NORTHEAST OHIO REGIONAL SEWER DISTRICT

2009 Mill Creek Highland Park Stream Restoration Study
Biological, Water Quality, and Habitat Survey Results

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Introduction

During 2009, the Northeast Ohio Regional Sewer District (NEORSD) conducted electrofishing, benthic macroinvertebrate surveys, water chemistry sampling, and habitat assessments at two headwater sites on Mill Creek, a tributary to the Cuyahoga River (Figure 1). The study sites at river miles (RM) 11.52 and 10.70 were in the upstream and downstream sections, respectively, of a proposed Fall 2010 restoration project in a degraded 3,200-foot stretch of Mill Creek through Highland Park Golf Course in Cuyahoga County (CCBH 2009a). The project is jointly funded by the Cuyahoga County Board of Health, NEORSD, and the City of Cleveland. CCBH secured an Ohio Environmental Protection Agency (EPA) grant for the project. The goal of the proposed restoration project is to improve in-stream habitat, stabilize severely eroding banks, reverse stream channel degradation, and restore previously destroyed riparian areas in the nearly mile-long section of Mill Creek severely impacted by stormwater runoff (CCBH 2009b).

The purpose of the study was to establish baseline monitoring data prior to remediation activities and to assess the impact of point and non-point sources of pollution such as storm sewer outfalls, and urban and golf course runoff. The baseline data can be utilized once restoration activities are complete to evaluate any changes to water quality and biological community health. Sampling was conducted by NEORSD Level 3 Qualified Data Collectors certified by Ohio EPA in Fish Community Biology, Benthic Macroinvertebrate Biology, Chemical Water Quality, and Stream Habitat Assessments as explained in the NEORSD study plan, *2009 Mill Creek Highland Park Golf Course Stream Restoration*, approved by Ohio EPA on May 12, 2009. Data will be submitted to the Ohio EPA within one year of the completion of sampling.

Figure 1 is a map of the sampling locations on Mill Creek, and Table 1 lists the sampling locations and their respective RM, 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 Department, Environmental Assessment Section.

Figure 1. Map of sampling zones at RM 11.52 and RM 10.70 in Mill Creek

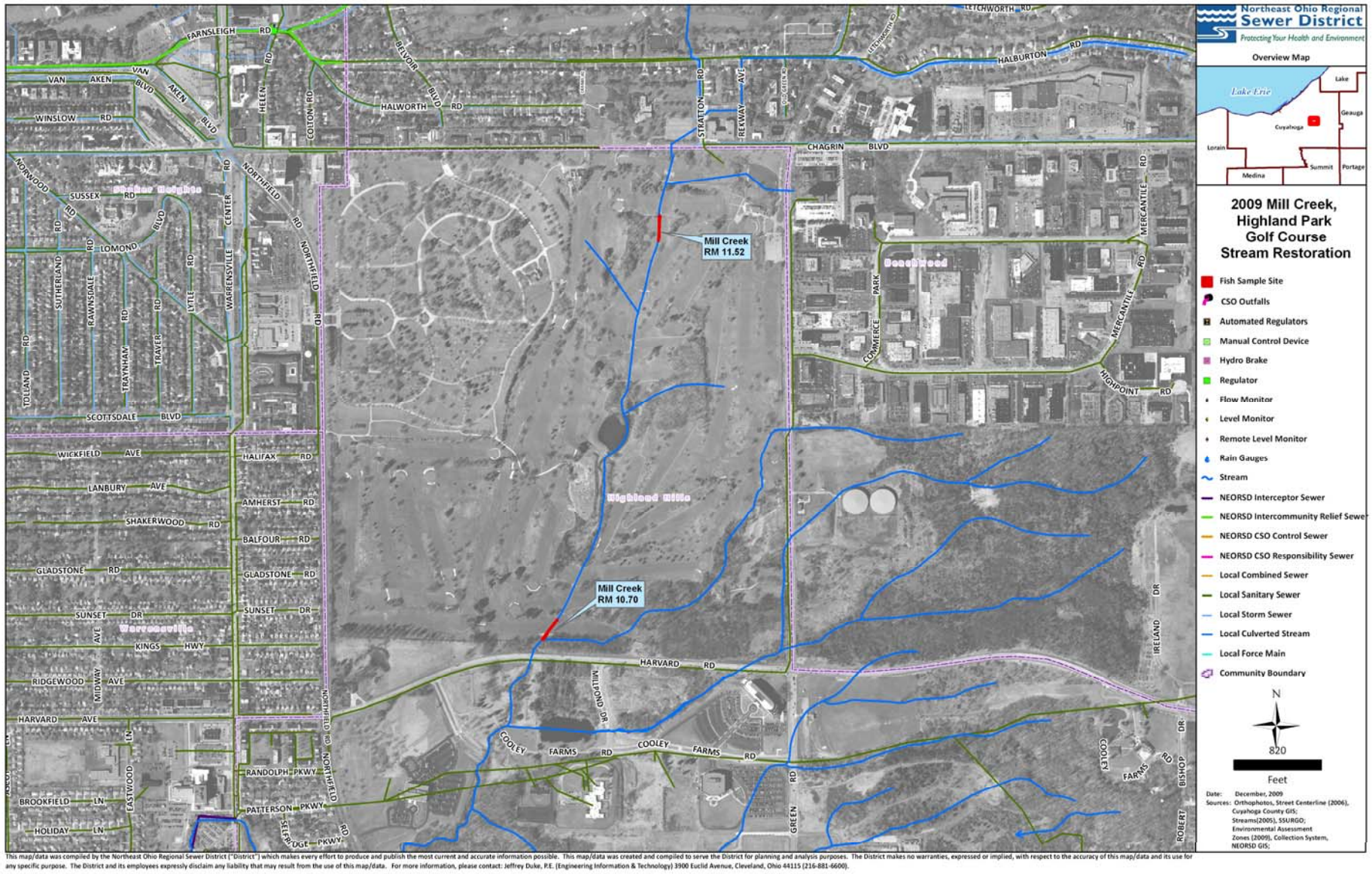


Table 1. 2009 Sample Locations

River Mile	Latitude	Longitude	Description	Quadrangle	Purpose
11.52	41.4621°N	81.5214°W	Upstream Section of Restoration	Shaker Heights	Evaluate chemistry, habitat, fish, & macroinvertebrates prior to restoration activities
10.70	41.4518°N	81.5255°W	Downstream Section of Restoration	Shaker Heights	Evaluate chemistry, habitat, fish, & macroinvertebrates prior to restoration activities

