NORTHEAST OHIO REGIONAL SEWER DISTRICT

2012 Mill Creek Environmental Monitoring: Biological, Water Quality, and Habitat Survey Results

Prepared by
The Water Quality and Industrial Surveillance Division

Introduction

In 2012, the Northeast Ohio Regional Sewer District (NEORSD) conducted stream monitoring activities at seven sites on Mill Creek, an urbanized tributary to the Cuyahoga River. Mill Creek has a natural waterfall, Mill Creek Falls (also known as Cataract Falls), that is a fish migration barrier at river mile (RM) 2.80. NEORSD assessed habitat and water chemistry conditions and evaluated the health of the fish and benthic macroinvertebrate communities at each site. The purpose of the 2012 monitoring was to gain an overall picture of the health of the creek and evaluate the impact of combined sewer overflows (CSO) and other environmental factors. The seven sites, which are along Mill Creek's Main Branch, are located at RMs 10.13, 8.30, 6.80, 3.15, 2.75, 0.70, and 0.12. These sites were first surveyed in 1995 as part of the Mill Creek Watershed Management Project, and were all surveyed again in 2011 and 2012.

Several of these locations also served as sites upstream and downstream of CSOs owned by NEORSD. The downstream site was located at RM 0.12, upstream of Canal Road, and the two upstream sites were located at RM 8.30 and 10.13. RM 0.12 and RM 8.30 have been sampled yearly since 1998 and 2002, respectively. Macroinvertebrate and water chemistry sampling at RM 0.12 was required by Ohio Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Permit No. 3PA00002*FD. A comparison of the fish and macroinvertebrate communities and the corresponding habitat and water chemistry data was used to help determine the extent to which the downstream communities were impacted by CSOs or other environmental factors.

The 2012 surveys were also in support of several NEORSD capital improvement projects designed to provide wet weather flow relief, stormwater storage capacity, and reduction/elimination of CSOs in the Mill Creek watershed. The Miles Avenue Relief Sewer (MARS) was completed in June 2010 and connects to the Lee Road Relief Sewer (LRRS), which began receiving live wastewater flow on June 28, 2012. The LRRS connects to the Mill Creek Tunnel, the third leg of which was under construction as Phase Three of the Mill Creek Tunnel Project (MCT-3C) until late 2012. The stream monitoring surveys will therefore also enable future evaluations of the effectiveness of the capital improvement projects in restoring the chemical and biological health of Mill Creek.

Stream monitoring activities were conducted at each site by NEORSD Level 3 Qualified Data Collectors certified by Ohio EPA in Fish Community Biology, Benthic Macroinvertebrate Biology, Chemical Water Quality, and Stream Habitat Assessment as explained in the NEORSD Study Plan *2012 Mill Creek Environmental Monitoring*, approved by Ohio EPA on May 15, 2012. The results obtained from these assessments were evaluated using the Ohio EPA's Qualitative Habitat Evaluation Index (QHEI), Index of Biotic Integrity (IBI), and Invertebrate Community Index (ICI). Water

chemistry data was compared to the Ohio Water Quality Standards (Ohio EPA, 2009a) to determine attainment of applicable designated uses. An examination of the individual metrics that comprise the IBI and ICI was used in conjunction with the water quality data and QHEI results in order to identify impacts to the fish and benthic macroinvertebrate communities, and results were compared to historical data to show temporal as well as spatial trends.

Figure 1 is a map of the sampling locations on Mill 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 (WQIS) Division.

