NORTHEAST OHIO REGIONAL SEWER DISTRICT

2018 Tinkers Creek Environmental Monitoring
Biological, Water Quality and Habitat Survey Results

Prepared by:
Water Quality and Industrial Surveillance
Division

Introduction

The lower Cuyahoga River has been designated as one of 42 Great Lakes Areas of Concern (AOC) by the International Joint Commission. Past monitoring indicated impairment of aquatic biota in the river and was the basis for the establishment of Total Maximum Daily Loads (TMDLs) for the Lower Cuyahoga River. The causes of impairment to the river were classified as organic enrichment, toxicity, low dissolved oxygen, nutrients, and flow alteration (Ohio EPA, 2003). Recent monitoring by the Northeast Ohio Regional Sewer District (NEORSD), however, has shown recovery of the biological community in some reaches of the river. Further monitoring throughout the watershed is necessary to determine what areas may be still impaired.

In 2018, NEORSD conducted environmental assessments including water chemistry sampling, habitat assessments, and fish and macroinvertebrate community surveys on Tinkers Creek, a tributary to the Cuyahoga River. The objective of this study was to conduct environmental monitoring on Tinkers Creek, and its tributary Wood Creek, in addition to four other tributaries to the Cuyahoga River as part of NEORSD's general watershed monitoring program. Portions of the tributary data collected will provide additional information to support the continued monitoring of the lower Cuyahoga AOC and the potential delisting of some beneficial use impairments.

Sampling was conducted by the NEORSD Environmental Assessment group of the Water Quality and Industrial Surveillance (WQIS) Division and occurred from June 15 through September 30, 2018 (through October 15 for fish sampling assessments), as required in the Ohio EPA *Biological Criteria for the Protection of Aquatic Life Volume III* (1987b). Sampling was conducted by NEORSD Level 3 Qualified Data Collectors (QDCs) 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 *2018 Cuyahoga River Tributaries Environmental Monitoring* approved by Ohio EPA on April 18, 2018.

Figure 1 is a study area map, noting the location of the sampling location evaluated during the 2018 study. Table 1 indicates the sampling location for the study sites on Tinkers Creek and Wood Creek with respect to river mile, latitude/longitude, description, and the types of surveys conducted. A digital photo catalog of the sampling locations is available upon request by contacting the NEORSD WQIS Division.
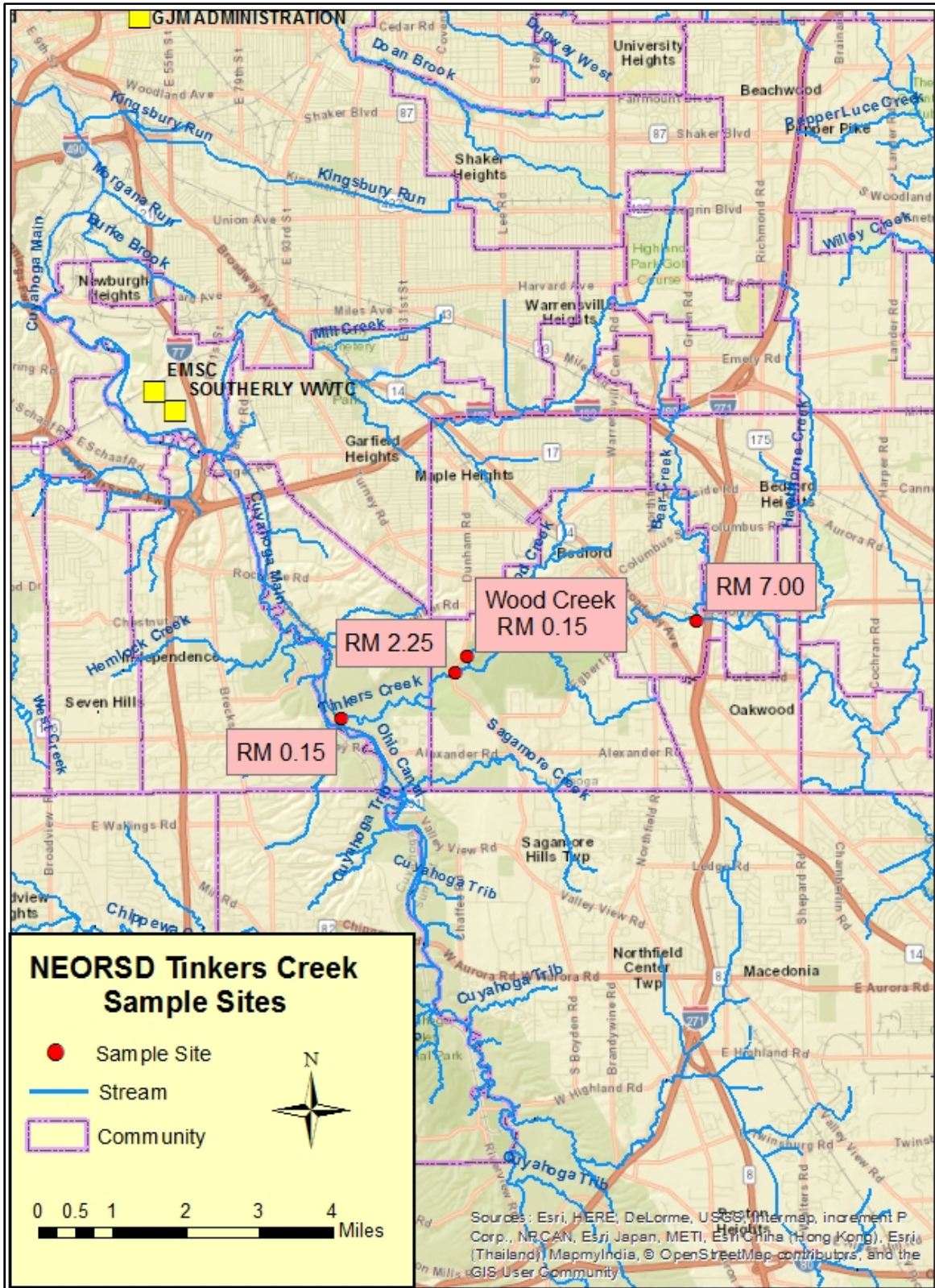
Figure 1. 2018 Tinkers Creek Monitoring Sites

Table 1. Monitoring Sites					
Site Location	Latitude	Longitude	River Mile	Description	Purpose
Tinkers Creek	41.3838	-81.5154	7.00	Upstream of Northfield Road Bridge. Metroparks Bedford Chagrin Parkway.	General watershed monitoring.
Tinkers Creek	41.3740	-81.5785	2.25	Upstream of Dunham Road	General watershed monitoring. Support Cuyahoga AOC.
Tinkers Creek	41.3654	-81.6083	0.15	Upstream of Canal Road	General watershed monitoring. Support Cuyahoga AOC.
Wood Creek, Tinkers Creek Tributary	41.3772	-81.5752	0.15	Upstream of Button Road	General watershed monitoring. Support Cuyahoga AOC.

