NORTHEAST OHIO REGIONAL SEWER DISTRICT

2010 Big Creek Environmental Monitoring: Biological, Water Quality, and Habitat Survey Results

Prepared by
The Water Quality and Industrial Surveillance Division

Introduction

During 2010, the Northeast Ohio Regional Sewer District (NEORSD) conducted electrofishing, benthic macroinvertebrate surveys, water chemistry sampling, and habitat assessments at three sites on Big Creek, a tributary to the Cuyahoga River. The study site at River Mile (RM) 0.15 on the Main Branch was required under the District's Combined Sewer Overflow (CSO) permit, Ohio Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Permit No. 3PA00002*FD. This site was downstream of all NEORSD-owned combined sewer overflows (CSOs) that discharge into Big Creek. According to the permit (1997), "discharges from combined sewer overflows shall not cause or significantly contribute to violations of water quality standards or impairment of designated uses." In support of the permit-required monitoring, studies at RM 4.40 on the Main Branch and RM 4.70 on the Ford Branch were conducted to determine the extent to which the downstream macroinvertebrate community at RM 0.15 was impacted by NEORSD CSO discharges and other environmental factors such as urban and stormwater runoff. Habitat Assessments and fish community surveys were also included as supplemental data.

Sampling was conducted by NEORSD Level 3 Qualified Data Collectors certified by Ohio EPA in Fish Community and Benthic Macroinvertebrate Biology, and Chemical Water Quality and Stream Habitat Assessments as explained in the NEORSD Study Plan *2010 Big Creek Environmental Monitoring*, approved by Ohio EPA on June 18, 2010. Data were submitted to the Ohio EPA within one year of the completion of sampling.

Figure 1 is a map of the sampling locations on Big Creek, and Table 1 lists the sampling locations and their respective River Mile, latitude/longitude, site description, and surveys conducted. A digital photo catalog of the sampling locations is available upon request by contacting the NEORSD Water Quality and Industrial Surveillance Division.

Figure 1. Map of sampling zones at RM 0.15, 4.40, and 4.70 in Big Creek

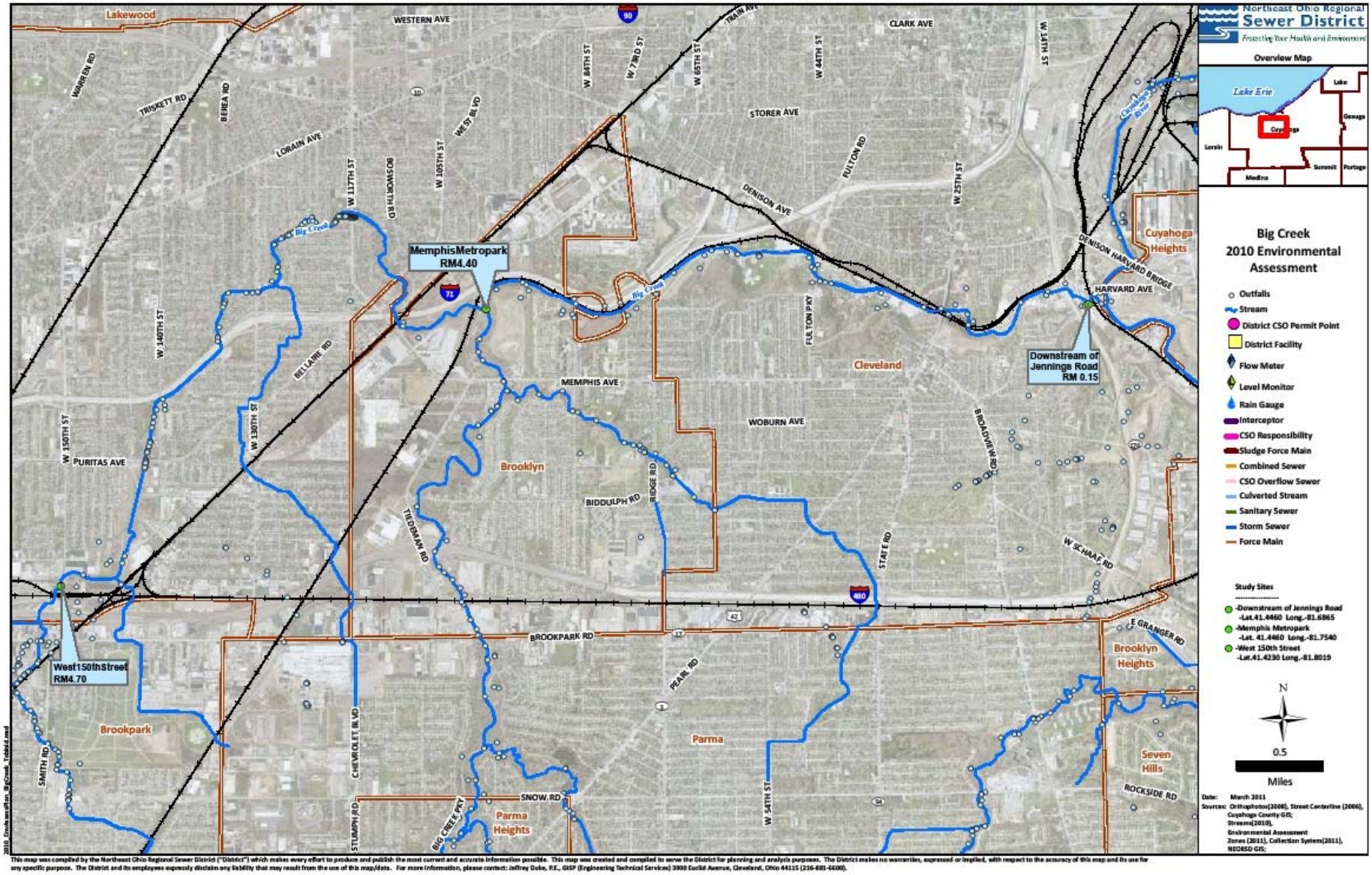


Table 1. List of Sampling Locations

Location	Latitude	Longitude	River Mile	Description	Quadrangle	Purpose
Big Creek – Main Branch	N41.4460°	W81.6865°	0.15	Downstream of Jennings Road	Cleveland South	Ohio EPA Permit No. 3PA00002*FD
Big Creek – Main Branch	N41.4460°	W81.7540°	4.40	Memphis MetroPark	Lakewood	Evaluate water chemistry, habitat, fish, and macroinvertebrates upstream of CSOs
Big Creek – Ford Branch	N41.4230°	W81.8019°	4.70	West 150th Street	Lakewood	Evaluate water chemistry, habitat, fish, and macroinvertebrates upstream of CSOs

Water Chemistry Sampling

Water chemistry samples were collected from RMs 0.15, 4.40, and 4.70 during five sampling events, beginning June 23, 2010 and ending July 21, 2010. To fulfill permit requirements under Ohio EPA NPDES Permit No. 3PA00002*FD, a sixth sample was collected at RM 0.15 on July 28, 2010. Chlorophyll *a* samples were collected on September 22, 2010 at each site. Samples collected on June 23, June 30, and July 14 were associated with wet weather events[1]. Techniques for water chemistry sampling and subsequent chemical analysis followed the *Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices* (OEPA, 2009).

Samples were collected in two 4-liter disposable polyethylene cubitainers with disposable polypropylene lids and two 473-milliliter plastic bottles. The plastic bottles were preserved with either trace sulfuric acid or trace nitric acid. The bacteriological samples were collected in a sterile 500 mL plastic bottle that was preserved with sodium thiosulfate. All samples were stored on ice in a cooler in the locked vehicle until they were relinquished to NEORSD's Analytical Services with a Chain of Custody (COC). A NEORSD Surface Water Condition Sampling Field Data Form detailing site observations was also completed for each sample. All Certificates of Analysis, COCs, and Surface Water Condition Sampling Field Data Forms are available upon request from the NEORSD Water Quality and Industrial Surveillance Division.