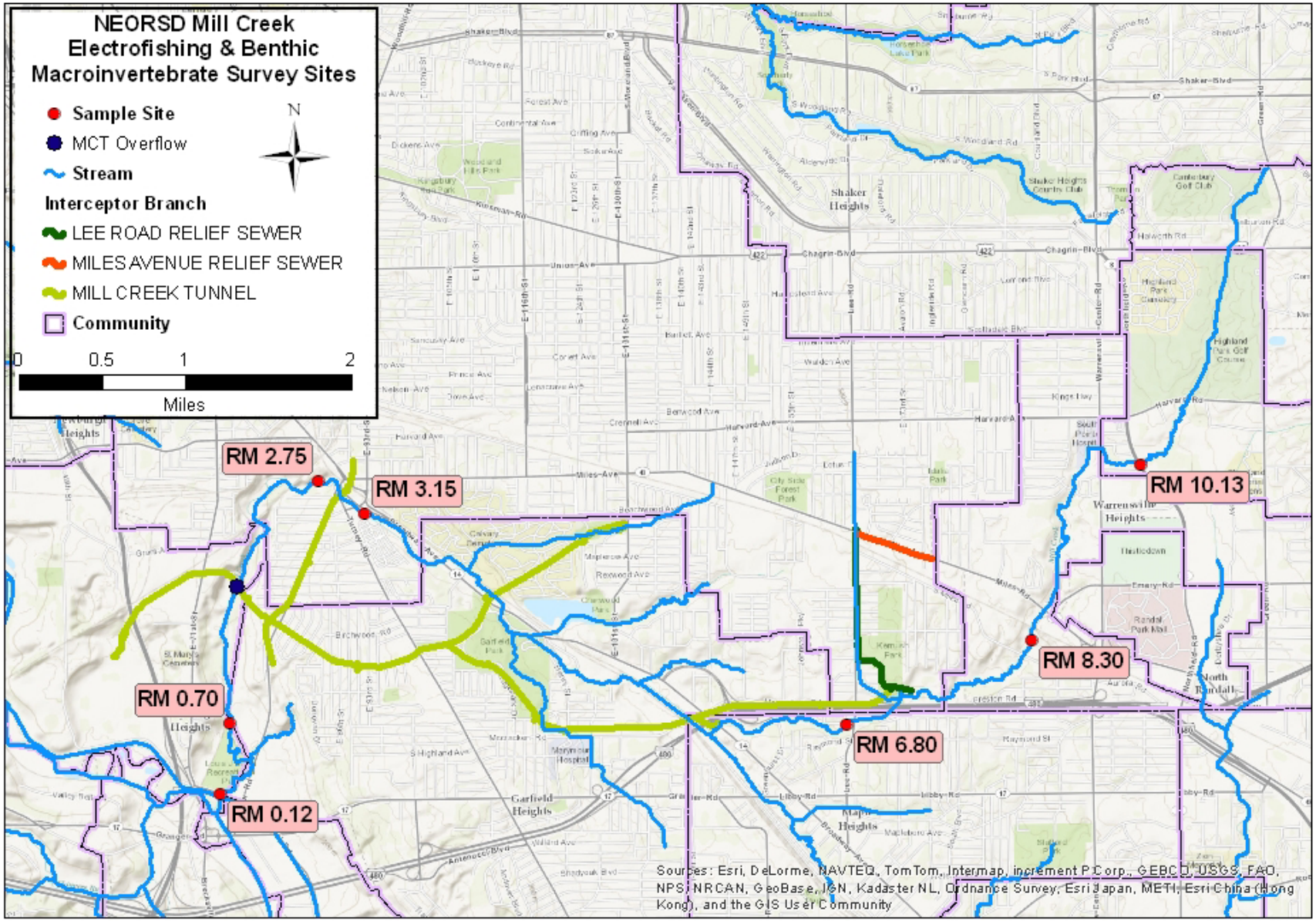


Figure 1. Sampling Locations

Table 1. 2012 Mill Creek Sampling Locations					
Location	Latitude	Longitude	River Mile	Location Information	Purpose[a]
Northfield Road	41.4460	-81.5312	10.13	Northfield Road	Evaluate overall watershed health, monitor in support of Capital Improvement projects
Upstream of South Miles Road	41.4305	-81.5442	8.30	Upstream of South Miles Road, upstream of Kerruish Park stormwater basin, first site upstream of NEORSD CSOs	Upstream of NEORSD CSOs, evaluate overall watershed health, monitor in support of Capital Improvement projects
Rex Avenue	41.4233	-81.5659	6.80	Rex Avenue, upstream of Wolf Creek, downstream of Kerruish Park stormwater basin	Evaluate overall watershed health, monitor in support of Capital Improvement projects
Upstream of Mill Creek Falls	41.4422	-81.6216	3.15	Broadway Avenue, upstream of Mill Creek Falls and downstream of Wolf Creek	Evaluate overall watershed health, monitor in support of Capital Improvement projects
Downstream of Mill Creek Falls	41.4451	-81.6271	2.75	Downstream of the Mill Creek Falls	Evaluate overall watershed health, monitor in support of Capital Improvement projects
Upstream of Warner Road Tributary	41.4240	-81.6376	0.70	Upstream of the Warner Road Tributary, adjacent to 5000 Warner Road	Evaluate overall watershed health, monitor in support of Capital Improvement projects
Upstream of Canal Road	41.4178	-81.6387	0.12	Upstream of Canal Road	Evaluate overall watershed health, monitor in support of Capital Improvement projects. Site required by Ohio EPA NPDES Permit No. 3PA00002*FD[b]

[a] Water Chemistry, habitat, fish, and benthic macroinvertebrates were evaluated at each site.
[b] Water chemistry and benthic macroinvertebrate monitoring was required at RM 0.12 by Ohio EPA NPDES Permit No. 3PA00002*FD.

Water Chemistry Sampling

Methods

Water chemistry and bacteriological sampling was conducted five times between June 19, 2012 and July 17, 2012, on Mill Creek at RMs 10.13, 8.30, 6.80, 3.15, 2.75, 0.70, and 0.12. To fulfill permit requirements under Ohio EPA NPDES Permit Number 3PA00002*FD, a sixth sample was collected at RM 0.12 on July 24, 2012. Techniques used for sampling and analyses followed the *Manual of Ohio EPA Surveillance Methods*

and Quality Assurance Practices (2012) and the Ohio EPA *Surface Water Field Sampling Manual* (2013). Chemical water quality samples from each site were collected with two 4-liter disposable polyethylene cubitainers with disposable polypropylene lids and two 473-mL plastic bottles. One of the plastic bottles was field preserved with trace nitric acid and the other was field preserved with trace sulfuric acid. All water quality samples were collected as grab samples. Bacteriological samples were collected in sterilized plastic bottles. At the time of sampling, measurements for dissolved oxygen, pH, temperature, and conductivity were collected using a YSI 600XL sonde. Duplicate samples and field blanks were collected at randomly selected sites, at a frequency not less than 10% 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, 2013).

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

X = sample/detection limit ratio

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

Mercury analysis for all of the sampling events was 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 Mill Creek was in attainment of those criteria. Instead, this type of mercury sampling was used as a screening tool to determine whether contamination was present above those levels typically found in the creek.

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

Results and Discussion

Five field blanks and five duplicate samples were collected during the study; one of each was collected during the first five sampling events. For the field blanks, there were 13 parameters that showed possible contamination. It is unclear how the field blanks became contaminated and may be due to inappropriate sample collection, handling, contaminated blank water and/or interference. Table 2 lists water quality parameters that were rejected, estimated, or downgraded from Level 3 to Level 2 data based on Ohio EPA data validation protocol.