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Water Chemistry Sampling

Methods

Five separate water chemistry and bacteriological sampling events were conducted between June 20 and July 28, 2018. Techniques used for sampling and analyses were conducted according to methods found in *Surface Water Field Sampling Manual for water quality parameters and flows* (Ohio EPA, 2018). Chemical water quality samples from each site were collected with a 4-liter disposable polyethylene cubitainer with a disposable polypropylene lid, three 473-mL plastic bottles and one 125-mL plastic bottle. The first 473-mL plastic bottle was field preserved with trace nitric acid, the second was field preserved with trace sulfuric acid, and the third bottle received no preservative. The sample collected in the 125-mL plastic bottle (dissolved reactive phosphorus) was filtered using a 0.45-µm PVDF syringe filter. All water quality samples were collected as grab samples. Bacteriological samples were collected in sterilized plastic bottles preserved with sodium thiosulfate. At the time of sampling, measurements for dissolved oxygen, pH, temperature, and conductivity were collected using either a YSI 600XL sonde or YSI EXO1 sonde. Duplicate samples and field blanks were each collected at randomly selected sites, at a frequency not less than 5% of the total samples collected. Relative percent difference (RPD) was used to determine the degree of discrepancy between the primary and duplicate sample (Formula 1).

$$\text{Formula 1:} \qquad RPD \; = \; \left(\frac{|x\text{-}y|}{((x+y)/2)} \right) \; * \; 100$$

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, 2018).

Formula 2:   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 completed 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 OMZA, it generally cannot be determined if Tinkers 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 stream.

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

Results and Discussion

For the 2018 study, two duplicate samples and two field blanks were collected for quality assurance and quality control (QA/QC) purposes. The duplicate samples were collected at Tinkers Creek RM 2.25 on June 27, 2018, and Wood Creek RM 0.15 on July 5, 2018. There were no rejections to report for either of the duplicate samples collected at either location. All RPD values were within the acceptable RPD range.

Two field blank samples were collected in the 2018 sampling season, one at Tinkers Creek RM 0.15 on June 20, 2018; and another at Tinkers Creek RM 2.25 on July 11, 2018. For the field blanks, there were two parameters that showed possible contamination. It is unclear how the field blank became contaminated and may be due to inappropriate sample collection, handling, and/or contaminated blank water. Table 2 lists water quality parameters that were listed as estimated, downgraded from Level 3 to Level 2 data, or rejected based on Ohio EPA data validation protocol.

Table 2. Parameters Affected by Possible Blank Contamination
COD
TKN

Paired parameters for all samples collected from each of the four sampling sites on Tinkers Creek and Wood Creek were evaluated for QA/QC purposes. The comparisons revealed no rejected data for the sampling sites, and one set of parameters with estimated data on one sampling date (Table 3). Because there were no exceedances associated with these parameters, qualification of these results did not significantly change the overall water chemistry assessment of Tinkers Creek and Wood Creek.

Table 3. Paired Data Parameter Analysis						
Date	Site	Parameter	Data Pair	Acceptable RPD (%)	Actual RPD (%)	Qualifier
6/27/2018	Tinkers Creek RM 2.25	*TS*	*TDS*	15.1	2.3	Estimated

     Tinkers Creek is designated as a State Resource Water (SRW), Warmwater Habitat (WWH), Agricultural Water Supply, Industrial Water Supply, and Primary Contact Recreation. Wood Creek has the same designations except it is not a SRW. The water chemistry samples collected at each site were compared to the applicable Ohio Water Quality Standards for the designated uses to determine attainment (Ohio EPA, 2018).

     Water chemistry sampling at Tinkers Creek RMs 0.15, 2.25, and 7.00, as well as Wood Creek RM 0.15, in 2018 revealed mercury concentrations that were below the method detection limit for EPA Method 245.1. It is expected, that the use of EPA Method 1631E, a low-level method, instead of EPA Method 245.1, would have resulted in exceedances of the criteria throughout the sampling period. Mercury may be introduced into Tinkers Creek and Wood Creek from urban runoff and atmospheric deposition within the watershed.

     The Primary Contact Recreation criteria for Tinkers Creek and Wood Creek include an *E. coli* criterion not to exceed a Statistical Threshold Value (STV) of 410 colony counts/100mL in more than ten percent of the samples taken during any 90-day period, and a 90-day geometric mean criterion of 126 colony counts/100mL (Ohio EPA, 2015a). In accordance with Ohio EPA procedure and practice to qualify *E. coli* exceedances for the Primary Recreation criteria, these calculations are formulated when there are at least five samples collected within a rolling 90-day period. The STV criterion was exceeded at all sites on Tinkers Creek and Wood Creek during the 2018 study (Table 4). Each site had more than ten percent of the samples collected that were greater than the statistical threshold value of 410 MPN/100mL. Tinkers Creek and Wood Creek also exceeded the primary contact recreation 90-day geometric mean at all sites. Potential sources of bacteria to the river could include overflows from the Bedford Heights Wastewater Treatment Plant, undocumented improper connections upstream of the study sites or simply fecal matter from animals such as raccoons. Apart from the probable mercury exceedances and the exceedances for *E. coli*, the sampling locations on Tinkers Creek and Wood Creek met all other water quality criteria for the 2018 season.