Instruments used for field analysis included a YSI-556 MPS Multi-parameter Water Quality Meter or a YSI 600XL Sonde for measuring dissolved oxygen, conductivity, pH, and water temperature. These meters were calibrated weekly for dissolved oxygen and specific conductance; pH was calibrated each day that sampling

[1] Wet weather sampling events: 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 of rain, samples collected that day and the following two days are considered wet weather samples. Rainfall data taken from the following NEORSD rain gages: RJA_A0030I at James Rhodes High School, and RJO_A0030I at John Marshall High School.

was conducted. A Hach HQ10 LDO Probe was utilized on July 14, 2010, for measuring dissolved oxygen.

Benthic and water column chlorophyll *a* sampling was also collected at each site on September 22, 2010. For the benthic samples, a total of 14-15 rocks were collected from three locations in the river within each site. The algal mass from a portion of each rock was scraped off and composited to form a slurry. Water column samples consisted of grab samples collected from the river in the same vicinity as the benthic samples. Chemical and physical water quality parameters measured in conjunction with the chlorophyll *a* samples included conductivity, dissolved oxygen, temperature, pH, total phosphorus, dissolved reactive phosphorus, nitrate+nitrite, alkalinity, turbidity, and total suspended solids.

Field blanks were obtained on June 30, 2010, and July 21, 2010, for QA/QC of the water samples. The field blanks appeared normal and did not show signs of contamination from site contaminants, such as airborne dust, not associated with the sample. Sample duplicates were collected from RM 4.40 on June 30, 2010, and RM 4.70 on July 14, 2010. The sample duplicate results were compared to the sample results using relative percent difference (RPD), given below in Formula 1.

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

X= is the concentration of the analyte in the primary sample
Y= is the concentration of the analyte in the duplicate sample

Each sample site was analyzed for 45 chemical parameters, plus 4 field measurements. The sample and the sample duplicate were compared for 43 individual laboratory parameters reported on the Certificate of Analysis. Neither hardness nor the nitrate+nitrite parameter was compared, since they are calculated from other parameters. After each RPD was calculated, any differences over 30% were investigated to determine the reason for the discrepancy. For the duplicates taken at RM 4.70, two potential discrepancies occurred. In each case, the parameter values were less than ten times their respective practical quantitation limit, indicating that the concentrations were very small and the slightest differences could cause an increase in the RPD. For the duplicates taken at RM 4.40, thirteen possible discrepancies occurred, twelve of which involved metals. Eight of the parameter values were less than ten times their respective practical quantitation limits. However, the remaining five discrepancies could not be explained in this way and are listed in Table 2. A possible reason for the unexplained discrepancies could be due to the fact that these samples were collected from a flowing body of water whose chemistry could be changing continuously.

Table 2. Unexplained Water Quality Discrepancies

Stream	River Mile	Date Collected	Parameter	Units	Sample ID	Sample Result	Duplicate ID	Duplicate Result	RPD Value
Big Creek	4.40	6/30/2010	Aluminum	µg/L	R-1006290006	57.14	R-1006290010	113.4	65.98
Big Creek	4.40	6/30/2010	Iron	µg/L	R-1006290006	105	R-1006290010	248.9	81.32
Big Creek	4.40	6/30/2010	Magnesium	µg/L	R-1006290006	24,400	R-1006290010	14,090	53.57
Big Creek	4.40	6/30/2010	Manganese	µg/L	R-1006290006	10.71	R-1006290010	14.99	33.31
Big Creek	4.40	6/30/2010	Sodium	µg/L	R-1006290006	147,800	R-1006290010	95,260	43.23

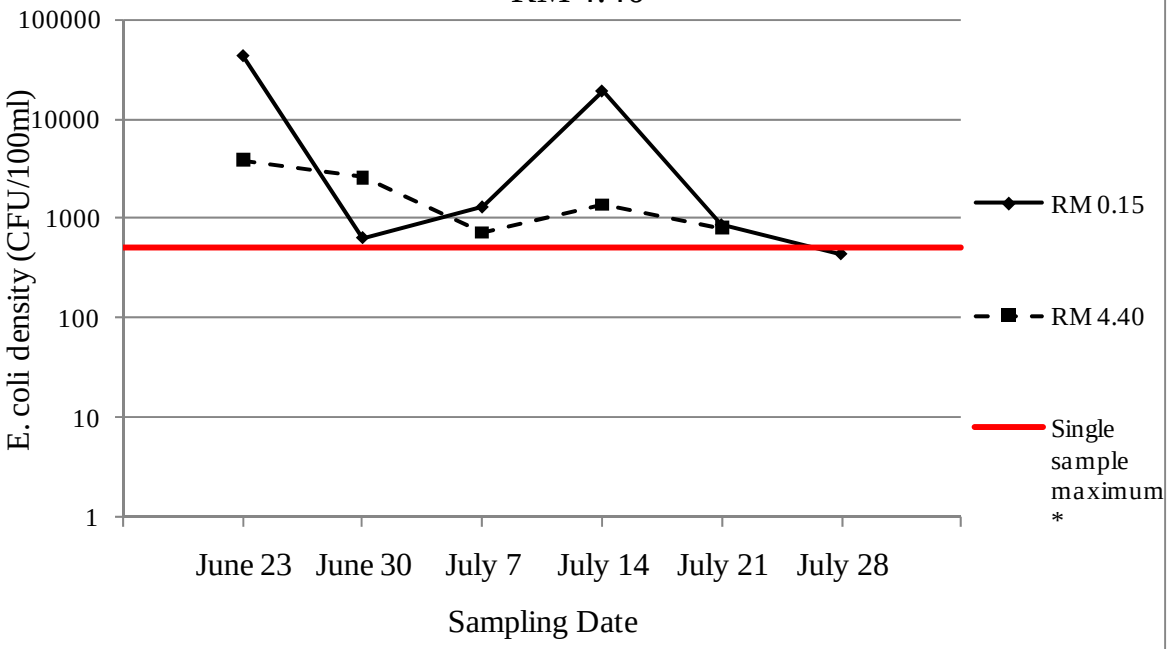
Results and Discussion

RM 0.15 and RM 4.40 on Big Creek are designated as warmwater habitat, agricultural water supply, industrial water supply, and Class B primary contact recreation waters. RM 4.40, which is located within the Cleveland Metroparks, is also designated as a State Resource Water. RM 4.70 on Big Creek is designated as agricultural water supply, industrial water supply, secondary contact recreation water, and a limited water resource – small drainageway maintenance. All of the samples collected for this study were in attainment of applicable Ohio Water Quality Standards (OAC 3745-1) with the exception of *Escherichia coli (E. coli)*. At both RM 0.15 and RM 4.40, the seasonal geometric mean of 161 colony-forming units per 100 milliliters (CFU/100 mL) was exceeded. The respective single sample maximums were also exceeded at RM 0.15, 4.40, and 4.70 in more than ten percent of samples taken during each 30-day period in which two or more samples were taken. Results are shown in Figures 2 and 3.

In the case of Big Creek RM 0.15, the exceedences on June 23, June 30, and July 14 were most likely due to wet weather. However, an improper connection, coupled with CSO discharges and urban and stormwater runoff, may have also contributed to the elevated bacteria densities. Approximately 1200 gallons per day of sanitary-sewage contaminated dry-weather flow was discovered in a storm sewer outfall downstream of CSO 045 on July 21, 2010. Bacteriological sampling results were as high as 225,000 CFU/100 ml (estimated count) of *E. coli* at the outfall. It was discovered that the east wing of Crestview Estates Apartment Complex was improperly connected to the storm sewer, which the City of Cleveland has since fixed. However, at the time this report was written, NEORSD was investigating other dry weather flow at the storm sewer outfall.

