10.10, and 7.00 to collect data for TKN, DRP, total phosphorus, TSS, BOD, chlorophyll *a,* and measured daily DO swings. The purpose of this additional sampling was to provide a more comprehensive understanding of the relationship between algal production, nutrient levels, and DO diel swings in the river and compare results to the proposed Ohio EPA eutrophication standards.

Table 6. Nutrient Seasonal Geomeans

River Mile	**20.75**	**16.20***	**12.10**	**11.30**	**10.75***	**10.10***	**8.60**	**7.00***
TKN (mg/L)	0.973	0.917	0.873	1.031	1.017	0.974	1.070	0.996
DRP (mg/L)	0.028	0.043	0.036	0.035	0.041	0.062	0.045	0.063
Total P (mg/L)	0.084	0.115	0.116	0.131	0.123	0.161	0.153	0.186
TSS (mg/L)	43.3	42.4	54.4	69.4	54.9	42.9	64.2	46.8
BOD (mg/L)	2.7	2.6	3.0	3.1	3.4	3.2	3.0	3.6
Chlorophyll *a* (µg/L) - water column**	---	2.594	---	---	5.252	3.431	---	4.51
DO Swing (mg/L) 9/4/18-9/6/18	---	1.52	---	---	1.84	1.48	---	2.02

*Contains additional data collected on 9/6/2018
**Grab sample
Enriched or over-enriched - chronic condition
Exceedance of the total phosphorus target level of 0.130 mg/L
Over-enriched - acute condition

The proposed eutrophication standards require sampling during "summer base-flow conditions". Of the six sampling events, four of these events were taken during or after wet-weather events (see Table 3 for wet-weather dates). TKN seasonal geomean levels for all eight sampling locations exceeded the "over-enriched, acute condition" criterion for the proposed eutrophication standards. All sites also exceeded the proposed seasonal geomean criterion of "enriched or over-enriched, chronic condition" for BOD. Total phosphorus

levels were acceptable upstream of RM 11.30 but exceeded the proposed total phosphorus target level at four of the five the downstream sample sites. The grab samples for sestonic chlorophyll and the 24-hour DO swing both yielded results in the acceptable range. Dry-weather grab samples from another NEORSD study at RM 10.95 and 0.20 on August 6, 2018, however, yielded chlorophyll results greater than 30 µg/L, indicating that periods of eutrophication may exist on the Cuyahoga River during the summer. Pulling data from the two dry-weather events (8/14/2018 and 9/6/2018) only, the BOD seasonal geomean exceeds the proposed criterion for "enriched conditions" at only four sampling sites, and the sites with total phosphorus exceedances falls to two. The wet-weather conditions that comprised a majority of the sampling efforts may be contributing to higher results than what may be expected during the summer base-flow conditions as the proposed eutrophication standards describe.

The NEORSD Southerly Wastewater Treatment Center (WWTC) discharges treated wastewater to the Cuyahoga River at RM 10.57. Southerly WWTC contains National Pollutant Discharge Elimination System (NPDES) permit number 3PF00002*MD, as issued by the Ohio EPA. This permit limits total phosphorus effluent concentrations to 1.10 mg/L weekly and 0.70 mg/L monthly. With the NPDES permit limit well above the proposed total phosphorus target level, the Southerly WWTC will likely continue to contribute to elevated total phosphorus concentrations in the Cuyahoga River downstream of its effluent discharge.

Land Cover Analysis

A land cover analysis was performed on the watershed areas that drain to each 2018 sample location. The United States Geologic Survey StreamStats Program (U.S. Geological Survey, 2012) was used to obtain a watershed polygon representing the watershed that drains to the location of each sample site. The corresponding watershed polygon was then imported into ArcMap 10.3 and the intersect tool was used to combine the watershed with the 2011 National Land Cover Database (Homer et.al, 2015). The resulting figure represented the different types of land cover that drain to each sample location. The entire Cuyahoga River watershed is presented in Figure 3. Percentages of the total area at each site were then calculated. Similar land cover types were combined and are displayed in Figure 4.

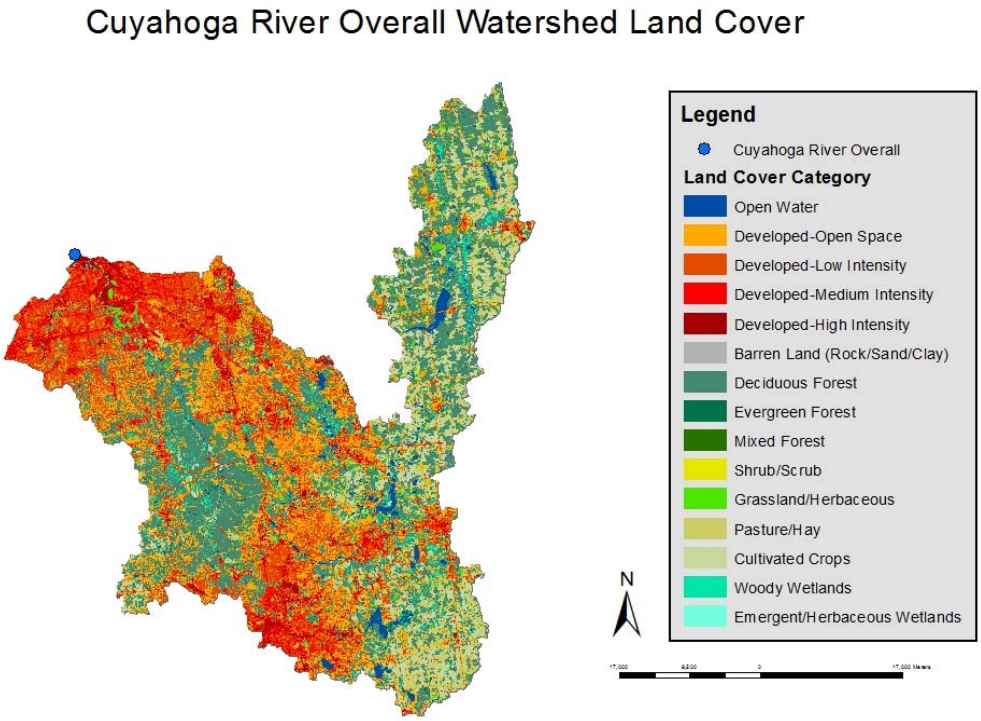


Figure 3. Cuyahoga River Watershed Land Cover Map

The Cuyahoga River watershed contains a highly developed landscape as it flows through the major cities of Akron and Cleveland. RM 20.75 contained the smallest percentage of developed land while RM 7.00 contained the largest percentage of developed land tributary to the sample site (Figure 4). Highly developed land consists of a vast landscape of impervious surfaces which quickly removes rainfall and increase stormwater runoff. This increased stormwater runoff leads to increased peak discharges, increased erosion, and increased pollutants transferred to the stream (USEPA, 1993). Pollutants associated with urban and industrial runoff include excess sediments, nutrients, pathogens, oxygen-demanding matter, heavy metals, and salts (Schueler, 1987). The highly developed and the urban landscapes that comprise a majority of the Cuyahoga River watershed may be having a negative effect on the overall water quality and lead to the degradation of aquatic biota.