Table 4. 2018 Tinkers Creek *E. coli* Densities (most-probable number/100mL)				
Date	RM 7.00	RM 2.25	RM 0.15	Wood RM 0.15
6/20/2018*	3304	1986	2166	10,650
6/27/2018	324	188	324	640
7/5/2018	4250	2235	7250	480
7/11/2018	283	309	333	114
7/18/2018*	206	135	650	364
90-Day Geometric Mean	766.9	510.9	1019.5	670.7

	Exceeds statistical threshold value (STV)
	Exceeds geometric mean criterion for 90-day period

*Wet-Weather Event: greater than 0.10 inches of rain but less than 0.25 inches, samples collected that day and the following day are considered wet-weather samples; greater than 0.25 inches, the samples collected that day and the following two days are considered wet-weather samples.

In 2015, the Ohio EPA Nutrients Technical Advisory Group released a proposed Stream Nutrient Assessment Procedure (SNAP) designed to determine the degree of impairment in a stream due to nutrient enrichment. SNAP assigns designations for quality of surface waters based on factors including dissolved oxygen (DO) swings, benthic chlorophyll *a*, total phosphorous, and dissolved inorganic nitrogen (Ohio EPA, 2015c). NEORSD did not assess DO swings or benthic chlorophyll *a* in 2018; however, nutrients were assessed.

Table 5 shows the nutrient concentrations for the Tinkers Creek and Wood Creek sites assessed in 2018. The results of dissolved inorganic nitrogen and total phosphorous were compared to Table 2 listed in the SNAP document. According to this section of SNAP, Tinkers Creek RMs 0.15 and 2.25 exhibit "levels typical of working landscapes; low risk to beneficial use if allied responses are within normal ranges,"; Tinkers Creek RM 7.00 exhibits "levels typical of enriched conditions; low risk to beneficial use if allied responses are within normal ranges; increased risk with poor habitat,"; and Wood Creek RM 0.15 exhibits levels "characteristic of tile-drained lands; otherwise atypical condition with moderate risk to beneficial use if allied responses (DO swings, benthic chlorophyll are elevated" (Ohio EPA, 2015). These narrative descriptions and numeric level results indicate that nitrogen may be a significant concern as a primary source of impairment at the Wood Creek RM 0.15 site. Nitrogen loading to Wood Creek may be a result of an upstream effluent discharge from the Bedford Wastewater Treatment Plant. As well, stormwater runoff from the landscaped areas of Cleveland Metroparks surrounding Wood Creek RM 0.15 may contribute to both nitrogen and phosphorus loading.

Table 5. 2018 Tinkers Creek Nutrient Concentrations		
Site	Total Phosphorus Geometric Mean (mg/L)	Dissolved Inorganic Nitrogen Geometric Mean (mg/L)
Tinkers Creek RM 0.15	0.068	2.88
Tinkers Creek RM 2.25	0.095	3.35
Tinkers Creek RM 7.00	0.149	3.34
Wood Creek RM 0.15	0.118	11.21

Habitat Assessment

Methods

Instream habitat assessments were conducted once at the sampling sites on Tinkers Creek and Wood Creek in 2018 using the Qualitative Habitat Evaluation Index (QHEI). NEORSD was unable to conduct an assessment at Tinkers Creek RM 0.15 because permission was not obtained from one of the property owners. In 2018, Ohio EPA Division of Surface Water staff conducted habitat assessments on several tributaries to the Cuyahoga River. Some of their sites coincided with NEORSD sites, including the one at Tinkers Creek RM 0.15. Therefore, their assessment was used for that site.

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 (55 for headwaters) or more suggests that sufficient habitat exists to support a fish community that attains the WWH criterion. 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 stream segment at Tinkers Creek RM 0.15 was assessed on July 30, 2018, by Ohio EPA. A QHEI score of 76.25 was calculated with a narrative rating of *Excellent* (Table 6), thereby exceeding the target score of 60 for WWH. Cobble and gravel were the dominant substrates found within the stream reach. Moderate instream cover consisted of overhanging vegetation, shallows, rootmats, deep pools, boulders, and woody debris. Other factors that provided a beneficial addition to the score were good overall channel morphology development, lack of channelization, and stable quality riffles within the reach.

The stream segment at Tinkers Creek RM 2.25 was assessed on July 12, 2018. A QHEI score of 59.0 was calculated with a narrative rating of *Fair*, nearly attaining the WWH target of 60 and the potential to support a healthy fish community. Bedrock and gravel were the dominant substrates present. Lack of adequate instream cover detracted from the overall score. In addition to the lack of instream cover, this reach suffered from low sinuosity, fair channel development, and a very narrow riparian buffer; all of which are factors contributing to the lower overall score. Regarding the riffles found within the reach, the QDC noted that the riffles may have appeared of good quality, but in fact were composed of poor substrate and were unstable (likely due to underlying bedrock).

The stream segment at Tinkers Creek RM 7.00 was assessed on July 12, 2018. A QHEI score of 73.5 was calculated with a narrative rating of *Good*, exceeding the target score of 60, and demonstrating the potential to support a healthy fish population. A moderate amount of diverse instream cover was present at this reach, including small amounts of shallows in slow water, deep pools, rootwads, and aquatic macrophytes; and a more moderate presence of boulders within the reach. This diversity contributes to the potential ability of the reach to support a healthy fish population. Additional features benefitting the reach include lack of channelization, minimal erosion, and quality stable riffles present. Low sinuosity of the reach and moderate embeddedness of the substrate were two factors that minorly detracted from the overall score.

The stream segment at Wood Creek RM 0.15 was assessed on June 28, 2018. A QHEI score of 69.5 was calculated with a narrative rating of *Good*, exceeding the target score of 55 for WWH. The dominant substrates found during evaluation were bedrock and boulders. The reach was lacking instream fish cover availability, with only a moderate-to-sparse presence of undercut banks, shallows in slow water, rootmats, boulders, and logs/woody debris. A bedrock-dominated substrate and an extremely high gradient to drainage ratio were among the major detractions from the overall QHEI score. Having minimal refuge areas along with an extremely high gradient may be a barrier to supporting a diverse fish community.