Table 2. Parameters affected by possible blank contamination			
Al	Cd	Cr^{+6}	Cu
DRP	Hg	NH_3	NO_2
NO_3+NO_2	Ti	TP	Turbidity
Zn			

For the five sets of duplicate samples that were collected, all of them had at least one parameter for which the RPD between the sample results was greater than acceptable (Table 3). Generally, no parameter was consistently a problem throughout the sampling; therefore the exact reasons for the discrepancies remain unknown. Potential sources include lack of precision and consistency in sample collection and/or analytical procedures, environmental heterogeneity and/or improper handling of samples.

Table 3. Duplicate samples with greater than acceptable RPDs		
Site	Date	Parameters
RM 10.13	6/26/12	Fe, Mn, TSS, Turbidity
RM 8.30	7/17/12	NH_3, TSS, Turbidity
RM 2.75	6/19/12	Hg
RM 0.70	7/10/12	Na
RM 0.12	7/24/12	NH_3, NO_3, NO_3+NO_2

An analysis of paired parameters throughout the sampling showed that all of the chromium and hexavalent chromium results, with the exception of one sample, needed to be either listed as estimated or rejected entirely. The reason for these parameters not meeting Ohio EPA's requirements may include differences in sampling and analysis methods, especially interferences in the determination of hexavalent chromium from other metals or turbidity (Eaton, Clesceri, & Greenberg, 1995).

Each of the seven sites on Mill Creek is designated as warmwater habitat (WWH), agricultural water supply, industrial water supply, and Class B primary contact recreation waters. Exceedances of the water quality standards associated with these uses occurred for only bacteria and mercury. The bacteriological criteria for *E. coli* consist of two components: a seasonal geometric mean and a value not to be exceeded in more than 10% of the samples collected during a 30-day period (single sample maximum). For those streams designated Class B primary contact recreation, these criteria are 161 colony-forming units (CFU)/100mL and 523 CFU/100mL, respectively. The seasonal geometric mean criterion was exceeded at all seven sites (Table 4). The single sample maximum criterion was also exceeded at all of the sites in each 30-day period with two or more samples.

Table 4. 2012 Mill Creek *E. coli* Densities (colony-forming units/100mL)

Date	RM 10.13	RM 8.30	RM 6.80	RM 3.15	RM 2.75	RM 0.70	RM 0.12
6/19/2012*	767	1533	10,000	8000	7200	1240	1380
6/26/2012	123	265	10,000	32,400	667	320	542
7/2/2012	920	860	5500	3300	700	680	820
7/10/2012	780	210	1033	1200	315	334	384
7/17/2012	700	383	31,400	1833	767	1133	1067
7/24/2012	---	---	---	---	---	---	298
Seasonal Geomean	543	489	7084	4518	959	633	649

*Wet weather event
--- No sample collected

Exceeds single sample maximum criterion for 30-day period starting on that date

Wet weather[1] could account for the elevated bacterial levels during the first sampling event; however, the rest of the samples were collected during dry weather. Rainfall resulted in 12 recorded wet weather overflows to Mill Creek during the period from June 15 to October 15, 2012 (Table 5), compared to 24 in 2011. These overflows contained a mixture of rainwater, urban and stormwater runoff, and raw sewage. Most of the sites had seasonal geometric means that were lower than in 2011. The exceptions to this were the site at RM 6.80, which was much higher in 2012, and the site at RM 3.15, which was about the same. The general decrease in the number of overflows and an overall lower amount of precipitation most likely caused the generally lower *E. coli* densities in 2012.

[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, the samples collected that day and the following two days are considered wet weather samples.

Table 5. Overflows to Mill Creek from June 15 to October 15, 2012			
Outfall Name	Location	Number of Overflows	Million Gallons (MG)
CSO 072	East 78th Street & Harvard Avenue	8	1.461
CSO 025	East 131st Street & Cranwood Park Boulevard	3	0.090
Mill Creek Tunnel Overflow	Shaft #3 Silo at Harvard Landfill	1	9.458

The human health nondrinking water and wildlife outside mixing zone average (OMZA) criteria for mercury, 0.0031 ug/L and 0.0013 ug/L, respectively, were also exceeded at all seven sites in 2012 (Table 6). The concentrations that were measured, however, did not indicate any contamination above normal levels. Atmospheric deposition may be a source of mercury in the Mill Creek watershed.

Table 6. 2012 Mill Creek Mercury Concentrations (µg/L)							
	RM 10.13	RM 8.30	RM 6.80	RM 3.15	RM 2.75	RM 0.70	RM 0.12
6/19/2012	<0.005	j0.017	j0.015	j0.016	--[1]	<0.005	<0.005
6/26/2012	j0.085	j0.008	j0.009	j0.012	j0.01	j0.009	j0.012
7/2/2012	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
7/10/2012	j0.015	j0.013	j0.014	j0.016	j0.013	j0.013	j0.014
7/17/2012	j0.01	j0.0095	j0.011	j0.008	j0.011	j0.022	j0.01
7/24/2012	---	---	---	---	---	---	<0.005

[1] Result did not meet requirements for Ohio EPA level 3 credible data

--- Sample not collected

Exceedance of Wildlife and Aquatic Life OMZAs for 30-day period beginning with that date, assuming "j" values are actual concentrations and concentrations below the MDL are zero.