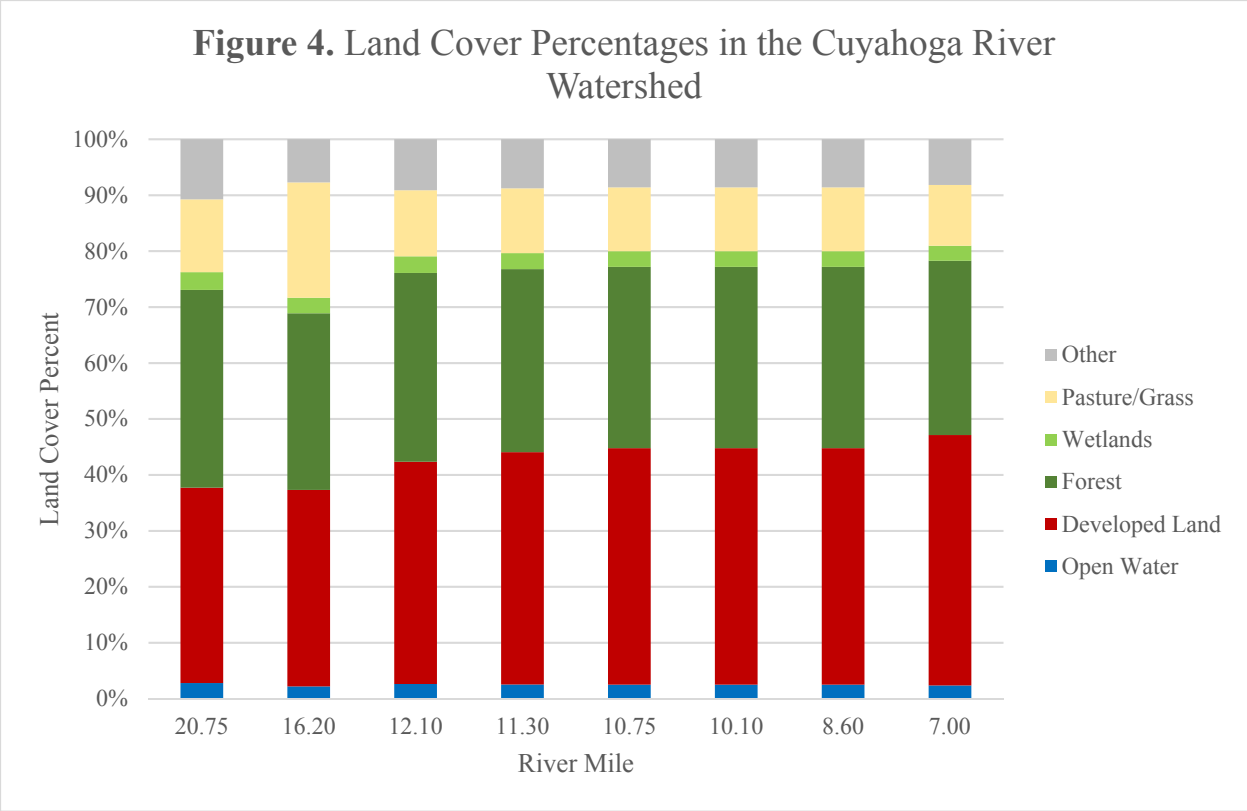


Figure 4. Land Cover Percentages in the Cuyahoga River Watershed

Habitat Assessment

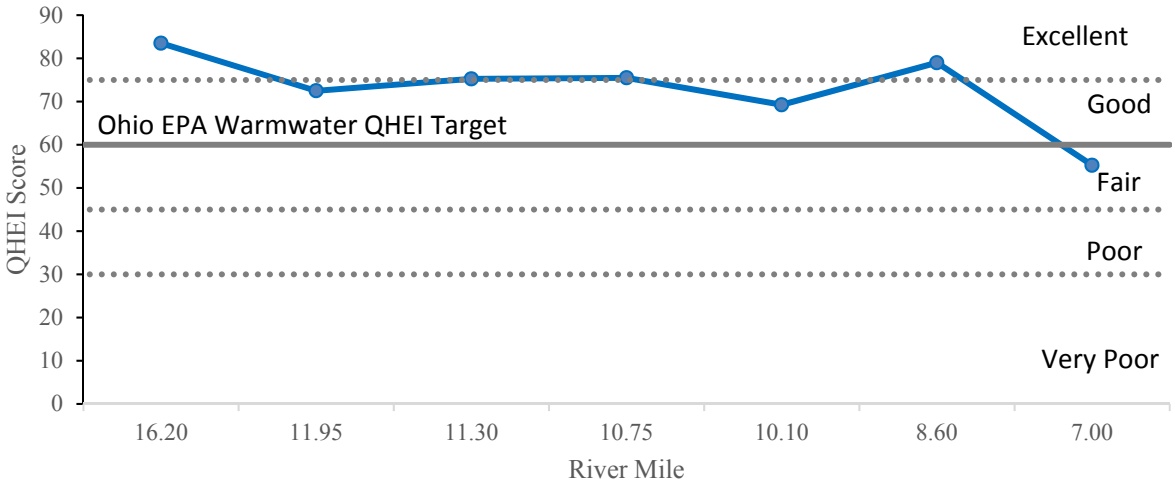
Methods

Instream habitat assessments were conducted once at each site from RM 16.20 to RM 7.00 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 greater than 60 on streams greater than 20 square miles 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 of the sites, with the exception of RM 7.00, received QHEI scores that exceeded Ohio EPA's target of 60 and, therefore, should be capable of supporting a WWH fish assemblage (Figure 5). The highest quality habitats were measured at RM 16.20, RM 11.30, RM 10.75 and RM 8.60 where scores revealed narrative ratings in the *Excellent* (≥ 75) range.