Table 6. 2018 Tinkers Creek and Wood Creek QHEI Results			
River Mile	Date	QHEI Score	Narrative
Tinkers Creek 0.15*	7/30/18	76.25	*Excellent*
Tinkers Creek RM 2.25	7/12/2018	59.0	*Fair*
Tinkers Creek RM 7.00	7/12/2018	73.5	*Good*
Wood Creek RM 0.15	6/28/2018	69.5	*Good*
*Assessment completed by Ohio EPA			

Table 7. Tinkers Creek Qualitative Habitat Evaluation Index Scores and Physical Attributes

			WWH Attributes											MWH Attributes — High Influence						MWH Attributes — Moderate Influence												
River Mile	QHEI Score	Habitat Rating	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max. Depth >40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	Channelized or no Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max. Depth <40 cm (WD, HW sites)	Total High Influence Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total Moderate Influence Attribute
Tinkers Creek RM 0.15	76.25	Excellent	x	x		x	x	x	x		x		7						0						x				x	x		3
Tinkers Creek RM 2.25	59.0	Fair	x				x	x	x	x			5				x		1					x	x	x						3
Tinkers Creek RM 7.00	73.50	Good	x	x		x		x	x		x		6						0						x				x	x		3
Wood Creek RM 0.15	69.50	Good	x	x	x	x	x	x	x	x	x	x	10						0													0

Fish Community Assessment

Methods

Two quantitative electrofishing passes were conducted by NEORSD on Tinkers Creek at RMs 0.15 and Wood Creek at RM 0.15 for the 2018 sampling season. One electrofishing pass was conducted at RM 2.25. In 2018, NEORSD was unable to get permission from one of the landowners at Tinkers Creek RM 0.15, which prevented NEORSD from electrofishing there. In 2018, Ohio EPA Division of Surface Water Staff conducted electrofishing surveys on several tributaries to the Cuyahoga River. Some of their electrofishing zones coincided with NEORSD zones, including the one at Tinkers Creek RM 0.15. Therefore, their survey was used to assess the fish community at RM 0.15. Ohio EPA also conducted a survey at RM 2.25. 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 0.20 kilometers for Tinkers Creek RMs 0.15, 2.25, and 7.00; and 0.15 kilometers for Wood Creek RM 0.15. 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 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.

The electrofishing results for each pass were compiled and utilized to evaluate fish community health through the application of the Ohio EPA 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 and wading sites are listed in Table 8.

| Table 8. Index of Biotic Integrity (IBI) Metrics ||
Headwater	Wading
Total Number of Native Species	Total Number of Native Species
Number of Darters & Sculpins	Number of Darters & Sculpins
Number of Headwater Species	Number of Sunfish Species
Number of Minnow Species	Number of Sucker Species
Number of Sensitive Species	Number of Intolerant Species
Percent Tolerant Species	Percent Tolerant Species
Percent Pioneering Species	Percent Top Carnivores
Percent Omnivores	Percent Omnivores
Percent Insectivores	Percent Insectivores
Number of Simple Lithophils	Percent Simple Lithophils
Percent DELT Anomalies	Percent DELT Anomalies
Number of Individuals	Number of Individuals

The second fish index utilized by Ohio EPA is the Modified Index of Well-being (MIwb). The MIwb, Formula 3 listed below, incorporates four fish community measures: numbers of individuals, biomass, and the Shannon Diversity Index (H) (Formula 4) based on numbers and weight of fish. The MIwb is a result of a mathematical calculation based upon the formula.

Formula 3:
$$MIwb = 0.5\,lnN + 0.5\,lnB + \overline{H}(No.) + \overline{H}(Wt.)$$

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

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

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

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

Formula 4:
$$\overline{H} = -\sum \left[\left(\frac{n_i}{N} \right) log_e \left(\frac{n_i}{N} \right) \right]$$

$n_i =$ Relative numbers or weight of species

$N =$ Total number or weight of the sample

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

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Results and Discussion

Based on the survey conducted by Ohio EPA, the fish community within the Tinkers Creek RM 0.15 sampling reach had an IBI score of 46, narratively *Very Good* (Table 9, Figure 2), and an MIwb score of 9.4, narratively *Very Good*, therefore attaining both the IBI and MIwb WWH criteria. Of all the specimens collected, there was only one DELT reported (erosion on a channel catfish). Only one intolerant taxon, stonecat madtom (*Noturus flavus*), was present. Regarding the total sample composition, 20 of the 21 total taxa were native species, and the dominant taxon was the greenside darter (*Etheostoma blennioides*), comprising 25.2% of the total sample. Overall, the IBI and MIwb scores for Tinkers Creek reflect the sampling site's QHEI score of 74.5, narratively *Good*, confirming the reach's ability to support a diverse and healthy fish population.

Table 9. 2018 Tinkers Creek and Wood Creek IBI Results								
	1st Pass			2nd Pass			Average	
River Mile	Date	IBI (*Narrative Rating*)	MIwb (*Narrative Rating*)	Date	IBI (*Narrative Rating*)	MIwb (*Narrative Rating*)	IBI (*Narrative Rating*)	MIwb (*Narrative Rating*)
Tinkers Creek RM 0.15*	7/30/2018	**46**(Very *Good*)	**9.4** (Very *Good*)	---	---	---	**46** (Very *Good*)	**9.4** (Very *Good*)
Tinkers Creek RM 2.25	7/12/2018	36 (*Good*)	**8.2** (*Good*)	9/24/2018	**40** (*Good*)	**9.2** (Very *Good*)	38 (*Good*)	**8.7** (*Good*)
Tinkers Creek RM 7.00	7/12/2018	26 (*Poor*)	*7.4 (Marginally Good)*	10/11/2018	30 (*Fair*)	6.0 (*Fair*)	28 (*Fair*)	6.7 (*Fair*)
Wood Creek RM 0.15	6/28/2018	20 (*Poor*)	---	10/11/2018	20 (*Poor*)	---	20 (*Poor*)	---
Bold = meets WWH criterion [IBI ≥40, MIwb≥7.9]								
Italics = non-significant departure from WWH criterion [IBI ≥36; MIwb ≥7.4]								
*Survey conducted by Ohio EPA								

The fish community within the sample reach at Tinkers Creek RM 2.25 resulted in an average IBI score of 38, narratively *Good*, and an average MIwb score of 8.7, narratively *Good*, therefore attaining the MIwb WWH criteria for the 2018 sampling season. With an IBI score of 38, RM 2.25 is in non-significant departure from IBI WWH criterion. Tinkers Creek RM 2.25 was another site near where Ohio EPA conducted its own electrofishing survey. NEORSD supplemented its data with Ohio EPA fish data from that survey.