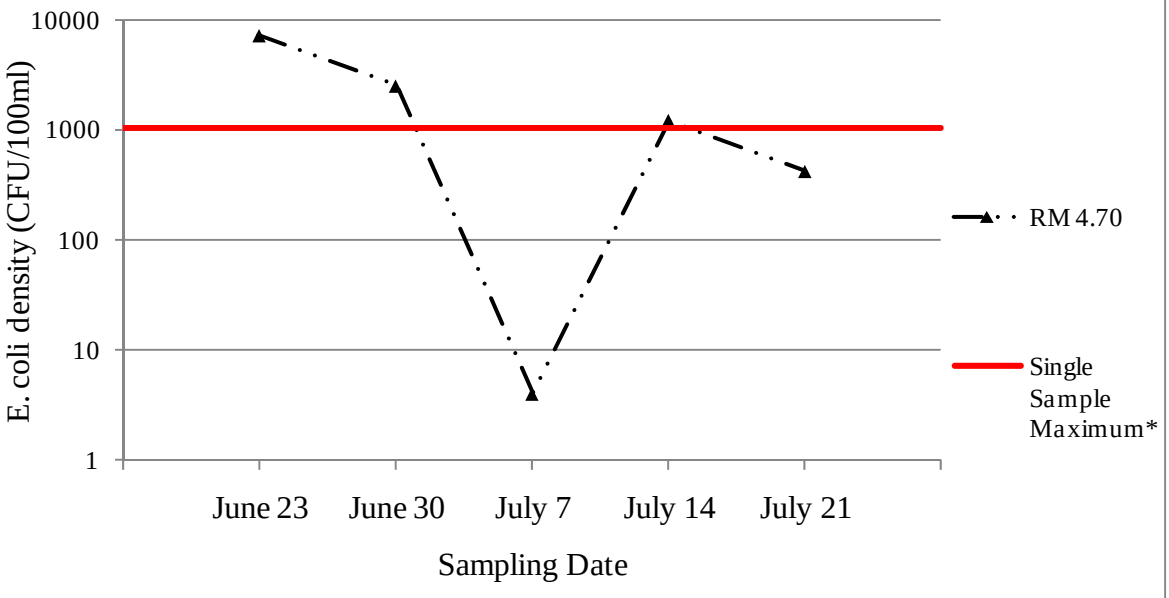
As for RM 4.40 and 4.70, the exceedences on June 23, June 30, and July 14 were most likely due to wet weather, but it is unclear what caused the elevated *E. coli* densities seen during dry weather, since both sites are upstream of NEORSD CSOs. Although no sources have been identified up to this point, potential sources of bacteriological contamination to the Big Creek watershed include sanitary sewer overflows, storm sewer outfalls, and urban and stormwater runoff.

Figure 2. 2010 *E. coli* Densities at Big Creek RM 0.15 and RM 4.40



* Class B Primary Contact Recreation *E. coli* single sample maximum of 523 CFU/100 ml not to be exceeded in more than 10% of the samples taken in a 30-day period. RM 0.15 and RM 4.40 exceeded this criterion, as well as the Class B Primary Contact Recreation *E. coli* seasonal geometric mean criterion of 161 CFU/100 ml

Figure 3. 2010 *E. coli* Densities at Big Creek RM 4.70



* Secondary Contact Recreation *E. coli* single sample maximum of 1030 CFU/100 ml not to be exceeded in more than 10% of the samples taken in a 30-day period. RM 4.70 exceeded this criterion.

Chlorophyll *a* sampling was also conducted at each site on September 22, 2010. The Ohio EPA is currently developing nutrient criteria for streams, and it is expected that these criteria will require chlorophyll *a* monitoring. The purpose of this sampling was to establish baseline levels for chlorophyll *a* and nutrients in Big Creek. Benthic chlorophyll *a* samples were collected from the algal biomass that is attached to the stream substrate, and water column samples captured the algal biomass that had sloughed off from the substrate. Table 3 below illustrates the results of this sampling.

Table 3. Chlorophyll *a* Sampling Results

	Unit	September 22, 2010		
		RM 0.15	RM 4.40	RM 4.70
Benthic Chlorophyll *a*	mg/m^2	27.6	29.6	103.2
Water Column Chlorophyll *a*	µg/L	2.02	2.66	2.737
Alkalinity	mg/L $CaCO_3$	116.6	104.9	132.9
Total Suspended Solids	mg/L	46	1.8	6.5
Turbidity	NTU	2.79	1.18	5.18
Total Phosphorus	mg/L	0.157	0.065	0.082
Soluble Reactive Phosphorus	mg/L	0.041	0.146	0.061
Nitrate +Nitrite	mg/L	0.336	0.412	0.68
Dissolved Oxygen	mg/L	9.96	10.92	6.6
Canopy	° open	119	39	97

As seen in Table 3, the water column chlorophyll *a* concentrations were similar among the sites. RM 4.70 had the highest benthic chlorophyll *a* concentrations, but all levels were below the change point of 107 mg/m^2 for the protection of biological integrity in high quality waters, derived by Miltner (2010). A change point, derived statistically in a change-point analysis, is a threshold in the explanatory (or independent) variable at which a significant change in the characteristics (such as mean and variance) of the response variable occurred (Qian et al, 2003).

Looking at the change points for benthic chlorophyll as the response variable, it is well documented that benthic chlorophyll levels are a function of light (open canopy) and nutrients (Miltner, 2010). The total phosphorus change point for benthic chlorophyll of 0.038 mg/L established by Miltner (2010) was exceeded at all three sites, which means that total phosphorus levels were high enough to cause an upward shift in benthic algal production. Ammonia-nitrogen was not measured, so it is unknown whether the dissolved inorganic nitrogen (DIN; the sum of ammonia-nitrogen and nitrate-nitrite nitrogen) change point of 0.435 mg/L for benthic chlorophyll was exceeded at RM 0.15 and 4.40 (Miltner 2010). However, it was exceeded at RM 4.70 by nitrate-nitrite nitrogen alone. Therefore, based upon these three change points, it appears that nutrient levels in Big Creek may be high enough to influence benthic algal production, but low enough that

benthic algae may not be negatively affecting the biological communities via dissolved oxygen levels. As explained below, information is needed on DO diurnal swings to evaluate this point.

As algae die off, they create an oxygen demand for bacterial decomposers that consume them; the greater the abundance of algae, the greater the oxygen demand. Algae can also affect diurnal DO ranges due to respiration. Dissolved oxygen levels were consistently much lower at RM 4.70 than at the other sites throughout the sampling season, differing by as much as 4.75 mg/L. It is important to note, however, that the lowest DO level in a diurnal range usually occurs in the morning, due to respiration of the algae overnight. All of the water chemistry grab samples were collected by noon, so additional evening sampling or installation of long-term data sondes instream will help determine whether the algae is causing large enough diurnal DO swings to negatively affect the biological communities, particularly the macroinvertebrates (Miltner, 2010). Although the low benthic chlorophyll levels in 2010 indicate that this may not be the case, additional sampling for chlorophyll *a*, nutrients, and dissolved oxygen is needed to better understand the effects, if any, that nutrients have on Big Creek.

