NORTHEAST OHIO REGIONAL SEWER DISTRICT

2009 Pepper Pike/Moreland Hills POTW Baseline Assessment Study

Prepared by
Water Quality and Industrial Surveillance's
Environmental Assessment Section

Introduction

During 2009, the Northeast Ohio Regional Sewer District (NEORSD) conducted water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys on the Chagrin River and three of its tributaries in the vicinity of the City of Pepper Pike and the Village of Moreland Hills, Ohio. Beginning in March 2010, four wastewater treatment plants (WWTP) in the area, the Jackson Valley WWTP, Quail Hollow WWTP, Creekside WWTP, and Woodland Glen WWTP, are scheduled to be decommissioned. Flow that is currently entering these facilities will be redirected to NEORSD's Easterly WWTP via the SOM Relief Sewer. The plants that are being decommissioned do not consistently meet the National Pollutant Discharge Elimination System permit limits. By removing these flows and conveying them to NEORSD, the water quality in the streams downstream of these WWTPs is expected to improve. The purpose of this study, therefore, was to evaluate the impact from these treatment plants on each of the streams to which they are tributary. Baseline data was collected downstream of each of these treatment plants and on the Chagrin River upstream and downstream of all tributaries. 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 *2009 Pepper Pike/Moreland Hills Publicly Owned Treatment Works (POTW's) Baseline Assessment Study Prior to Decommissioning* approved by Ohio EPA on May 12, 2009. These results will be compared to data collected after the WWTPs are decommissioned to determine any improvements to water quality and related changes in the biological communities.