Habitat Assessment

Methods

Instream habitat assessments were conducted once at each site on Mill Creek in 2012 using the Qualitative Habitat Evaluation Index (QHEI). The QHEI was developed by the Ohio EPA to assess aquatic habitat conditions that may influence the presence or absence of fish species by evaluating the physical attributes of a stream. The index is based on six metrics: stream substrate, instream cover, channel morphology, riparian

zone and bank condition, pool and riffle quality, and stream gradient. The QHEI has a maximum score of 100, and a score of 60 or more suggests that sufficient habitat exists to support a fish community that attains the warmwater habitat criterion (Ohio EPA, 2003). A more detailed description of the QHEI can be found in Ohio EPA's *Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)* (2006). QHEI field sheets for each site are available upon request from the NEORSD WQIS Division.

Results and Discussion

The QHEI scores for each of the sites are shown in Table 7, below, and Figure 3. Each of the sites met the target QHEI score of 60, and the scores at RMs 10.13, 8.30, 2.75, and 0.70 also exceeded a score of 70 for headwater sites, which indicates that they have the potential to support exceptional warmwater fish communities.

Table 7. 2012 Mill Creek QHEI Results and Stream Flows

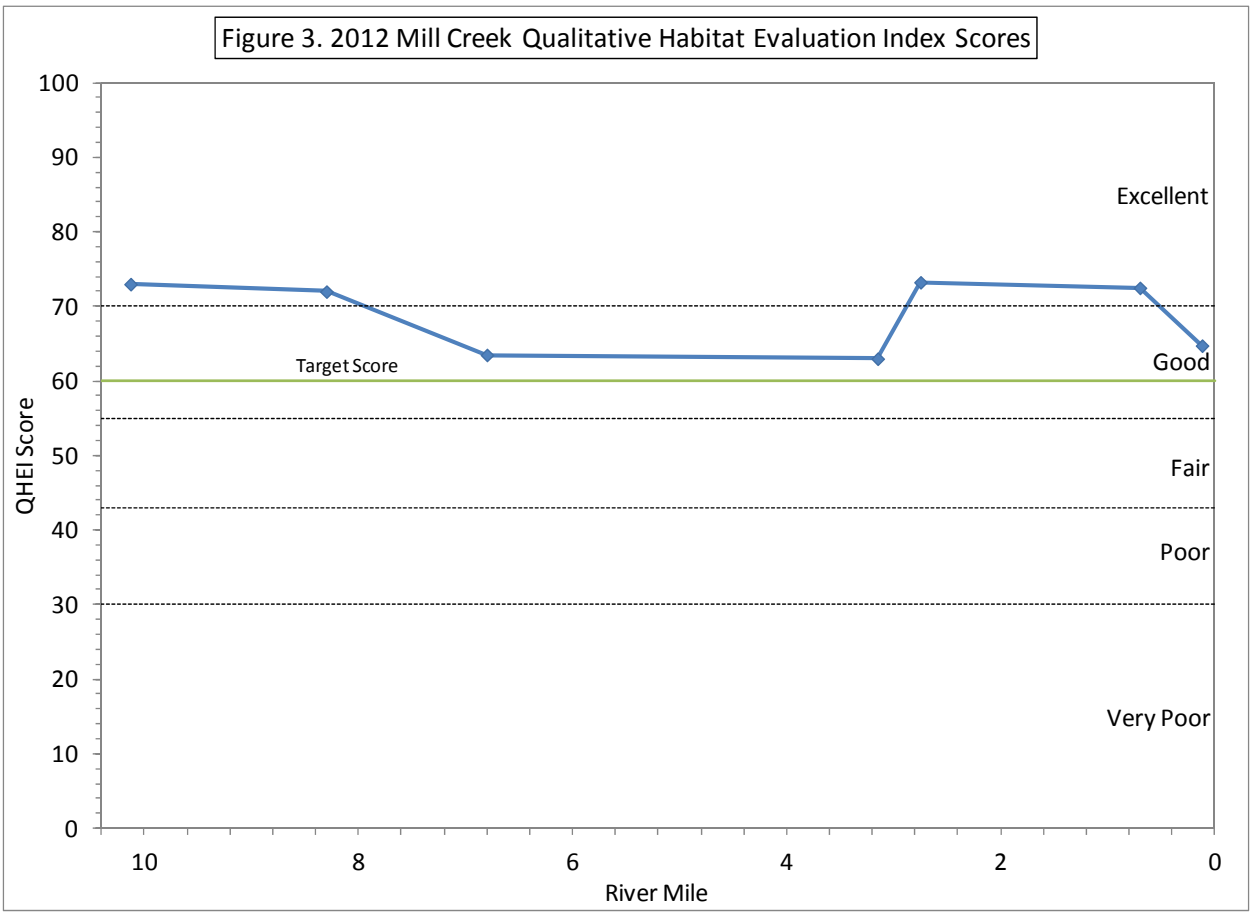
River Mile	Date	QHEI Score	Narrative	Stream Flow (ft^3/s)*
10.13	September 10, 2012	73	*Excellent*	10
8.30	September 21, 2012	72	*Excellent*	5.7
6.80	September 21, 2012	63.5	*Good*	5.7
3.15	September 21, 2012	63	*Good*	5.7
2.75	October 1, 2012	73.25	*Excellent*	6.5
0.70	October 1, 2012	72.5	*Excellent*	6.5
0.12	October 1, 2012	64.75	*Good*	6.5

*Provisional flow data obtained from USGS 04208460 Mill Creek flow gauge in Garfield Heights, Ohio

Cobble, gravel, and/or sand were the predominant substrates throughout Mill Creek with the exception of RM 2.75, which was dominated by boulders in the downstream section of the electrofishing zone and bedrock in the upstream section. Instream cover was sparse to nearly absent in the five downstream sites, and approaching moderate in the upper two sites. There are pockets of woods and fields along Mill Creek, but much of the watershed is residential, urban, and/or industrial, and the uppermost headwaters of Mill Creek are surrounded by golf courses. Most of the sites were at least moderately embedded, with RM 0.12 exhibiting spongy deposits, and the stream bottom was littered with artificial substrate such as bricks and broken cement.