Habitat Assessment

Qualitative Habitat Evaluation Index (QHEI) scores were determined for RM 0.15 and RM 4.40 on August 9, 2010, and for RM 4.70 on August 10, 2010. 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, stream channel morphology, riparian and bank condition, pool and riffle quality, and stream gradient. 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). A QHEI score of 60 or more suggests that sufficient habitat exists to support a fish community that attains the warmwater habitat criterion (Ohio EPA, 2003). In 2010, all three sites met the target score of 60 (Table 4). QHEI field sheets for each site are available upon request from the NEORSD Water Quality and Industrial Surveillance Division.

Table 4. 2010 Big Creek Qualitative Habitat Evaluation Scores

Site Location	Score	Narrative Score
River Mile 0.15	70.5	*Good*
River Mile 4.40	60.5	*Good*
River Mile 4.70	62.0	*Good*

RM 0.15 on the Main Branch of Big Creek begins downstream of the Jennings Road Pump Station and CSO 045, and extends to approximately 300 feet upstream of the confluence with the Cuyahoga River. The creek has a predominantly gravel and sand substrate and features a large riffle, several runs, and deep pools. Instream cover is moderate to sparse and consists of undercut banks, overhanging vegetation, slow shallows, boulders, and logs or woody debris. The creek has a very narrow riparian zone to buffer the surrounding urban and industrial land use, and the bank on river right has heavy to severe erosion.

RM 4.40 on the Main Branch of Big Creek is located within the Cleveland Metroparks Memphis Picnic Area, approximately 100 feet upstream of the confluence with the West Branch. The predominant substrates are boulders and bedrock surrounded by cobble, gravel, and sand, creating a series of riffles and runs. The site has no sinuosity, and channel walls still exist at the upstream end. Instream cover consists of slow shallows and high quality boulders. The banks have little to no erosion, and the bank on river left has a very narrow riparian zone compared with a moderate riparian zone on river right. The surrounding land use is primarily residential/park on river left and urban/industrial on river right.

RM 4.70 is located west of West 150th Street and north of Interstate 480. The substrate consists mainly of gravel and sand with some scattered boulders and cobble and sections of muck and detritus. The creek has low sinuosity, slow current velocity, and lacks a functional riffle. There is moderate instream cover consisting of undercut banks, overhanging vegetation, slow shallows, rootmats and rootwads, deep pools, boulders, and logs or woody debris. The creek has a narrow to very narrow riparian zone with little to no erosion, and the surrounding land use is urban/industrial. QHEI scores from 2007-2009 were all below 60, and the higher score in 2010 can be largely attributed to an increase in the amount and quality of instream cover.

Electrofishing

Methods

Longline electrofishing was conducted at least twice at each site. RM 0.15 was sampled on July 1, September 2, and September 23, 2010. RM 4.40 and RM 4.70 were each sampled on July 1 and September 8, 2010. Sampling consisted of shocking all habitat types within the sampling zone while moving from downstream to upstream. The sampling zone was 0.2 kilometers for RM 0.15, and 0.15 kilometers for RMs 4.40 and 4.70. The methods followed those described in Ohio EPA's *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987a) and *III* (1987b). Fish were identified to species level, counted, and examined for the presence of external anomalies including deformities, erosions, lesions, and tumors (DELTs). Fish at RM 0.15 were also weighed.

Fish were then returned to the waters from which they were collected with the exception of those collected as voucher specimens. Lists of the species, numbers, pollution tolerances and incidence of DELT anomalies are available upon request from the NEORSD Water Quality and Industrial Surveillance Division.

The electrofishing results for each pass were utilized to calculate the Index of Biotic Integrity (IBI) for RM 4.40 and 4.70 (headwater sites), and RM 0.15 (wading site). The IBI was developed by the Ohio EPA to evaluate fish community health by incorporating 12 metrics based upon structural and functional attributes of the fish community (Ohio EPA, 1987a). The structural attributes are based upon fish numbers and diversity, while the functional attributes reflect environmental tolerances, feeding strategies, reproductive requirements, and incidence of disease. The metrics are listed below, with headwater metrics listed first when they differ from wading metrics.

1. Number of native species
2. Number of darter species
3. Number of headwater species / sunfish species
4. Number of minnow species / sucker species
5. Number of sensitive species / intolerant species
6. Proportion of tolerant species
7. Proportion of omnivores
8. Proportion of insectivores
9. Proportion of pioneering species / top carnivores
10. Number of individuals
11. Number of simple lithophils
12. Proportion with DELT anomalies

Individual metric scores in each respective index are determined by comparing the fish data collected at RMs 0.15, 4.40, and 4.70 with values expected at reference sites in a similar geographical region. The individual metric scores were added together to produce an overall IBI score for each site. The maximum possible score is 60 and the minimum is 12. The IBI score corresponds to narrative ratings of *Exceptional, Good, Marginally Good, Fair, Poor,* or *Very Poor*.

The second index utilized by the Ohio EPA is the Modified Index of Well-being (MIwb). The MIwb, given in Formula 2, incorporates four fish community measures: numbers of individuals, biomass, and the Shannon Diversity Index (Formula 3) based on numbers and weight of fish. The result of the mathematical calculation is the MIwb score, which also corresponds to a narrative rating based upon the geographical region.

Formula 2: $$MIwb = 0.5\ lnN + 0.5\ lnB + \bar{H}(No.) + \bar{H}(Wt.)$$

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

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

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

Formula 3: $$\overline{H} = -\sum\left[\left(\frac{n_i}{N}\right)log_e\left(\frac{n_i}{N}\right)\right]$$

n_i = Relative numbers or weight of species

N = Total number or weight of the sample

Since the drainage area at RM 4.40 and RM 4.70 was less than 20 square miles, Ohio EPA's Modified Index of Well-Being (MIwb) was not calculated for those sites.

Results and Discussion

The Warmwater Habitat (WWH) IBI criteria in the Erie-Ontario Lake Plain (EOLP) ecoregion is 38 for wading sites and 40 for headwater sites. A site is considered in non-significant departure if it is within 4 IBI units of its applicable criterion. The MIwb criterion for wading sites is 7.9; non-significant departure is within 0.5 units. Although the biocriteria do not apply to limited resource waters such as RM 4.70, NEORSD conducted biomonitoring at this site for reference purposes only. Table 5 shows the individual scores for each pass conducted in 2010, and Table 6 lists the average IBI and MIwb scores for each site from 2007 – 2010.

Table 5. 2010 Big Creek IBI and MIwb scores

		1st Pass		2nd Pass		3rd Pass		Average	
Location	River Mile	IBI	MIwb	IBI	MIwb	IBI	MIwb	IBI	MIwb
Downstream of Jennings Road	0.15	26	5.8	32	6.6	28	5.9	29	6.1
Memphis MetroPark	4.40	34	---	*36*	---	---	---	35	---
West 150th Street	4.70	16	---	16	---	---	---	16	---

Italics = non-significant departure from WWH criterion (≥36 ICI units)

Table 6. 2007 – 2010 Average Big Creek IBI & MIwb Scores

			IBI		MIwb	
River Mile	Type	Year	Score	Narrative Rating	Score	Narrative Rating
0.15	Wading	2010	29[a]	Fair	6.1[a]	Fair
		2009	26	Poor	5.6	Poor
		2008	32[a]	Fair	6.6[a]	Fair
		2007	28[a]	Fair	5.3[a]	Poor
4.40	Headwater	2010	35[a]	Fair	---	---
		2009	*36*[b]	Marginally Good	---	---
		2008	32	Fair	---	---
		2007	34	Fair	---	---

Table 6. 2007 – 2010 Average Big Creek IBI & MIwb Scores						
			IBI		MIwb	
River Mile	Type	Year	Score	Narrative Rating	Score	Narrative Rating
4.70	Headwater	2010	16[a]	Very Poor	---	---
		2009	16	Very Poor	---	---
		2008	12	Very Poor	---	---
		2007	16	Very Poor	---	---