Figure 2. 2018 Tinkers Creek Average IBI Scores

*Non-significant departure (≤4 IBI units) from applicable criterion.
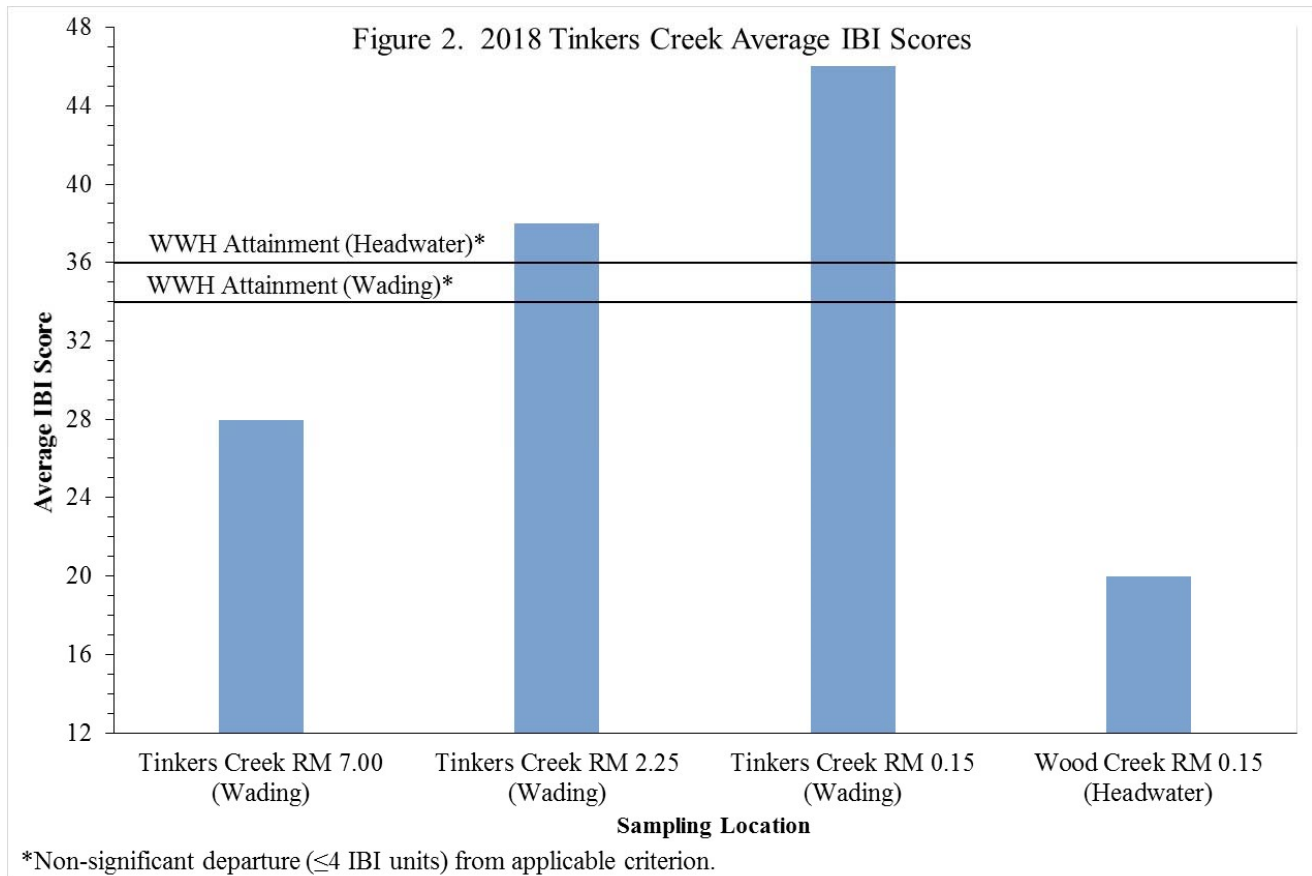
The first electrofishing pass, completed by NEORSD staff, on July 12, 2018, resulted in an IBI score of 36, narratively *Good*, and an MIwb score of 8.2, narratively *Good*. No DELTs were reported among any of the specimens collected during this event. Positively contributing factors to these scores included the total number of individuals (1462) as well as the proportion of simple lithophils (37.83%). Some metrics were negatively impacted, such as Number of Intolerant Species present and Proportion of Tolerant Species, with each only scoring "1" on the IBI metric. The dominant species of the sample population was central stoneroller minnow (*Campostoma anomalum*), accounting for 32.8% of the population sample. While the stoneroller minnow is considered to have an intermediate tolerance to pollution by the Ohio EPA, the second-most dominant species, the white sucker (*Catostomus commersonii*), accounting for 29.3% of the sample population, was designated highly tolerant to pollution. The overall sample was dominated by pollution-tolerant species (42.82%) with 7 taxa (of 12 designated with values) classified as moderately tolerant to pollution or poorer.

The second electrofishing sample event for RM 2.25 was completed on September 24, 2018, by Ohio EPA staff and resulted in an IBI score of 40, narratively *Good*, and an MIwb score of 9.2, narratively *Very Good*. An increase of total species, including the addition of one pollution-intolerant species, stonecat madtom (*Noturus flavus)*, occurred for this sampling event at RM 2.25. There were two DELTs reported in this sampling

event, a deformity on a smallmouth bass (*Micropterus dolomieu*) as well as a northern hogsucker (*Hypentelium nigricans*), resulting in a reported DELT percentage of 0.39%. In 2018, Tinkers Creek RM 2.25 resulted in a QHEI score of 59.0, narratively *Fair*. While this site just narrowly missed the target score of 60, the fish sample population collected still demonstrated the reach's potential to support a diverse fish community.