Water Chemistry Sampling

Water chemistry samples were collected from RM 11.52 and 10.70 during five sampling events, beginning July 20, 2009 and ending August 18, 2009. Samples collected on July 20, August 3, and August 10, 2009, 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) with the exception of pH. Prior to August 14, 2009, the pH meter was being calibrated weekly instead of daily as required by the *Surveillance Methods* (OEPA 2009). Thus, samples collected prior to that date were not compared to the OEPA Water Quality Standards for pH.

Samples were collected in two 4-liter disposable polyethylene cubitainers with a disposable polypropylene lid and two 473-milliliter plastic bottles. The plastic bottles were preserved with either trace sulfuric acid or trace nitric acid. 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). All COCs associated with this study are available upon request. A Surface Water Condition Sampling Field Data Form detailing site observations was also completed for each sample.

Instruments used for field analyses included a YSI-556 MPS Multi-Parameter Water Quality Meter or a YSI 600XL Sonde for measuring dissolved oxygen, specific conductance, and water temperature. These meters were calibrated weekly for dissolved

[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: RBH_A00301 in Beachwood, RMA_A00301 in Maple Heights, RMN_A00301 in Moreland Hills, and RSG_A00301 in Shaker Heights.

oxygen and specific conductance. A Hanna HI 98129 pH meter was used for field pH when the YSI-556 MPS and YSI 600 XL Sonde failed to meet quality assurance and quality control (QA/QC) requirements for pH calibration.

A sample duplicate from RM 11.52 and a field blank were obtained on August 18, 2009, for QA/QC of the water samples. The field blank appeared to be normal, and did not show signs of contamination from transporting the samples. The sample duplicate results were compared to the sample results using relative percent difference (RPD), given in Formula 1.

Formula 1.

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

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

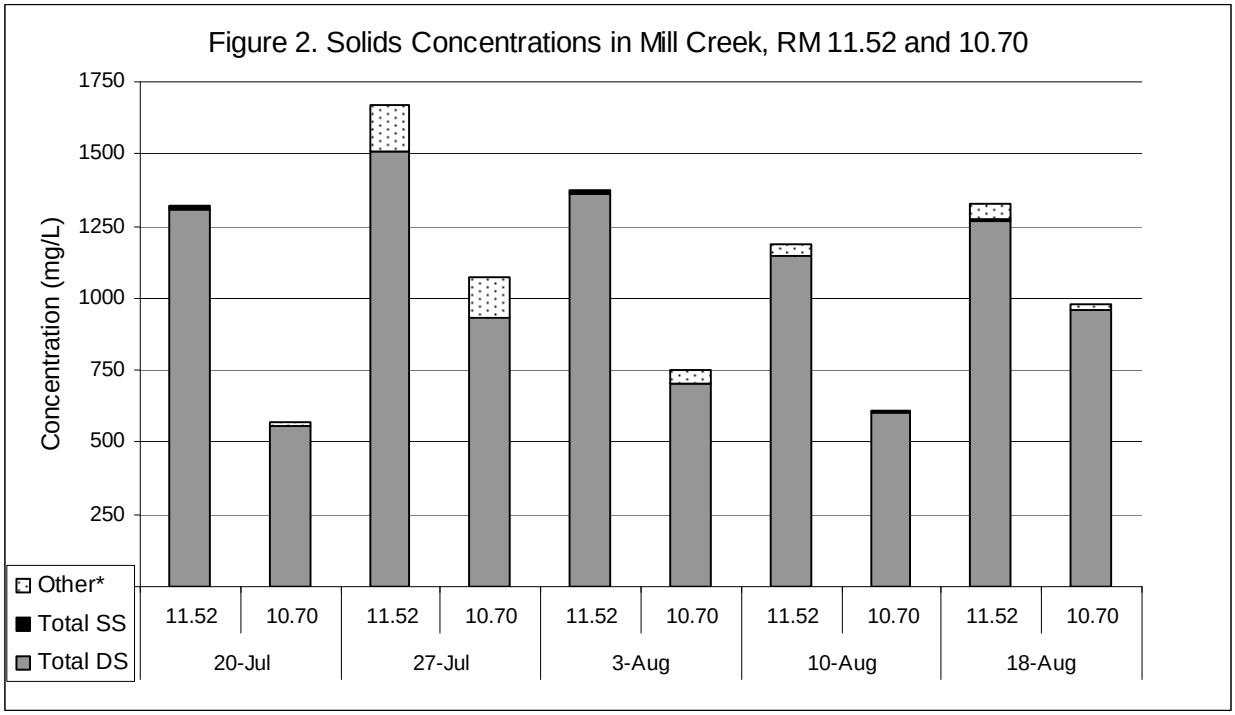
Each sample site was analyzed for 42 chemical parameters, plus 4 field measurements. The sample and the sample duplicate were compared for each of the 40 individual laboratory parameters reported on the Certificate of Analysis. Neither hardness nor the nitrate+nitrite parameter was compared, since they are calculated from other parameters. After each RPD was calculated, any differences over 30% were investigated to determine the reason for the discrepancy. Four possible 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.

