

**Biological and Water Quality Survey  
of the Mahoning River near Thomas Steel Strip  
Corporation in Warren**

**Trumbull County, Ohio**

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## REPORT SUMMARY

Macroinvertebrate, water, and stream sediment sampling was conducted during the summer of 2006 to bracket the Thomas Steel Strip Corporation/Dicky Run storm sewer discharge to the Mahoning River. The survey also duplicated similar sampling efforts from a 1994 biological and water quality survey of the Mahoning River basin (<http://www.epa.state.oh.us/dsw/documents/mahon94.pdf>). Samples were collected at four locations: (1) Summit Street (RM 39.1) upstream from the Dicky Run storm sewer, (2) the Dicky Run storm sewer discharge (RM RM 39.07), (3) the Dicky Run storm sewer mixing zone (RM 39.06), and (4) downstream from Dicky Run at East Market Street (RM 38.3). Invertebrate Community Index (ICI) scores were calculated for each location following standard Ohio EPA biological sample methods (Ohio EPA, 1989). Chemical samples were collected following standard quality assurance guidelines (Ohio EPA, 2006).

Benthic macroinvertebrate communities upstream from the discharge were marginally good but met the minimum WWH biocriterion. Artificial substrate samplers from the mixing zone reflected fair quality but communities were not indicative of acute toxicity. However, qualitative natural substrate sampling revealed a strong toxic response with the near absence of organisms along the immediate west bank. The artificial substrates were collected about six feet from the streamside and may have been exposed to a mixture of both effluent and receiving water over the six-week sampling period. In contrast, qualitative sampling included the extreme west bank and the influence of the discharge appeared more severe as the concentrated effluent hugged the river's edge immediately downstream. Similar observations and more severe impacts in the natural substrate community were noted during 1994 sampling. Potential impacts associated with the discharge appeared largely restricted to the mixing zone since communities met the minimum WWH biocriterion at East Market Street, less than a mile downstream.

Grab water chemical samples showed a violation of the inside mixing zone maximum (IMZM) statewide Water Quality Standards criterion for total copper (68 ug/l measured) in one of two sample events (OAC 3745-1-07 Table 7-9). The level of total copper discharged from the Dicky Run storm sewer was 182 ug/l at the time of the exceedance (sample collected 08/09/2006). Although OAC 3745-1-25, Table 25-1 indicates that there exists a site specific IMZM copper criterion for Thomas Steel Strip Corp, information provided by Ohio EPA Water Quality Standards Section staff indicates that the text in OAC 3745-1-25 is no longer applicable (see pages 3-4).

Analysis of sediment chemistry showed a lower level of total copper within the Dicky Run storm sewer mixing zone sediment than upstream, which suggests that intermittent and high levels of copper in the mixing zone water is a more likely

stressor, as opposed to chronic exposure to copper in sediment, to help explain the observed depression of the macroinvertebrate community. The only sediment metal that was higher in the mixing zone than upstream at Summit Road was zinc, but the measured value of 194 mg/kg zinc was lower than the probable effect level of 315 mg/kg reported by MacDonald et al. (2000).

In conclusion, the results of the 2006 survey indicated that an intermittent discharge of total copper from the Thomas Steel Strip facility resulted in a violation of the IMZM Water Quality criterion in 1 of 2 samples collected. Strong toxic effects in the benthic macroinvertebrate community from qualitative samples were observed along the shore hugging habitat where the elevated level of copper occurred. Intermittent discharge of elevated copper would be one stressor to help explain the toxic response in the macroinvertebrates. The spatial extent along the Mahoning River shoreline of this negative impact is unknown. However, macroinvertebrate community health and diversity approximately 0.86 river miles downstream from the storm sewer (near East Market St.) was similar to that found upstream near Summit St. Sediment bioassays should be conducted to determine if the levels of elevated nickel observed throughout the area have a negative effect on the macroinvertebrate species unique to the Mahoning River mainstem.

