2007 Cuyahoga River Biological, Water Quality and Habitat Survey Results

Introduction

During 2007, the Northeast Ohio Regional Sewer District[1] (NEORSD) conducted electrofishing, benthic macroinvertebrate and water chemistry sampling and habitat assessments of the Cuyahoga River. The purpose of the sampling was to assess the biological communities and the water and habitat qualities of the Cuyahoga River and determine any impacts from point and nonpoint sources of pollution. In addition to sites immediately upstream (US) and downstream (DS) of Southerly WWTC, supplemental sites were sampled to determine any impacts from Mill Creek, West Creek and Tinkers Creek, all tributaries to the Cuyahoga River. River Mile (RM) 16.20, located upstream of Southerly WWTC, served as a reference site as it has been in known Warmwater Habitat (WWH) biological attainment according to the Ohio Environmental Protection Agency (EPA) since 2000 (*Total Maximum Daily Loads for the Lower Cuyahoga River*, 2003). Figure 1 is a map of the sampling locations on the Cuyahoga River, and Table 1 indicates the sampling locations with respect to RM, latitude/longitude, description and surveys conducted.

[1] 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 approved by Ohio EPA on July 2, 2007 (*Cuyahoga River Electrofishing & Benthic Macroinvertebrate Surveys*, 2007).

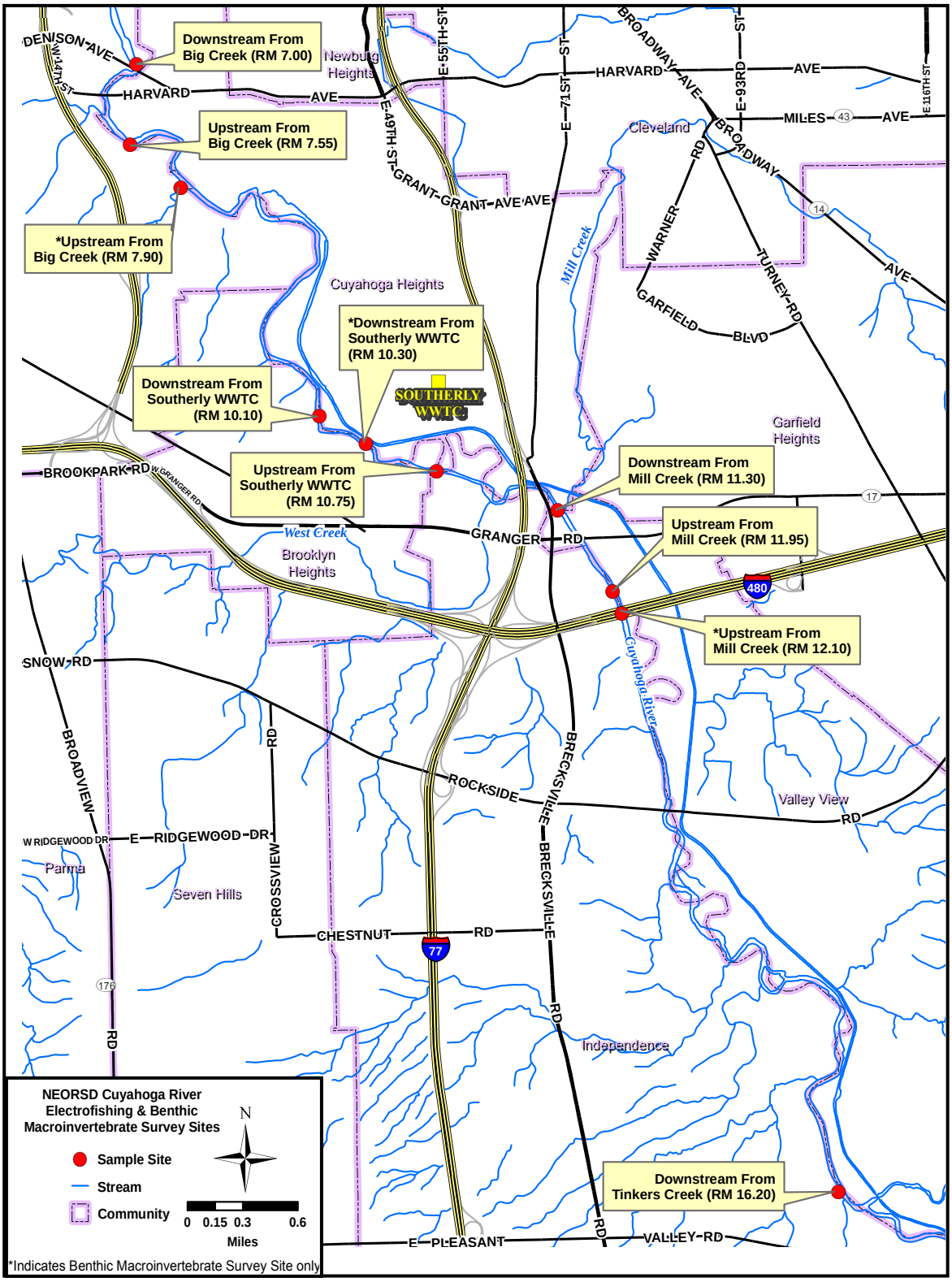

Figure 1. NEORSD Cuyahoga River Biological, Habitat and Water Chemistry Sites

Table 1. 2007 Cuyahoga River Locations					
Location	Latitude	Longitude	River Mile	Description	Purpose
Old Riverview Road	N41.3681°	W81.6139°	16.20	Downstream of the confluence with Tinkers Creek	Background data for fish, habitat, macroinvertebrates and water chemistry
Upstream of Mill Creek	N41.4123° N41.4101°	W81.6364° W81.6346°	[2]12.10 11.95	Upstream of the confluence with Mill Creek (I-480)	Evaluate Mill Creek discharge on fish, habitat, macroinvertebrates and water chemistry
Downstream of Mill Creek	N41.4178°	W81.6446°	11.30	Downstream of the confluence with Mill Creek	Evaluate Mill and West Creek discharges on fish, habitat, macroinvertebrates and water chemistry
Upstream of Southerly WWTC	N41.4196°	W81.6547°	10.75	Upstream of Southerly WWTC effluent discharge	Evaluate West Creek and Southerly WWTC discharge on fish, habitat, macroinvertebrates and water chemistry
Downstream of Southerly WWTC	N41.4214° N41.4242°	W81.6590° W81.6638°	[3]10.30 10.10	Downstream Southerly WWTC effluent discharge	Evaluate Southerly WWTC discharge on fish, habitat, macroinvertebrates and water chemistry
Upstream of Big Creek	N41.4405° N41.4437°	W81.6772° W81.6822°	[2]7.90 7.55	Upstream of the confluence with Big Creek	Evaluate Big Creek discharge on fish, habitat, macroinvertebrates and water chemistry
Downstream of Big Creek	N41.4497°	W81.6815°	7.00	Downstream of the confluence with Big Creek	Evaluate Big Creek discharge on fish, habitat, macroinvertebrates and water chemistry

Water Chemistry Sampling

Water chemistry samples were collected from each location approximately once a week, resulting in 11 sampling events, beginning July 10, 2007 and ending September 25, 2007. The techniques that were used for the water chemistry sampling and chemical analyses followed the *Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices* (2006). Field analyses included the use of a Marsh-McBirney FloMate Model 2000 Portable Flow Meter, which measures flow in feet per second, and a YSI-556 MPS Multi-Parameter Water Quality Meter to measure dissolved oxygen, water temperature, specific conductivity and pH at the time of sampling. There were no exceedances of

[2] Macroinvertebrates and water chemistry samples sample sites.
[3] The site at RM 10.30 has historically been the downstream of Southerly WWTC sampling location. The site at RM 10.10 was added in 2006 because it is in an area more conducive to macroinvertebrate colonization due to the presence of a functional riffle and is also within the electrofishing zone. Both sites were sampled for macroinvertebrates in 2007.

applicable outside mixing zone maximum water quality criteria for the protection of aquatic life or 30-day outside mixing zone average water quality criteria for the protection of aquatic life. Average concentrations of all parameters are listed in Table 2. Raw data sheets are available upon request.

Table 2. 2007 Cuyahoga River Average Dry Weather Concentrations

		DS Tinkers Creek	US Mill Creek	DS Mill Creek	US Southerly WWTC	DS Southerly WWTC	US Big Creek	DS Big Creek
Parameter	Units	RM 16.20	RM 11.95	RM 11.30	RM 10.75	RM 10.10	RM 7.55	RM 7.00
Alkalinity	mg/L	145	145	146	144	125	126	125
Hardness	mg/L	244	245	243	241	230	233	231
Total Solids	mg/L	648	650	652	652	671	671	673
Suspended Solids	mg/L	23	21	25	20	18	18	17
Dissolved Solids	mg/L	582	587	587	586	597	608	604
Total Phosphorus	mg/L	0.22	0.21	0.20	0.20	0.36	0.32	0.33
Dissolved Reactive Phosphorus	mg/L	0.16	0.14	0.14	0.13	0.30	0.27	0.27
Ammonia	mg/L	0.03	0.03	0.02	0.02	0.07	0.05	0.07
Nitrate	mg/L	3.74	3.70	3.70	3.59	7.26	6.81	6.83
Chemical Oxygen Demand	mg/L	16	16	16	17	20	21	21
Sodium	µg/L	92710	107590	106250	106090	111280	109290	111020
Magnesium	µg/L	16880	16980	16905	16815	16340	16570	16450
Calcium	µg/L	69975	70220	69400	68720	65260	66130	65585
Potassium	µg/L	6263	6468	6448	6369	13140	12346	12257
Manganese	µg/L	74.2	70.8	72.0	75.5	63.0	61.1	63.6
Iron	µg/L	662	583	611	662	556	534	597
Aluminum	µg/L	235.5	203.0	224.3	244.5	206.8	208.4	229.9
Copper	µg/L	4.2	4.6	4.3	5.7	5.0	4.9	5.5
Total Metals[4]	µg/L	20.7	21.6	20.2	24.1	31.9	29.9	32.3
Zinc	µg/L	13.8	13.8	13.0	14.3	19.4	18.2	18.8
Nickel	µg/L	2.3	2.8	2.5	3.7	6.4	5.9	7.0
Thallium	µg/L	5.8	5.7	5.7	5.6	5.5	5.4	5.3

Habitat Assessment

A Qualitative Habitat Evaluation Index (QHEI) score was determined for each of the seven electrofishing zones on the Cuyahoga River. QHEI sheets for each site that was evaluated are available upon request. The QHEI, developed by Ohio EPA, 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

[4] Sum of Cr, Cu, Zn and Ni. Cr not included in table because the metal was not detected in any of the samples.

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, *Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)*, June 2006.

Ohio EPA has set a target score of 60 for the QHEI[5]. Warmwater habitat sites that meet this target are expected to be capable of meeting applicable biological criteria. Of the seven sites that were evaluated on the Cuyahoga River in 2007, only the site upstream from Big Creek was below the target of 60 (Table 3). At this site, low scores were received for each of the six QHEI metric components. The physical habitat in this section of the river consisted of sand and muck substrate with heavier silt and sparse instream cover. Channel morphology consisted of poor pool/riffle development with moderate stream bank erosion.