RM 11.52 and RM 10.70 on Mill Creek are designated as warmwater habitat, agricultural water supply, industrial water supply, and primary contact recreation waters. All of the samples collected for this study were in attainment of applicable Ohio Water Quality Standards (OAC 3745-1).

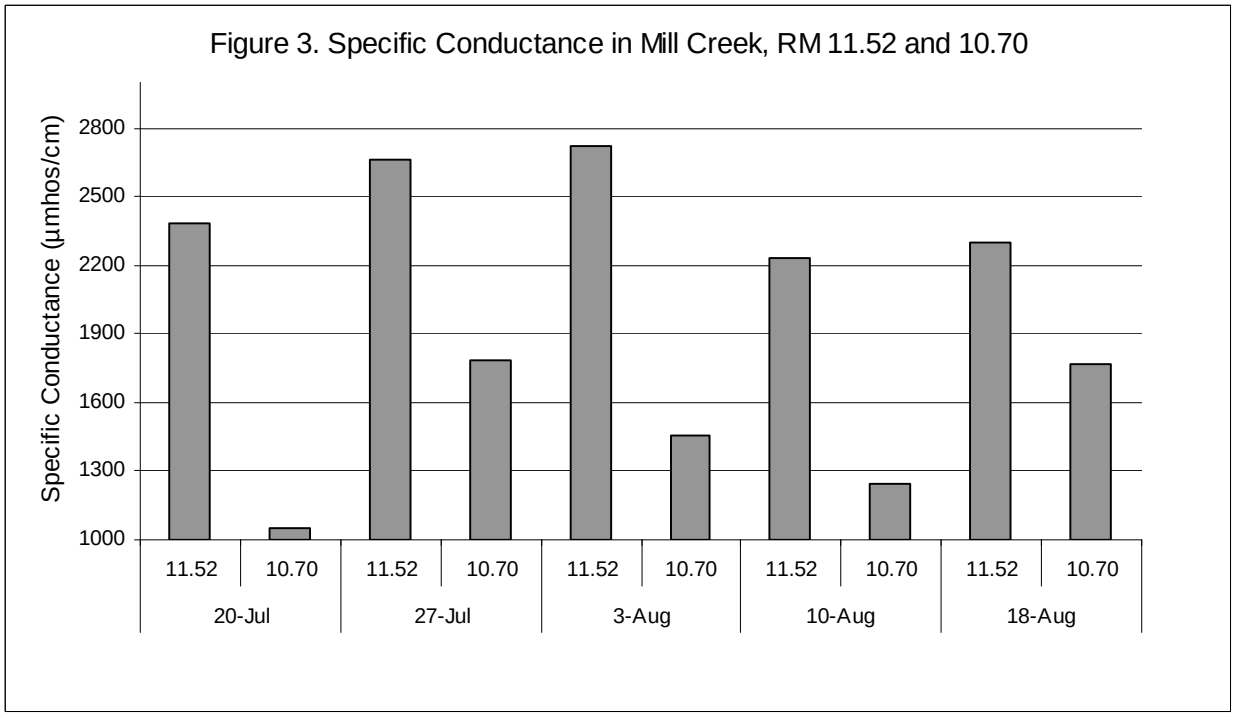
Upon closer inspection of the data, some interesting trends appeared, particularly when comparing results between the two sites. It should be noted that the water chemistry results explained below are based upon a limited data set, and so conclusions about their significance to the biological communities must be based upon best professional judgment.

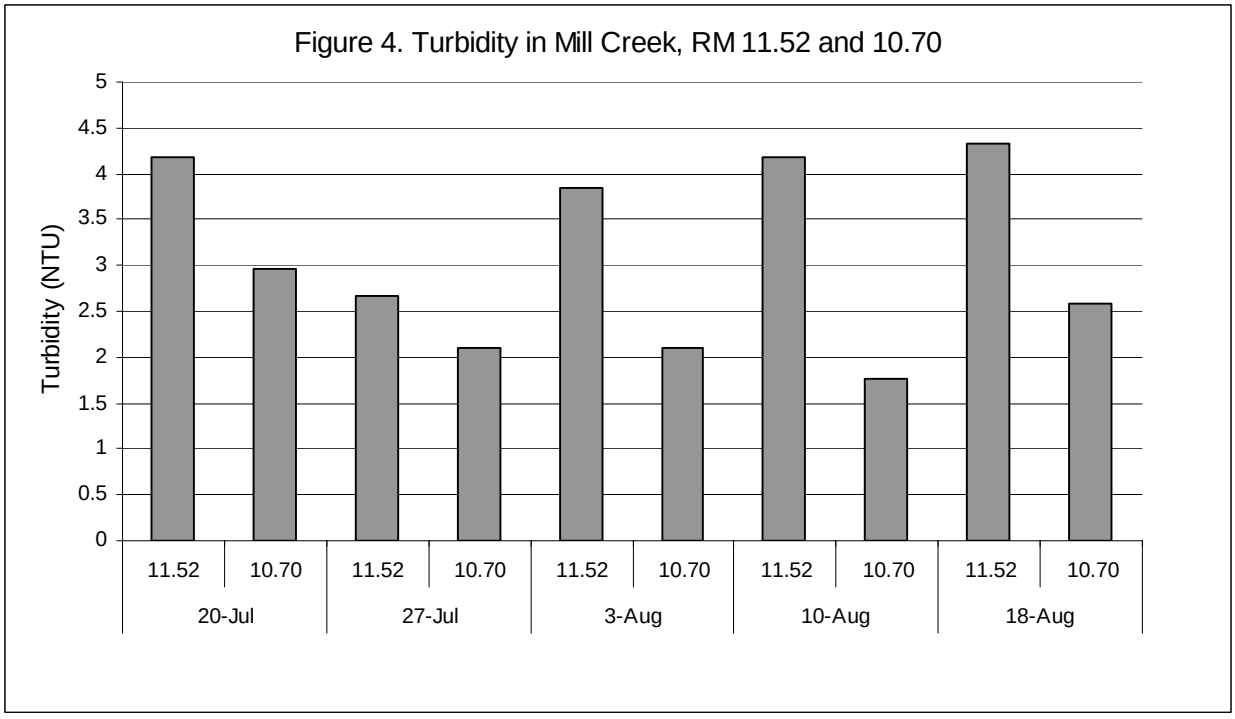
One interesting trend was that RM 11.52 had consistently higher concentrations of total dissolved solids than RM 10.70 (see Figure 2). The difference between sites was even greater on wet weather days, although for both sites the concentration of dissolved solids dropped due to dilution. Concentrations of total dissolved solids and total solids at RM 11.52, averaging 1319.6 mg/L and 1375.6 mg/L, respectively, were about 75% higher than concentrations found at RM 10.70. Total suspended solids levels were