Figure 5. 2018 Cuyahoga River Qualitative Habitat Evaluation Index Scores



Individual components of the QHEI can also be used to evaluate whether a site is capable of meeting its 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 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).

All sites evaluated in 2018 either had never been channelized or have recovered from channelization, exhibited maximum depths greater than 40 cm, demonstrated low sinuosity, and contained a moderate to high overall substrate embeddedness as shown in Table 7. With the exception of RM 7.00, all sites displayed the WWH characteristics of boulder/cobble/gravel substrates and fast currents and eddies. RM 7.00 exhibited the lowest score during the 2018 sampling. This site contained no riffle, a dominant substrate type of sand, and consisted of the lowest amount of WWH attributes. Comparing QHEI scores to the previous year, RM 10.75 increased from a *Good* narrative to *Excellent*, with the remaining sites receiving the same narrative rating as the previous year.

Table 7. 2018 Qualitative Habitat Evaluation Index scores and physical attributes

			WWH Attributes											MWH 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 Attributes**
16.20	83.50	*Excellent*	X	X		X		X	X	X	X	X	**8**						**0**						X				X	X		**3**
11.95	72.50	*Good*	X	X				X	X		X		**5**			X	X		**2**		X			X	X				X	X		**5**
11.30	75.25	*Excellent*	X	X		X		X	X	X	X		**7**				X		**1**		X			X	X				X	X		**5**
10.75	75.50	*Excellent*	X	X		X		X	X	X	X		**7**				X		**1**					X	X				X	X		**4**
10.10	69.25	*Good*	X	X					X	X	X		**5**				X		**1**					X	X				X	X		**4**
8.60	79.00	*Excellent*	X	X		X		X	X		X	X	**7**						**0**		X				X				X	X		**4**
7.00	55.25	*Fair*	X								X		**2**				X		**1**		X	X		X	X			X	X		X	**7**

Fish Community Biology Assessment

Methods

One quantitative electrofishing pass was conducted at the four downstream most sites in 2018. A second pass could not be conducted due to flow conditions in the river. Electrofishing sampling was not conducted at RMs 16.20, 11.95 and 11.30 due to a log jam impeding boat access upstream of RM 10.75. The site at RM 20.75 could not be sampled due the absence of a previous boat launch at that site. A list of the dates when the surveys were completed, along with approved flow measurements from the United States Geological Survey gage station in Independence are shown in Table 8. Sampling was conducted using boat electrofishing techniques and consisted of shocking all habitat types within a sampling zone while moving from upstream to downstream by slowly and steadily maneuvering the boat as close to shoreline and submerged habitat as possible. The sampling zone was 0.50 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.

Table 8. Sampling Dates and River Flows

Date	Sites sampled (RMs)	Daily Mean Flow (CFS)
7/16/2018	10.75, 10.10, 8.60	322
7/19/2018	7.00	263

The electrofishing results 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 abundance and diversity. Functional attributes are based upon fish community aspects such as feeding strategies, environmental tolerances, and disease symptoms. These metrics are individually scored by comparing the data collected at the survey site with values expected at reference sites located in a similar geographical region. The maximum possible IBI score is 60 and the minimum possible score is 12. The summation of the 12 individual metrics scores provides a single-value IBI score, which corresponds to a narrative rating of *Exceptional, Good, Marginally Good, Fair, Poor* or *Very Poor*. The 12 metrics utilized for boat sites are listed in Table 9.

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: $$MIwb = 0.5\ lnN + 0.5\ lnB + \overline{H}(No.) + \overline{H}(Wt.)$$

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

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

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

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

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

n_i = Relative numbers or weight of species

N = Total number or weight of the sample

The Cuyahoga River is located completely within the Erie-Ontario Lake Plains (EOLP) ecoregion and follows the EOLP IBI metric scoring. The WWH IBI scoring criterion in the EOLP ecoregion is 40 and 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 10). 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.

Table 9. IBI Metrics (Boat sites)
Total Number of Indigenous Fish Species
Percent Round-bodied Suckers
Number of Sunfish Species
Number of Sucker Species
Number of Intolerant Species
Percent Tolerant Species
Percent Omnivore Species
Percent Insectivore Species
Percent of Top Carnivore Species
Number of Individuals in a Sample
Percent of Simple Lithophilic Spawners
Percent of Individuals with DELTs

Table 10. Fish Community Biology Scores for Boat sites in the EOLP Ecoregion							
Ohio EPA Narrative	Very Poor	Poor	Fair	Marginally Good	Good	Very Good	Exceptional
IBI Score	12-17	18-27	26-35	36-39	40-43	44-47	48-60
MIwb Score	0-4.9	5.0-6.3	6.4-8.1	8.2-8.6	8.7-9.0	9.1-9.5	≥9.6
Ohio EPA Status	Non-Attainment			NSD	Attainment		
NSD – Non-Significant Departure of WWH attainment							

Results and Discussion

The 2018 IBI and MIwb scores from each sample site are listed below in Table 11. For the MIwb, all four sites were calculated to be in attainment of the warmwater habitat criterion. The highest MIwb score was calculated at RM 10.10, which is the first site downstream of the NEORSD Southerly WWTC effluent discharge. The lowest score was observed at RM 7.00, which has historically received the lowest MIwb score on the Cuyahoga River upstream of the ship channel.

Table 11. 2018 Cuyahoga River IBI and MIwb Results			
Location	River Mile	IBI (*Narrative*)	MIwb (*Narrative*)
Upstream from Southerly WWTC	10.75	24 *(Poor)*	**8.9 (*Good*)**
Downstream from Southerly WWTC	10.10	32 *(Fair)*	**9.5 (*Very good*)**
Upstream from Big Creek	8.60	34 *(Fair)*	**8.7 (*Good*)**
Downstream from Big Creek	7.00	28 *(Fair)*	*8.5 (Marginally good)*
Bold = meets WWH criterion [IBI ≥40; MIwb ≥8.7] *Italics = non-significant departure from WWH criterion [IBI ≥36; MIwb ≥8.2]*			