The highest QHEI was obtained at the furthest upstream sampling site on the Cuyahoga River, downstream from Tinkers Creek. This site received generally high scores in each of the six QHEI metrics. The section of stream in this area is located within the Cuyahoga Valley National Park (CVNP) and consisted of cobble and sand substrate with little silt and abundant stream cover. Channel morphology consisted of good pool/riffle development with little to no stream bank erosion.

QHEI scores upstream and downstream from Southerly WWTC have remained consistent and the physical habitat has remained moderately stable over the years 1991-2007. Scores have ranged from 64-77, *Good* to *Excellent*.

Table 3. Cuyahoga River, 1997-2007
Qualitative Habitat Evaluation Index Scores

Site Location	1997	1998	1999	2001	2003	2004	2006	2007
DS Tinkers Creek RM 16.20	-	-	-	-	-	-	-	79(E)
US Mill Creek RM 11.95	-	-	-	-	-	-	-	75(E)
DS Mill Creek RM 11.30	-	-	-	-	-	-	-	78(E)
US Southerly WWTC RM 10.75	73(G)	69(G)	77(E)	75(E)	76(E)	70(G)	75(E)	76(E)
DS Southerly WWTC RM 10.10	64(G)	66(G)	67(G)	69(G)	67(G)	68(G)	72(G)	71(G)
US Big Creek RM 7.55	-	-	-	65(G)	-	-	57(F)	51(P)
DS Big Creek RM 7.00	64(G)	66(G)	66(G)	67(G)	-	-	66(G)	73(E)
(E)- Excellent (G)- Good (P)- Poor								

[5] Ohio EPA. 2003. Total Maximum Daily Loads for the Lower Cuyahoga River. Ohio EPA, Division of Surface. Water Standards and Technical Support Section. Online, last accessed 11/3/05.

Electrofishing

Methods

Electrofishing was accomplished by utilizing the Northeast Ohio Regional Sewer District's (NEORSD) 17-foot Coffelt aluminum electrofishing boat. Boat electrofishing consists of shocking all habitat types within a sampling zone that is 0.5 kilometers in length, while moving from upstream to downstream. Electrofishing was completed on the river under relatively low flow conditions. The average daily flows recorded by the United States Geological Survey gage station in Independence for each of the passes were 195, 265 and 247 cubic feet per second, respectively.

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. A detailed description of the sampling methods utilized in the fish surveys can be found in Ohio EPA's *Biological Criteria for the Protection of Aquatic Life, Volumes II* (1987, updated January 1, 1988 and November 8, 2006) and *III* (1987, updated September 30, 1989).

The electrofishing results for each pass were compiled and utilized to evaluate fish community health through the application of two Ohio EPA indices, the Index of Biotic Integrity (IBI) and the Modified Index of Well Being (MIwb). The IBI incorporates 12 community metrics representing structural and functional attributes. The structural attributes are based upon fish community aspects such as fish numbers and diversity. Functional attributes are based upon fish community aspects such as feeding strategies, environmental tolerances and disease symptoms. These metrics are individually scored by comparing the data collected at the survey site with values expected at reference sites located in a similar geographical region. The maximum possible IBI score is 60 and the minimum possible score is 12. The summation of the 12 individual metrics scores provides a single-value IBI score, which corresponds to a narrative rating of *Exceptional, Good, Marginally Good, Fair, Poor or Very Poor*.

The MIwb incorporates four fish community measures: numbers of individuals, biomass, and the Shannon Diversity Index (H) based on numbers and weight of fish. Unlike the IBI score, the MIwb is a result of a mathematical calculation based upon the formula:

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

Where:

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

Shannon Diversity Index

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

Where:

n_i = Relative numbers or weight of species

N = Total number or weight of the sample

Results

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.

In 2007, the upper electrofishing zone on the Cuyahoga River, downstream from Tinkers Creek, produced 393 fish representing 24 different species of fish over two passes. The predominant fish species collected at this site were the northern hog sucker and common shiner, comprising 37 percent of the total fish collected. Of the total fish collected, 39 percent were designated sensitive species, which includes species considered to be “moderately intolerant” and “common intolerant” to pollution.

Electrofishing sites upstream and downstream from Mill Creek produced 400 fish and 370 fish respectively over two passes. Twenty-seven different species were collected on the Cuyahoga River at the site upstream from Mill Creek and 21 different species

were collected at the site downstream from Mill Creek. Twenty-eight percent of the species collected upstream were comprised of pollution-sensitive species and 52 percent of the species collected downstream were pollution sensitive.

In 2007, 1,046 fish representing 37[6] different species were collected on the Cuyahoga River at the site upstream from the Southerly WWTC effluent over three passes. Also, 1,064 fish representing 32 different species were collected on the Cuyahoga River at the site downstream from the Southerly WWTC effluent over three passes. The predominant fish species collected at the upstream site was the northern hog sucker, comprising 20 percent. At the downstream site, the creek chub comprised 15 percent of the total fish collected. Of the total fish collected both upstream and downstream from the Southerly WWTC effluent, 42 percent and 25 percent were designated "moderately intolerant" to pollution, respectively.

Additionally encountered in 2007 was a fish that was previously never collected on the Cuyahoga River. The bigmouth shiner[7] (*Notropis dorsalis*) was collected upstream from Southerly WWTC on October 8, 2007. The bigmouth shiner is very limited in its distribution in Ohio streams, inhabiting only the Black and Rocky Rivers and preferring sandy substrates in streams. It is also listed as a threatened species by the Ohio Division of Wildlife. The bigmouth shiner was identified from a subset of fish samples collected on October 8, 2007.

Also collected on the Cuyahoga River upstream from Southerly WWTC was a black redhorse[8], which is designated "common intolerant" and is found in streams of highest quality (Ohio EPA's *Biological Criteria for the protection of Aquatic Life Volumes II* [1987, updated January 1, 1988 and November 8, 2006] and *III* [1987, updated September 30, 1989]).

In 2007, 247 fish representing 22[9] different species were collected on the Cuyahoga River at the site upstream from Big Creek. Also, 282 fish from 19 different species were collected on the river at the site downstream from Big Creek. Two electrofishing passes were conducted at these sites. The predominant species collected at the upstream and downstream sites were the common white sucker and gizzard shad, respectively. Of the total fish collected upstream and downstream of Big Creek, 21 percent upstream and 18 percent downstream were designated "moderately intolerant" to pollution.

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[6] Does not include possible black redhorse collected. The Ohio State University (OSU) College Museum of Biological Diversity was not able to verify the specimen with 100 percent confidence.
[7] Verified by the OSU College Museum of Biological Diversity
[8] The OSU College Museum of Biological Diversity was not able to verify the specimen with 100 percent confidence.
[9] Does not include possible black redhorse collected. The OSU College Museum of Biological Diversity was not able to verify the specimen with 100 percent confidence.

Cuyahoga River average IBI and MIwb scores from 2007 are listed in Table 4 and shown in Figures 2 and 3. The sites downstream from Tinkers Creek and downstream from Mill Creek had IBI scores that were within non-significant departure from the Warmwater Habitat (WWH) criterion of 40, effectively meeting the criterion. Each of these sites also had one pass that met or was within non-significant departure of the Exceptional Warmwater Habitat (EWH) criterion of 48. For the MIwb, all of the sites except for upstream from Big Creek had scores that met or were within non-significant departure from the WWH criterion of 8.7. In addition, the sites immediately upstream and downstream from Southerly WWTC also met or were within non-significant departure from the EWH criterion for the MIwb.

Table 4. 2007 Cuyahoga River IBI and MIwb Scores

		IBI Scores				MIwb Scores			
Site	RM	Pass 1	Pass 2	Pass 3	Average	Pass 1	Pass 2	Pass 3	Average
DS Tinkers Creek	16.20	30	**48**	---	*39*	*8.5*	**8.7**	---	*8.6*
US Mill Creek	11.95	28	32	---	30	**9.0**	7.9	---	*8.5*
DS Mill Creek	11.30	32	**44**	---	*38*	*8.2*	*8.3*	---	*8.3*
US Southerly WWTC	10.75	30	*36 (38*)*	*36*	34 (35*)	**9.0**	**9.5 (*9.5)**	**9.8**	**9.4**
DS Southerly WWTC	10.10	34	34	*36*	35	**9.3**	**9.8**	**9.9**	**9.7**
US Big Creek	7.55	22 (24*)	26	---	24 (25*)	7.6	7.6	---	7.6
DS Big Creek	7.00	32	34	---	33	**8.7**	7.8	---	*8.3*

Bold Underline = meets Exceptional Warmwater Habitat (EWH) criteria [IBI ≥48; MIwb ≥9.6]

Bold = meets Warmwater Habitat (WWH) criteria [IBI ≥40; MIwb ≥8.7]

Italics = non-significant departure from WWH criteria [IBI ≥36; MIwb ≥8.2]

--- = Electrofishing survey not conducted

(*) = score calculated with black redhorse

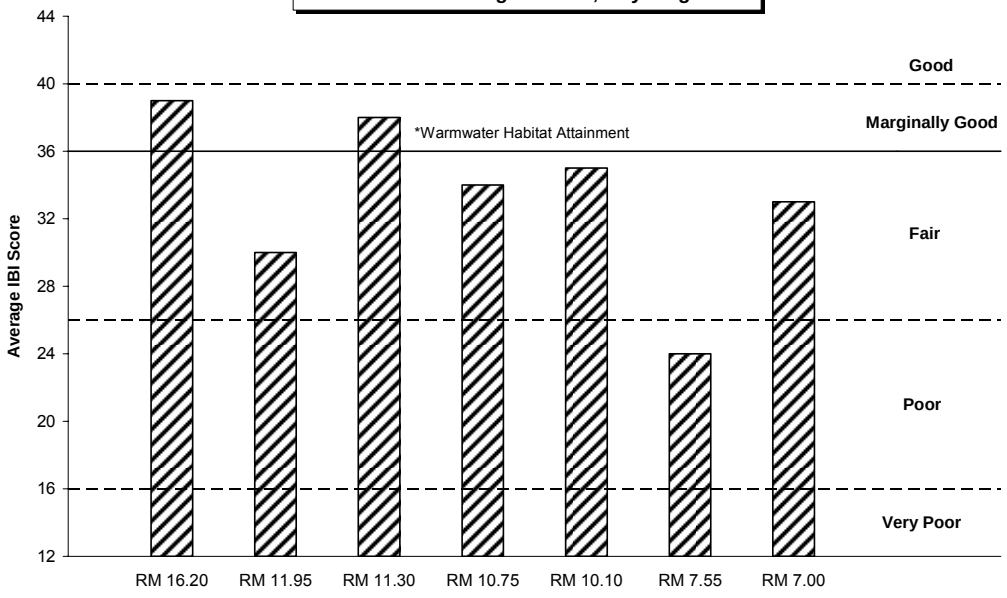
Fish community health was evaluated on the Cuyahoga River, downstream from Tinkers Creek, and showed fish community metric scores high in numbers of native species, sunfish species, and sucker species; additionally, a high score was obtained in the proportion of insectivores, carnivores, and lithophils. These high scores were obtained on at least one of two passes. A high score is defined as an individual metric attaining a score of five. Ratings of 5, 3, or 1 are assigned to each metric score, with 5 being the highest and 1 the lowest. Very few DELT anomalies were observed on fish at this site.

The fish community metrics that scored high upstream from Mill Creek were the proportion of insectivores and number of sunfish species. The downstream site scored high in proportions of round bodied suckers, tolerant species, insectivores, carnivores, and simple lithophils on at least one of two passes.