similar between sites, peaking at 3.6 mg/L at RM 11.52. Specific conductance (Figure 3) and turbidity (Figure 4), on average, were about 67% higher at RM 11.52 than at RM 10.70 as well. An existing pond between the sites may be playing a role in settling out some of the solids, resulting in lower concentrations at RM 10.70 downstream.



* Other solids may include volatile solids that are not specifically tested for during laboratory analysis.





In terms of conductivity, it is important to note that water chemistry results from samples collected between July 20 and August 18, 2009 show that RM 11.52 had higher concentrations of several substances contributing to conductivity than RM 10.70. Temperature and iron levels were similar between sites, but aluminum, calcium, magnesium, and sodium levels were consistently higher at RM 11.52 when sample results for each date were compared. Chlorides, sulfates, and phosphates were not tested for during that time period. This correlates with the observation that conductivity was, on average, 67% higher at RM 11.52 than at RM 10.70.

The stream restoration project may have a positive effect on the stream's ability to assimilate many of these aforementioned substances, and through restoration of the riparian zones and stabilization of the eroding banks, may reduce their influx in the first place. Subsequent monitoring once the restoration project is complete will demonstrate whether and to what extent water quality in the stream has improved.

Habitat Assessment

Qualitative Habitat Evaluation Index (QHEI) scores were determined for RM 11.52 and 10.70 on October 7, 2009. The QHEI was developed by the Ohio EPA to assess the aquatic habitat conditions 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.

These metrics 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 *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 at the site to support a fish community that achieves the warmwater habitat criterion. The QHEI results for RM 10.70 and 11.52 are provided in Table 2. QHEI field sheets for each site are available upon request.

Table 2. 2009 Mill Creek Qualitative Habitat Evaluation Scores

Site Location	Score	Narrative Score
River Mile 11.52	48.25	Fair
River Mile 10.70	47.00	Fair

River Mile 11.52, a straight section of stream in the upstream section of the proposed restoration site, had a predominantly cobble and sand substrate with moderate to extensive embeddedness and sparse instream cover consisting of overhanging vegetation and deep (> 1m) pools. The site had a fairly developed riffle-pool complex of high pool quality. The bank on river right exhibited moderate to little or no erosion, while the bank on river left had moderate erosion.

River Mile 10.70, a channelized section of stream at the southern edge of the golf course in the downstream section of the proposed restoration, also had a predominantly cobble and sand substrate with moderate embeddedness. Instream cover consisted of sparse overhanging vegetation, boulders, aquatic macrophytes, and logs or woody debris. The site had a poorly developed riffle-pool complex, with shallow pools but higher quality riffles than RM 11.52. The stream had stable substrates and banks, with little to no erosion. RM 10.70 scored better than RM 11.52 in every regard to habitat with the exception of pool quality and riffle/pool complex development. The gradient is steep at both headwater sites (43.47 to 50 feet per mile) and the drainage area is less than two square miles. Both sites are surrounded by a grass golf course with no riparian width.

Electrofishing

Methods

Longline electrofishing was conducted once at each site on September 18, 2009, a dry weather day. Sampling consisted of shocking all habitat types within the 0.15 kilometer sampling zone while moving from downstream to upstream. 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 were then returned to the waters from which they were collected. Lists of the species, numbers, pollution tolerances and incidence of DELT anomalies for fish collected at each site are available upon request.

The electrofishing results for each pass were utilized to calculate the headwater Index of Biotic Integrity (IBI) for each 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. 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 symptoms. The metrics specific to headwater habitats are listed below:

1. Number of native species
2. Number of darter species
3. Number of headwater species
4. Number of minnow species
5. Number of sensitive species
6. Proportion of tolerant species
7. Proportion of omnivores
8. Proportion of insectivores
9. Proportion of pioneering species
10. Number of individuals
11. Number of simple lithophilic species
12. Proportion with DELT anomalies