### Water and Sediment Chemistry Evaluation

Water and sediment sampling was conducted within the Mahoning River during the summer of 2006 to bracket the Thomas Steel Strip/Dicky Run storm sewer discharge. Grab water samples were collected at four locations: (1) Summit Street (RM 39.1) upstream from the Dicky Run storm sewer, (2) the Dicky Run storm sewer discharge (RM 39.07), (3) the Dicky Run storm sewer mixing zone (RM 39.06), and (4) downstream from Dicky Run at East Market Street (RM 38.3). Water samples were collected on August 9 and August 23, 2006. Sediment samples were collected from the three Mahoning River locations on August 9, 2006. The results of the water samples are presented in Table 1, the results of the sediment samples are presented in Table 2.

### **Sampling Results**

Grab water chemical sampling on August 9 and 23, 2006 showed a violation of the IMZM statewide Water Quality Standards criterion for total copper (68 ug/l measured) in one of the two sample events (OAC 3745-1-07 Table 7-9). The level of total copper discharged from the Dicky Run storm sewer was 182 ug/l at the time of this exceedance (sample collected 08/09/2006). Although OAC 3745-1-25 Table 25-1 indicates that there exists a site specific IMZM copper criterion for Thomas Steel Strip Corp. based on a dissolved copper translator model in lieu of total recoverable copper, information provided by Ohio EPA Water Quality Standards Section staff

indicates that the text in OAC 3745-1-25 is no longer applicable:

*In 1997, Ohio adopted the provisions of the Great Lakes Initiative into its WQS rules. Part of that adoption included a revision of the statewide criteria for copper to those that appear in OAC 3745-1-07 today. These include an IMZM of 54 ug/l total recoverable copper and 52 ug/l dissolved copper at a hardness of 200 mg/l. However, the Agency failed to make appropriate revisions to the site-specific copper criterion listed in OAC 3745-1-25 when it made the revisions to the statewide copper criteria in OAC 3745-1-07. Since the Agency adopted dissolved copper criteria in 1997 into OAC 3745-1-07, the site-specific dissolved copper criterion in OAC 3745-1-25 should have been removed at the same time. (memo from C. Skalski, WQS Section, October 2007)*

To observe an exceedance of the IMZM copper criterion in one of two random sample events suggests that many more such events would likely occur on an annual basis. Monthly operating report data submitted to Ohio EPA from Thomas Strip Steel Corp. indicates a long term problem with copper being discharged from the 001 NPDES permitted discharge. On 10/12/2005, a total copper of 144 ug/l was reported, exceeding the 130 ug/l permit limit (11/7/2005 letter from Eric Howland to Ohio EPA). Data collected by Ohio EPA during a compliance sample inspection (10/11-12/2005) showed a total copper of 160 ug/l, free cyanide of 120 ug/l, and ammonia-N of 27.3 mg/l; an Ohio EPA compliance sample inspection on 06/13-14/2005 showed a total copper of 140 ug/l and ammonia-N of 37.2 mg/l. During both of these 2005 compliance samples, the effluent was acutely toxic to Ceriodaphnia, with toxicity persisting into the mixing zone samples. On April 10, 2005, a total copper of 219 ug/l was reported, exceeding the 130 ug/l permit limit (June 7, 2005 letter from Eric Howland to Ohio EPA). More recently, three exceedances of the 130 ug/l total copper permit limit have been report (160 ug/l on 2/21/2007; 236 ug/l on 5/1/2007; 270 ug/l on 6/5/2007).

Free cyanide was detected in both mixing zone samples (49 and 18 ug/l) but was below detection limit (< 5 ug/l) upstream from Dicky Run. Any detection of free cyanide in waters of the state is cause for concern because it is normally not present above the 5 ug/l detection limit. The maximum amount of free cyanide recorded in the mixing zone was lower than the WWH IMZM criterion in OAC 3745-1-07, Table 7-9 for the Ohio River basin. The potential for synergistic toxic effects from the combined presence of elevated copper and cyanide exists. Ammonia-N was not sampled during the survey as an oversight, but elevated levels of ammonia would be expected to be discharged from the Dicky Run storm sewer on an intermittent basis based on historical NPDES effluent sampling for Thomas Steel Strip.