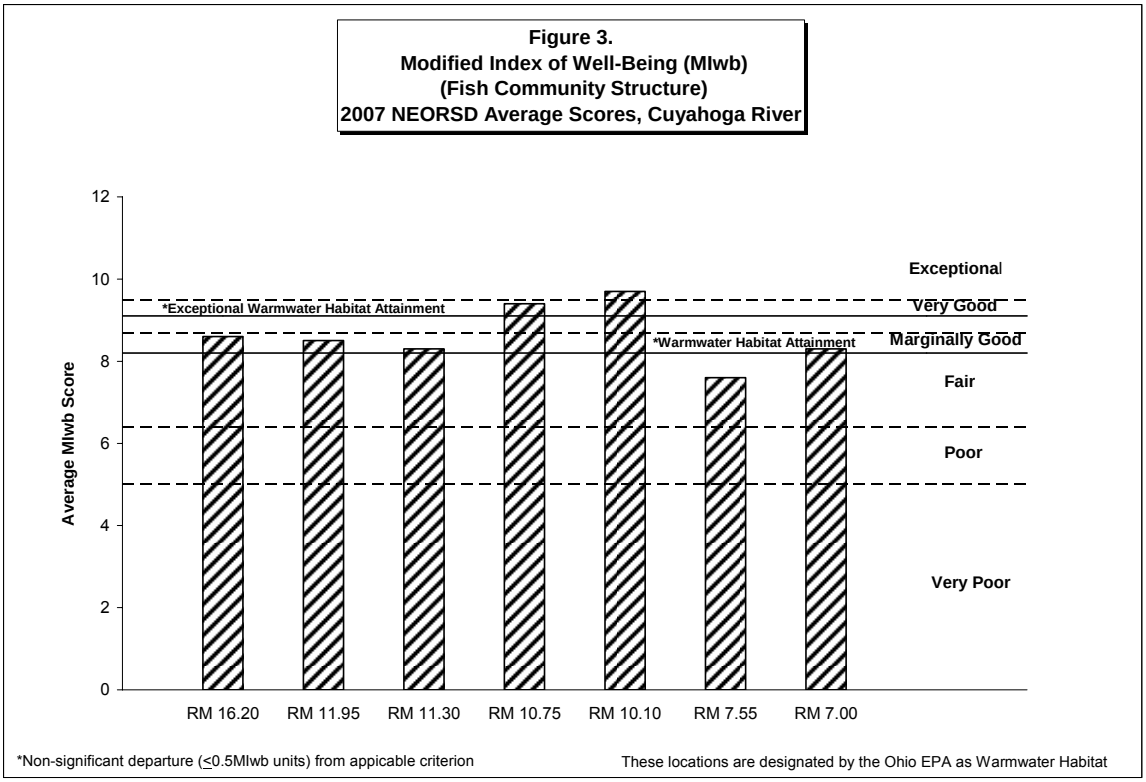
The assessment of the fish community index scores that scored high upstream from Southerly WWTC according to the IBI were the number of native fish and sucker

species collected. The upstream site also scored high on number of individuals collected, proportion of simple lithophils, carnivores, insectivores, and number of sunfish and total fish collected. These metrics scored high on at least one of the three sampling passes.

Figure 2.
Index of Biotic Integrity (IBI)
(Fish Community Structure and Function)
2007 NEORSD Average Scores, Cuyahoga River



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



The downstream from Southerly site scored high in number of native and sunfish species collected. Additionally, on at least one of the three sampling passes, the downstream site scored high in number of sucker species and total individuals collected.

In 2006, five new species of fish were collected in the Cuyahoga River immediately upstream and downstream from Southerly WWTC. These fish included the flathead catfish, brook silverside, silverjaw minnow, rainbow darter and mimic shiner. In 2007, only the brook silverside and silverjaw minnow were collected; however, three[10] additional species were collected. These three fish species were the spotted sucker, the bigmouth shiner, and silver redhorse. The silver redhorse is considered to be moderately intolerant to pollution, while the other two species have an intermediate tolerance to pollution.

Fish community health was also evaluated on the Cuyahoga River upstream and downstream from Big Creek. The upstream site showed fish community metric scores scoring high in numbers of fish with few DELT anomalies on one of two passes. The downstream site scored high in proportion of pollution tolerant species on both sampling

[10] Possibly four species; however, the black redhorse was not included since the species was not verified with 100 percent confidence by the Ohio State University Museum of Biological Diversity.

passes and high in a greater proportion of top carnivores and the metric of fish with DELT anomalies, all indicating better stream quality.

In 2006, four new species of fish were collected in the Cuyahoga River upstream and downstream from Big Creek. These fish included the silver redhorse, brook silverside, spotted sucker and lake trout. In 2007, none of these fish were collected during either sampling pass on the river.

The results from 2007 were examined to determine what factors may be influencing the IBI and MIwb scores that were obtained at each site. The first factor that was examined was water chemistry. In doing so, it was found that there were no exceedances from water quality standards for the protection of aquatic life during either dry or wet weather sampling. Previously shown in Table 2 are the average concentrations for water quality parameters that were measured during the dry weather sampling at each of the locations. None of the measured parameters appear to be directly related to the IBI or MIwb scores, as the concentrations at sites that did not score well are similar to those that did. Based on these results, it appears that something besides water chemistry is having the most influence on the health of the fish community. It also suggests that Mill Creek, West Creek, Southerly WWTC and Big Creek, all potential point sources of pollution, are not having a noticeable impact on the fish community.

While the differences in scores at the seven sites did not appear to be related to water chemistry, they may be explained, in part, by differences in their habitat characteristics. The highest QHEI was obtained at the furthest upstream sampling site on the Cuyahoga River, downstream from Tinkers Creek. This was also the same site with the highest IBI score. In contrast, the lowest QHEI score was obtained upstream from Big Creek. Low scores were obtained for each of the six QHEI metric components and were most likely the major limiting factor to achieving higher IBI and MIwb scores upstream at this site.

In addition to examining what factors most influenced the 2007 fish index scores, an analysis was also done to determine how those scores have changed over time. In doing so, it was found that over the last sixteen years, the IBI and MIwb scores in the Cuyahoga River have generally improved (Table 5 and Figures 4 through 7). Even though the IBI scores for the sites immediately upstream and downstream from Southerly and upstream from Big Creek were slightly lower than in 2006, they are within the range of normal sampling variability and are not an indication of poorer fish community health. For the MIwb, the scores at the four downstream sites were the highest ever obtained there. In addition, 2007 was the first year that the Cuyahoga River sites upstream and downstream from Southerly WWTC met EWH biocriteria for this index.

Table 5.
Cuyahoga River, 1990-2007
Average Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb) Scores

Year	DS Tinkers Creek RM 16.20		US Mill Creek RM 11.95		DS Mill Creek 11.30		US SWWTC RM 10.75		DS SWWTC RM 10.10		US Big Creek RM 7.55		DS Big Creek RM 7.00	
	IBI	MIwb	IBI	MIwb	IBI	MIwb	IBI	MIwb	IBI	MIwb	IBI	MIwb	IBI	MIwb
1990	-	-	-	-	-	-	15	4.5	15	4.6	-	-	-	-
1991	-	-	-	-	-	-	17	5.5	16	5.6	-	-	18	6.1
1992	-	-	-	-	-	-	20	5.6	19	6.6	-	-	21	5.9
1997	-	-	-	-	-	-	25	7.5	17	6.1	-	-	18	6.2
1998	-	-	-	-	-	-	26	7.8	27	7.6	-	-	21	5.5
1999	-	-	-	-	-	-	31	*8.2*	31	*8.6*	-	-	24	7.0
2001	-	-	-	-	-	-	30	7.2	29	*8.2*	18	5.6	22	6.1
2003	-	-	-	-	-	-	34	7.6	28	7.8	27	6.8	23	7.0
2004	-	-	-	-	-	-	35	8.0	35	*8.4*	-	-	-	-
2006	-	-	-	-	-	-	*39*	**8.8**	*36*	*8.5*	30	7.0	31	7.8
2007	*39*	*8.6*	30	*8.5*	*38*	*8.3*	34	**9.4**	35	**9.7**	24	7.6	33	*8.3*

Bold = meets Exceptional Warmwater Habitat (EWH) criteria [IBI ≥48; MIwb ≥9.6]

Bold = meets Warmwater Habitat (WWH) criteria [IBI ≥40; MIwb ≥8.7]

Italics = non-significant departure from WWH criteria [IBI ≥36; MIwb ≥8.2]