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

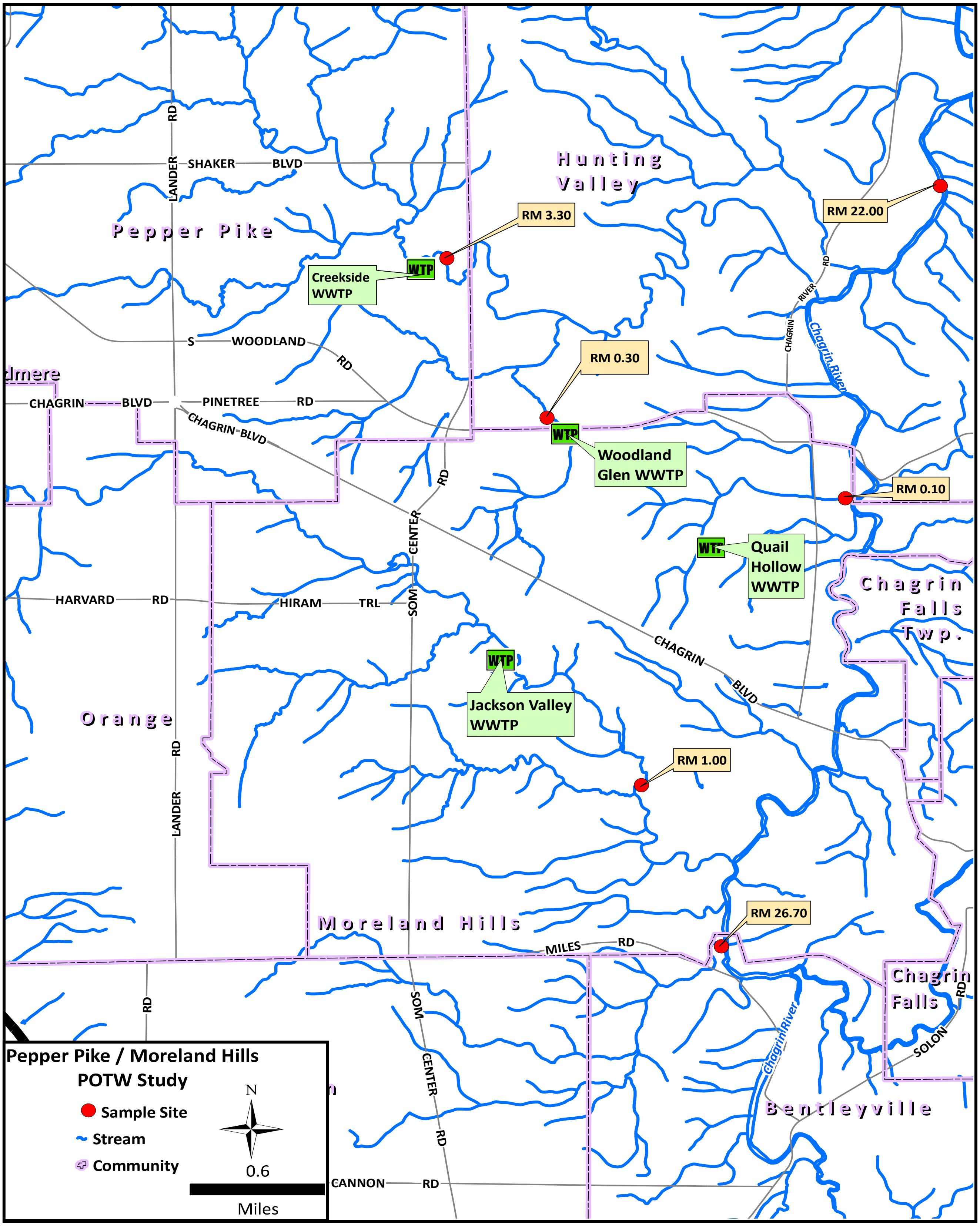

Figure 1. Chagrin River and Tributaries Biological, Habitat and Water Chemistry Sites

Table 1. Sampling Locations						
Location	Latitude	Longitude	River Mile	Description	Quadrangle	Purpose
Miles Road and Bentleville Road	N41.4250°	W81.4176°	26.70	Chagrin River Upstream of Wiley Creek	Chagrin Falls	Background data for fish, habitat and macroinvertebrates
37855 Jackson Road	N41.4360°	W81.4242°	1.00	Wiley Creek Downstream of Jackson Valley WWTP	Chagrin Falls	Evaluate Wiley Creek and Jackson Valley WWTP discharge on fish, habitat and macroinvertebrates
3780 Chagrin River Road	N41.4553°	W81.4066°	0.10	Unnamed tributary Creek to Chagrin River Downstream of Quail Hollow WWTP	Chagrin Falls	Evaluate Unnamed Creek and Quail Hollow WWTP discharges on fish, habitat and macroinvertebrates
South Woodland Road West of Windrush Drive	N41.4610°	W81.4318°	0.30	Unnamed tributary Creek to Pepper-Luce Creek Downstream of Woodland Glen WWTP	Chagrin Falls	Evaluate Unnamed Creek and Woodland Glen WWTP discharges on fish, habitat and macroinvertebrates
3226 S.O.M. Center Road	N41.4719°	W81.4401°	3.30	Pepper-Luce Creek Downstream of Creekside WWTP	Chagrin Falls	Evaluate Pepper-Luce Creek and Creekside WWTP discharges on fish, habitat and macroinvertebrates
3051 Chagrin River Road	N41.4764°	W81.3982°	22.00	Chagrin River Downstream of Pepper-Luce Creek	Chagrin Falls	Evaluate Creeks' and WWTPs' discharges on fish, habitat and macroinvertebrates

Water Chemistry Sampling

Water chemistry samples were collected at each of the locations five times between July 22nd and August 18th. This sampling coincided with the installation period for Hester-Dendy samplers. The techniques used for water chemistry sampling and chemical analyses generally followed the *Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices* (2009a). Field analyses included the use of a YSI 556 multi-parameter meter or YSI 600XL sonde to measure dissolved oxygen, water temperature, specific conductivity and pH at the time of sampling. Some pH measurements were also taken using a Hanna Meter HI 98129. After the study, it was determined that the pH was being calibrated once a week and not daily. Therefore, some of the samples have field pH measurements that did not follow the Ohio EPA Surveillance Methods.

All of the sites monitored during the study with the exception of Wiley Creek, are designated warmwater habitat, agricultural water supply, industrial water supply, and primary contact recreation (Ohio EPA, 2009b). Wiley Creek also has the latter three designations, but is designated coldwater habitat rather than warmwater habitat. The sites on the Chagrin River have an additional designation of seasonal salmonid habitat, in effect from October through May. Upon application of the Ohio water quality standards associated with each of these designations, there were three instances in which exceedances actually occurred and one possible exceedence for pH (Table 2).