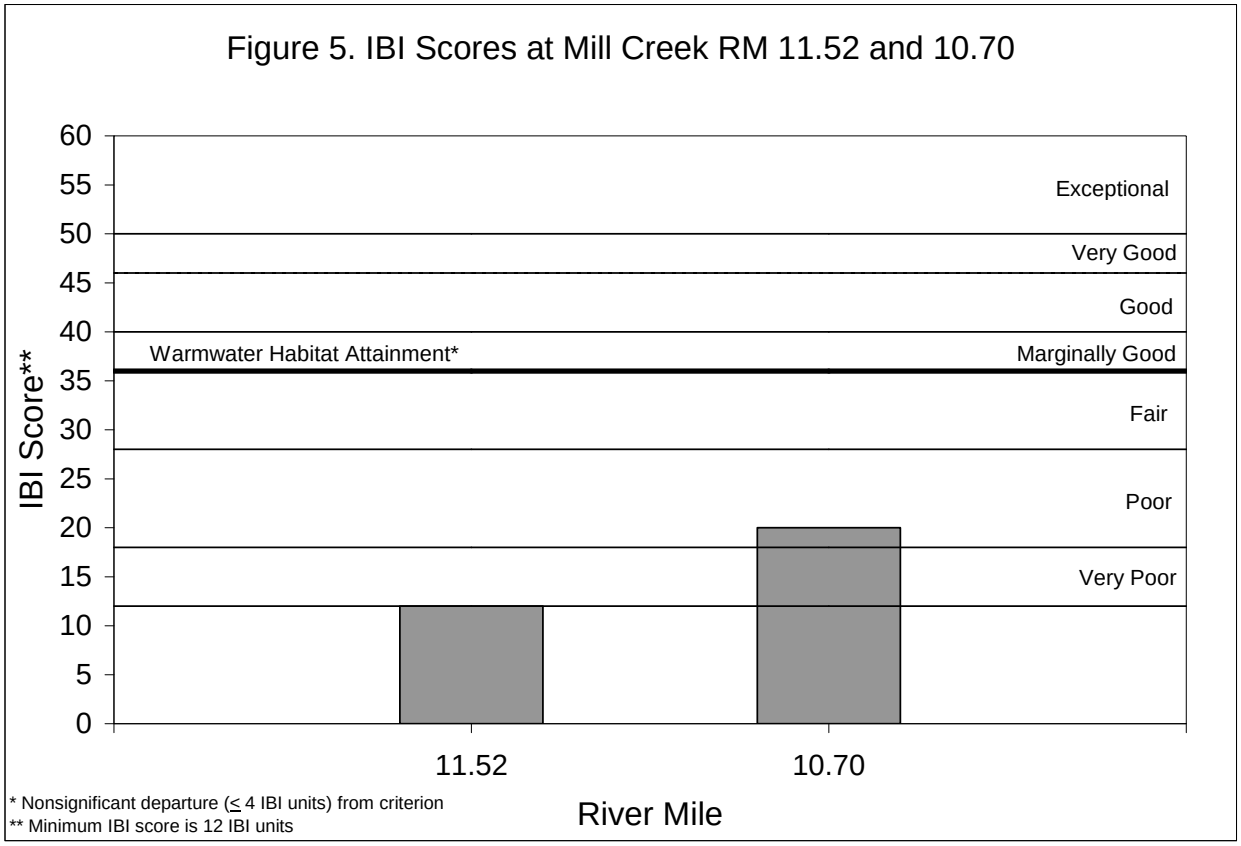
Individual metric scores are determined by comparing the fish data collected at RM 10.70 and 11.52 with values expected at reference sites in a similar geographical region. The individual scores metric were added together to produce an overall IBI score for each site. The maximum possible score is 60 and the minimum is 12. The IBI score corresponds to narrative ratings of *Exceptional, Good, Marginally Good, Fair, Poor,* or *Very Poor*. Since the drainage area at both sites was less than 20 square miles, Ohio EPA's Modified Index of Well-Being (MIwb) was not calculated for either site.

Results and Discussion

The Warmwater Habitat (WWH) IBI criterion for headwater sites in the Erie-Ontario Lake Plain ecoregion is 40. Neither site was in attainment of the criterion (Figure 5). RM 11.52 had an IBI score of 12, while RM 10.70 had an IBI score of 20 (Table 3).

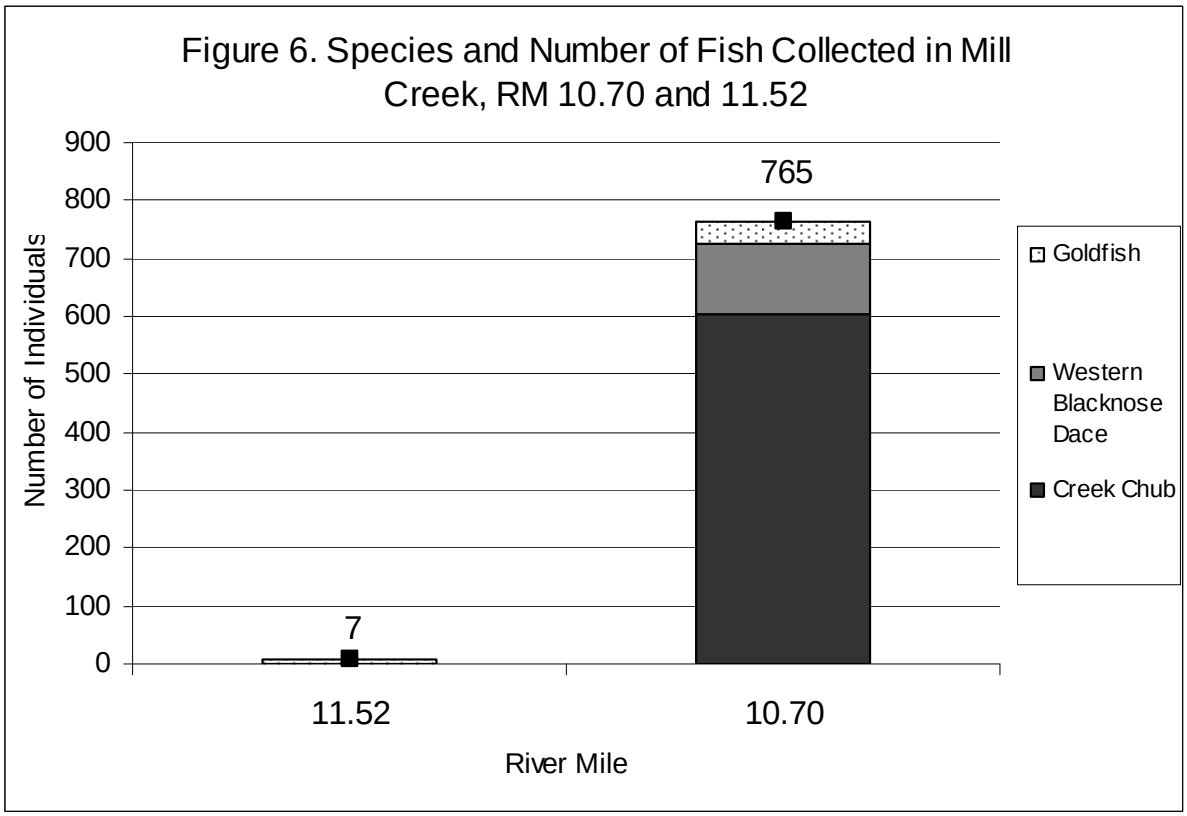
Table 3. 2009 Mill Creek Index of Biotic Integrity (IBI) Scores