The electrofishing sampling reach at Tinkers Creek RM 7.00 averaged an IBI score of 28, narratively *Fair*, and an MIwb score of 6.7, narratively *Fair* for the 2018 sampling events. This sampling reach was therefore in non-attainment of both the IBI and the MIwb criteria for 2018. The first electrofishing pass, completed on July 12, 2018, resulted in an IBI score of 26, narratively *Poor*, and an MIwb score of 7.4, narratively *Marginally Good*. Thirteen total taxa were present, all of which were native species. However, important species groups were absent, including darter species and intolerant species. The only darter species collected was the johnny darter (*Ethestoma nigrum*). There were zero intolerant species collected. Additionally, two sucker species were present, including the common white sucker (*Catostomus commersonii*) and the northern hog sucker (*Hypentelium nigricans*), providing for an improvement to the overall IBI score. One of the higher scoring metrics in the sample population was the number of sunfish species present, with three species. The species included northern rockbass (*Ambioplites rupestris*), green sunfish (*Lepomis cyanellus*), and northern bluegill sunfish (*Lepomis macrochirus*). Regarding pollution tolerance, seven (of nine taxa with Ohio EPA designated values) were classified as moderately tolerant or poorer.

The second electrofishing pass for Tinkers Creek RM 7.00, completed on October 11, 2018, resulted in an IBI score of 30, narratively *Fair*, and an MIwb score of 6.0, narratively *Fair*. There was a reduction in the number of total taxa as well as the total number of fish collected during this sampling event. Eleven total taxa were collected during this electrofishing pass. None of the specimens collected were reported to have any DELTs. One reason for the increase in the IBI score was due to a higher percentage of insectivores in the sample population (from 4.11% on 7/12/18 to 29.56% on 10/11/18). Additionally, an increase in the proportion of top carnivores increased from 4.90% to 6.92%. This increase resulted in an additional two points being added to the total IBI score when compared to the first pass. While Tinkers Creek RM 7.00 resulted in a QHEI score of 73.5 for the 2018 sampling season, it is evident that the sample populations collected do not correlate with that score. This stream segment also flows downstream of an Interstate 480/271 overpass and could possibly be adversely impacted from stormwater runoff from the highway, and/or possible nutrient loading from the nearby Cleveland Metroparks golf course property. In addition to impacts from upstream, there is a natural fish barrier, the Great Falls of Tinker Creek (Figure 3), downstream of the site that prevents the migration of fish upstream.
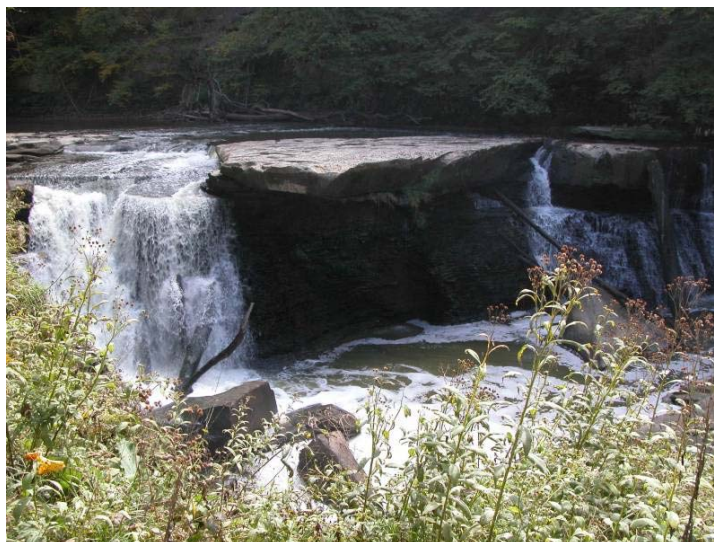
Figure 3. Great Falls of Tinkers Creek

The electrofishing sampling reach at Wood Creek averaged an IBI score of 20, narratively *Poor* for the 2018 sampling events. This sampling reach is therefore in non-attainment of the IBI criterion for 2018. During the first electrofishing pass, completed June 28, 2018, the reach resulted in an IBI score of 20, narratively *Poor*. While no DELTs were recorded in any of the specimens, only two taxa were collected during this event, including blacknose dace (*Rhinicthys atratulus*) and the creek chub (*Semotilus atromaculatus*). Only 41 total specimens were collected; 14 western blacknose dace and 27 creek chubs. Both species are designated as highly tolerant to pollution according to the Ohio EPA, and having an absence of intolerant species as well as most other significant species groups, contributed to the low score achieved during this event.

For the second electrofishing pass, completed October 11, 2018, the sampling reach at Wood Creek RM 0.15 again resulted in an IBI score of 20, narratively *Poor*. During this sampling event, there was an increase in the total number of specimens collected, with 14 specimens of blacknose dace and 82 specimens of the creek chub. Just like the first pass, there were no DELTs reported on any of the specimens. Similar to the previous pass, the reach was also absent of important species groups, contributing to the low score. Wood Creek RM 0.15 is likely impacted from the upstream Bedford Wastewater Treatment Plant, and possible stormwater runoff from the local golf course within the bordering Cleveland Metroparks. While Wood Creek RM 0.15 resulted in a QHEI score of 69.5 (narratively *Good*), lack of in-stream fish cover combined with a dominant bedrock substrate, a high-gradient, and a natural fish barrier at the confluence with Tinkers Creek are all likely to have an impact for this reach to sustain a healthy and diverse fish population.