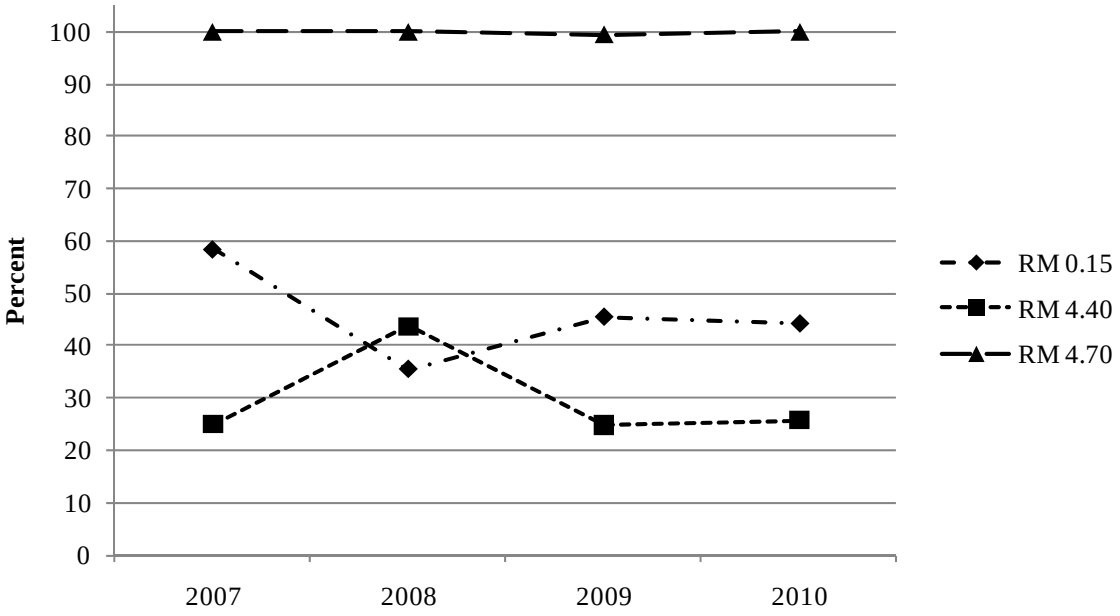
[a]Average score
[b]*Non-siginificant departure from WWH criterion (≥36 IBI units)*

River Mile 0.15

The fish community at RM 0.15 had an average IBI score of 29 and an average MIwb score of 6.1, both *Fair*. The fish community did not attain the WWH biocriteria. Twenty species of fish were caught in the three passes, and about 44% of the total catch consisted of highly pollution-tolerant individuals such as common white suckers (*Catostomus commersonii*), yellow bullheads (*Ictalurus natalis*), and green sunfish (*Lepomis cyanellus*). Yellow bullheads and white suckers each accounted for about 27.6% of the total biomass. Figure 4 below shows how the proportion of tolerant species at RM 0.15 compares with the other two sites.

Despite the prevalence of tolerant fishes, several species that contributed positively to the overall IBI score were found at this site for the first time in 2010. They include the warmouth sunfish (*Lepomis gulosus*), a top carnivore; the johnny darter (*Ethestoma nigrum*) and the common emerald shiner (*Notropis atherinoides*), both insectivores; and the golden redhorse (*Moxostoma erythrurum*), an insectivorous, simple lithophilic species. Given this site's close proximity to the Cuyahoga River, it is possible that these species are migrating upstream and are not representative of typical resident species found in Big Creek.

Figure 4: Proportion of Pollution-Tolerant Species at Big Creek RMs 0.15, 4.40, and 4.70 from 2007-2010



While the fish community at this site is not impaired to the same extent that the community at RM 4.70 is, the community IBI and MIwb scores are consistently lower than would be expected by the *Good* habitat score and the warmwater habitat use designation. Environmental stressors such as CSOs, the improper sanitary sewer connection, and urban and stormwater runoff may be negatively affecting the fish community. This is reflected in two metrics that have never scored above a 1 since NEORSD began sampling here. This includes the number of darter species (only two found, and not concurrently) and the number of individuals excluding tolerants. In 2007, 2009, and 2010, this site also had a greater proportion of DELT anomalies than both RM 4.70 and RM 4.40. DELT anomalies tend to occur most frequently in fish communities that are stressed by urban runoff and CSOs (Ohio EPA, 1987b).

River Mile 4.40

Big Creek River Mile 4.40 had an average score of 35, or *Fair*, in non-attainment of the WWH biocriterion. It should be noted that the IBI score from the second pass (36) was in non-significant departure of the biocriterion. The community continues to be dominated by central stoneroller minnows (*Campostoma anomalum*). A few individuals of a pollution sensitive species, the sand shiner (*Notropis stramineus*), have been found at this site since 2007. Sand shiners prefer riffles and pools with sand and gravel substrates, clear water with a swift current, and little to no siltation or aquatic vegetation (Trautman, 1981), all of which are found at this site. One individual of a related species, the

bigmouth shiner (*Notropis dorsalis*), was also found in 2010. Bigmouth shiners were first discovered at RM 4.40 in 2008, and are listed as a threatened species by the Ohio Division of Wildlife.

Bigmouth Shiner (*Notropis dorsalis*)

Since 2007, several metrics have never scored higher than a 1, the lowest score. These include the number of darter species, headwater species, sensitive species, and simple lithophilic species, as well as the proportion of insectivores. As the diversity of species in each of these five metrics increases, and the abundance of insectivores increases, the overall IBI score increases. The only headwater species found at this site was the western blacknose dace (*Rhinicthys atratulus*), which, along with the common white sucker, is also a simple lithophilic species. No darters have been found. On a better note, DELT anomalies have been consistently absent in the population. Given that this site is upstream of NEORSD CSOs, limiting factors for the community may be habitat characteristics such as a lack of diverse instream cover and deep pools, and the influx of urban and stormwater runoff.

River Mile 4.70

Big Creek River Mile 4.70 obtained a score of 16, or *Very Poor*, on both electrofishing surveys. The fish community in the first survey consisted of four common white suckers (*Catostomus commersonii*) and nine northern fathead minnows (*Pimephales promelas*), both highly tolerant species. The second survey saw higher abundances of these species plus a few individuals of two other highly tolerant species, the goldfish (*Carassius auratus*) (also an exotic species), and the creek chub (*Semotilus atromaculatus*). Northern fathead minnows are most abundant in small water bodies without competition from other fish species, particularly the bluntnose minnow (*Pimephales notatus*) (Trautman, 1981). Indeed, RM 4.70 had the lowest diversity of any of the sites and a complete absence of bluntnose minnows, and thus the largest fathead minnow population (almost 80% of the total catch). Eleven of the twelve metrics scored a 1 in each survey; the only metric that scored a 5 was the proportion of DELT anomalies, of which there were none. The fish community and the IBI metric scores at this site have remained relatively unchanged since sampling began in 2007.

Big Creek Ford Branch, which includes this site, is designated as a Limited Resource Water – small drainageway maintenance, which means that the site lacks the existence of, and potential for, the necessary channel morphology and habitat to support

any of the other aquatic life uses (warmwater habitat, coldwater habitat, etc) due to regular maintenance for drainage purposes (OAC 3745-1-07). Given this use designation, the *Very Poor* fish communities found at this site since 2007 are not unexpected. While the 2010 habitat score of 62 seems to indicate this site can support a warmwater community of fish, it should be noted that this site is almost entirely a slow-moving glide habitat with bacterial contamination, an embedded and often mucky substrate, and no functional riffle.