Site Location	Score	Narrative	Attainment Status
River Mile 11.52	12	Very Poor	Non
River Mile 10.70	20	Poor	Non



The fish community at RM 11.52 consisted of seven highly tolerant, omnivorous, nonnative goldfish (*Carassius auratus)*. None of the fish had noticeable DELT anomalies, but the metric still scored a 1 since there were less than 25 fish collected. Since the MIwb was not calculated due to the small drainage area of each site, fish were not required to be weighed during sampling.

The fish community at RM 10.70 consisted of three highly tolerant species: the goldfish, the Western blacknose dace (*Rhinichthys atratulus*), and the creek chub (*Semotilus atromaculatus*). The creek chub, a pioneering species, was the most abundant, with 604 individuals out of the 765 total. The western blacknose dace and the creek chub are both native minnow species; the dace is designated as a simple lithophilic headwater species as well. The dace is also a prey species for the creek chub, utilizing an avoidance strategy to avoid becoming a meal (Fraser & Emmons 1984). None of the species are considered insectivorous. Of the twelve metrics, all but two scored a 1. A creek chub with a deformed body was the only DELT anomaly seen, giving that metric a score of 5. The goldfish, comprising 5.23% of the total catch, was the only omnivorous species, resulting in a score of 5 for that metric as well. The total number of fish collected for each site is given in Figure 6.



Habitat characteristics at RM 11.52 and 10.70, as identified in the QHEI assessments, may have had an influence on fish community distribution. For example, western blacknose dace prefer clear streams with sand and gravel substrates, although they can tolerate brief periods of turbidity. They require well-defined riffles for spawning, and as a prey species that utilizes an avoidance strategy, they rely on instream cover such as undercut banks, rootwads and rootmats, deep pools, and shade created by overhanging vegetation for their survival (Trautman 1981).

Although it is considered a highly tolerant, pioneering species by the Ohio EPA, the creek chub has been documented to be less abundant in streams that are highly turbid, polluted, and silted. Creek chubs prefer streams with well-defined riffles and deep pools, instream cover to hide from danger, and cleaner substrates of sand, gravel, boulders, or bedrock (Trautman 1981).

Despite the fact that RM 10.70 had a lower overall QHEI score, its habitat was more suitable for the western blacknose dace and the creek chub than RM 11.52, and it promoted a higher abundance of goldfish. Riffles were better defined and more stable and the substrate was less embedded and silt-covered. RM 10.70 also had a greater variety of instream cover, including overhanging vegetation, some shade, boulders, aquatic plants, and logs or woody debris, although this cover was still sparse overall. Water chemistry results, as described in the Water Chemistry Sampling section, also

indicated that RM 10.70 had less turbidity, conductivity, and total and dissolved solids than RM 11.52. Both sites were similar in gradient, so gradient was probably not a limiting factor influencing fish community distribution between sites (Trautman 1981).

Goldfish are an exotic, omnivorous species that are tolerant to cooler water temperatures, extreme turbidity and siltation, and domestic and industrial pollutants, but less so than other highly tolerant species like carp. Goldfish also prefer streams with dense vegetation (Trautman 1981). In comparison to the western blacknose dace and the creek chub, the goldfish's greater adaptability to increased pollution and poorer habitat may help explain why it was the only species present at both RM 11.52 and RM 10.70, while the other two species were only found at RM 10.70.

Macroinvertebrate Sampling

Methods

Macroinvertebrate sampling was conducted at RM 11.52 and RM 10.70 using a modified multi-plate Hester-Dendy (HD) sampler, an artificial substrate sampler used for quantitative assessment. Five identical HD samplers were tied to a cinderblock and installed at each site on July 13, 2009, for a six-week period. The HDs were retrieved from each site on August 25, 2009, a dry weather day. Qualitative sampling with a D-frame dip net for all available taxa inhabiting all available habitats in the sampling area was conducted during 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. Field sheets are available upon request.

The macroinvertebrate samples were shipped to EA Engineering, Science and Technology, Incorporated in Deerfield, IL for identification and enumeration. When specimen condition and life stage permitted, specimens were identified to the lowest practical taxonomic level as described in the Ohio EPA *Volume III* manual (1987b). The taxa lists and enumerations are available upon request. The macroinvertebrate community at each site was assessed using Ohio EPA's Invertebrate Community Index (ICI). The ICI consists of ten community metrics based on drainage area, 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

Since the drainage area at each site was less than 10 square miles, and the ICI is not calibrated to drainage areas that small, a drainage area of 10 square miles was used for each metric in accordance with the Ohio EPA (1987b) *Volume III* manual. Each metric has four different scoring categories of 0, 2, 4, and 6 points. At 6 points, the community is comparable to exceptional macroinvertebrate communities found in Ohio EPA's relatively unimpacted reference sites in the respective eco-region. The ten metric scores are added together to produce the overall ICI score.