In addition to examining overall QHEI scores, individual components of the index can also be used to evaluate whether a site is capable of meeting the warmwater habitat designated use (Table 8). This is done by categorizing specific attributes as indicative of either a warmwater habitat or modified warmwater habitat (Rankin, 1995). Attributes that are considered characteristic of modified warmwater habitats are further classified as

being of moderate or high influence to 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 warmwater habitat attainment (Ohio EPA, 1999).



Only one site, RM 8.30, had less than one high and four moderate-influence attributes. This site scored in the *Excellent* range, as did RMs 10.13, 2.75 and 0.70. RM 8.30 also had the greatest number of WWH attributes, with RM 0.70 a close second. As for the rest of the sites, most lacked adequate instream cover, a high-influence attribute, and had four or more moderate-influence attributes, mostly related to fair to poor development, low sinuosity, and moderate to high embeddedness of riffles and the overall stream reach. The presence of these modified warmwater habitat characteristics indicates that these sites would be less likely to meet the warmwater habitat criterion. While these limitations may help define whether the sites can physically support warmwater habitat fish communities in and of themselves, it is important to note that Mill Creek Falls, located at RM 2.80, acts as a migration barrier to fish from the Cuyahoga River and lower reaches of Mill Creek that may otherwise colonize these sites in accordance with their habitat and water quality characteristics.

Table 8. Qualitative Habitat Evaluation Index scores and physical attributes																																
				MWH Attributes																												
				WWH Attributes											High Influence						Moderate Influence											
River Mile	Average IBI Score	QHEI Score	Habitat Rating	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinousity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max. Depth >40 cm	Low-Normal Riffle Embeddedness	**Total WWH Attributes**	Channelized or no Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max. Depth <40 cm (WD, HW sites)	**Total High Influence Attributes**	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	**Total Moderate Influence Attribute**
10.13	20	73	Excellent	x				x				x		3				x		1					x				x	x	x		4
8.30	22	72	Excellent	x	x		x	x	x	x		x		7						0										x	x		2
6.80	22	63.5	Good	x	x					x		x		4				x		1		x			x	x				x	x		5
3.15	20	63	Good	x								x		2				x		1					x	x			x	x	x		5
2.75	30	73.25	Excellent	x	x					x		x		4				x		1					x	x				x	x		4
0.70	38	72.5	Excellent		x		x	x		x		x	x	6	x			x		2		x								x			2
0.12	38	64.75	Good				x			x		x		3				x		1	x					x				x	x		4

Electrofishing

Methods

Longline electrofishing was conducted once at RMs 10.13, 8.30, 6.80, 3.15, 2.75, and twice at RMs 0.70 and 0.12 on Mill Creek in 2012. A list of the dates when the surveys were completed, along with flow as measured at the United States Geological Survey gage station in Garfield Heights, is given in Table 9. Sampling was conducted using longline electrofishing techniques and consisted of shocking all habitat types within a sampling zone while moving from downstream to upstream. The sampling zone was 0.15 kilometers for each site. The methods that were used followed Ohio EPA protocol methods as detailed in *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987a) and *III* (1987b). Fish collected during the surveys were identified 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 9. Sampling Dates and River Flows**

Date	Sites sampled (RMs)	Daily Mean Flow (CFS*)
6/18/12	10.13, 6.80	12
6/20/12	8.30	5.2
6/21/12	3.15, 2.75, 0.70,	4.3
10/1/12	0.70	6.5

*Provisional data

**Measured at USGS 04208460 Mill Creek flow gauge in Garfield Heights, Ohio.

The electrofishing results for each pass were compiled and utilized to evaluate fish community health through the application of two Ohio EPA indices, the Index of Biotic Integrity (IBI) and the Modified Index of Well-Being (MIwb). The IBI incorporates 12 community metrics representing structural and functional attributes. The structural attributes are based upon fish community aspects such as fish numbers and diversity. Functional attributes are based upon fish community aspects such as feeding strategies, environmental tolerances, and disease symptoms. These metrics are individually scored by comparing the data collected at the survey site with values expected at reference sites located in a similar geographical region. The maximum possible IBI score is 60 and the minimum possible score is 12. 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 headwater are listed in Table 10.

Table 10. IBI Metrics (Headwater)
Total number of Native Species
Number of Darters & Sculpins
Number of Headwater Species
Number of Minnow Species
Number of Sensitive Species
Percent Tolerant Species
Percent Pioneering Species
Percent Omnivores
Percent Insectivores
Number of Simple Lithophils
Percent DELT Anomalies
Number of Fish

Individual metric scores in each respective index are determined by comparing the fish data collected at each site 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 a narrative rating of *Exceptional, Very Good, Good, Marginally Good, Fair, Poor,* or *Very Poor*.

Lists of the species, numbers, pollution tolerances and incidence of DELT anomalies for fish collected during the electrofishing passes at each site are available upon request from the NEORSD WQIS Division.