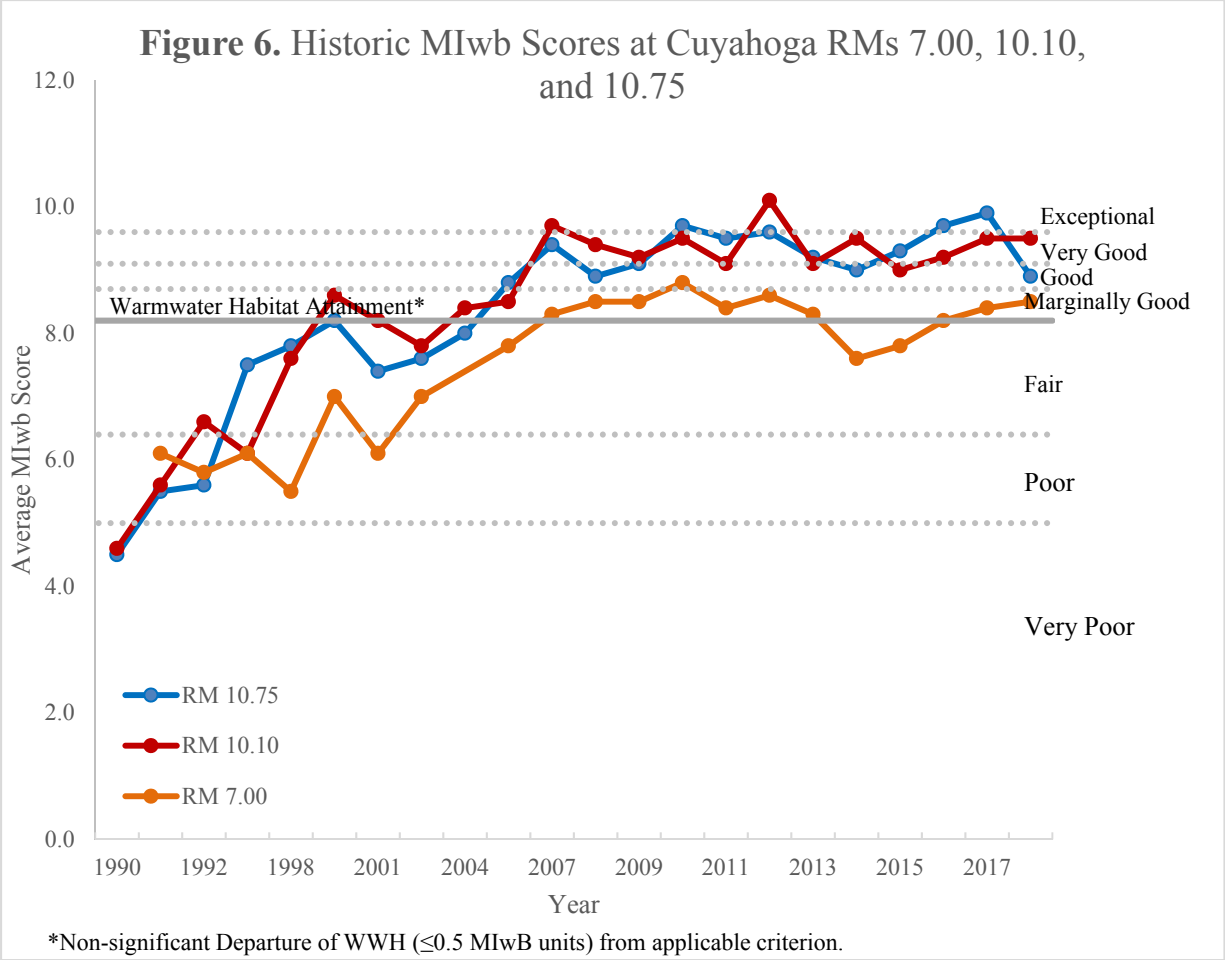
All sites, except RM 7.00, received a QHEI score greater than 60, suggesting that habitat is not a limiting factor in the fish community attaining the warmwater habitat criterion (Ohio EPA, 2006). RM 7.00 received a QHEI score of 55.25, displaying the least amount of functional habitat of the four sample sites and may be a factor contributing to the site's lower MIwb score. Overall, there was a slight decrease in MIwb scores at all four sites from the previous year and may be due to a lower abundance of species collected at RMs 10.75, 8.60, and 7.00. Historical trends of the Cuyahoga River MIwb scores (Table 12 and Figure 6) display a gradual increase over time, with scores consistently exceeding the WWH criterion since 2009.

Table 12. Cuyahoga River Historic MIwb Scores (1990-2018)

Year	RM 20.75	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00
1990	-	-	-	-	4.5	4.6	-	-
1991	-	-	-	-	5.5	5.6	-	6.1
1992	-	-	-	-	5.6	6.6	-	5.8
1997	-	-	-	-	7.5	6.1	-	6.1
1998	-	-	-	-	7.8	7.6	-	5.5
1999	-	-	-	-	8.2	*8.6*	-	7.0
2001	-	-	-	-	7.4	*8.2*	-	6.1
2003	-	-	-	-	7.6	7.8	-	7.0
2004	-	-	-	-	8.0	*8.4*	-	-
2006	-	-	-	-	**8.8**	*8.5*	-	7.8
2007	-	*8.6*	*8.5*	*8.3*	**9.4**	**9.7**	-	*8.3*
2008	-	**9.9***	*8.2*	**9.1**	**8.9**	**9.4**	-	*8.5*
2009	-	**9.9***	**8.8**	**9.5**	**9.1**	**9.2**	**9.0**	*8.5*
2010	-	**9.5**	**9.0**	**9.7***	**9.7***	**9.5**	**9.2**	**8.8**
2011	-	**9.6***	**8.7**	**8.9**	**9.5**	**9.1**	**8.8**	*8.4*
2012	-	-	**9.2**	**9.5**	**9.6**	**10.1***	**9.6***	*8.6*
2013	-	-	8.3	**9.2**	**9.2**	**9.1**	**8.8**	*8.3*
2014	-	-	**9.1**	**9.3**	**9.0**	**9.5**	*8.2*	7.6
2015	-	-	**-**	**-**	**9.3**	**9.0**	*8.8*	7.8
2016	-	-	*8.6*	**9.5**	**9.7***	**9.2**	**9.1**	*8.2*
2017	8.1	**10.2***	**9.7***	*8.6*	**9.9***	**9.5**	**9.4**	*8.4*
2018	-	-	-	-	**8.9**	**9.5**	**8.7**	*8.5*

Bold = meets WWH criterion [≥8.7]
Italics = non-significant departure from WWH criterion [≥8.2]
***Meets Exceptional WWH Criterion**

During the 2018 sampling season, all four sites assessed for fish community biology failed to meet the WWH IBI criterion of 40 (Table 10 and Figure 7). RM 10.75 received an IBI narrative of *Poor*, while RMs 10.10, 8.60, and 7.00 all received IBI narratives of *Fair*. A decrease in IBI scores from 2017 was observed at all four sites, with the most significant decrease observed at RM 10.75. The RM 10.75 IBI score decreased from an average IBI score of 42 in 2017, to a score of 24 in 2018 and was the lowest score observed at this site since 1992. A section of riffle-run habitat was not able to be effectively electrofished at this location due to swift, deep currents and large woody debris which provided unsafe boating conditions; this may be one reason for the lower IBI score.