Macroinvertebrate Community Assessment

Methods

Macroinvertebrates were sampled quantitatively using modified Hester-Dendy (HD) samplers in conjunction with a qualitative assessment of Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly), also referred to as EPT taxa, inhabiting available habitats at the time of HD retrieval. Sampling was conducted at the Tinkers Creek and Wood Creek sampling locations listed in Table 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 Third Rock Consulting of Lexington, Kentucky, for identification and enumeration. Specimens were identified to the lowest practical taxonomic level as defined by the Ohio EPA (1987b). Lists of the species collected during the quantitative and qualitative sampling 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) (Ohio EPA 1987b, DeShon 1995). The ICI consists of ten community metrics (Table 10), 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.
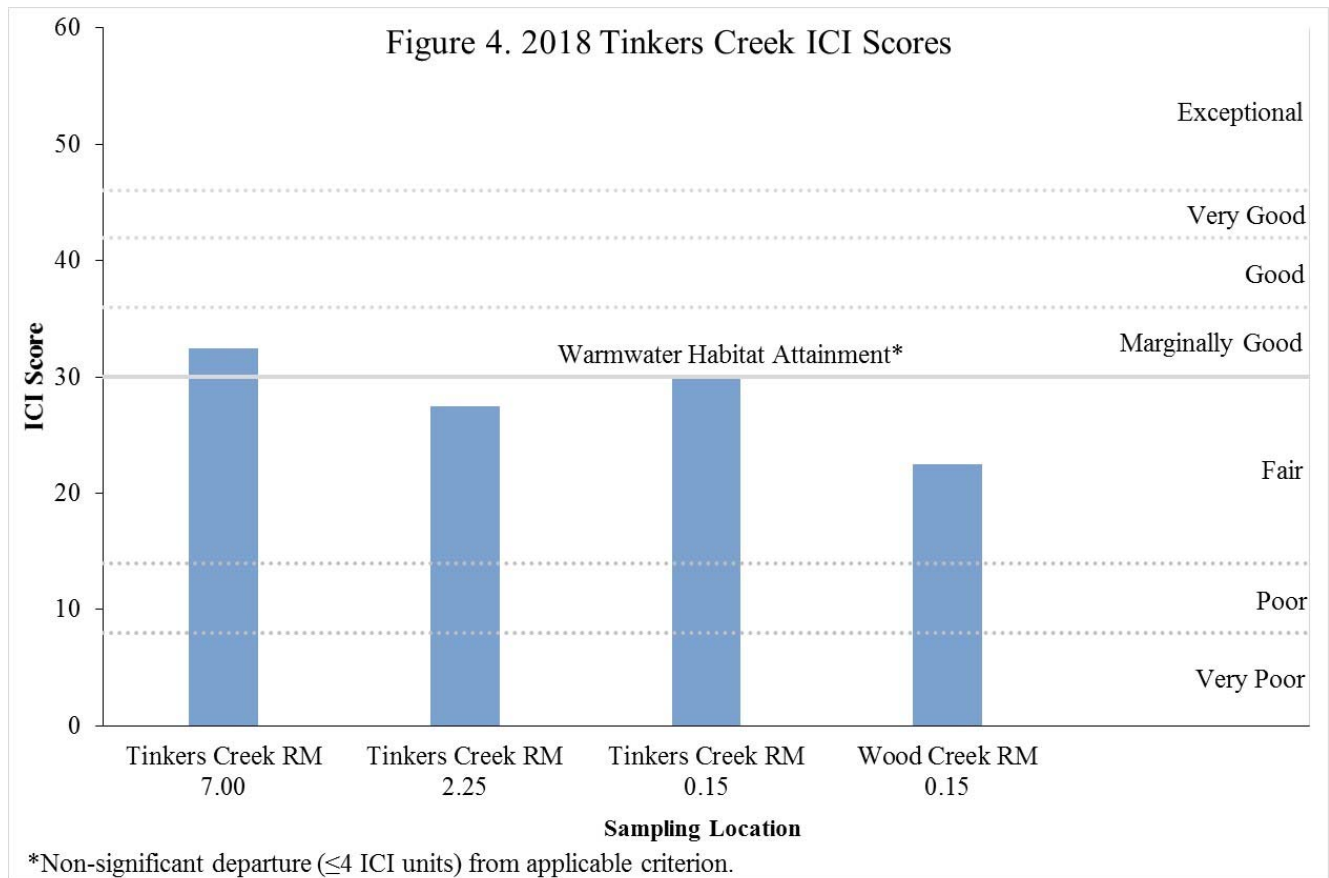
Table 10. ICI Metrics
Total Number of Taxa
Number of Mayfly Taxa
Number of Caddisfly Taxa
Number of Dipteran Taxa
Percent Mayflies
Percent Caddisflies
Percent Tanytarsini Midges
Percent Other Diptera and Non-insects
Percent Tolerant Organisms (As Defined)
Number of Qualitative EPT Taxa

The HD samplers were successfully recovered from all sampling sites on Tinkers Creek and Wood Creek during the 2018 season. Combined with qualitative macroinvertebrate sampling on the day of HD retrieval, this allowed for a calculated ICI score to assess each of the sampling sites.

The macroinvertebrate community at Tinkers Creek RM 7.00 resulted in an ICI score of 38, narratively *Good*, for 2018, exceeding the WWH criterion. A total of 51 taxa were collected at the sampling site, from the HD sampler and qualitative dipnet sampling. Only 0.98% of the 7060 organisms collected from the HD sampler were considered tolerant (as defined), an indication that more sensitive organisms would thrive in the reach. One of the reductions to the ICI score was the number of Ephemeroptera taxa present in the sample population. Five taxa were present, including *Baetis flavistriga*, *Baetis intercalaris*, *Stenacron sp., Maccaffertium terminatum*, and *Tricorythodes sp*. For a stream of this size and drainage area, it is ideal to have a population assemblage with 8 or more taxa. The population abundance of Ephemeroptera and Trichoptera accounted for 29.5% of all organisms collected. The "number of caddisfly taxa" and "percent caddisflies" metrics both scored well and contributed positively to the IBI score. This high proportion of Ephemeroptera and Trichoptera species within the sample is another indication of the ability of the stream to sustain a healthy macroinvertebrate population.