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 to use the data with confidence (DeShon 1995). Flow during HD installation and retrieval at RM 11.52 was 0.17 fps and 0.02 fps, respectively. Flow during HD installation and retrieval at RM 10.70 was 0.13 fps and 0.05 fps, respectively.

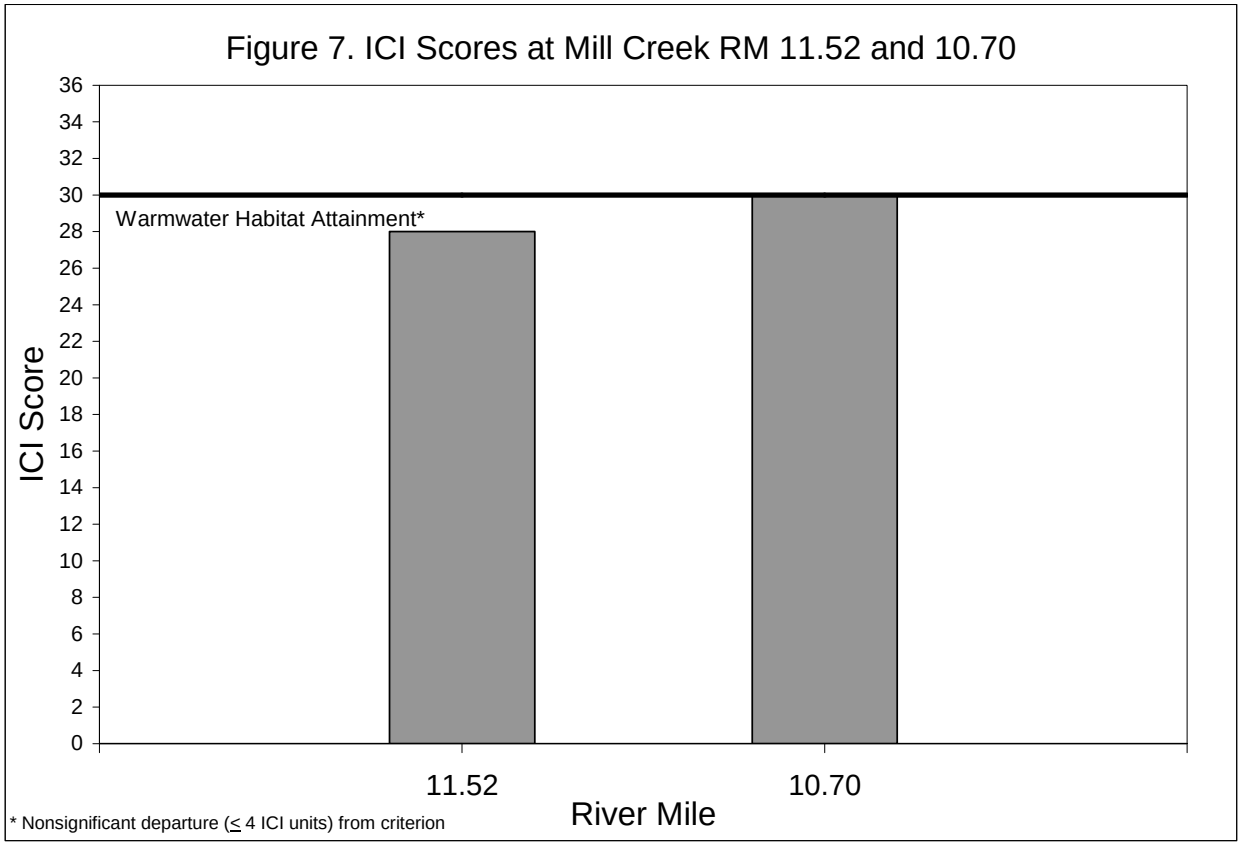
Results and Discussion

The warmwater habitat (WWH) ICI criterion for the Erie-Ontario Lake Plain ecoregion is 34. The site at RM 10.70 was in non-significant departure (≤4 ICI units) of the criterion, effectively attaining it, while the site at RM 11.52 was in non-attainment of the criterion. Table 4 shows a summary of sampling results at each of the sites, and Figure 7 shows a graphical summary of ICI scores.

Table 4. 2009 Mill Creek Invertebrate Community Index (ICI) Results

River Mile	Score	Narrative Rating	Density (Organisms/ft^2)	Total Quantitative Taxa	Total Qualitative Taxa	Qualitative EPT Taxa	Coldwater Taxa
11.52	28	Fair	1029	20	22	3	*Micropsectra sp.*
10.70	*30*	Marginally Good	638	22	10	0	*Micropsectra sp.*