Analysis of sediment chemistry (Table 2) showed a lower level of total copper within the Dicky Run mixing zone sediment than upstream. The results suggest intermittent and high levels of copper in the mixing zone water is a more likely stressor, as opposed to chronic exposure to copper in sediment, to help explain the depression of the macroinvertebrate community in the shore hugging mixing zone habitat.

Table 1. Summary of surface water chemical data collected from the Mahoning River upstream and downstream from the Dickey Run storm sewer (August 2006).

Location	Summit Street (dwst dam)	Summit Street (dwst dam)	Dickey Run Storm sewer	Dickey Run Storm sewer	Dickey Run Mixing Zone	Dickey Run Mixing Zone	West Market Street (upst)	West Market Street (upst)
River Mile	39.1	39.1	39.07	39.07	39.06	39.06	38.3	38.3
Date/time	08/09/06 1153 hr	08/23/06 1059 hr	08/09/06 1228 hr	08/23/06 1121 hr	08/09/06 1251 hr	08/23/06 1114 hr	08/09/06 1317 hr	08/23/06 1139 hr
Parameter								
Sp. Conductivity ( umho/cm at 25C )	446	440	1671	2569	648	1281	462	468
Temperature ( C )	23.57	22.33	28.95	28.01	24.58	24.52	24.29	22.51
Dissolved oxygen ( mg/l )	7.91	8.07	6.82	6.54	7.88	7.70	8.65	8.30
Dissolved oxygen % Saturation	93.1	93.0	88.9	83.0	95.1	92.0	103.7	96.0
pH ( su )	7.75	7.71	na	8.98	8.32	8.51	7.92	7.78
Aluminum ( ug/l )	247	<200	209	<200	250	<200	<200	<200
Barium ( ug/l )	31	35	21	24	27	28	31	33
Calcium ( mg/l )	40	38	71	200	53	130	41	39
Chromium ( ug/l )	<30	<30	<30	<30	<30	<30	<30	<30
Copper ( ug/l )	<10	<10	182	29	<b>68*</b>	17	<10	<10
Iron ( ug/l )	650	464	249	142	472	287	480	455
Magnesium ( mg/l )	12	12	19	17	15	15	13	12
Manganese ( ug/l )	214	178	32	30	144	92	180	164
Nickel ( ug/l )	<40	<40	131	<40	44	<40	<40	<40
Potassium ( mg/l )	5	4	9	5	6	5	5	4
Sodium ( mg/l )	28	25	254	308	109	176	31	28
Strontium ( ug/l )	152	128	239	370	179	266	154	129
Zinc ( ug/l )	<10	<10	24	17	13	11	<10	<10
Mercury ( ug/l )	<0.20	na	<0.20	na	<0.20	na	<0.20	na
Arsenic ( ug/l )	<2.0	2.1	<2.0	<2.0	2.8	<2.0	<2.0	2.5
Cadmium ( ug/l )	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Lead ( ug/l )	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Selenium ( ug/l )	<2.0	<2.0	<2.0	<2.0	<2.0	<4.0	<2.0	<2.0
Cyanide-Free ( ug/l )	<5	<5	97	15	49	18	<5	na
Hardness ( mg/l )	149	144	255	569	194	386	156	147

\* = Exceedance of the IMZM total copper WQS criterion at the measured water hardness.

The only metal in sediment that was higher in the mixing zone sample than upstream at the Summit Road sample location was zinc, but the measured value of 194 mg/kg zinc is lower than the probable effect level of 315 mg/kg reported by MacDonald et al. (2000). Cyanide in sediment was not sampled.

Table 2. Summary of stream sediment collected from the Mahoning River upstream and downstream from Dickey Run storm sewer (August 2006). Bold values exceed the consensus based sediment quality guidelines (PEC)<sup>a</sup> from MacDonald et al. (2000).