Individual metrics in the IBI also were examined to determine specific components of the fish community that decreased from the previous year. In 2018, RM 10.75 saw a decrease of 18 IBI units compared to 2017. RM 10.75 showed a decrease in the following IBI metrics: number of individuals, proportion of round-bodied suckers, insectivore species, and simple lithophil species. RM 10.75 also observed an increase in DELT anomalies, proportion of omnivores and proportion of tolerant species. RM 8.60 saw a decrease of 9 IBI units compared to 2017, due to significant decreases in the proportion of round-bodied suckers and simple lithophils. RMs 10.75, 10.10, and 8.60 all showed a decrease in the proportion of round-bodied suckers and simple lithophils. Round-bodied suckers are known to be intolerant of highly turbid waters and siltation, while simple lithophilic species require clean gravel and/or cobble for successful reproduction (Ohio EPA 1987a).

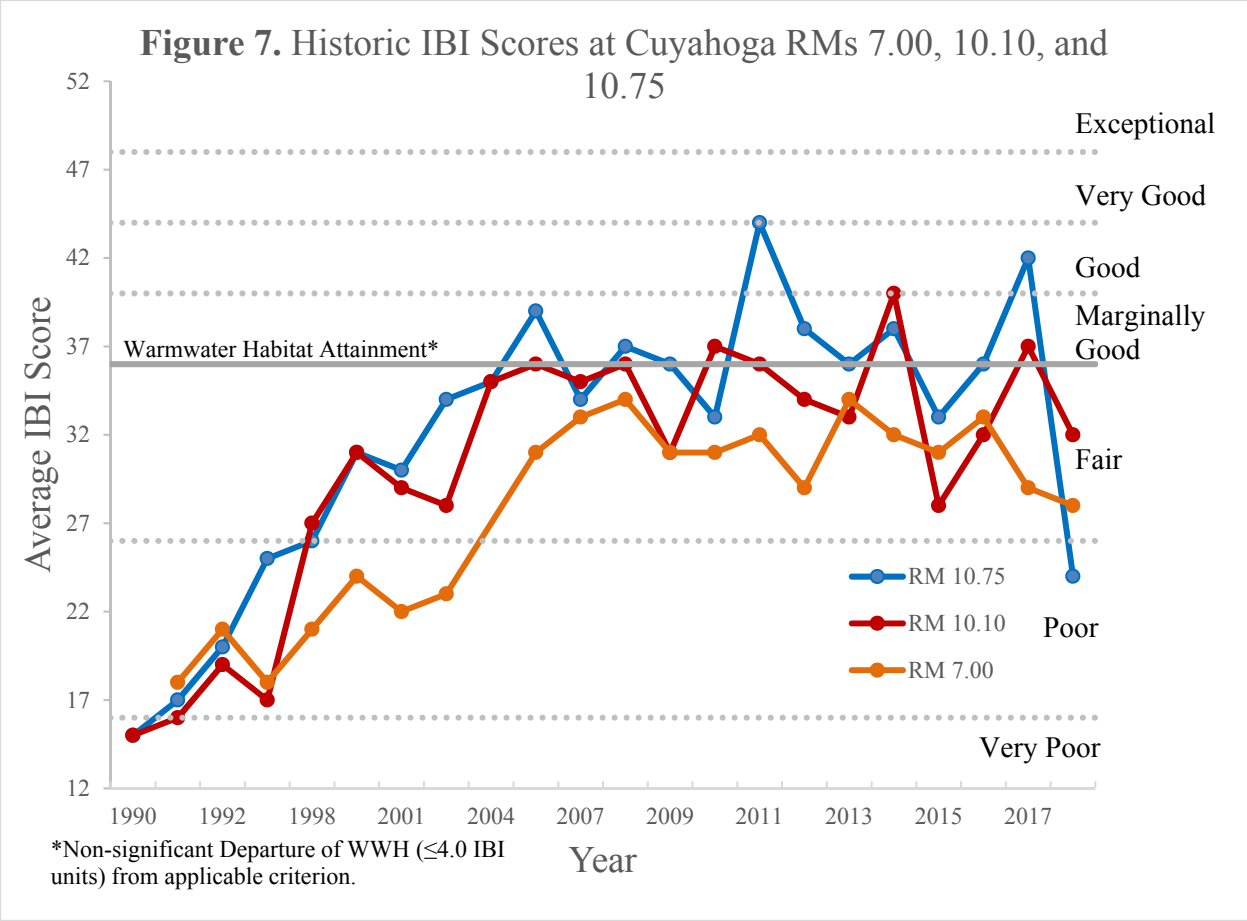
Over the summer of 2018, the Hemlock Creek Trail project contributed intermittent loads of sediment to the Cuyahoga River at RM 14.33, raising turbidity levels, and may have negatively affected the IBI scores at downstream sites. The increased turbidity was evident on July 16, 2018, as a load of sediment flowed through the Cuyahoga River during

the electrofishing sampling. The increased turbidity from this project may have been a contributing factor in the decrease of the IBI metrics for round-bodied sucker and simple lithophilic species, as they may have looked for refuge during times of high turbidity and sedimentation. Based on this, the 2018 IBI scores are likely not indicative of the normal Cuyahoga River fish community, as previous years have shown much higher scores (Table 13).