- = Electrofishing survey not conducted

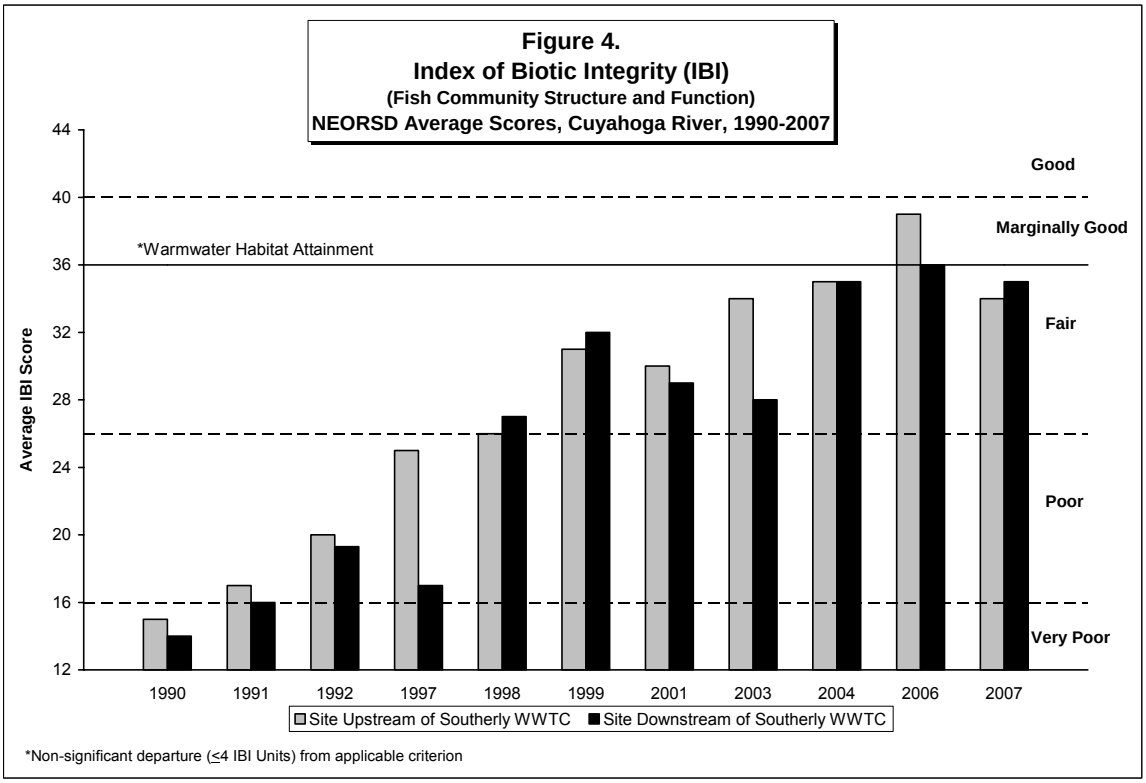
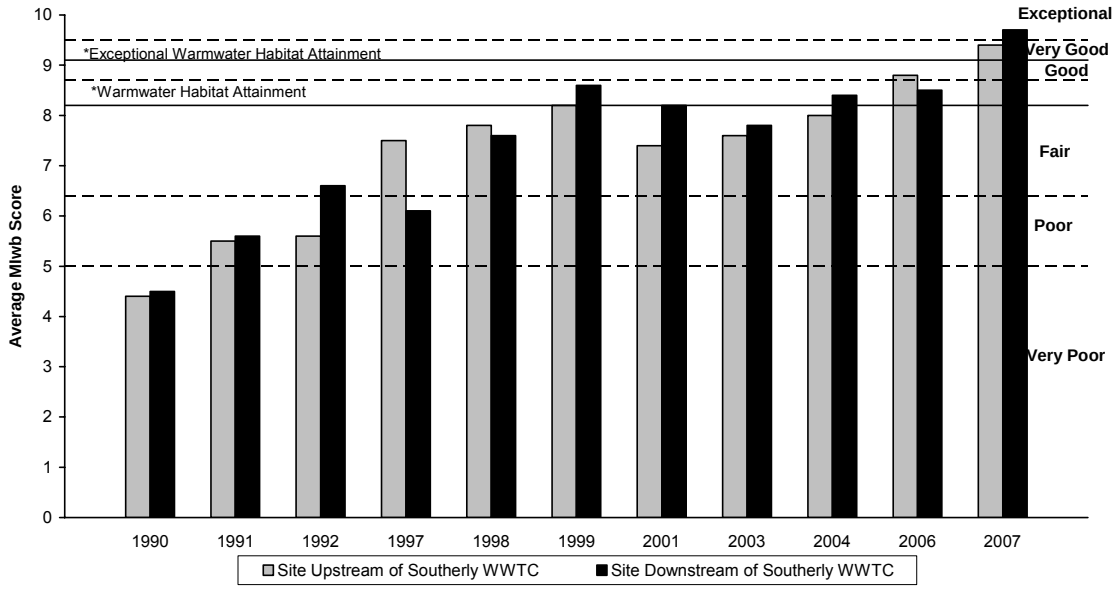
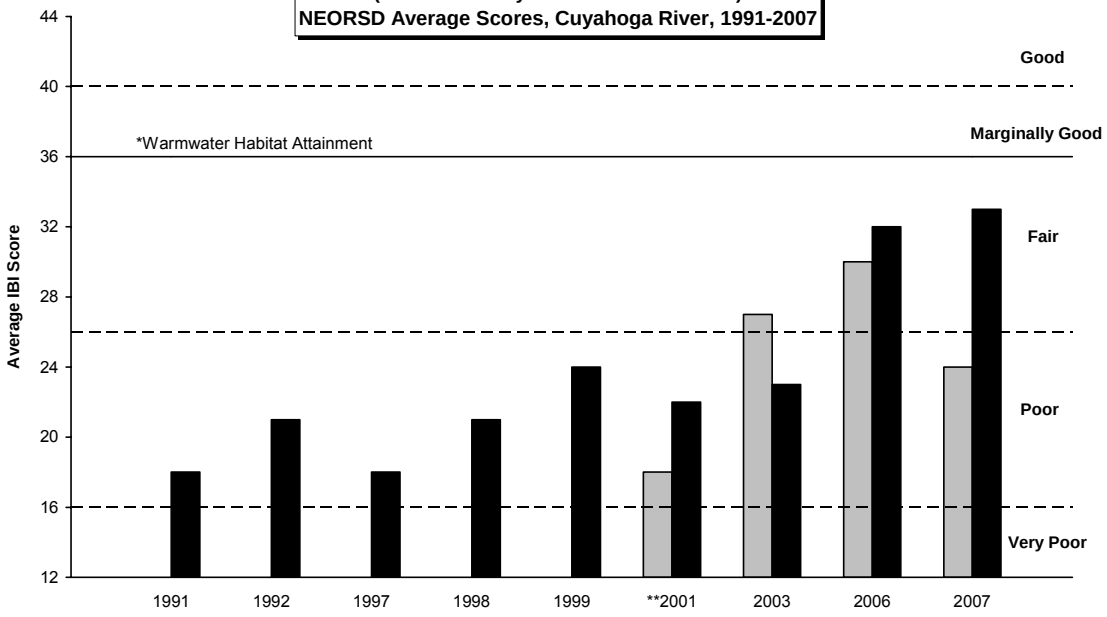


Figure 5.
Modified Index of Well-Being (MIwb)
(Fish Community Structure)
NEORSD Average Scores, Cuyahoga River, 1990-2007



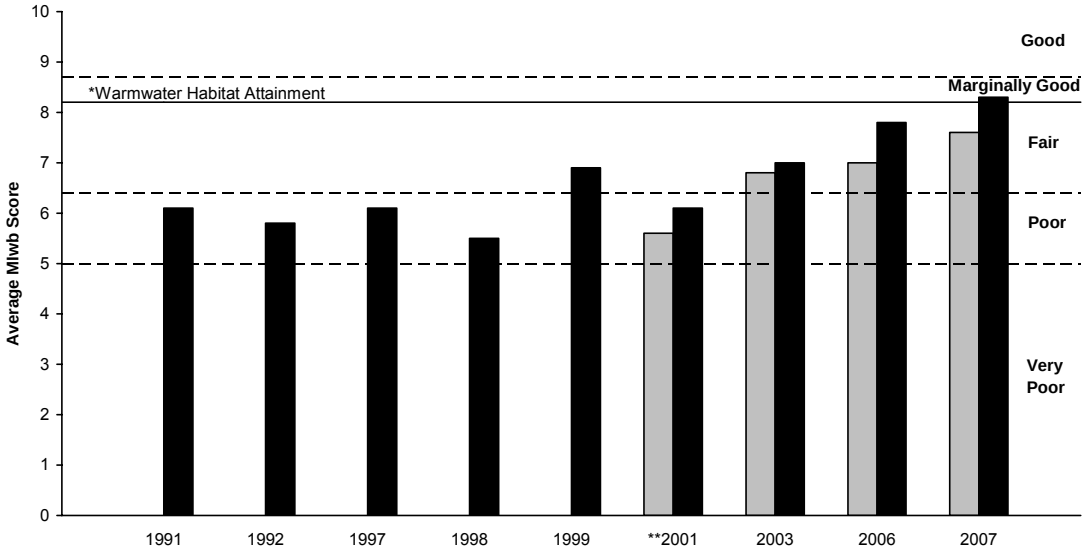
*Non-significant departure(≤0.5 Miwb Units) from applicable criteria

Figure 6.
Index of Biotic Integrity (IBI)
(Fish Community Structure and Function)
NEORSD Average Scores, Cuyahoga River, 1991-2007



*Non-significant departure (≤4 IBI units) from applicable criterion
**Indicates one electrofishing pass

Figure 7.
Modified Index of Well-Being (MIwb)
(Fish Community Structure)
NEORSD Average Scores, Cuyahoga River, 1991-2007



*Non-significant departure (≤0.5 Miwb units) from applicable criterion
**Indicates one electrofishing pass

Historical fish data have shown the presence of limited amounts of pollution-sensitive fish collected on the river, with the river being dominated by pollution-tolerant species. A trend analysis for the years of collection shows a general increase in numbers of native species and percentage of pollution-sensitive fish collected (Figures 8, 9 and 10). In recent years, EWH characteristic species such as the black redhorse[11], larger smallmouth bass, and mimic shiner (Ohio EPA's *VAP Biocriteria Training Manual Biocriteria Program overview, Fish Sampling Methods* (July, 1998)) have been collected on the river, resulting in higher index scores. Although the percentage of pollution-sensitive fish decreased downstream of Southerly in 2007, this was not due to a decrease in the number of these fish collected. Instead, it was the result of the much larger number of other species of fish that were collected at that site during all three passes. The current numbers of native species and pollution-sensitive fish (Figure 11) indicates exceptional diversity and biotic integrity at most of these sites and has most likely resulted from improvements in water quality.

[11] The OSU College Museum of Biological Diversity was not able to verify the specimen with 100 percent confidence.

Figure 8.
Number of Native Fish collected by NEORSD on the Cuyahoga River 1991-2007

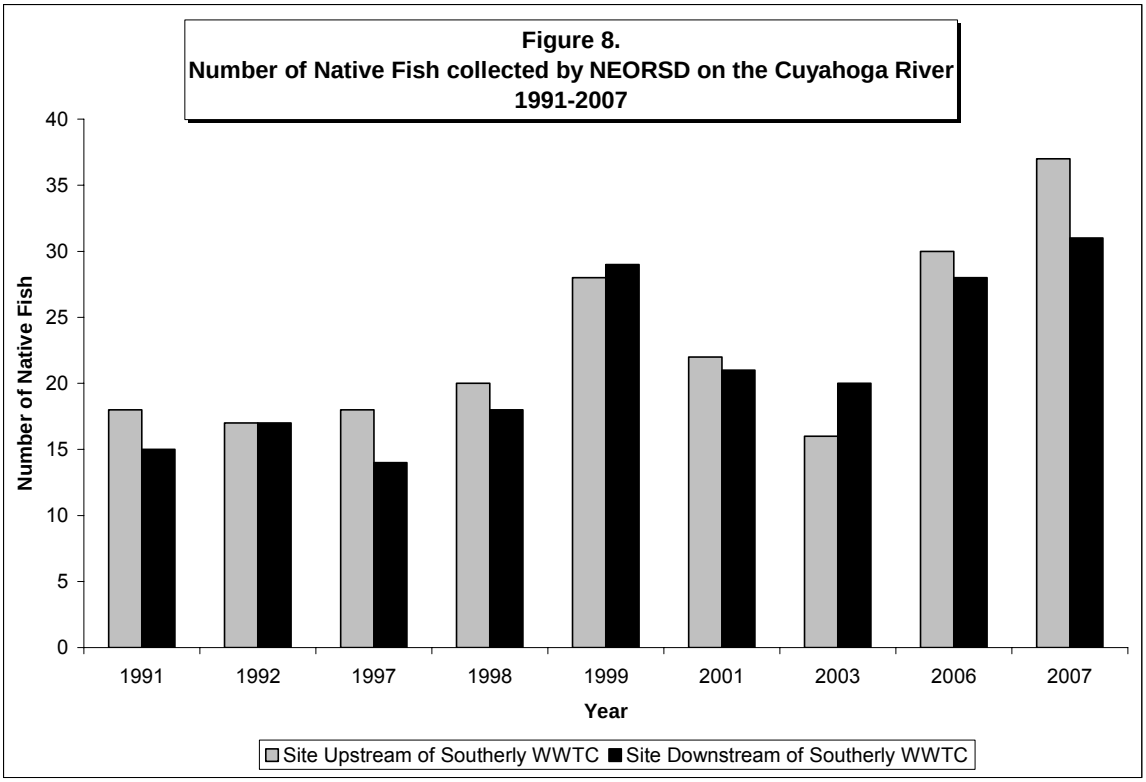
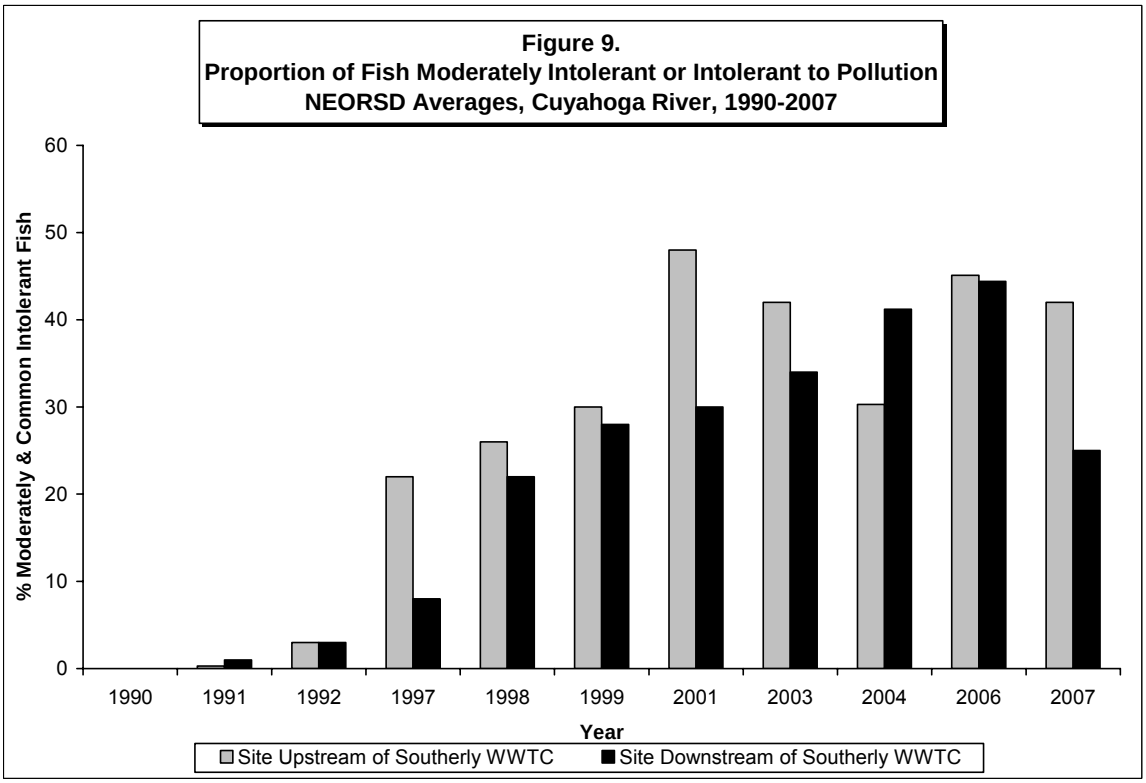