Table 2. Chagrin River and Tributaries Water Quality Exceedances (Outside Mixing Zone Maximum or Minimum)

Site	Date	Parameter	Value	Standard
Unnamed tributary creek to Chagrin River Downstream of Quail Hollow WWTP	8/5/2009	pH*	9.14	6.5-9.0
Unnamed tributary creek to Pepper-Luce Creek Downstream of Woodland Glen WWTP	7/29/2009	Copper	24.59	22.05
	8/5/2009	Dissolved Oxygen	3.96	4.00
	8/18/2009	Dissolved Oxygen	3.93	4.00

*pH sensor not calibrated on day of sampling as required by Ohio EPA methods

On August 5th, elevated pH was found at the site on the unnamed tributary to Chagrin River downstream of the Quail Hollow WWTP. When the measurement was taken, it was noticed that there was a large amount of algae present in the stream at this location. As a result of photosynthesis, pH levels can become elevated in areas with algal blooms, which may be what occurred on this occasion. As mentioned previously, however, Ohio EPA methods require the calibration of pH sensors on the day that they are used. Since calibration did not occur on the day when the elevated pH was found, the elevated pH is being presented only as a possible water quality impairment and not an actual exceedance of the water quality standard.

During the sampling, there was one exceedance of the Protection of Aquatic Life Outside Mixing Zone Maximum criterion for copper, which occurred on the unnamed tributary creek to Pepper-Luce Creek downstream of the Woodland Glen WWTP (Table 2). Based on running averages of copper and hardness, this also resulted in an exceedance for Outside Mixing Zone Average for 12% of the 30-day periods that included the dates that samples were collected. The reason for this exceedance is unclear, since it occurred during dry weather[1].

The other two exceedances found during the study were for dissolved oxygen (DO) also at the location downstream of the Woodland Glen WWTP. On both occasions, the measured DO was just under the Outside Mixing Zone Minimum for the protection of aquatic life. On these two days, the temperature at this site was lower than the other sites that were monitored, so elevated temperature did not appear to be the cause for the low DO. The BOD, however, was found to be higher than 5, indicating possible organic enrichment. An investigation into the reason for the low DO readings was conducted on August 21, 2009, and September 1, 2009. It was found on both days that although the DO at the site was in attainment of the criterion, it was lower than what was measured upstream of the Woodland Glen WWTP. Therefore, effluent from the WWTP may have been responsible for the lower DO observed downstream of the plant on the days in which the criterion was not met.

As part of quality assurance/quality control measures, the relative percent difference (RPD) between duplicate samples was calculated. The acceptable RPD for field duplicates is considered to be ≤30 percent. Three duplicate samples were collected as part of this study in 2009. Of the duplicate samples, there were two instances in which the RPD was greater than 30%. For one of these, the average of the selenium results for the two samples collected from the unnamed tributary to the Chagrin River downstream of the Quail Hollow WWTP on July 29, 2009, was less than ten times the practical quantitation limit. Therefore, the relatively high RPD that was calculated (128%) was most likely due to the low concentration of selenium that was measured.

The second occurrence of an RPD greater than 30% occurred in the samples collected from the Chagrin River site at RM 26.70 on August 18, 2009. In this case, the calculated RPD for ammonia was found to be 41%. It is uncertain why the RPD was so high, since the measured values were well above the PQL.

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[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 were considered wet weather samples.

Habitat Assessment

Habitat assessments were conducted one time at each site during 2009 using Ohio EPA's Qualitative Habitat Evaluation Index (QHEI). The QHEI is used to assess the aquatic habitat conditions at each sample location by providing an evaluation of the physical components 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. These metrics describe the physical attributes of a stream and may be important in explaining why fish species are present or absent. A more detailed description of the QHEI can be found in Ohio EPA's (2006a), *Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)*. QHEI sheets for each site evaluated are available upon request.

Most of the sites that were evaluated were rated either "Good" or "Excellent" and met the target goal of 60 set by the Ohio EPA (Table 3). Sites meeting this goal are expected to attain the warmwater habitat or coldwater habitat designated uses. Two of the sites also exceeded a score of 75, which indicates that they have the ability to support exceptional warmwater habitat communities.