Location	Summit Street (dwst dam)	Dickey Run Mixing Zone	West Market Street (upst bridge)	McDonald et al. (2000) PEL/SEL/PEC <sup>a</sup>
River Mile	39.1	39.06	38.3	
Date/time	08/09/06 1153 hr	08/09/06 1251 hr	08/09/06 1317 hr	
Parameter				
% Solids	73.7	78.1	79.5	
Aluminum ( mg/kg )	6640	4950	8670	
Barium ( mg/kg )	81.0	50.0	139	
Calcium ( mg/l )	28800	17500	13400	
Chromium ( mg/kg )	<b>130</b>	41	42	90/110/111
Copper ( mg/kg )	68.2	44.4	45.2	197/110/149
Iron ( mg/kg )	50700	21200	44100	
Magnesium ( mg/kg )	4340	4490	3480	
Manganese ( mg/kg )	2190	843	2060	
Nickel ( mg/kg )	<b>104</b>	<b>73</b>	<b>94</b>	36/75/48.6
Potassium ( mg/kg )	<920	<931	<986	
Sodium ( mg/kg )	<2300	<2330	<2470	
Strontium ( mg/kg )	62	33	41	
Zinc ( mg/kg )	97.4	194	258	315/820/459
Mercury ( mg/kg )	0.053	0.049	<0.024	0.49/2.0/1.06
Arsenic ( mg/kg )	14.1	8.97	27.4	17/33/33
Cadmium ( mg/kg )	0.217	0.142	0.270	3.5/10.0/4.98
Lead ( mg/kg )	85	43	45	91/250/128
Selenium ( mg/kg )	<0.92	<0.93	<0.88	

<sup>a</sup> PEL = Probable Effect Level

SEL = Severe Effect Level

PEC = Probable Effect Concentration. Consensus based concentrations above which harmful effects on aquatic life are likely to be observed

Two metals, chromium and nickel, were at levels predicted to have negative effects on aquatic life at the upstream Summit Street location. The macroinvertebrate community ICI was 4 points lower than the ecoregion biocriterion (ICI = 34) in 2006, and showed a 4 point decline from the 1994 survey but was within the range of variance for the index. It is possible that the elevated levels of chromium and nickel

in sediment may help explain the marginal ICI score. However, sediment samples were not collected at this location in 1994 so analysis of trends is not possible. Nickel in sediment was elevated at all three sample locations, but lowest at the mixing zone location. Thus sediment nickel alone cannot explain the toxic signature on macroinvertebrates in the shore hugging habitat since higher levels of nickel were found at locations where ICI values were minimally attaining the WQS biocriterion. Cyanide in sediment was not sampled.

### Macroinvertebrate Evaluation

Macroinvertebrate sampling conducted in 2006 bracketed the Thomas Strip Steel/storm water discharge in Warren and duplicated sampling efforts from a Mahoning River survey in 1994 (<http://www.epa.state.oh.us/dsw/documents/-mahon94.pdf>). Samples were collected from the Mahoning River at Summit Street (RM 39.1), the Thomas Steel mixing zone (RM 39.06), and downstream at East Market Street [RM 38.3 (Table 3)].

#### **Sampling Results**

Since WWH biocriteria do not apply inside the mixing zone, biological sampling was primarily conducted to determine if the Thomas Strip Steel effluent resulted in rapid lethality (*i.e.*, acutely toxic conditions). Acute toxicity in the macroinvertebrates generally results in severely degraded communities reflecting Very Poor quality (*i.e.*, ICI score = 0-6 or narrative evaluations fall in the Very Poor range). Toxic impacts often result in very low population densities and diversity, the elimination of most, if not all sensitive species, and a predominance of pollution tolerant populations, particularly those tolerant of toxic substances. Severe toxic impacts may result in the elimination of all species.