Figure 9.
Proportion of Fish Moderately Intolerant or Intolerant to Pollution NEORSD Averages, Cuyahoga River, 1990-2007



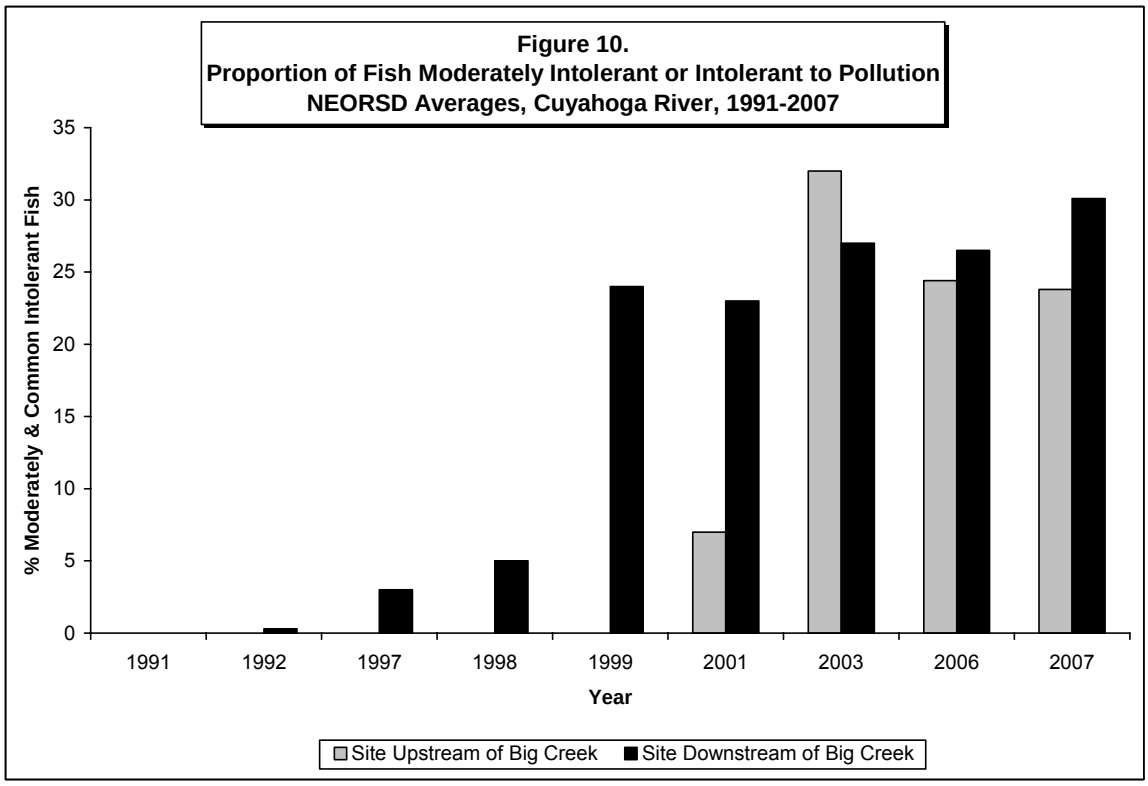


Figure 10.
Proportion of Fish Moderately Intolerant or Intolerant to Pollution
NEORSD Averages, Cuyahoga River, 1991-2007
% Moderately & Common Intolerant Fish
0
5
10
15
20
25
30
35
1991
1992
1997
1998
1999
2001
2003
2006
2007
Year
Site Upstream of Big Creek
Site Downstream of Big Creek

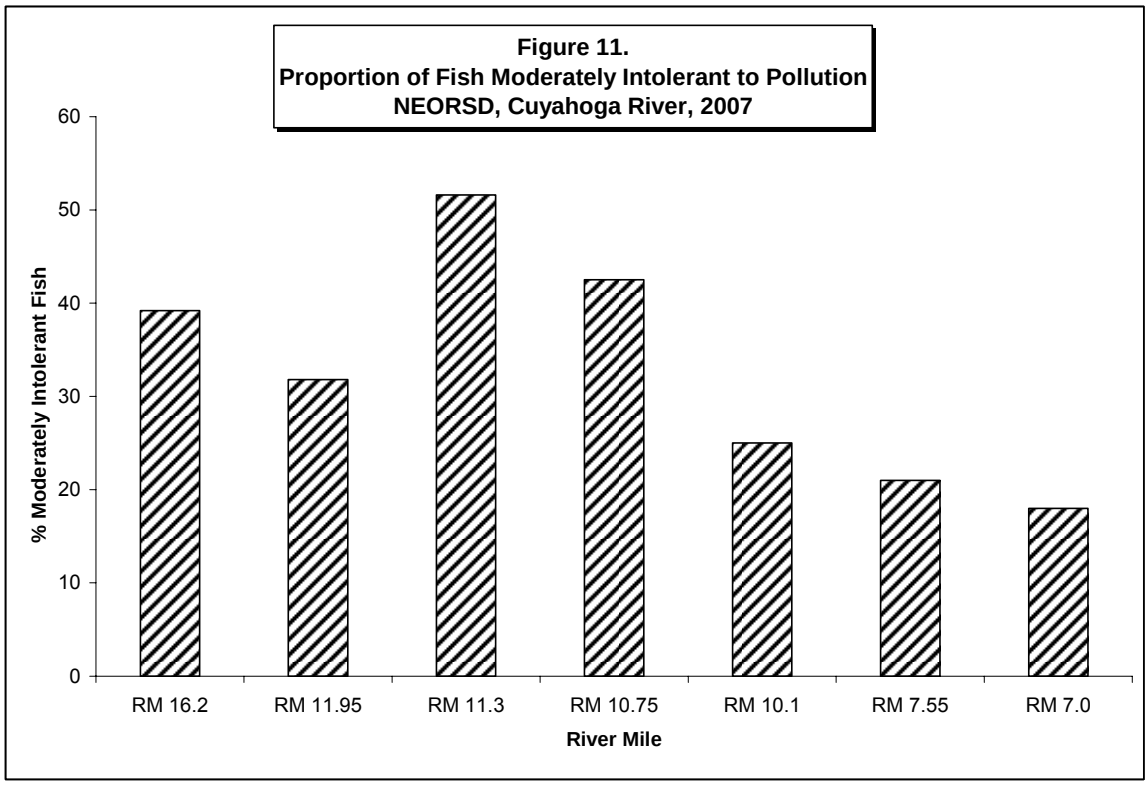


Figure 11.
Proportion of Fish Moderately Intolerant to Pollution
NEORSD, Cuyahoga River, 2007
% Moderately Intolerant Fish
0
10
20
30
40
50
60
RM 16.2
RM 11.95
RM 11.3
RM 10.75
RM 10.1
RM 7.55
RM 7.0
River Mile

Several other changes also show the continued improvements in the river. For example, in 2007, a large number of young golden and shorthead redhorses were collected at most of the sites during at least one electrofishing pass. This is the first time that such numbers of these small fish were collected on the river during NEORSD sampling. The presence of these fish indicates that these pollution-sensitive species have established a successful breeding population in the river, which would not have occurred if water quality were not good.

Finally, another indicator of improved water quality is the collection of a possible wild steelhead trout smolt in West Creek near RM 0.20 by NEORSD on August 28, 2007. West Creek is a tributary to the Cuyahoga River just upstream from the Southerly WWTC. It is not known if the steelhead smolt actually hatched from West Creek, another tributary or the Cuyahoga River. In 2000, the Ohio EPA collected several young steelhead from the Cuyahoga River and several upstream tributaries. There are a number of tributaries within the Cuyahoga River basin that have suitable spawning gravel for successful steelhead reproduction. Regardless of whether the young steelhead hatched from West Creek, another tributary or the Cuyahoga River, successful spawning is occurring within the basin because of improved water quality and suitable habitat.

Macroinvertebrate Sampling

Methods

Macroinvertebrates in the Cuyahoga River were sampled quantitatively for a six-week period in 2007 using modified Hester-Dendy (HD) samplers in conjunction with a qualitative assessment of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa inhabiting the available natural substrates at the time of artificial substrate retrieval. Quantitative and qualitative macroinvertebrate samples were shipped to EA Engineering, Science and Technology for identification and enumeration. EA Engineering, Science and Technology identified the specimens to the lowest practical taxonomic level and whenever possible, to the level of taxonomy recommended in Ohio EPA's *Biological Criteria for the Protection of Aquatic Life, Volume III* (1987, updated September 30, 1989 and November 8, 2006).