Table 13. Cuyahoga River Historic IBI Scores (1990-2018)

Year	RM 20.75	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00
1990	-	-	-	-	15	15	-	-
1991	-	-	-	-	17	16	-	18
1992	-	-	-	-	20	19	-	21
1997	-	-	-	-	25	17	-	18
1998	-	-	-	-	26	27	-	21
1999	-	-	-	-	31	31	-	24
2001	-	-	-	-	30	29	-	22
2003	-	-	-	-	34	28	-	23
2004	-	-	-	-	35	35	-	-
2006	-	-	-	-	*39*	*36*	-	31
2007	-	*39*	30	*38*	34	35	-	33
2008	-	**44**	34	*38*	*37*	*36*	-	34
2009	-	**45**	*38*	**44**	*36*	31	**40**	31
2010	-	**43**	*39*	*39*	33	*37*	**41**	31
2011	-	**47**	*39*	35	**44**	*36*	**40**	32
2012	-	-	*36*	35	*38*	34	*38*	29
2013	-	-	**41**	**42**	*36*	33	**41**	34
2014	-	-	**44**	**42**	*38*	**40**	34	32
2015	-	-	-	-	33	28	32	31
2016	-	-	*39*	34	*36*	32	**41**	33
2017	28	**50***	*38*	*38*	**42**	*37*	**43**	29
2018	-	-	-	-	24	32	34	28

Bold = meets WWH criterion [≥40]
Italics = non-significant departure from WWH criterion [≥36]
***Meets Exceptional WWH Criterion**



Habitat does not seem to be a limiting factor contributing to the poor 2018 fish community scores in the Cuyahoga River as the QHEI scores show that significant habitat exists for the fish community to meet WWH attainment at all sites but RM 7.00. Like past years, the metric for number of pollution-intolerant fish scored poorly at all sites as there was only one pollution-intolerant fish, the stonecat madtom (*Noturus flavus*), collected among all sites in 2018. Nutrient levels in the Cuyahoga River also do not seem to be significantly affecting the fish community as similar nutrient concentrations were observed in 2016 and all sites were found to be in full or partial attainment of the WWH criteria.

Water quality conditions continue to be one reason why pollution-intolerant fish are rarely observed in the lower Cuyahoga River. Exceedances of the bacteriological criteria indicates that there may be sanitary sewage contamination present throughout the Cuyahoga River, especially during wet-weather events and periods of elevated flows. Sources of sanitary sewage may be due to combined sewer overflows, illicit discharges, stormwater runoff, and failing HSTS. The stress to fish associated with such pollutants could therefore be a hindrance to the establishment and presence of pollution-intolerant species.

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 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 NEORSD 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 14), 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 result 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 15) and a site is within non-significant departure if the score falls within 4 ICI units of the criterion.

Table 14. ICI Metrics
Total Number of Taxa
Number of Mayfly taxa
Number of Caddisfly taxa
Number of Dipteran taxa
Percent Mayflies
Percent Caddisflies
Percent Tanytarsini Midges
Percent Other Diptera and Non-Insects
Percent Tolerant Organisms (as defined)
Number of Qualitative EPT Taxa

Table 15. Invertebrate Community Index (ICI) Range for EOLP Ecoregion								
Ohio EPA Narrative	Very Poor	Poor	Low Fair	Fair	Marginally Good	Good	Very Good	Exceptional
ICI Score	0-6	8-12	14-20	22-28	30-32	34-40	42-44	46-60
Ohio EPA Status	Non-Attainment				NSD	Attainment		
NSD – Non-Significant Departure of WWH attainment								

Results and Discussion

All sampling sites, with the exception of RM 7.00, were calculated to be in attainment of the WWH ICI criterion (Table 16 and Figure 8) during the 2018 sampling season. The HD was washed out and unable to be recovered from RM 20.75 due to the unstable sand substrate. RM 7.00 received a *Fair* narrative rating and did not meet the WWH ICI criterion. Temporal data displayed in Table 17 shows a slight decrease in ICI scores from the previous sampling year at all sites except RMs 10.75 and 8.60. Although the majority of the sites saw a decrease in ICI scores, all sites with the exception of RM 7.00 were calculated to be in attainment of the WWH ICI criterion.

Table 16. 2018 Cuyahoga River Macroinvertebrate Results							
Location	River Mile	ICI Score	Density (Organisms per square foot)	Total Number of Taxa	Number of Qualitative EPT Taxa	% Tolerant (as defined)	Narrative Rating
Upstream of State Route 82	20.75	--	--	38*	11*	--	*Good**
Downstream of Tinkers Creek	16.20	**44**	1008	53	13	0.63%	*Very Good*
Upstream of Mill Creek	11.95	**38**	746	56	9	11.77%	*Good*
Downstream of Mill Creek	11.30	**34**	758	49	9	18.31%	*Good*
Upstream of Southerly WWTC	10.75	**38**	1305	48	9	11.62%	*Good*
Downstream of Southerly WWTC	10.10	**36**	1309	49	8	20.53%	*Good*
Upstream of Big Creek	8.60	**40**	36.8	50	9	0.54%	*Good*
Downstream of Big Creek	7.00	18	338.2	33	4	62.86%	*Fair*

Bold indicates attainment of WWH criterion of 34
*Data and interpretation from qualitative sampling only

*Non-significant Departure of WWH (≤4 ICI units) from applicable criterion.