Macroinvertebrate Sampling

Methods

Quantitative macroinvertebrate sampling was conducted at RM 0.15, 4.40, and 4.70 using a modified multi-plate Hester-Dendy (HD) artificial substrate sampler. Five identical HD sampler replicates were tied to a cinder block and initially installed at each site on June 17, 2010, for a six-week period. The HDs were retrieved from RM 4.40 and 4.70 on August 2, 2010. The HD at RM 0.15 was reinstalled twice during the sampling season. The sampler was found missing on June 23, 2010, and a new one was installed on July 1; the HD may have been washed out due to a morning storm on June 22, 2010. After the second installation at RM 0.15 on July 1, 2010 there were two other storm events that occurred that may have been the reason the HD was displaced yet again. The HD was carefully moved upstream of the riffle on July 14, 2010, to prevent future relocation. Since macroinvertebrates were seen living on the HD and it was still under water, the installation period was not reset. The HD was retrieved on August 10, 2010.

Qualitative sampling with a D-frame dip net for all available taxa inhabiting all available habitats in the sampling area was conducted during each HD retrieval. Methods for sampling followed the Ohio EPA manual *Biological Criteria for the Protection of Aquatic Life, Volume III* (1987b). Stream flow was measured using a Marsh-McBirney FloMate Model 2000 Portable Flow Meter during HD installation and retrieval, and an NEORSD Macroinvertebrate Field Sheet was completed during HD retrieval at each site. The macroinvertebrate samples were sent to AMT in Ravenna, Ohio, for identification and enumeration. Specimens were identified to the lowest practical taxonomic level as described in the Ohio EPA *Biological Criteria for the Protection of Aquatic Life, Volume III* (1987b). Field sheets and taxa lists and enumerations are available upon request from the NEORSD Water Quality and Industrial Surveillance Division.

The macroinvertebrate community at each site was assessed using Ohio EPA's Invertebrate Community Index (ICI) (Ohio EPA, 1987a). The ICI consists of ten community metrics listed below. Metrics 1-9 are based upon the quantitative sample, while Metric 10 is based upon the taxa richness of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) in the qualitative sample.

1. Total number of taxa
2. Total number of mayfly taxa
3. Total number of caddisfly taxa
4. Total number of dipteran taxa
5. Percent mayflies
6. Percent caddisflies
7. Percent Tanytarsini midges
8. Percent other dipterans & non-insects
9. Percent tolerant organisms
10. Total number of qualitative EPT taxa

Scoring criteria for all ten metrics is dependent upon drainage area. The scoring of an individual sample is based on the relevant attributes of that sample compared to equivalent data from reference sites in the Erie-Ontario Lake Plain (EOLP) ecoregion. Metric scores range from six points for values comparable to exceptional community structure to zero points for values that deviate strongly from the expected range of values based on scoring criteria established by Ohio EPA (1989). The sum of the individual metric scores resulted in the ICI score for that particular location.

HDs and qualitative samples were collected at all three locations and an ICI score was determined from those samples. AMT calculated the ICI scores either by hand utilizing graphs from DeShon (1995), or from formulas received from the Ohio EPA in June 2008. Since stream flow over the HD is second only to water quality in determining the macroinvertebrate community represented during sampling, stream flow should be 0.3 feet per second (fps) or greater for comparability (DeShon, 1995). The flow during installation and retrieval at RM 0.15 and 4.40 met this requirement; flow at RM 4.70 was much lower, measured at 0.08 fps during installation and 0.10 fps during retrieval.

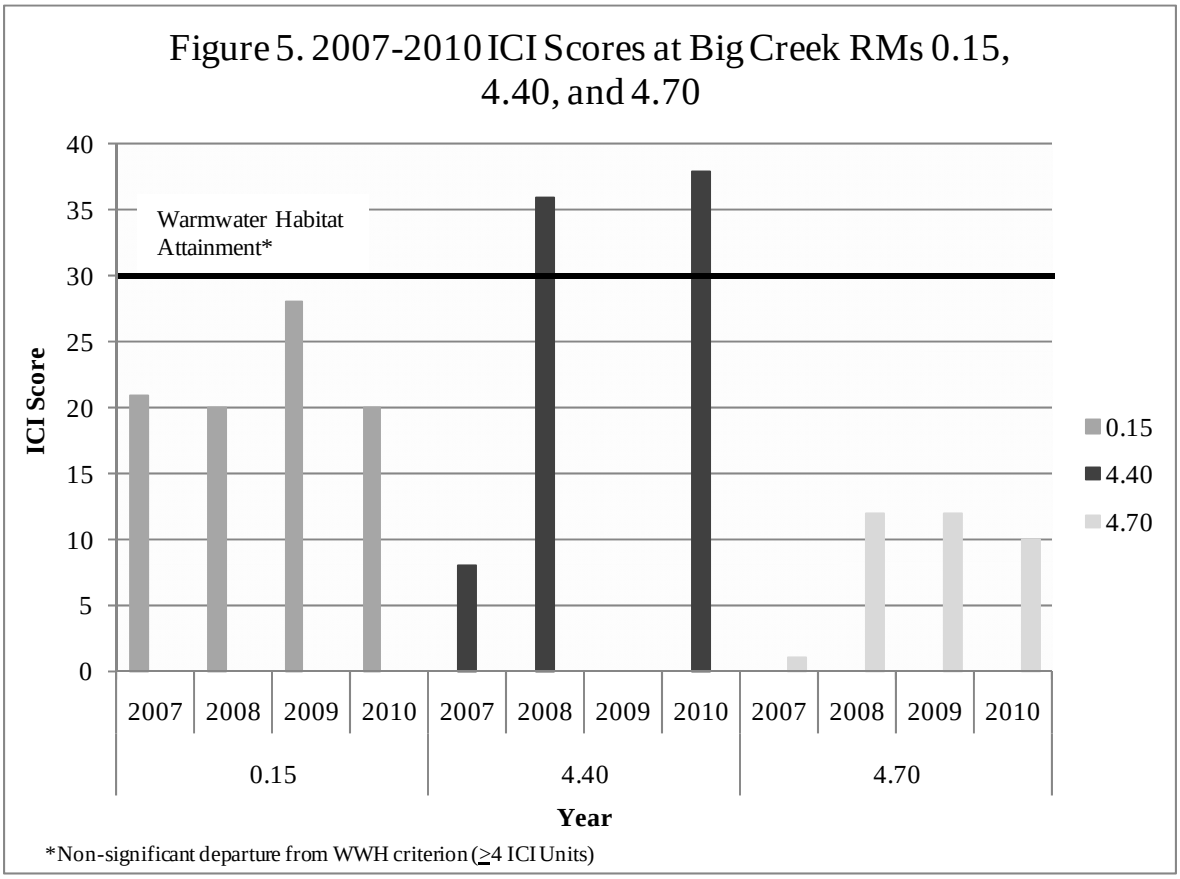
Results and Discussion

The WWH ICI criterion for the EOLP ecoregion is 34. This criterion applies to RM 0.15 and 4.40, but does not apply to RM 4.70 due to its designation as a Limited Resource Water. The ICI score from RM 4.70 will be utilized for discussion purposes only in this report. Table 7 summarizes the sampling results and Figure 5 shows historical ICI scores. Note: an HD was not collected at RM 4.40 in 2009.