Between the upstream and mixing zone sites, ICI scores declined from Marginally Good to Fair, and percentages of mayflies, caddisflies, and tanytarsini midges (sensitive metrics) experienced substantial declines (Figure 1). Conversely, the percentage of tolerant taxa increased sharply, from 16% to 81%, primarily due to an increase in aquatic worms (Oligochaeta). Oligochaetes are considered quite tolerant to a variety of pollutants but are most commonly associated with organic enrichment and low DO levels.

Despite these impacts, the mixing zone artificial substrate community was quite diverse (47 taxa), and included 9 mayflies and caddisflies (EPT taxa) and 12 pollution sensitive taxa. The predominance of enrichment tolerant oligochaetes, high taxa richness, and modest numbers of sensitive taxa suggest conditions over the artificial substrates were degraded but not extremely toxic. In order to maintain adequate current and depth over the artificial substrates, the mixing zone samplers were set

about 6 feet off shore. Visually, the samplers appeared to be within the effluent plume but may have been near the outer edge of the discharge and exposed to a mix of effluent and Mahoning River flow during the six-week sampling period.

Table 3. Summary of macroinvertebrate data collected from artificial substrates (quantitative evaluation) and natural substrates (qualitative evaluation) in the Mahoning River study area, July-September, 2006 and 1994. Mixing zone samples are denoted in *italics*.

<b>Mahoning River</b>								
<b>Quantitative Evaluation</b>								
River Mile (Year)	Density (#/ft <sup>2</sup> )	Quant. Taxa	Qual. Taxa	Qual. EPT <sup>a</sup>	Total Taxa	Sensitive Taxa (Qual.)	ICI	Narrative Evaluation
39.1 (2006)	527	33	44	11	61	14	30 <sup>ns</sup>	M. Good
39.1 (1994)	560	30	35	7	51	7	34	Good
<i>39.06 (2006)</i>	<i>519</i>	<i>47</i>	<i>9</i>	<i>1</i>	<i>52</i>	<i>1</i>	<i>24</i>	<i>Fair</i>
<i>39.06 (1994)</i>	<i>378</i>	<i>24</i>	<i>5</i>	<i>0</i>	<i>28</i>	<i>0</i>	<i>16</i>	<i>Fair</i>
38.3 (2006)	476	37	48	14	63	16	30 <sup>ns</sup>	M. Good
38.2 (1994)	300	34	31	6	51	6	26*	Fair
<b>Ecoregion Biocriteria: Invertebrate Community Index (ICI)</b>								
Erie-Ontario Lake Plain (EOLP)								
WWH			EWH			MWH <sup>e</sup>		
34			46			22		
a	EPT = total Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) taxa richness.							
*	Significant departure from ecoregional biocriterion (>4 ICI units); poor and very poor results are underlined.							
ns	Nonsignificant departure from ecoregional biocriterion (≤4 ICI units).							

In contrast to the artificial substrates, qualitative natural substrate collections indicated significant impacts in the mixing zone. Only 9 taxa in very low densities were found despite adequate substrate and margin habitat quality (*i.e.*, root mats and undercut banks, submerged sticks, tree limbs, etc). Organisms were virtually absent along the margin but similar habitats immediately upstream supported large numbers of scuds (*Gammarus fasciatus*), crayfish, and damselflies. While not particularly sensitive, the abundance of these populations was obviously greater upstream from the discharge. Within the mixing zone, small amounts of oil were kicked up, deposits of black muck or solids were observed along the banks, and occasional large chunks of a hard, whitish-green precipitate were found. A discarded auto battery was also observed.

Less than a mile downstream, ICI scores improved to the marginally good range (ICI=30) at East Market Street (RM 38.3). ICI score, EPT taxa richness (25) and sensitive taxa richness (17) were all very similar to upstream collections at Summit Road and reflected similar quality.