Table 17. Cuyahoga River Historic ICI Scores

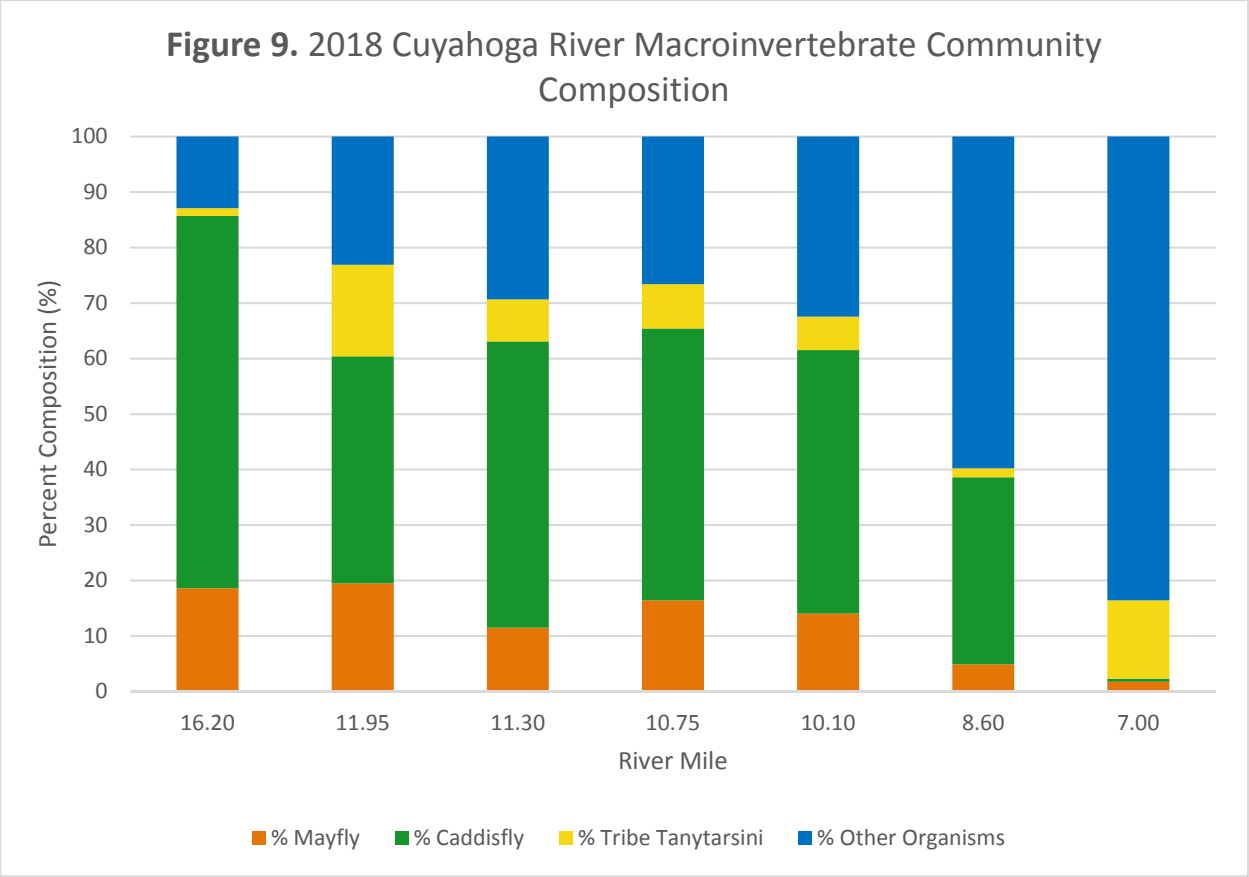
Year	RM 20.75	RM 16.20	RM 12.10	RM 11.30	RM 10.75	RM 10.10	RM 8.60	RM 7.00
2006	---	30	---	---	**38**	**34**	---	---
2007	---	**34**	**35**	**34**	*32*	**36**	---	**38**
2008	---	**40**	**40**	**40**	**40**	**40**	---	**38**
2009	---	**36**	**38**	**36**	**42**	**38**	**36**	**42**
2010	---	**36**	**40**	**40**	**36**	32	**44**	**34**
2011	---	**40**	**36**	**36**	*30*	---	---	26
2012	---	**40**	**44**	**38**	**40**	**34**	**40**	*30*
2013	---	**36**	**40**	**34**	**46***	**34**	**42**	**38**
2014	---	**44**	---	**48***	---	**34**	*30*	28
2015	---	**44**	**44**	**46***	**50***	**44**	**44**	24
2016	---	---	*30*	*32*	*32*	**38**	28	*32*
2017	*30*	**46**	**48***	**42**	**38**	**38**	**38**	*32*
2018	--	**44**	**38**	**34**	**38**	**36**	**40**	18

Bold indicates attainment of WWH criterion of 34
Italics indicates non-significant departure (≤4 ICI units) from criterion
***Meets Exceptional WWH Criterion**

For the Cuyahoga River RM 20.75, a Hester-Dendy sampler was unable to be recovered during the 2018 sampling season. Therefore, a narrative assessment was designated for this site based on data from qualitative sampling, and by utilizing the best professional judgment of the lead QDC. Factors considered in the assignment of narrative ratings included, but were not limited to: historical data from the site, total site drainage area, macroinvertebrate population composition in the qualitative sample with respect to the number of total taxa, EPT taxa, pollution sensitive taxa, and pollution tolerant taxa, and organism abundance within individual families or groups noted during sample collection.

The Cuyahoga River at RM 20.75 was assigned a narrative rating of *Good* in 2018 based off the qualitative sample. This is an improvement from 2017 as this site received an ICI score of 30 which corresponds to a *Fair* narrative rating. In 2018, there were two more overall taxa (38 qualitative taxa) collected compared to 2017 (36 qualitative taxa). Eleven of the 38 total taxa present in 2018 were either classified as *tolerant* or *moderately tolerant* to pollution according to the 2018 Ohio EPA Macroinvertebrate Taxa List. Four of the 38 taxa were classified as *moderately intolerant* with the remaining taxa classified as *facultative*. Eleven EPT taxa were collected during the 2018 qualitative sampling, which is an increase of four EPT taxa that were collected in 2017. The narrative rating of *Good* was assigned primarily due to the increased number of EPT taxa and overall taxa collected during the qualitative sampling event.

Figure 9 displays the overall macroinvertebrate composition of each sample population collected with regard to four major metrics: Percent Mayflies, Percent Caddisflies, Percent Tribe Tanytarsini, and Percent Other Organisms. The first three above-mentioned taxa groups are predominantly sensitive to pollution and are a good indicator of healthy streams when the organisms are present in abundant densities. However, when considering the "Other Organisms" metric, the majority of these organisms are known to be tolerant to pollution and therefore may be an indicator of poor stream quality. An overwhelming density of "other organisms" may be an indication of a macroinvertebrate community that is largely tolerant to water pollution.



RM 7.00 had the lowest percentages of mayflies and caddisflies, but the highest percentages of other organisms. These characteristics differ from the other sample sites in 2018, which demonstrated a more balanced macroinvertebrate community. The low proportion of mayfly, caddisfly, and tribe tanytarsini taxa may be contributing to RM 7.00 receiving a low ICI score and scoring below the ICI WWH attainment criterion.

Overall, ICI scores in 2018 were slightly lower compared to previous years, yet still meeting the ICI WWH criterion at all sample sites except RM 7.00. The increased sediment loads that the Hemlock Creek Trail project contributed over the 2018 sampling season may have caused the lower than normal ICI scores. With the exception of the 2016 bioassessments, the lower Cuyahoga River (within the Cuyahoga River AOC) has consistently met its designated WWH ICI criterion since 2006. The general increase in scores in 2017 and 2018 aid in showing that the 2016 sampling season may have been affected by an anomaly such as weather as opposed to a true indication of water quality.