Results

Ohio EPA uses the Invertebrate Community Index (ICI) to evaluate the overall aquatic macroinvertebrate community in streams. The ICI consists of ten functional and structural community metrics, each with four scoring categories. Metrics 1-9 are based on the quantitative sample, while Metric 10, the number of

Ephemeroptera/Plecoptera/Trichoptera (EPT) taxa, is based on the qualitative sample. Eight of the ten metrics are positive metrics, where an increase in the metric value indicates a *positive* increase, or beneficial increase, in the biological quality of the site. However, Metric #8 (Percent Other Dipteran and Non-insect Composition) and Metric #9 (Percent Tolerant Organisms) are classified as negative metrics. Therefore, an increase in either metric value indicates a *negative* increase, or beneficial decrease, in the biological quality of the site. An example of a beneficial decrease would be a decrease in the population of pollution tolerant organisms at a site. The total of the individual metric scores result in the ICI score; where the higher the score, the less impacted the site. This point system evaluates the sample against Ohio EPA's relatively unimpacted reference sites. It should be noted that use of the ICI alone can only determine partial attainment of WWH biocriteria. In order to determine full attainment, an ICI score must be paired with Index of Biotic Integrity (IBI) and Modified Index of Well Being (MIwb) data, which are based on a survey of the fish community, for the same site. Macroinvertebrate sampling results from 2007 are presented in Table 6. It should be noted that RM 12.10A and RM 12.10B represent first and second colonization periods, respectively. A list of collected taxa is available upon request.

Table 6. 2007 Cuyahoga River ICI Metric and Index Scores

	RM 16.20	RM 12.10 A	RM 12.10 B	RM 11.30	RM 10.75	RM 10.30	RM 10.10	RM 7.90	RM 7.00
Index/Metric	Value (Score)	Value (Score)	Value (Score)	Value (Score)	Value (Score)	Value (Score)	Value (Score)	Value (Score)	Value (Score)
Total Organisms	427	1011	3912	1570	934	106	2412	374	408
Total Taxa	15(2)	23(4)	32(4)	26(4)	23(4)	10(0)	26(4)	21(2)	24(4)
Mayfly Taxa	1(0)	3(2)	3(2)	2(0)	1(0)	0(0)	3(2)	3(2)	3(2)
Caddisfly Taxa	6(6)	3(4)	5(4)	5(4)	5(4)	4(4)	4(4)	3(4)	5(4)
Dipteran Taxa	5(2)	11(4)	15(6)	10(4)	12(4)	1(0)	14(6)	10(4)	10(4)
% Mayfly Composition	0.2(2)	1.5(2)	25.9(4)	3.2(2)	0.2(2)	0(0)	0.3(2)	4.0(2)	1.5(2)
% Caddisfly Composition	87.4(6)	65.9(6)	47.1(6)	65.1(6)	46.3(6)	80.2(6)	64.5(6)	71.9(6)	60.5(6)
% Tanytarsini Composition	0.7(2)	2.0(2)	0.2(2)	2.0(2)	5.8(2)	0(0)	3.3(2)	3.5(2)	2.9(2)
% Other Dipteran Composition	2.1(6)	16.4(6)	20.6(4)	22.4(4)	36.1(2)	4.7(6)	23.2(4)	8.6(6)	17.4(6)
% Tolerant Organisms	0(6)	0.3(6)	7.4(0)	1.7(6)	1.0(6)	0.9(6)	0.5(6)	1.1(6)	0.2(6)
Qualitative EPT Taxa	8(2)	4(0)	7(2)	8(2)	6(2)	8(2)	4(0)	6(2)	6(2)
Total ICI Scoring	**34**	**36**	**34**	**34**	*32*	24	**36**	**36**	**38**
Narrative Rating	Good	Good	Good	Good	Marginally Good	Fair	Good	Good	Good

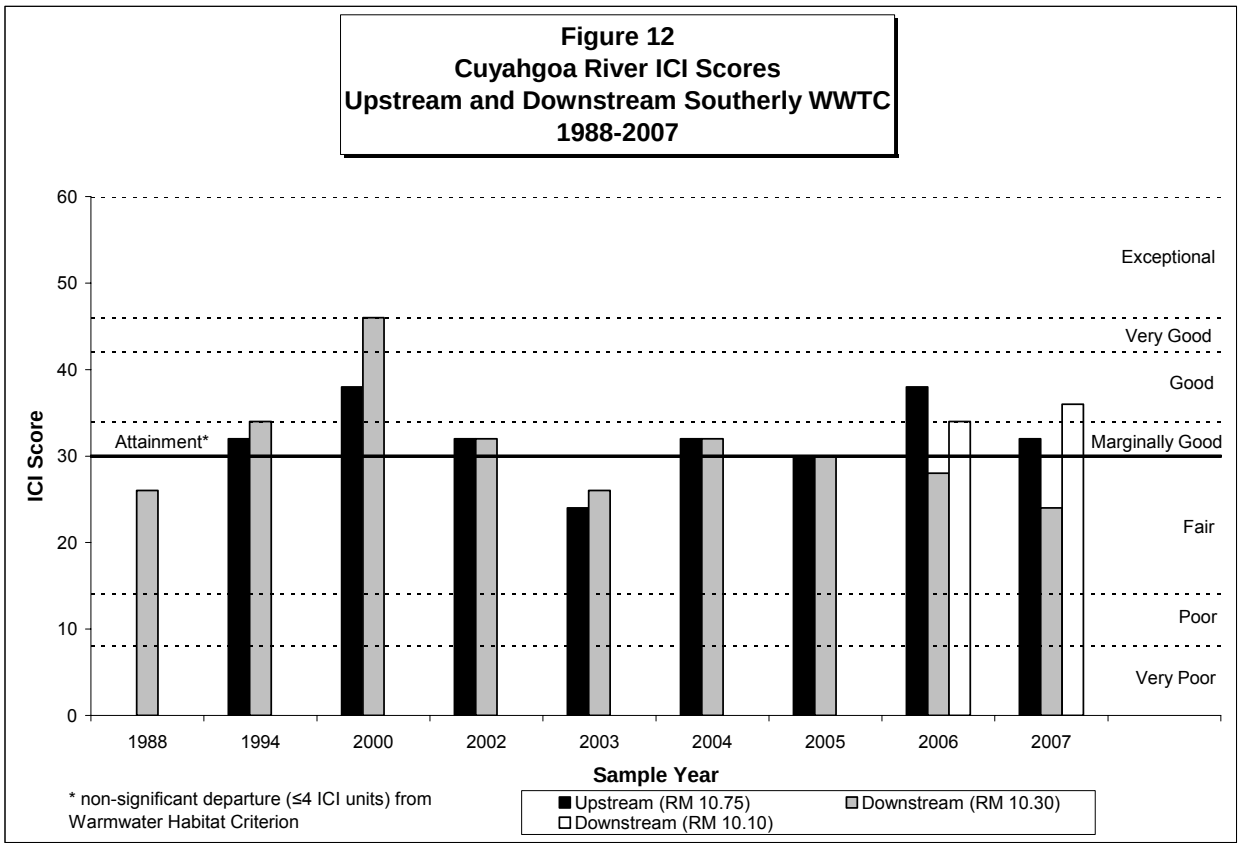
Bold = meets Warmwater Habitat (WWH) criteria [ICI ≥34]
Italics = non-significant departure from WWH criteria [ICI ≥30]

Sites RM 10.75, RM 10.30 and RM 10.10

Historic ICI scores from 1988 to 2007 are displayed graphically in Figure 12. In 2004, Cuyahoga River sites upstream and downstream of Southerly WWTC, RM 10.75 and RM 10.30 respectively, both resulted in ICI scores of 32, a higher score for each site

than in 2003. A score of 32 falls within the *Good* range and also within non-significant departure (≤4 ICI units) of the WWH attainment criterion of 34 for the Erie/Ontario Drift and Lake Plain ecoregion. Scores within non-significant departure are considered to be in attainment of the WWH criterion. ICI scores at both sites decreased to 30 (*Marginally Good*) in 2005, but remained within attainment. In 2006, the ICI score for RM 10.75 increased to 38 (*Good*), while RM 10.30 decreased to 28 (*Fair)*. ICI scores decreased in 2007 to 32 at RM 10.75 and 24 at RM 10.30. In general, ICI scores for RM 10.75 have remained in attainment, since 2004. On the contrary, the ICI scores for RM 10.30 have decreased since 2004 to the *Fair* range, and have not been in attainment since 2005. The ICI scores at RM 10.10, 34 for 2006 and 36 for 2007, indicate attainment. This site is located 0.2 miles downstream of RM 10.30, but is in an area more conducive to macroinvertebrate colonization compared to RM 10.30, due to the presence of a functional, cobble/gravel riffle located in shallow water of moderate flow. Due to their proximity, water quality conditions are most likely similar for RM 10.30 and RM 10.10, and both will therefore be sampled in 2008 in order to compare results. As the difference in ICI scores between the two sites appears to be solely due to physical habitat features, NEORSD staff believes it would be acceptable for the ICI score at RM 10.10 to be used as a replacement of the ICI score at RM 10.30, especially when evaluating the impact of Southerly WWTC on the Cuyahoga River. Individual metric values and scores are presented in Table 6.

Figure 12
Cuyahgoa River ICI Scores
Upstream and Downstream Southerly WWTC
1988-2007



Additional Sites RM 16.20, RM 12.10, RM 11.30, RM 7.90 and RM 7.00

RM 16.20, the furthest upstream site on the Cuyahoga River, resulted in an ICI score of 34, which is in attainment of the WWH criterion. This is an increase from the 2006 ICI score of 32, which was also within attainment. This location is meant to serve as a reference site for the study as it has been in an area of known attainment by the Ohio EPA since 2000.

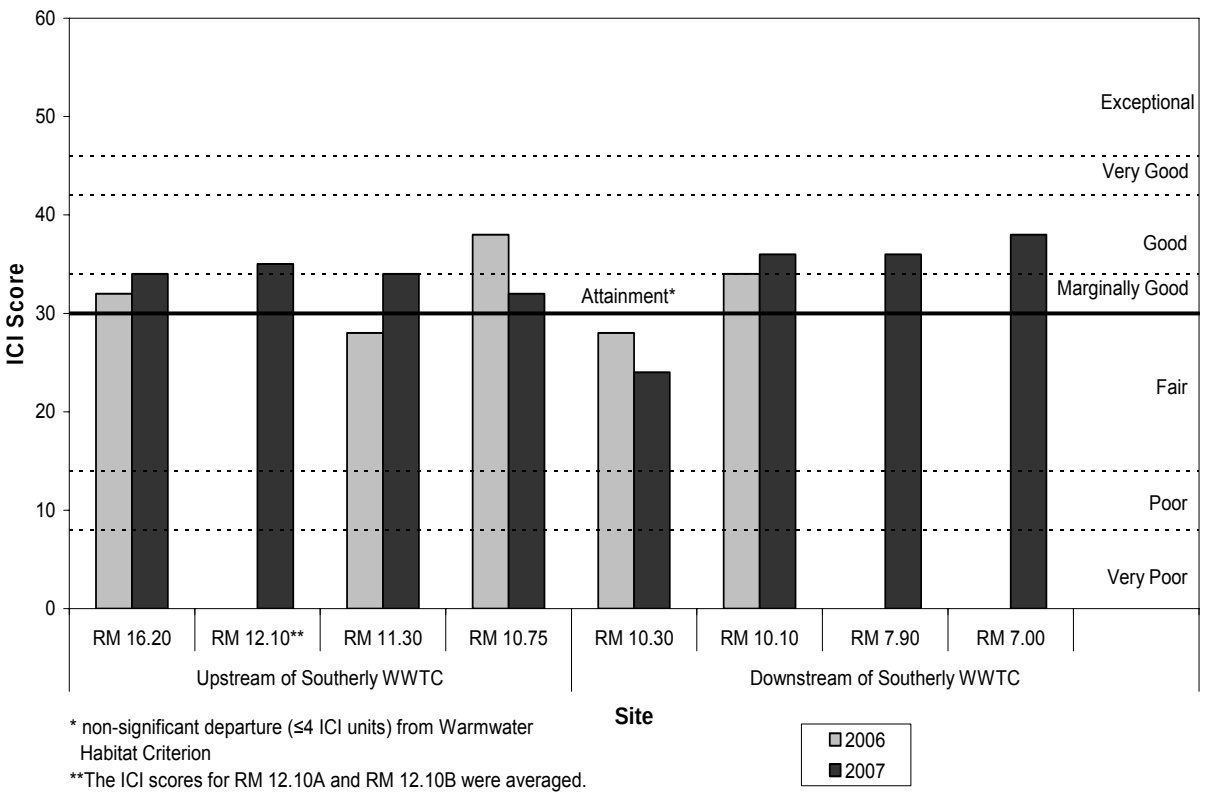
RM 12.10, located upstream of the confluence of Mill Creek, had an ICI score of 36 for the first colonization period (RM 12.10A) and 34 for the second colonization period (RM 12.10B), both periods showing attainment of the WWH criterion. This was the only site with two colonization periods, as the HD sampler for the first colonization period was found buried two weeks before retrieval due to high flows for the previous 2-3 weeks. As it was unknown how long the HD sampler had been buried, it was unburied/reset and a second HD sampler was installed next to the original and collected later in September. Therefore, as both HD samplers appeared to be well colonized during retrieval and the identification process, both ICI scores are valid for evaluation and were used to create an average score for RM 12.10.