Results and Discussion

The WWH IBI criterion in the Erie-Ontario Lake Plain (EOLP) ecoregion is 40 for headwater sites. A site is considered in non-significant departure if it is within 4 IBI units of its applicable criterion. Therefore, an IBI score of 36 is considered to be in attainment. The two most downstream sites were in attainment of this criterion, while the other ones failed to meet it (Table 11). Scores in 2012 were the same or similar to those in 2011 (Table 12). Generally, no significant changes in IBI scores have occurred at the four most upstream sites since the first time that NEORSD surveyed them. For the other three sites, however, there has been an overall increase in scores.

Table 11. 2012 Mill Creek IBI Results						
River Mile	Average IBI Score	Narrative	Individual IBI Scores	Total No. of Species	No. of Native Species	No. of fish collected
10.13	20	*Poor*	20	3	2	243
8.30	22	*Poor*	22	3	3	217
6.80	22	*Poor*	22	3	3	106
3.15	20	*Poor*	20	2	2	264
Mill Creek Falls						
2.75	30	*Fair*	30	8	7	248
0.70	*38*	*Marginally Good*	36	13	12	1521
			40	18	17	1472
0.12	*38*	*Marginally Good*	32	13	13	858
			44	17	16	658
*Provisional flow data obtained from USGS 04208460 Mill Creek flow gauge in Garfield Heights, Ohio *Non-significant departure from WWH criterion (≥36 IBI units)*						

Table 12. Mill Creek Historic IBI scores							
Year	RM 10.13	RM 8.30	RM 6.80	RM 3.15	RM 2.75	RM 0.70	RM 0.12
1995	19	---	17	16	17	22	18
2007	---	22	---	---	---	---	32
2008	---	20	---	---	---	---	24
2009	---	22	---	---	---	---	36
2010	---	23	---	---	---	---	33
2011	20	22	22	23	31	36	36
2012	20	22	22	20	30	38	38
Bold = meets WWH criterion [IBI ≥40]							
Italics = non-significant departure from WWH criterion [IBI ≥36]							
--- Sampling not conducted							

The fish communities upstream of the Mill Creek Falls showed the influence of that barrier on them. The total number of species collected at each site was limited to either two or three even though the habitat should have been capable of supporting more. Nearly all of the fish collected at these sites were either blacknose dace or creek chubs. Because these species can act as generalist feeders, the metric score for the proportion of omnivores, which scored a "5" at all of the sites, may have been inflated. However, because the macroinvertebrate sampling indicated a potentially adequate number of organisms, it is uncertain what the dominant food source was for these fish. As a result of this uncertainty, no adjustments to the overall IBI scores were made for these sites. The only other metric that scored a "5" was the number of DELTs; only 2 in total were found at the four sites. In addition to the Mill Creek Falls, pollution by CSOs, illicit

discharges or stormwater and urban runoff, as indicated by elevated *E. coli* densities, may have also been a contributing factor to the poor fish community, especially at RMs 6.80 and 3.15. All of the fish collected at these four sites were pollution-tolerant species.

At the downstream sites, the fish community was much healthier. For the two most downstream sites, 2012 was the second year in a row in which the IBI criterion was met. Reductions in combined and sanitary sewage within this section of the creek due to the construction of the Mill Creek Tunnel may have allowed a greater number of migrating fish from the Cuyahoga River to move into the creek. A lack of darter and headwater species indicates, though, that there may still be some water quality issues remaining in the creek as these species are typically found in areas with low environmental stress (Ohio EPA, 1987b). Although the site immediately downstream of Mill Creek Falls failed to meet the WWH criterion, a larger number of species was collected there than upstream of the falls. Possibly, a fewer number of fish from the Cuyahoga river are making it to that site than those further downstream, though there are no physical barriers preventing them from doing so. Even so, the increase in IBI scores since sampling first was conducted there in 1995 indicates a general improvement in the fish community with the potential for scores to increase further in upcoming years.

Macroinvertebrate Sampling

Methods

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

The macroinvertebrate samples were sent to Midwest Biodiversity Institute (MBI) of Columbus, Ohio, 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 the NEORSD WQIS Division.

The overall aquatic macroinvertebrate community in the stream was evaluated using Ohio EPA's Invertebrate Community Index (ICI) (OEPA 1987a, Ohio EPA undated). The ICI consists of ten community metrics (Table 13), each with four scoring categories. Metrics 1-9 are based on the quantitative sample, while Metric 10 is based on

the qualitative EPT taxa. The total of the individual metric scores result in the overall score. This scoring evaluates the community against Ohio EPA's reference sites for each specific eco-region.

Table 13. 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

Results and Discussion

The WWH ICI criterion in the EOLP ecoregion is 34. A site is considered in non-significant departure if it is within 4 ICI units of the criterion and therefore would also be in attainment. All of the sites met or were within non-significant departure of the criterion in 2012, rating either *Good* or *Marginally Good* (Table 14). The site that scored the lowest, but was still in attainment of the criterion, was the one at RM 6.80. This site had the lowest density of organisms and had a relatively high percentage of organisms considered tolerant to pollution.