Table 7. 2010 Big Creek Invertebrate Community Index (ICI) Results

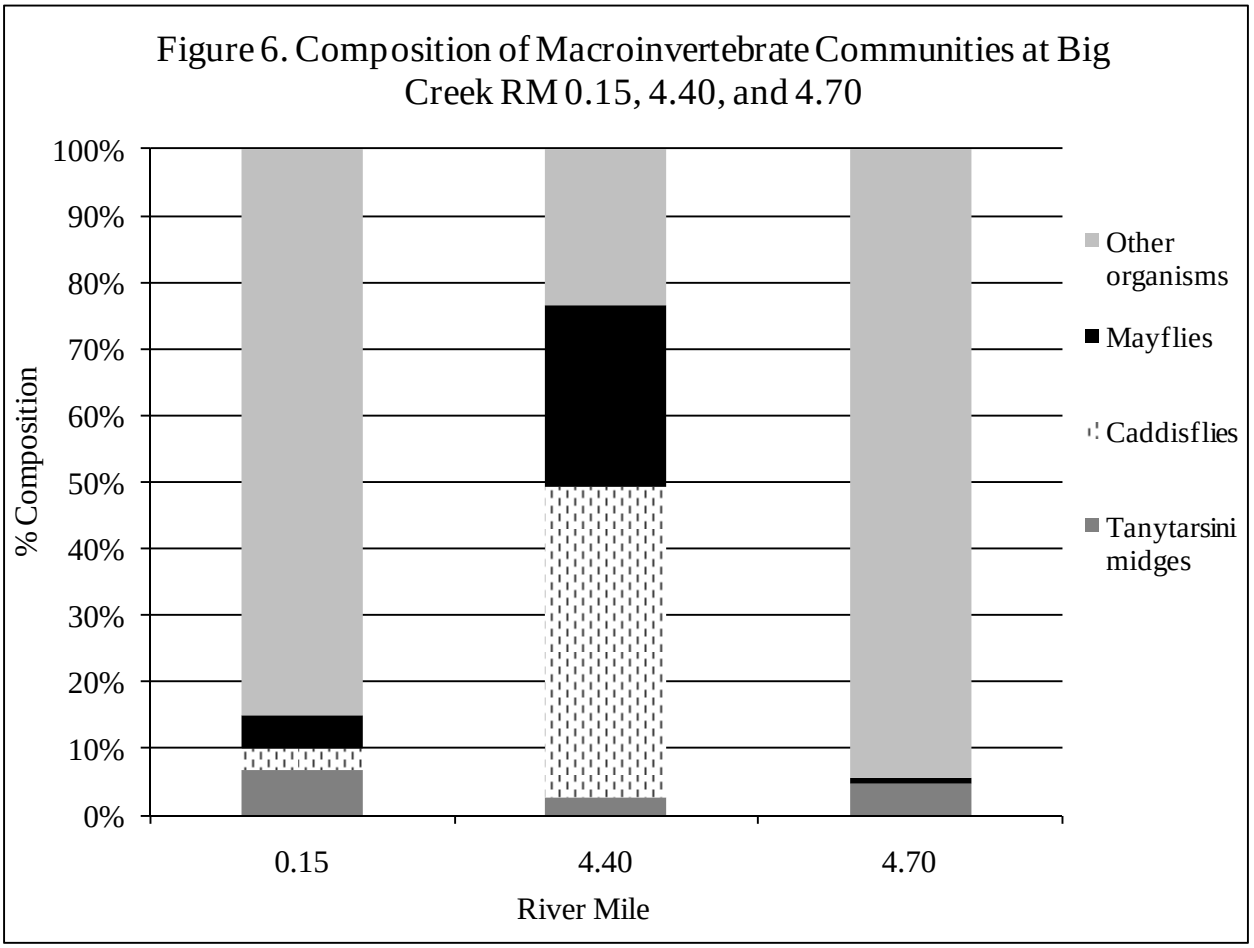
River Mile	ICI Score	Narrative Rating	Quantitative Taxa	Qualitative Taxa	Qualitative EPT Taxa
0.15	20	*Fair*	30	25	3
4.40	**38**	*Good*	23	24	6
4.70*	10	*Poor*	24	22	1

Bold = attainment of WWH criterion (ICI ≥ 34 units)
*The WWH biocriterion does not apply to this site.



River Mile 0.15

In 2010, Big Creek RM 0.15 obtained an ICI score of 20, or *Fair*, and did not attain the WWH biocriterion (Figure 5). This was a significant drop (≥ 4 ICI units) from 2009's score of 28, but was the same as the average score obtained in 2008. The percent Trichoptera in the HD sample also followed a similar pattern, dropping from 21% in 2009 to about 3% in 2010. Dipterans excluding tribe Tanytarsini midges and non-insects, mainly midges and pollution-tolerant aquatic worms, dominated the macroinvertebrate community. Only three EPT taxa were found in the qualitative sample, compared with six taxa in 2009. On a better note, a few moderately pollution-intolerant individuals appeared in the HD sample from the taxa *Ceratopsyche sparna*, *Ceratopsyche morosa* sp. group, *Rheotanytarsus* sp, and *Tanytarsus sepp*. Two individuals of the caddisfly species *Cyrnellus fraternus* were also found at this site for the first time in 2010.



The percent community composition for RM 0.15 is shown in Figure 6, above, along with RM 4.40 and 4.70. The macroinvertebrate community at RM 0.15 lacked the more balanced proportions seen at RM 4.40, where the community was in attainment of the WWH biocriterion. For example, mayflies comprised over 27% of the population at RM 4.40, compared with 5% at RM 0.15 and 0.64% at RM 4.70. Due to their sensitivity to pollution, mayflies are an indicator of good water quality, and their abundance diminishes rapidly under degrading environmental conditions (Ohio EPA, 1987a). The score at RM 0.15 had been steadily improving until 2010, when it dropped by 8 ICI units (Table 8). The contamination at RM 0.15 from sewage, low flow conditions in 2010, and other environmental factors may have negatively affected the macroinvertebrate community and contributed to the decrease in score.