Sample site RM 11.30 replaced RM 11.50 for 2007, as RM 11.30 is located upstream of RM 10.75 but further downstream of the confluence of Mill Creek with the Cuyahoga River than RM 11.50. NEORSD staff believes that RM 11.30 may represent more of a complete mix zone than RM 11.50. RM 11.50 received an ICI score of 28 in 2006, and therefore, was not in attainment. RM 11.30 received an ICI score of 34 in 2007 and was therefore, in attainment. It is unknown if this location change resulted in an attainment score for 2007 compared to a non-attainment score in 2006. General habitat features are similar for RM 11.50 and RM 11.30 and neither site had any exceedances of applicable outside mixing zone maximum water quality criteria for the protection of aquatic life (RM 11.50 in 2006 and RM 11.30 in 2007) or 30-day outside mixing zone average water quality criteria for the protection of aquatic life (RM 11.30 in 2007).

RM 7.90, located downstream of Southerly WWTC and upstream of the Big Creek Confluence with the Cuyahoga River, had an ICI score of 36, which is in attainment of the WWH criterion.

RM 7.00, also located downstream of Southerly WWTC and downstream of the confluence of Big Creek with the Cuyahoga River, was also in attainment of the WWH criterion with an ICI score of 38. The 2006 and 2007 ICI scores for these sites in comparison to upstream and downstream of Southerly WWTC are depicted graphically in Figure 13.

Figure 13
2006 and 2007 Cuyahoga River ICI Scores



Individual Biological Metrics

Taxa Richness

Of the eight sites sampled in 2007, the greatest number of taxa, 32, occurred at RM 12.10B, while the lowest number, 10, occurred at RM 10.30. The reference site for the study, RM 16.20, had 15 taxa. Taxa richness remained constant from 2006 to 2007 at RM 10.75 and increased at RM 10.10.

Total Caddisfly Taxa

The number of caddisfly taxa, 6, was highest at site RM 16.20 compared to all of the sites sampled in 2007. RM 12.10A and RM 7.90 had the lowest number of caddisfly taxa, 3. The total number of caddisfly taxa increased from 2006 to 2007 at RM 10.75 and decreased at RM 10.10.

Percent Caddisfly Composition

In 2007, of the eight sites sampled, the largest percent of caddisflies, 87.4%, occurred at RM 16.20 while the lowest percentage, 46.3%, occurred at RM 10.75. The percent of caddisflies from 2006 to 2007 increased at RM 10.75, from 44.9% to 46.3% and decreased at RM 10.10, from 68.2% to 64.5%.

Total Mayfly Taxa

The largest number of mayfly taxa, 3, occurred at RM 12.10, RM 10.10, RM 7.90 and RM 7.00 in 2007 and the smallest number, 0, occurred at RM 10.30. RM 16.20 had 1 mayfly taxon. The number of mayfly taxa decreased from 2006 to 2007 at RM 10.75 from 2 to 1 and increased at RM 10.10 from 2 to 3.

Percent Mayfly Composition

Of the eight sites sampled in 2007, the largest percent of mayflies, 25.9%, occurred at RM 12.10B and the smallest, 0% at RM 10.30. RM 16.20 had 0.2%. Mayfly compositions at both RM 10.75 and RM 10.10 decreased in 2007 from percentages of 14.7% and 3.9% to 0.2% and 0.3%, respectively.

Total Diptera Taxa

Of the eight sites sampled in 2007, RM 12.10B had the largest number of Dipteran taxa, 15, while RM 10.30 had one taxon. RM 16.20 had the second lowest number of Dipteran taxa, 5. The number of Dipteran taxa at RM 10.75 in 2007, 13, decreased from 2006 to 12 while the number of Dipteran taxa increased at RM 10.10 in 2007 compared to 2006, from 9 to 14.

Percent Tanytarsini Composition

RM 10.75 had the largest percent Tanytarsini composition, 5.8%, in 2007 compared to the eight other sites sampled. RM 10.30 had 0%, which was the lowest percentage of Tanytarsini midges in 2007. The reference site, RM 16.20, had 0.7% Tanytarsini composition. At RM 10.75 and RM 10.10, 2007 percentages decreased compared to 2006, with RM 10.75 decreasing from 9.7% to 5.8% and RM 10.10 from 7.7% to 3.3%.

Percent Other Dipterans and Non-Insects Composition

In 2007, of the eight sites sampled, RM 16.20 had the smallest percent other composition with 2.1%, while RM 10.75 had the largest percent other composition with 36.1%. This was an increase for RM 10.75 compared to 25.8% in 2006. RM 10.10 had a percent other composition of 23.2% in 2007, an increase from 18.3% in 2006.

Percent Tolerant Organism Composition

RM 16.20 had the lowest percentage of tolerant organisms, 0%, in 2007 of the eight sites sampled. RM 12.10B had the highest percentage of tolerant organisms, 7.4%, in 2007. Both RM 10.75 and RM 10.30 had decreases in percentage of tolerant organism composition in 2007. The percentage of tolerant organism composition at RM 10.75 decreased from 1.4% in 2006 to 1.0% in 2007 and remained constant at RM 10.10 at 0.5% for 2006 and 2007.

Qualitative EPT

RM 16.20, RM 11.30 and RM 10.30 had the highest number of EPT taxa, 8, of all the sites sampled in 2007. RM 12.10A and RM 10.10 had the lowest number of EPT taxa, 4. Compared to 2006 results, RM 10.75 remained constant with 6 EPT taxa in 2007 while the EPT taxa at RM 10.10 decreased from 6 to 4 in 2007.

Discussion

Sites RM 10.75, RM 10.30 and RM 10.10

The 2007 ICI score at RM 10.75 decreased by six points from the 2006 ICI score, which indicates a decline in upstream water quality, due to non-point sources, upstream tributaries and/or the river itself. An increase/decrease of four or less points from year to year is considered negligible and can be attributed to natural variation and/or sampling error (DeShon, 1995). The decrease in ICI score that was seen at RM 10.75 is specifically due to a large decrease in mayfly composition and a large increase of other dipteran composition. As seen in Figure 14, of the ten metrics that comprise the ICI score, two metrics remained constant from 2006 to 2007 (number of total taxa and qualitative EPT taxa), four metrics *negatively* decreased or declined (number of mayfly taxa, number of dipteran taxa, percent mayfly composition and percent tanytarsini composition), one metric *negatively* increased (other dipteran composition), two metrics *positively* increased or improved (number of caddisfly taxa and percent caddisfly composition) and one metric *positively* decreased or improved (percent tolerant organisms). Due to the metrics that *negatively* increased and *negatively* decreased, the ICI score from 2006, 38, decreased in 2007 to 32.

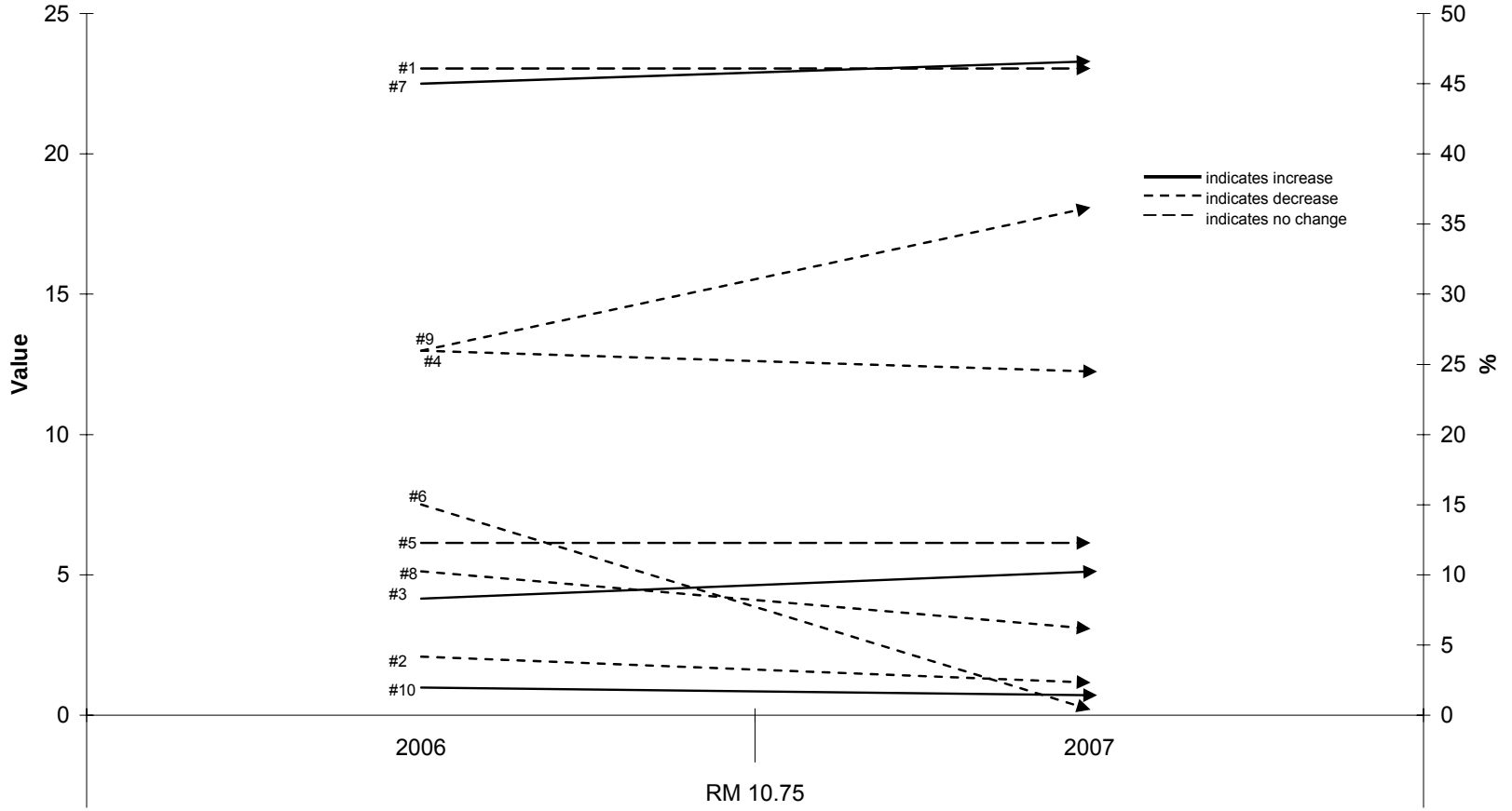
While the 2007 ICI score at RM 10.10 increased by two points from the 2006 ICI score, as previously indicated, an increase/decrease of four points or less is considered negligible (DeShon, 1995). Regardless, continuous attainment of the WWH criterion is being achieved at RM 10.10. The increase in ICI score in 2007 was primarily due to an increase in total number of taxa, specifically with an increase in the number of dipteran taxa. Figure 15 shows that of the ten metrics that comprise the ICI score, three metrics