Table 14. 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
Northfield Road	10.13	36	399	37	3	5.0	Good
Upstream of South Miles Road	8.30	38	388	41	4	10.3	Good
Rex Avenue	6.80	30	101	39	4	42.8	Marginally Good

Table 14. 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 Mill Creek Falls	3.15	34	495	39	5	1.2	Good
Downstream of Mill Creek Falls	2.75	40	343	38	5	3.6	Good
Upstream of Warner Road Tributary	0.70	36	890	35	6	1.4	Good
Upstream of Canal Road	0.12	38	1092	43	6	7.4	Good

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

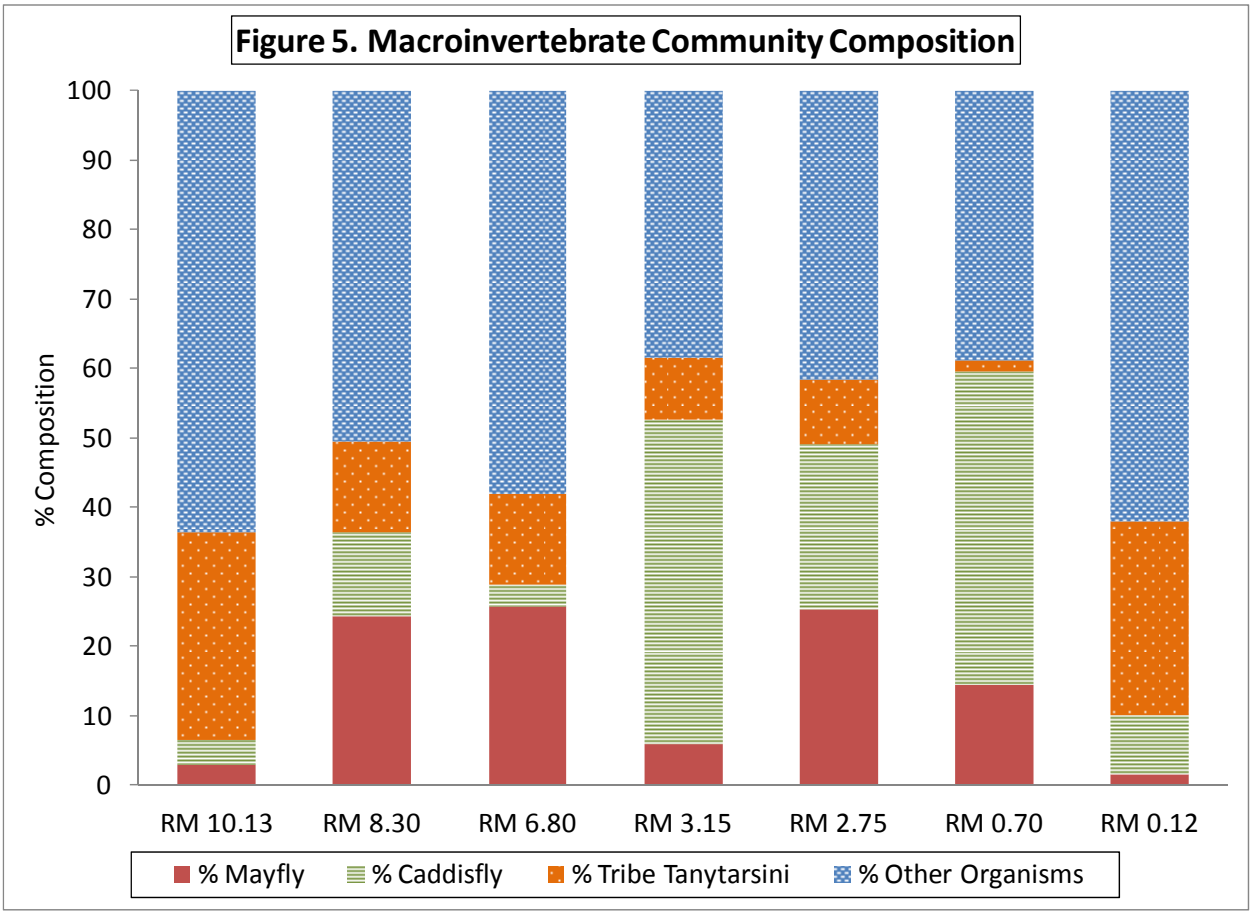
When comparing the scores obtained in 2012 to past NEORSD sampling on Mill Creek, it was found that those from 2012 were the highest ever received at all of the sites (Table 15). Part of the reason for this may be due to the generally low flows in 2012; the average monthly flow during the period when the HD was installed was the lowest that it has been for the last five years (Table 16). It has been found that there is less disruption of the macroinvertebrate community when flows are not elevated (Holomuzki & Biggs, 2000). Potentially, improvements in the macroinvertebrate community could also lead to improvements in the fish community by providing an increased source of food.

Table 15. Mill Creek Historic ICI scores							
Year	RM 10.13	RM 8.30	RM 6.80	RM 3.15	RM 2.75	RM 0.70	RM 0.12
1995	22	---	---	---	**38**	20	18
1999	---	---	---	---	---	---	*32*
2000	---	---	---	---	---	---	28
2001	---	---	---	---	---	---	12
2002	---	17	---	---	---	---	*30*
2003	---	3	---	---	---	---	9
2004	---	16	---	---	---	---	10
2005	---	10	---	---	---	---	28
2006	---	7	---	---	---	---	20
2007	---	14	---	---	---	---	22
2008	---	21	---	---	---	---	*31*

Table 15. Mill Creek Historic ICI scores							
Year	RM 10.13	RM 8.30	RM 6.80	RM 3.15	RM 2.75	RM 0.70	RM 0.12
2009	---	24	---	---	---	---	**34**
2010	---	*30*	---	---	---	---	28
2011	*32*	---	---	---	**40**	**34**	---
2012	**36**	**38**	*30*	**34**	**40**	**36**	**38**
Bold = meets WWH criterion [ICI ≥34]							
Italics = non-significant departure from WWH criterion [ICI ≥30]							
--- No ICI score available							