Table 11. Invertebrate Community Index (ICI) Scores	
River Mile	ICI Score (*Narrative Rating*)
Tinkers Creek RM 7.00	**38** (*Good*)
Tinkers Creek RM 2.25	**34** (*Good*)
Tinkers Creek RM 0.15	**36** (*Good*)
Wood Creek RM 0.15	30* (*Marginally Good*)
Bold – Attainment of WWH criterion * - Non-significant departure (≤4 ICI units) from applicable criterion	

Tinkers Creek RM 0.15 resulted in an ICI score of 36 with a narrative rating of *Good* for 2018 (Table 11, Figure 3), therefore exceeding the WWH criterion of 34. Of the 56 total taxa collected in both the HD and qualitative sampling, eight representative species from the EPT were present, including five Ephemeropterans: *Baetis flavistriga*, *Baetis intercalaris*, *Stenacron sp., Maccaffertium terminatum*, and *Caenis sp.*; and three Trichopterans: *Cheumatopsyche sp.*, *Ceratopsyche morosa*, and *Hydropsyche depravata group*. As well, the individuals collected from these species accounted for 36.4% of all the organisms collected on the HD sampler. A strong presence of EPT taxa in this stream reach is an indication of good water quality, which is reflected in the ICI score. A minimal presence (0.92%) of tolerant (as defined) organisms was another factor that provided a positive contribution to the overall score. The presence of stable and quality riffles, providing an oxygen-rich environment, along with quality substrate dominated by cobble and gravel may have also contributed to the dominance of these macroinvertebrates.

Figure 4. 2018 Tinkers Creek ICI Scores

*Non-significant departure (≤4 ICI units) from applicable criterion.

The macroinvertebrate community at Wood Creek RM 0.15 resulted in an ICI score of 30, narratively *Marginally Good*, for 2018. The ICI score was within non-significant departure from WWH criterion. Between the HD and qualitative dipnet sampling, 44 different taxa were collected within this stream reach. Dominating the sample population were Dipterans, accounting for 14 of the 44 total taxa collected, which positively affected the ICI score. However, as these taxa were proportionally abundant (79.23% of all organisms collected), the ICI score suffered from this low-scoring metric. Five Trichopteran taxa were present in the sample population, including the following: *Chimarra aterrima*, *Polycentropus sp.*, *Cheumatopsyche sp.*, *Ceratopsyche sparna*, and *Hydropsyche depravata group*. The presence of these five taxa, as well as their population proportion (14.87% of all organisms collected), both had a positive influence on the overall ICI score. Conversely, the presence and population proportion for another good water quality indicator, Ephemeroptera, were severely low within this sample population. Only two taxa, *Baetis flavistriga* and *Baetis intercalaris*, were represented in the sample, which accounted for 7.14% of the total population. Wood Creek RM 0.15 is a high gradient stream segment dominated by a bedrock substrate, both of which may have been prohibitive to achieving a more diverse and higher quality macroinvertebrate community.

Conclusions

The results of the water chemistry sampling, habitat assessments, and fish and benthic macroinvertebrate community surveys conducted by NEORSD in 2018 indicate that the Tinkers Creek/Wood Creek watershed may have been impacted by a variety of environmental stressors and various aquatic habitat limitations. Three of the four sampling locations that were evaluated achieved at least partial Aquatic Life Use Attainment status, with Tinkers Creek RMs 0.15 and 2.25 achieving full biological attainment. The site on Wood Creek was in non-attainment (Table 12).

Bacteriological sampling within the Tinkers Creek and Wood Creek sampling sites showed elevated densities of *E. coli*, which is regarded as an indicator of poor water quality conditions. These water quality exceedances may be attributed to stormwater runoff or failing home septic systems in the surrounding residential areas. As well, nutrient-enriched conditions were evident at two of the sampling locations, Tinkers Creek RM 7.00, and Wood Creek RM 0.15. Resulting from these water quality conditions, the fish and/or macroinvertebrate communities at each sampling site may have been disturbed through overall loss of taxa, individuals, or population shifts toward more pollution-tolerant species.

Undesirable habitat conditions within some of the sampling locations presented another challenge and may have prohibited the support of more diverse and higher-quality fish and/or macroinvertebrate communities. Sparseness or complete lack of in-stream cover for fish and unstable substrate or poor riffles for macroinvertebrates were likely to have been the largest contributing factors.

Bacteriological and nutrient issues may be able to be improved to achieve attainment of water quality status, therefore improving the overall quality of the in-stream biological community. The matters surrounding quality of habitat, however, and the associated impacts to the fish and macroinvertebrate communities, may not be easily remediated. Permanent anthropogenic changes to the area surrounding the Tinkers Creek and Wood Creek watershed may prevent restoration of some habitat, including issues with erosion, instream cover, and channel sinuosity. Ultimately, water quality will need to improve within the watershed before any noticeable changes are present in the biological communities.

River Mile	Aquatic Life Use Attainment Status	Average IBI Score (*Narrative Rating*)	Average MIwb Score (*Narrative Rating*)	ICI Score (*Narrative Rating*)	QHEI Score (*Narrative Rating*)	Water Quality Exceedances
Table 12. 2018 Tinkers Creek/Wood Creek Survey Results						
Tinkers Creek RM 7.00	PARTIAL	28 *(Fair)*	6.7 *(Fair)*	38 *(Good)*	74.5 *(Good)*	*E. coli*
Tinkers Creek RM 2.25	FULL	38 *(Good)*	8.7 *(Good)*	34 *(Good)*	59.0 *(Fair)*	*E. coli*
Tinkers Creek RM 0.15	FULL	46 *(Very Good)*	9.4 *(Very Good)*	36 *(Good)*	76.25 *(Excellent)*	*E. coli*
Wood Creek RM 0.15	NON	20 *(Poor)*	N/A	30 *(Marginally Good)*	69.5 *(Good)*	*E. coli*

WWH biocriterion attainment: IBI score of 40 (Headwater), 38 (Wading); MIwb score of 7.9 (Wading); ICI score of 34
Non-significant departure: ≤4 IBI units; ≤0.5 MIwb units; ≤4 ICI units

Acknowledgments

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

Kelsey Amidon
Hannah Boesinger
Nya Dreyfuss
Seth Hothem
Ron Maichle
Mark Matteson, Author
Mario Meany
Denise Phillips
John Rhoades
Eric Soehnlen
Justin Telep

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

Analytical Services Division – Completed analysis for all water chemistry sampling

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