positively increased or improved (number of total taxa, number of mayfly taxa and number of dipteran taxa), five metrics *negatively* decreased or declined (number of caddisfly taxa, qualitative EPT taxa, percent mayfly composition, percent caddisfly composition and percent tanytarsini composition), one metric *negatively* increased or declined (percent other dipteran composition) and one metric remained constant (percent tolerant organisms). Despite the fact that five metrics *negatively* decreased or declined, the decrease in the individual metric scores were not substantial. Additionally, the increase in total number of taxa and number of dipteran taxa offset the metrics that *negatively* decreased and resulted in an ICI score of 36 for 2007, an increase from the 2006 ICI score of 34.

In general, it is possible that the decreases in ICI scores at RM 10.75 can be attributed to natural variability from year to year and/or impacts of pollution or toxics. Furthermore, it is notable that as the ICI score at RM 10.30, downstream of Southerly WWTC, decreased, the ICI score at RM 10.75, upstream of Southerly WWTC, also decreased. Therefore, the decrease in ICI scores may be attributable to water quality conditions upstream of Southerly WWTC, though most likely not from West Creek. Water quality sampling by NEORSD during 2007 on West Creek did not result in any exceedances of the WWH aquatic life use designation.

Continued monitoring is necessary to determine if the decrease of the ICI score at RM 10.75 is the beginning of new macroinvertebrate community trends or is temporary as a result of natural variation. One habitat variable in 2007 may have been a change in flow rate of the Cuyahoga River due to short durations of heavy rainfall. In 2007, the average flow during the HD colonization period, as recorded at the United States Geological Survey gage located in Independence, Ohio, was 642 cubic feet per second (cfs), compared to 718 cfs in 2006. While a decrease of 76 cfs in average flow most likely is not significant, the total rainfall for the colonization period in 2007 was 11.6 inches compared to 4.82 inches in 2006. This increase in rainfall but not average flow would indicate short time periods of heavy rainfall. Three large rainfall events, 1.73 inches of rain occurred from July 24, 2007 to July 27, 2007, 4.36 inches of rain occurred from August 5, 2007 to August 10, 2007 and 3.69 inches of rain occurred from August 19, 2007 to August 21, 2007, can account for 84% of rainfall during the colonization period in 2007. Periods of high rainfall and temporary higher flows may have scoured the HD samplers, thereby reducing the number and diversity of macroinvertebrates collected.

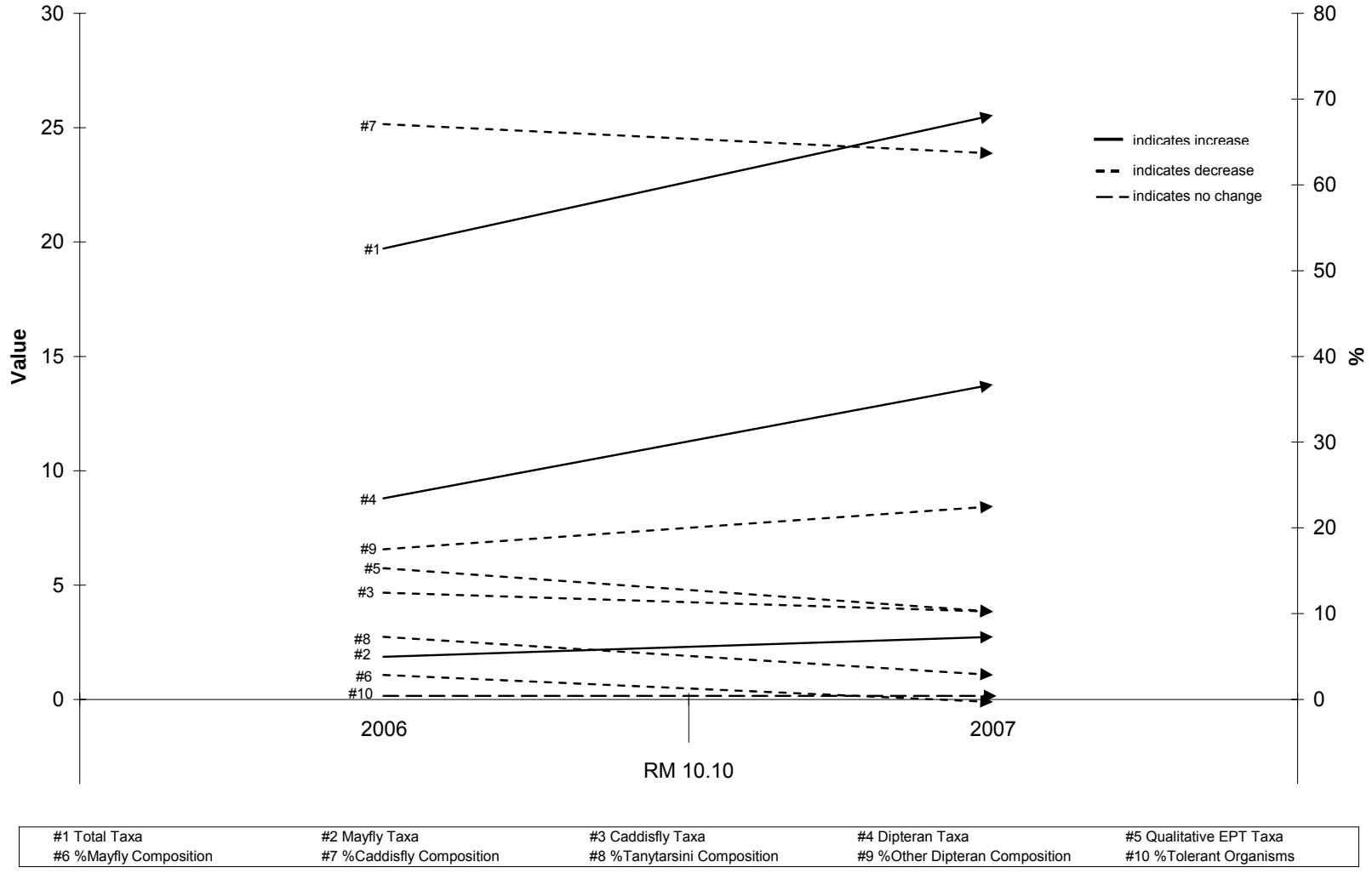
Figure 14.
2006 v. 2007 ICI Data for Cuyahoga River Upstream of Southerly WWTC



#1 Total Taxa	#2 Mayfly Taxa	#3 Caddisfly Taxa	#4 Dipteran Taxa	#5 Qualitative EPT Taxa
#6 % Mayfly Composition	#7 % Caddisfly Composition	#8 % Tanytarsini Composition	#9 % Other Dipteran Composition	#10 % Tolerant Organisms

#1 and #5: no change in metric score #2, #4, #6 and #8: *negative* decrease #10: *positive* decrease
#3 and #7: *positive* increase #9: *negative* increase

Figure 15.
2006 v. 2007 ICI Data for Cuyahoga River Downstream of Southerly WWTC



#3, #5, #6, #7 and #8: *negative* decrease #1, #2 and #4: *positive* increase
#9: *negative* increase #10: no change in metric score

Additional Sites RM 16.20, RM 12.10, RM 11.30, RM 7.90 and RM 7.00

Of the five additional sites, RM 7.00 had the highest ICI score of 38. The other four sites were also in attainment, with ICI scores ranging from 34 to 36. The score at RM 7.00 is rather significant as it is located downstream of Southerly WWTC and downstream of Big Creek, a major tributary to the Cuyahoga River. This indicates that neither Big Creek, Southerly WWTC, National Pollution Discharge Elimination System permitted discharges, CSO-033 nor any non-point sources had deleterious effects on the macroinvertebrate communities on the Cuyahoga River at this location.

At sites that were also sampled in 2006, RM 16.20 and RM 11.30 (replaced RM 11.50 which was sampled in 2006), ICI scores increased from 32 to 34 for RM 16.20 and from 28 to 34 for RM 11.30. As of 2007, according to Ohio EPA data from 2000 and NEORSD data from 2006 and 2007, RM 16.20 has been in attainment for seven years. Additionally, an ICI score of 34 at RM 11.30 indicates attainment of the WWH criterion and that Mill Creek, another major tributary of the Cuyahoga River, did not appear to have an impact on the macroinvertebrate community in the Cuyahoga River in 2007 at this location.

RM 12.10 and RM 7.90 were also new sampling locations for 2007 and both locations indicated attainment of the WWH criterion with ICI scores of 36/34 and 36, respectively. RM 12.10 and RM 7.90 are both upstream of potential impact sources, Mill Creek and Big Creek, respectively, and had scores within two points of the downstream locations, RM 11.30 and RM 7.00, respectively. This upstream/downstream similarity in scores further indicates that Mill Creek and Big Creek are not negatively affecting the macroinvertebrate communities on the Cuyahoga River. Additional sampling in 2008 will be necessary at all of these locations to determine long-term trends and biocriteria attainment status at each site.

Conclusion

Overall, the health of the fish and macroinvertebrate communities in the Cuyahoga River have improved substantially over the past seventeen years. This is most likely due to cleaner conditions in the river resulting from pollution reduction projects completed by NEORSD and other communities. For example, a pretreatment program for industry, incorporating federal pretreatment standards since 1984, has reduced loadings of metals to Southerly WWTC and thus improved effluent quality. Upgrades to Southerly WWTC, including treatment processes for nitrification and dechlorination, have also resulted in improved effluent quality. Increased collection of wet weather flows for treatment has resulted in less pollution from sewage overflows reaching the river. Further upstream, upgrades to the Akron Wastewater Treatment Plant and the decommissioning of smaller wastewater treatment plants, whose flows are now conveyed to Southerly WWTC via the

NEORSD Cuyahoga Valley Interceptor, have also reduced the amount of pollution entering the river. Continued efforts at reducing pollution impacts are needed to ensure that, in upcoming years, the biotic community continues to improve and become more diverse and maintain attainment of biological criteria.