In addition to examining overall QHEI scores, individual components of the index can also be used to evaluate whether a site is capable of attaining the warmwater habitat designated use. 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). Generally, the sites in the current study with QHEI scores of at least 60 had the majority of their characteristics falling into the warmwater habitat classification (Table 3). The only high-influence modified warmwater habitat attribute that was found at any of these sites was sparse instream cover.

In contrast, the one site that did not meet EPA's target score, located on the unnamed tributary to the Chagrin River downstream of the Quail Hollow WWTP, had the majority of its characteristics indicative of a modified warmwater habitat stream. The section of the stream that was evaluated was channelized with poor development and no sinuosity. Because of its channelization, instream cover was nearly absent and there was no riparian cover. A lack of deep pools and a high quality riffle also contributed to its low QHEI score and may have directly influenced the biological communities at this location.

Table 3. Qualitative Habitat Evaluation Index scores and physical attributes

																				MWH Attributes												
			WWH Attributes											High Influence						Moderate Influence												
River Mile	QHEI Score	Habitat Rating	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	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. Dept <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**
Chagrin River																																
26.70	76.00	Excellent	x			x	x	x	x		x		6						0										x			1
22.00	71.50	Good	x	x		x			x	x	x	x	7				x		1					x	x							2
Wiley Creek																																
1.00	80.00	Excellent	x	x		x	x	x	x	x	x		8						0											x		1
Unnamed tributary to Pepper-Luce Creek downstream of Woodland Glen WWTP																																
0.30	62.00	Good	x			x	x		x		x	x	6				x		1		x			x				x	x			4
Pepper-Luce Creek																																
3.30	71.25	Good	x	x		x	x		x		x		6				x		1		x							x	x	x		4
Unnamed tributary to Chagrin River downstream of Quail Hollow WWTP																																
0.20	37.00	Poor				x				x			2	x		x	x	x	4					x	x		x	x		x		5

Electrofishing

Methods

Electrofishing passes were conducted one time at each site in 2009. 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 150 meters for the headwater sites and 200 meters for the wading sites. The methods that were used followed Ohio EPA protocol methods as detailed in *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987a) and *III* (1987b). Fish collected during the surveys were identified, weighed, and examined for the presence of DELT anomalies (deformities, eroded fins, lesions, and tumors). All fish were then released to the waters from which they were collected, except for vouchers and those that could not be easily identified in the field.

The electrofishing results for each pass were compiled and utilized to evaluate fish community health through the application of two Ohio EPA indices, the Index of Biotic Integrity (IBI) and the Modified Index of Well Being (MIwb). The IBI is used for both wading and headwater sites, while the MIwb does not apply to headwater sites. 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 MIwb, Formula 1 below, incorporates four fish community measures: numbers of individuals, biomass, and the Shannon Diversity Index (H) (Formula 2 below) based on numbers and weight of fish. The MIwb is a result of a mathematical calculation based upon the formula.

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

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

Results and Discussion

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

As shown in Table 4, results from the electrofishing surveys indicate that the two sites on the Chagrin River were in full attainment of warmwater habitat criteria for the IBI and MIwb. The IBI scores were also within non-significant departure from exceptional warmwater habitat, and for RM 26.70, were similar to those obtained by Ohio EPA in 2003[2]. Both sites achieved the highest scores for those IBI metrics associated with trophic composition, proportion of simple lithophils, and proportion of tolerant species. Other indications of a healthy fish population include the presence of three pollution-intolerant species (river chub [*Nocomis micropogon*], rosyface shiner [*Notropis rubellus*] and stonecat madtom [*Noturus flavus*]) and a high percentage of pollution-sensitive fish. The metrics that scored poorly included the number of sucker species at both sites and the number of sunfish species at RM 22.00. It is uncertain why these metrics did not score better, but for suckers, it may be a result of the dam near RM 18.00 preventing upstream migration of redhorse species from Lake Erie. Based on the overall index scores, though, it appears as if both sites are of high quality and that the WWTPs discharging to the nearby tributary streams are having minimal, if any, impact on the health of the downstream fish community in the Chagrin River.