Conclusions

For the 2018 sampling season, none of the Cuyahoga River sites met full attainment of the aquatic life criterion (Table 18). A full bioassessment (fish, macroinvertebrate, and water chemistry) was conducted on only four of the eight Cuyahoga River sites in 2018. RMs 16.20, 11.95, and 11.30 were only assessed for macroinvertebrate community and water chemistry and were calculated to be in full attainment of the ICI WWH criterion. The 2017 fish community biology scores at these sites were shown to meet the IBI WWH criterion, suggesting that if these sites were assessed for fish community biology in 2018, they would likely achieve full WWH attainment if not impacted by the sedimentation of the Hemlock Creek Trail project.

The 2018 Ohio EPA Integrated Report shows the Cuyahoga River at 61.3 percent full WWH attainment over 24.2 miles in 2016. Based on the data from this report, this percent is likely to decrease due to RM 10.75 being downgraded from full to non-attainment, RMs 10.10 and 8.60 being downgraded from full to partial attainment, and RM 7.00 being downgraded from partial to non-attainment in 2018. However, the decreased fish IBI scores that were observed in 2018 may not be indicative of the normal fish community in the Cuyahoga River. Over the summer of 2018, the Hemlock Creek Trail project contributed intermittent loads of sediment to the Cuyahoga River at RM 14.33, raising turbidity levels, and may have negatively affected the fish and macroinvertebrate community scores at downstream sites.

As in years past, assessments in 2018 showed water quality impairments at all sites which may be preventing the establishment of a healthier biological community. Following significant rainfall events, significant Water Quality Standards exceedances for *E. coli* densities may be attributable to combined sewer overflows and urban runoff, as well as other sources. Effluent from Southerly WWTC did not appear to significantly contribute to these exceedances since the *E. coli* densities were also elevated upstream of the Southerly WWTC effluent discharge and did not increase downstream. At RMs 11.30, 10.75, 10.10, 8.60, and 7.00, there were exceedances of the mercury wildlife and human health nondrinking criteria. These exceedances, however, did not indicate any contamination above those levels normally found in streams in Northeast Ohio.

Overall, monitoring of the Cuyahoga River since the 1990s has shown improvements in water quality over time. Fewer water quality exceedances are being observed and overall biological assessments have shown increased scores. While some water quality parameters are still likely causing impairments to the river, the overall health of the sites sampled in 2018 has greatly improved since sampling first began. The present impairment at RM 20.75 is attributable to the Route 82 dam, which is scheduled for removal to begin as early summer 2019. The removal of this dam will eliminate a fish passage barrier and improve the water quality of the river by restoring it to its natural and free flowing state. Although the removal of this dam may contribute to increased sediment

loading downstream during construction, the dam removal will likely result in improvements to water quality and biological communities over time.

Table 18. 2018 Cuyahoga River Survey Results

River Mile	Aquatic Life Use Attainment Status	IBI Score (Narrative Rating)	MIwb Score (Narrative Rating)	ICI Score (Narrative Rating)	QHEI Score (Narrative Rating)	Water Quality Exceedances
20.75	N/A	--	--	(*Good*)**	--	*E. coli*
16.20	N/A	--	--	44 *(Very Good)*	*83.50* *(Excellent)*	*E. coli*
11.95	N/A	--	--	38 *(Good)*	72.50 *(Good)*	*E. coli*
11.30	N/A	--	--	34 *(Good)*	75.25 *(Excellent)*	*E. coli,* Mercury, Total Phosphorus*
10.75	NON	24 *(Poor)*	8.9 *(Good)*	38 *(Good)*	75.50 *(Excellent)*	*E. coli,* Mercury
10.10	PARTIAL	32 *(Fair)*	9.5 *(Very Good)*	36 *(Good)*	69.25 *(Good)*	*E. coli,* Mercury, Total Phosphorus*
8.60	PARTIAL	34 *(Fair)*	8.7 *(Good)*	40 *(Good)*	79.00 *(Excellent)*	*E. coli,* Mercury, Total Phosphorus*
7.00	NON	28 *(Fair)*	8.5 *(Marginally Good)*	18 *(Fair)*	55.25 *(Fair)*	*E. coli,* Mercury, Total Phosphorus*

WWH biocriteria 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
*Proposed Nutrient Water Quality Standards for Ohio's Large Rivers
**Based on qualitative sample and best professional judgement
Note: Based on best professional judgement, the Hemlock Creek Trail project may have negatively impacted the aquatic communities in the Cuyahoga River. These scores do not appear to be representative of normal river conditions.

Acknowledgments

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

Kelsey Amidon
Hannah Boesinger
Nya Dreyfuss
Seth Hothem
Jill Knittle
Mark Matteson
Denise Phillips
John W. Rhoades
Eric Soehnlen
Justin Telep, Author

WQIS Paraprofessional Interns: Shadrack Ampomah, John Capuano, Trevor Connelly, Miranda DeGarmo, Marcus Jenkins, Kirk Kallenborn

Analytical Services Division – Completed analysis for all water chemistry sampling

References

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K. (2015). *Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information.* Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354

Miltner, Robert J. (2017). Eutrophication Endpoints for Large Rivers in Ohio, USA. Springer International Publishing AG.

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. (1999). *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (MAS/1999-1-1). Columbus, OH: Division of Surface Water.

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. (2018a). *Surface Water Field Sampling Manual for water quality parameters and flows*. Columbus, Ohio: Division of Surface Water.

Ohio Environmental Protection Agency (2018b). *Ohio 2018 Integrated Water Quality Monitoring and Assessment Report*. Division of Surface Water

Ohio Environmental Protection Agency. (2018c). *State of Ohio Water Quality Standards Ohio Administrative Code Chapter 3745-1* (Effective January 2, 2018). Columbus, OH: Division of Surface Water, Standards and Technical Support Section.

Ohio Environmental Protection Agency. (2018d). *Early Stakeholder Outreach – Nutrient Water Quality Standards for Ohio's Large Rivers (OAC 3745-1-36)*. Division of Surface Water.

Rankin, E.T. (1995). Habitat indices in water resource quality assessments. In W.S. Davis and T. Simon (eds.). *Biological Assessment and Criteria: Tools for Risk-based Planning and Decision Making* (pp. 181-208). Boca Raton, FL: Lewis Publishers.

Schueler, T., 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban Best Management Practices.* Metropolitan Washington Council of Governments, Washington, DC.

United States Environmental Protection Agency. (1993). *Urban Runoff Pollution Prevention Control Planning.* Cincinnati, OH: Office of Research and Development, Center for Environmental Research Information.

U.S. Geological Survey (2012). *The StreamStats program for Ohio*, online at https://water.usgs.gov/osw/streamstats/ohio.html