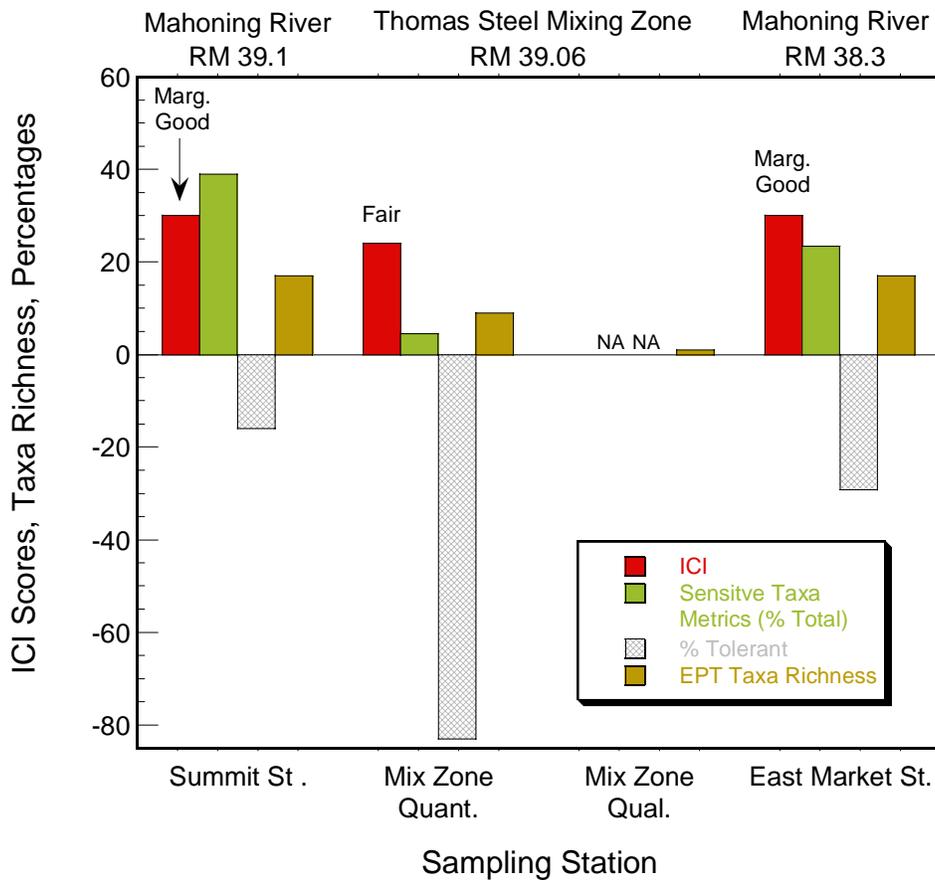


Figure 1. ICI scores and selected community attributes associated with artificial substrate and natural substrate samples in the Mahoning River and Thomas Steel Strip mixing zone, Aug.-Sept., 2006. [Note: “Sensitive taxa metrics” refers to the combined percentage of mayflies, caddisflies, and tanytarsini midges on the artificial substrate samplers. Sensitive taxa percentage and EPT taxa richness are considered positive water quality attributes. Tolerant taxa percentage is considered a negative attribute.

**Macroinvertebrate Trends: 1994-2006**

Based on ICI scores, water quality conditions upstream from Thomas Strip Steel have not changed significantly since 1994 (Figure 2, Table 3). Community health

ranged from Good in 1994 to Marginally Good in 2006 but both scores were within the range of natural variation for the index ( $\pm 4$  ICI points). Some improvement was apparent as the number of total sensitive taxa doubled (from 14 to 28) and total EPT taxa richness increased from 11 to 17.