For the other locations that were sampled, none were in attainment of the IBI criterion. Since these were all headwater sites, the MIwb is not applicable. The site on Pepper-Luce Creek scored the best of these sites and was close to being in non-significant departure of the criterion. This site had a high number of individuals, most of which were not of species considered to be highly pollution tolerant. However, its lack of more pollution intolerant fish, as measured by the number of darter or sensitive species, prevented it from meeting attainment. Because this site had a relatively high QHEI score, this is an indication that water quality may be an impairment to the fish community. However, there is a dam downstream of the site that prevents upstream migration of fish from the Chagrin River that may also be preventing attainment (Figure 2).

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[2] Ohio EPA obtained scores of 46 for the IBI and 8.8 for the MIwb on September 11, 2003 (Ohio EPA, 2006b).

Table 4. Index of Biotic Integrity and Modified Index of Well-Being Scores			
Stream & Location	**River Mile**	**IBI Score**	**MIwb Score**
Chagrin River Upstream of Wiley Creek	26.70	**46**	**8.6**
Wiley Creek Downstream of Jackson Valley WWTP	1.00	24	N/A
Unnamed tributary creek to Chagrin River Downstream of Quail Hollow WWTP	0.10	26	N/A
Unnamed tributary creek to Pepper-Luce Creek Downstream of Woodland Glen WWTP	0.30	14	N/A
Pepper-Luce Creek	3.30	34	N/A
Chagrin River Downstream of Pepper-Luce Creek	22.00	**44**	**8.8**

Bold indicates attainment of applicable criterion

The site on Wiley Creek received the highest QHEI score of any site evaluated and should be capable of supporting an exceptional warmwater habitat community. This was not found to be occurring, as the electrofishing survey resulted in IBI score that rated only *Poor*. Although this site is designated coldwater habitat, no species associated with such a designation were collected. The site also had the second-lowest number of fish found at the headwater sites. These results, in conjunction with the predominance of highly pollution-tolerant fish and lack of more sensitive species found at this location, indicate possible water quality impacts impacting the fish community. However, natural barriers to fish migration downstream of the site may be more of an impediment to a healthier fish population (Figure 3).

Figure 2. Dam on Pepper-Luce Creek

Figure 3. Fish migration barrier on Wiley Creek

Another location with an IBI score considered to be *Poor* was the one on the unnamed tributary to the Chagrin River downstream of the Quail Hollow WWTP. Only three different species were collected at this site, with all of the fish except for one being highly pollution tolerant. Since this site also had habitat considered to be *Poor*, it is possible that both habitat and water quality limitations are contributing to degradation of the fish community.

Of all the sites sampled, the one on the unnamed tributary to the Pepper-Luce Creek downstream of the Woodland Glen WWTP scored the poorest and was barely above the minimum IBI score of 12. Only 12 fish were collected at this site, most of which were pollution tolerant. As noted previously, there were a couple of instances observed when the DO concentrations in the stream were below the applicable water quality standard. This lack of oxygen may be a factor in the low number of fish collected at this site.

Macroinvertebrate Sampling

Methods

Macroinvertebrates were sampled quantitatively for a six-week period 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. Methods for sampling followed an approved modification of the Ohio EPA's (1987b) *Biological Criteria for the Protection of Aquatic Life, Volume III.*

The quantitative and qualitative macroinvertebrate samples were shipped to EA Engineering, Science and Technology (Deerfield, IL) for identification and enumeration. Specimens were identified to the lowest practical taxonomic level, as long as the maturity and condition of specimen allowed. The lowest practical level of taxonomy is defined by the Ohio EPA (1987b).

The overall aquatic macroinvertebrate community in the streams was evaluated using Ohio EPA's Invertebrate Community Index (ICI), (OEPA 1987a). The ICI consists of ten community metrics, 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 ICI score. This scoring evaluates the community against Ohio EPA's relatively unimpacted reference sites for each specific eco-region.

Results and Discussion

Five of the sites that were sampled were in attainment or non-significant departure (≤4 ICI units) from the warmwater habitat ICI criterion of 34 (Table 5). The upstream site on the Chagrin River had the highest ICI score, density of organisms, number of total taxa, and number of EPT taxa of any site sampled. While the downstream site had slighter fewer taxa than upstream, it still had more than the tributary sites. Both sites had a relatively high number of caddisflies and a low percentage of pollution-tolerant organisms. The results for the downstream site indicate no significant water quality impacts from the WWTPs that are discharging upstream of it.