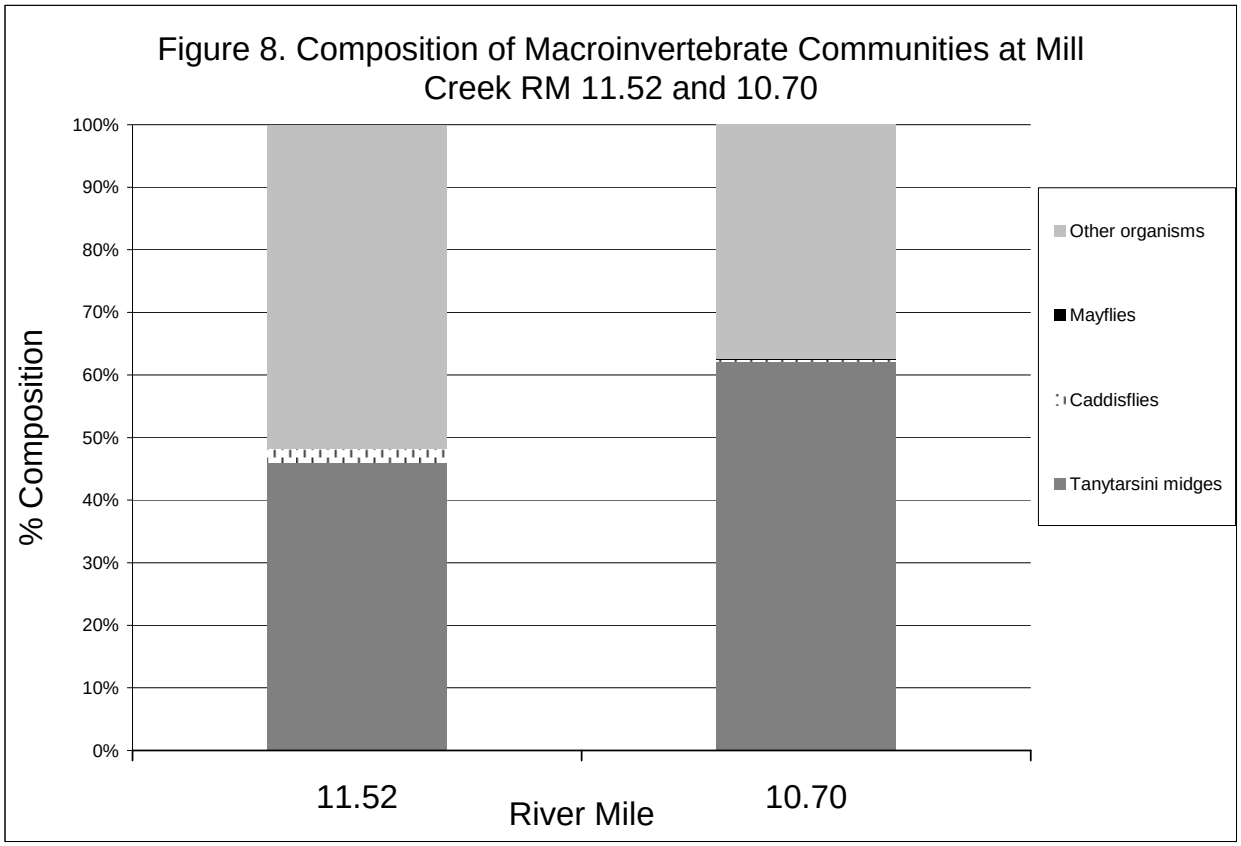
Italics = nonsignificant departure from WWH criterion (ICI ≤4 units)



The macroinvertebrate community collected with the HD at RM 11.52 consisted of 5,143 organisms representing 20 taxa. One caddisfly taxa, *Hydroptila* sp., was collected, comprising 2.2% of the sample. Fifteen dipteran taxa were collected, including three tribe Tanytarsini midge taxa: *Micropsectra* sp. (a coldwater taxa), *Paratanytarsus* sp., and organisms from the *Tanytarsus glabrescens* group. The relatively high abundance of these three taxa contributed to a score of 6 for the percent tribe Tanytarsini metric. A low relative abundance of tolerant organisms, including Oligochaeta, *Cricotopus bicinctus*, *Polypedilum illinoense*, and *Physa* sp., gave Metric 9 a score of 4. While this site had three qualitative EPT taxa, *Baetis flavistriga*, *Cheumatopsyche* sp., and the *Hydropsyche depravata* group, the metric still had a score of zero. There were no stoneflies collected at this site.

A total of 3,191 organisms were collected in the quantitative sample at RM 10.70, including one mayfly taxa, *Baetis flavistriga*, and two caddisfly taxa, *Cheumatopsyche* sp. and *Hydroptila* sp. Mayflies and caddisflies each comprised about 0.2% of the population. The three tribe Tanytarsini midge species found at RM 11.52 were also found at RM 10.70, in addition to *Tanytarsini sepp*. These midges comprised 62.2% of the population, a higher abundance than at RM 11.52, giving Metric 7 a score of 6. RM 10.70 also had a lower abundance of tolerant organisms (4.1%), scoring a 6 for Metric 9

as well. None of the EPT taxa were collected in the qualitative sample. Figure 8 shows the community composition at the two sites.



Overall, RM 11.52 had a higher abundance and diversity of macroinvertebrates than RM 10.70, but the community had a greater prevalence of tolerant organisms and other dipteran species and non-insects, such as snails. The better pool quality and riffle/pool complex development at RM 11.52 may have contributed to the higher abundance and diversity of macroinvertebrates at that site.

Conclusions

The macroinvertebrate communities at RM 11.52 and RM 10.70 on Mill Creek outperformed the respective fish communities. The fish community at RM 11.52 was especially poor, consisting of only seven highly-tolerant goldfish. However, neither site was in attainment of its Warmwater Habitat designated use. Even though the macroinvertebrate community at RM 10.70 was in attainment of its respective criterion, the fish community at that site received a narrative rating of Poor. This put the site as a whole in non-attainment of the designated use.

The goal of the proposed restoration project on Mill Creek is to improve in-stream habitat, reverse stream channel degradation, stabilize severely eroding banks, and restore previously destroyed riparian areas (CCBH 2009b). While such a project may not necessarily reduce stormwater runoff to Mill Creek, it may heighten the stream's capacity to assimilate this environmental disturbance and therefore increase the health of its fish and macroinvertebrate communities. There may also be reductions in the solids concentrations, conductivity, and turbidity of the stream. The restoration work planned for the instream habitat may also improve the QHEI scores to the target score of 60 that will likely support a healthy warmwater habitat fish community. A comparison of post-project water chemistry, QHEI, fish, and macroinvertebrate sampling to this baseline study will demonstrate the effects of the restoration project on the ecology of Mill Creek.

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