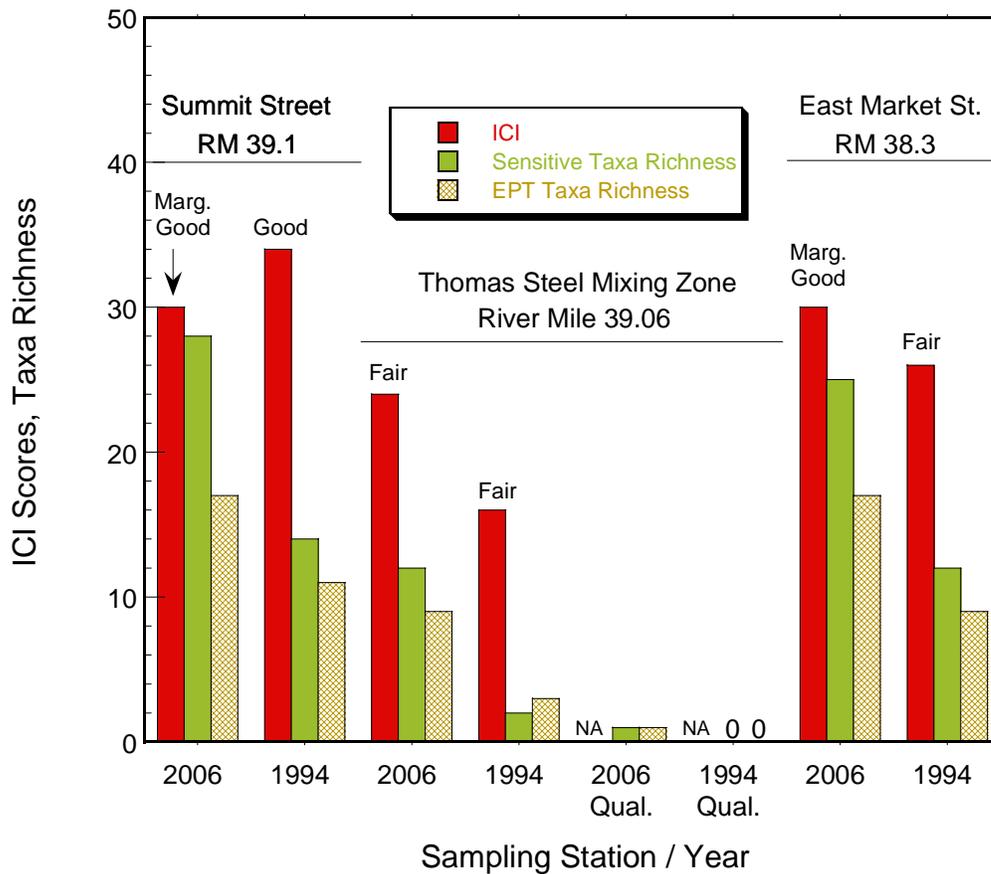


Figure 2. ICI scores and selected community attributes associated with artificial substrate and natural substrate samples in the Mahoning River and Thomas Steel Strip mixing zone, 1994-2006.

Mixing zone results were also similar between sampling years. ICI scores increased from 16 in 1994 to 24 in 2006 (both Fair), primarily the result of increases in taxa richness and sensitive midge taxa on the artificial substrates. However, pollution tolerant taxa, particularly aquatic worms, continued to account for over 80% of total organisms in both 1994 and 2006 collections. Both samplers tended to reflect degraded but not extremely toxic conditions with some improvement noted by 2006.

In contrast to the artificial substrates, qualitative natural substrate sampling revealed a much stronger toxic response in both 1994 and 2006. Total taxa richness (9 in 2006, 5 in 1994) and population densities were very low during each survey and both field crews noted the effluent plume tended to hug the extreme left bank. Given these observations, differences between the artificial substrate and natural substrate results may be related to variation in exposure to effluent concentrations across the effluent plume. Bioassay sampling in 1994 found the effluent was acutely toxic.

Less than a mile downstream at East Market St., the 2006 ICI score was Marginally Good (IBI=30) and was an insignificant departure from the WWH biocriterion. The 2006 samples represented a modest improvement over the fair quality conditions in 1994 (ICI=26) and, like collections upstream at RM 39.1, increases in EPT and sensitive taxa suggest a general improvement in this stretch of the Mahoning River since 1994.

#### Acknowledgements:

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