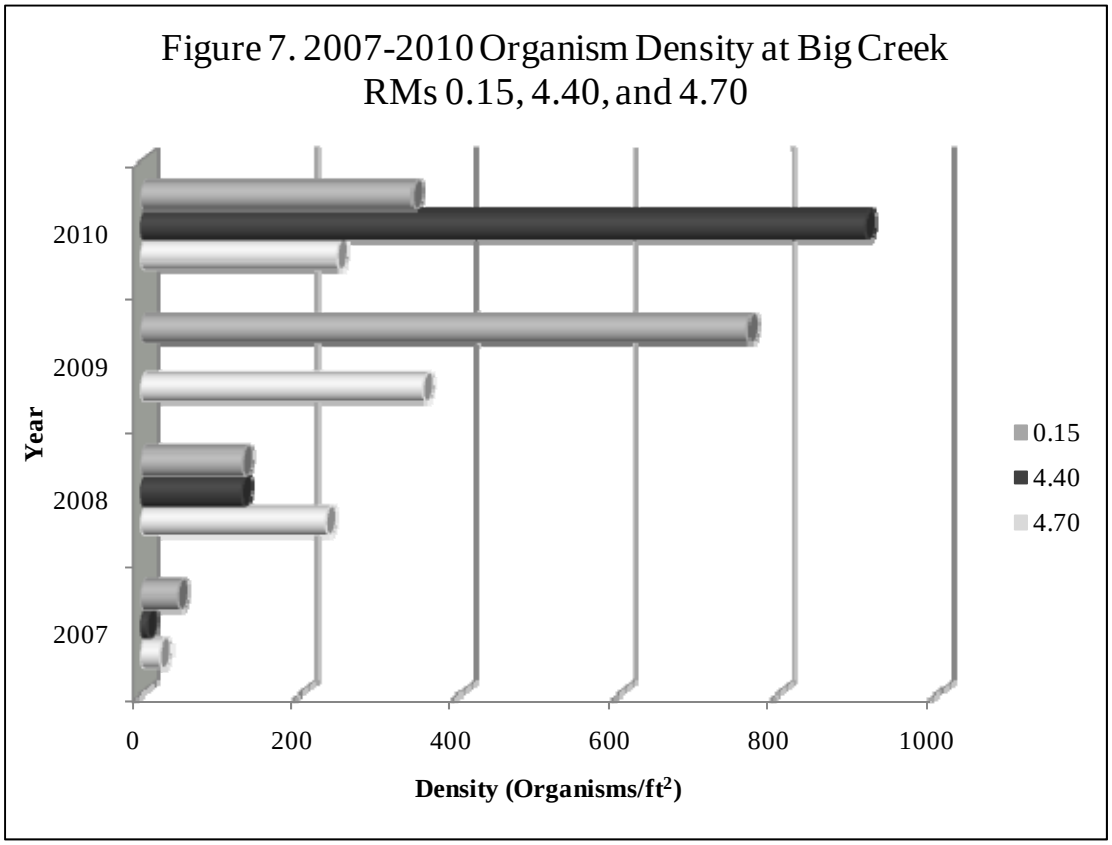
River Mile 4.40

In 2010, Big Creek RM 4.40 obtained an ICI score of 38, or *Good*, in attainment of the WWH biocriterion. This was two ICI units higher than the score obtained in 2008, and it is also consistent with the narrative rating in 2009, which indicated that the site had the potential to support a WWH macroinvertebrate community. As seen in Figure 6,

mayflies, particularly *Baetis flavistriga*, comprised 27.2% of the population in 2010, compared with 22.5% in 2008. The percent caddisflies also increased considerably from 4.9% in 2008 to 46.5% in 2010, but the tribe Tanytarsini midges, another pollution sensitive group, dropped from 33.8% to 2.6%. However, the percentage of tolerant organisms decreased by almost two-thirds from 2008 (10%) to 2010 (3.5%) and the total number of organisms increased sevenfold, indicating that water chemistry conditions may be improving at RM 4.40. This site also had bacteriological contamination, but it was generally less than RM 0.15.

The organism density, as shown in Figure 7, was low at each site in 2007 and steadily increased through 2009. Starting in 2009, techniques for anchoring and retrieving the HDs were changed for each site. In previous years, steel rebar was driven into the substrate to anchor the HD, but this would often cause undesirable relocation of the HD during high flow events. In 2009 and 2010, the HD cinderblock was placed on the stream bed and wedged into place with rocks. As for retrieval, techniques prior to 2009 involved detaching the HD samplers from the concrete block while still under water into a bucket equipped with a #30 sieve, removing the bucket from the stream, disassembling the HD samplers in the bucket, and placing the samplers into a 1000 milliliter container with 5 milliliters of formalin. However, it was believed that smaller organisms may have been able to escape through the #30 sieve. Beginning in 2009, HDs were detached from the concrete block and placed directly into separate plastic containers while under water, then removed from the stream and preserved with a formalin solution. This method is believed to produce a more accurate account of macroinvertebrates compared to previous years.

However, it is unclear whether, or if so to what extent, this change in methods impacted the organism density. The organism density at RM 4.70 increased from 2008 to 2009, but dropped back to 2008 levels in 2010. RM 0.15 saw a similar pattern, although the drop from 2009 to 2010 was not as pronounced. Density increased from 2008 to 2010 at RM 4.40, but without quantitative 2009 data, it is unknown whether this increase was consistent. The overall greater densities in 2009 and 2010 relative to earlier years may have been, at least in part, the result of the change in HD anchorage and retrieval techniques, which allowed for more of the smaller organisms to be retained in the sample. However, the decrease in organism density in 2010 at two of the three sites suggests that other factors, such as seasonal rainfall and potential sources of pollution, may have also played a role in affecting organism density.



River Mile 4.70

In 2010, Big Creek RM 4.70 obtained an ICI score of 10, or *Poor*. This was a drop of 2 ICI units from the score obtained in 2008 and 2009. Due to this site's designation as a Limited Resource Water, small drainageway maintenance, the WWH biocriterion does not apply. RM 4.70 continues to be dominated by pollution-tolerant organisms, mainly midges and aquatic worms. Sensitive mayflies and caddisflies have been either very low in abundance, or absent altogether. In 2010, only eight mayflies from the family *Baetidae* were collected on the HD, and caddisflies (*Cheumatopsyche* sp.) were collected only in the qualitative sample. As seen in Figures 6 and 7, RM 4.70 had the lowest density and diversity of organisms of the Big Creek sites in 2010.

A Qualitative Community Tolerance Value (QCTV) score was also calculated for RM 4.70 using the qualitative sampling data. The QCTV score is based solely upon qualitative sample, and is commonly calculated as the median pollution tolerance value from the collected species that have an associated tolerance value (DeShon, 1995). QCTV scores can be used in conjunction with best professional judgment to help determine attainment status when an HD is not recovered, or in the case of RM 4.70, when an HD was recovered but flow conditions were not optimal for colonization. Higher QCTV scores are related to the presence of taxa associated with higher ICI scores,

although a QCTV score and an ICI score are not directly comparable. If the QCTV score in the Erie Ontario Lake Plain (EOLP) ecoregion is less than 34.30, it is associated with the presence of taxa seen in waters that are typically associated with poorer water quality (Ohio EPA, 1999). RM 4.70 obtained a median QCTV score of 27.3 (25^{th} percentile - 21.7 and 75^{th} percentile - 34.3), which provides further evidence that the macroinvertebrate community does not have the potential to achieve the WWH criterion, even if it were applicable. The very low current velocity and contamination from urban runoff, as seen in the bacteriological results, and other environmental factors may be causing the degradation in the macroinvertebrate community.

Conclusions

The results of NEORSD's fish and benthic macroinvertebrate surveys, water chemistry sampling, and habitat assessments at RMs 0.15, 4.40, and 4.70 on Big Creek indicate that the stream continues to be impacted by a complex combination of environmental factors such as urban and stormwater runoff, CSOs, SSOs, and other sources of pollution not yet identified, although some indications of localized improvement are being seen.

RM 0.15, which is downstream of NEORSD CSOs near the confluence with the Cuyahoga River, was in non-attainment of the WWH biocriteria for fish and macroinvertebrates, with both communities receiving *Fair* ratings. RM 0.15 had the highest QHEI score of the three sites (70.5), indicating that the site should be capable of supporting a WWH community. However, sources of pollution associated with bacteriological contamination coupled with low flow in 2010 may be the cause for the lower than expected fish and macroinvertebrate community scores at this site. RM 0.15 had the two highest *E. coli* densities (43,000 CFU/100 mL on June 23 and 19,000 CFU/100 mL on July 14), which may be due to an improper sanitary connection discovered just upstream of the site in July, as well as the environmental factors mentioned above.

RM 4.70, a Limited Resource Water upstream of NEORSD CSOs, received *Very Poor* and *Poor* ratings for its fish and macroinvertebrate communities, respectively. The WWH biocriteria do not apply to this site, and several of the chemical criteria are less stringent than those associated with WWH criteria. Sources of pollution associated with bacteriological contamination, urban and stormwater runoff, and habitat limitations such as slow current velocity and the absence of a functional riffle, are expected to continue to limit the fish and macroinvertebrate communities at this site.

Of the three sites, RM 4.40, which is upstream of NEORSD CSOs, fared the best. Its fish community received an average IBI score just one unit below non-significant

departure of the WWH criterion, and its macroinvertebrate community achieved WWH attainment. This puts the site as a whole in partial attainment of the WWH biocriteria. The bigmouth shiner, a threatened species in Ohio, was also found at the site for the third year in a row. As for the Big Creek watershed as a whole, further efforts to reduce CSOs, SSOs, stormwater and urban runoff, and other potential sources of pollutants may contribute to the recovery of healthy biological communities in Big Creek.

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