Table 16. Average Monthly Flow (cfs)*			
	June	July	August
2008	19.8	18.0	8.5
2009	10.8	21.0	24.6
2010	23.7	18.2	11.0
2011	15.0	18.9	22.1
2012	6.0	8.3	6.9
*As measured at USGS gage station at Garfield Heights			

An evaluation of the macroinvertebrate community composition showed that the overall percentage of the pollution-sensitive taxa groups, mayflies, caddisflies, and tribe Tanytarsini midges, varied by each site. There was also a high degree of variability among the sites for each of the taxa groups. At some of the sites more mayflies were present, while at others, Tanytarsini midges or caddisflies were dominant. Site-specific habitat features could be one reason for these differences. Reductions in wet and dry weather sources of pollution to Mill Creek are expected to result in an overall increase in all of these organisms throughout the watershed.



Conclusions

The Mill Creek watershed was evaluated in 2012 to determine the impact of CSOs on the stream and any improvements that may occur following construction of the Mill Creek Tunnel and its associated projects. As in 2011, water chemistry sampling showed that bacterial contamination, potentially coming from CSOs, illicit discharges or stormwater and urban runoff, and mercury were the two types of water quality exceedances still occurring in the creek. However, due to a lower amount of precipitation in 2012 and potentially greater CSO control, overall bacterial contamination in the creek was lower than in 2011.

Biological surveys of fish and macroinvertebrate showed there may still be some impact to those communities from water quality issues. Although the two most downstream sites were in full attainment of the applicable criteria, there was a general lack of sensitive fish at them, an indication of some environmental stress. The upstream sites were in partial attainment of the criteria, meeting the one for macroinvertebrates, but missing the one for fish. Mill Creek Falls may be the greatest limiting factor preventing establishment of a healthy fish community in the upstream section of the creek, as the available habitat should be capable of supporting one. However, bacterial contamination

and any associated pollutants are also likely affecting the fish community there. At the four upstream sites only pollution-tolerant fish were collected. The macroinvertebrate community at RM 6.80 may also be impacted by such contamination, as there was a much higher percentage of pollution-tolerant organisms found there compared to the other sites.

The Lee Road Relief Sewer was completed in June 2012, part way through the sampling, while the last phase of the Mill Creek Tunnel was finished in late 2012. Completion of the first two phases of the Tunnel may have contributed to some of the improvements in the biological communities that have been observed in the lower sections of the creek in recent years. It is therefore expected that improvements will continue as a result of completion of the other projects. Monitoring in 2013 and subsequent years will help to document any of those improvements.

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References

Cuyahoga County Board of Health. (2012). Comprehensive Outfall Database, Phase II Sampling Summary Report, 2005-2010.

DeShon, JE. (1995). Development and application of the Invertebrate Community Index (ICI). In Davis and Simon (Eds.), *Biological assessment and criteria, tools for water resource planning and decision making* (pp. 217-243). Boca Raton, FL: Lewis Publishers.

Eaton, A.D., Clesceri, L.S., and Greenberg, A.E. (Eds). (1995). Method 3500-Cr D. Colorimetric Method, *Standard Methods for the Examination of Water and Wastewater* (19th ed.) (pp. 3-59 and 3-60). Washington, D.C.: American Public Health Association.

Holomuzki, J.R., & and Biggs, B.J.F. (2000). Taxon-specific responses to high-flow disturbance in streams: implications for population persistence. *Journal of the North American Benthological Society*, 19, 670-679.

National Oceanic and Atmospheric Administration (NOAA). (2012). Ohio Climate Division 3 Precipitation, January-December 1895-2011. NOAA's National Climatic Data Center. Information accessed on January 20, 2012 from http://www.ncdc.noaa.gov/temp-and-precip/time-series/index.php

Ohio Administrative Code. OAC 3745-1 (October 15, 2009).

Ohio Environmental Protection Agency. (1987a, updated January 1988, September 1989, November 2006, and August 2008). *Biological criteria for the protection of aquatic life: Volume II: Users manual for biological field assessment of Ohio surface waters.* Columbus, OH: Division of Water Quality Planning and Assessment, Ecological Assessment Section.

Ohio Environmental Protection Agency. (1987b, updated September 1989, March 2001, November 2006, and August 2008). *Biological criteria for the protection of aquatic life: Volume III: Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities.* Columbus, OH: Division of Water Quality Planning and Assessment, Ecological Assessment Section.

Ohio Environmental Protection Agency. (1999). *Biological and Water Quality Study of the Cuyahoga River and Selected Tributaries, Volume 1*. (Ohio EPA Technical Report MAS/1997-12-4). Columbus, OH: Division of Surface Water.

Ohio Environmental Protection Agency. (2003). *Total Maximum Daily Loads for the Lower Cuyahoga River*. Columbus, Ohio: 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, Ecological Assessment Section.

Ohio Environmental Protection Agency. (2009b). *Manual of Ohio EPA Surveillance*

Methods and Quality Assurance Practices. Columbus, OH: Division of Surface Water.

Ohio Environmental Protection Agency. (2013). *Surface Water Field Sampling Manual for water column chemistry, bacteria and flows*. Columbus, Ohio: Division of Surface Water.

United States Environmental Protection Agency. (2007). *Aquatic life ambient freshwater quality criteria – copper* (EPA-822-R-07-0001). Washington, DC: Office of Water, Office of Science and Technology.