Table 5. Macroinvertebrate Results

Stream & Location	River Mile	ICI Score	Density	Number of Total Taxa	Number of EPT Taxa	Notable Collections
Chagrin River Upstream of Wiley Creek	26.70	**44**	2552	31	15	*Parengnetina media, Acentrella turbida, Leucotrichia pictipes*
Wiley Creek Downstream of Jackson Valley WWTP	1.00	**36**	806	24	5	*Zavrelia, Boyeria grafiana*
Unnamed tributary creek to Chagrin River Downstream of Quail Hollow WWTP	0.10	**30**	927	19	1	
Unnamed tributary creek to Pepper-Luce Creek Downstream of Woodland Glen WWTP	0.30	18	1085	16	0	
Pepper-Luce Creek	3.30	**40**	1905	32	4	
Chagrin River Downstream of Pepper-Luce Creek	22.00	**38**	1052	22	13	*Parengnetina media, Acentrella turbida*

Bold indicates attainment of criterion

On the unnamed tributary to Chagrin River downstream of the Quail Hollow WWTP, there was a high percentage of tanytarsini midges and a low percentage of tolerant organisms, which both signify a healthy macroinvertebrate population. Indications of impairment included an absence of mayflies and the collection of only one EPT taxa in the qualitative sample. Overall, though, the results indicate that if water quality is impacting the macroinvertebrate community at this location, it is not significantly doing so, since the ICI score was in non-significant departure of the criterion.

The results for the site on Wiley Creek also suggest that water quality is not a major factor impacting the macroinvertebrate community at that location. While this site had a low percentage of mayflies, it also had a low percentage of pollution-tolerant organisms. In addition, four coldwater taxa were collected on Wiley Creek. These taxa included *Boyeria grafiana*, *Diamesa*, *Parametriocnemus*, and *Zavrelia*. The collection of these taxa supports the change in use designation to coldwater habitat by Ohio EPA following their last sampling on this stream in 1995 (Ohio EPA, 1997).

The only site that did not meet the ICI criterion was on the unnamed tributary to Pepper-Luce Creek downstream of the Woodland Glen WWTP. This site had the lowest number of taxa collected on any HD or qualitative sample. No mayflies and only two caddisflies were collected on the HD and no EPT taxa were found during qualitative sampling. The only ICI metric that scored a six, which is the highest possible, was the percent tanytarsini midges. The low score that was received by this site may be related to water quality issues in the stream, specifically the low dissolved oxygen levels found on two occasions.

Conclusions

The purpose of this study was to collect baseline data to determine if effluent from the four WWTPs that are to be decommissioned were negatively impacting the biological community at downstream locations. Results from the Chagrin River indicate no overall impact from the WWTPs, as the site downstream of all the tributaries was similar to the upstream site, and both were in full attainment of the biocriteria. Because of this, it is not expected that any significant changes will occur at the downstream location after the WWTP are decommissioned.

The sites that were sampled downstream of the Jackson Valley, Creekside, and Quail Hollow WWTPs were in partial attainment of the biocriteria, meeting the ICI criterion, but not the IBI criterion. The first two of these streams had downstream migration barriers that were likely impacting the fish community. For the site downstream of the Quail Hollow WWTP, habitat is most likely the limiting factor, as the QHEI score was below that which is expected to meet attainment of the warmwater habitat criteria. There is no strong indication that water quality impacts are significantly affecting the biological community at these sites since the macroinvertebrate results are indicative of a healthy population.

The final tributary stream that was sampled, downstream of the Woodland Glen WWTP, was in non-attainment of the biological criteria. Although this site was also upstream of the dam on Pepper-Luce Creek, results for both the fish and macroinvertebrate communities suggest that water quality issues may be more of a detriment to meeting attainment. Because of this, decommissioning of the treatment plant may result in some improvement to the biological community at this location.

Each of the sites in the study will be assessed again once all the WWTPs are decommissioned. For the sites on the streams that have barriers preventing upstream fish passage, additional sites should be sampled downstream of the barriers to more effectively determine any improvements. The results from these assessments may help to determine if the WWTPs were contributing to impacts to the biological community when they were still operational.

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