Biological and Water Quality Study of the Ottawa River and Principal Tributaries, 2010

Allen, Auglaize, Hardin, Hancock and Putnam Counties

Ohio EPA Technical Report EAS/2012-12-13

Division of Surface Water
Ecological Assessment Section
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Prepared by:

State of Ohio Environmental Protection Agency
Division of Surface Water

Ecological Assessment Section
Groveport Field Office
4675 Homer Ohio Lane
Groveport, Ohio 43125

Water Quality Group
Northwest District Office
347 N. Dunbridge Rd.
Bowling Green, Ohio 43402

John Kasich, Governor, State of Ohio
Scott J. Nally, Director, Ohio Environmental Protection Agency

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Study Area Description – Katie McKibben
Pollutant Loadings – Dan Glomski
Chemical Water Quality – Dan Glomski, Katie McKibben
Chemical Water Quality Trends – Charles Boucher
Fish Tissue Analysis – Mylynda Shaskus, Ed Moore, Jr.
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Copies of this report are located on the Ohio EPA internet web page (http://www.epa.ohio.gov/dsw/document_index/psdindx.aspx) or may be available on CD from:

Ohio EPA
Division of Surface Water
Ecological Assessment Section
4675 Homer Ohio Lane
Groveport, Ohio 43125
(614) 836-8777

Biological and Water Quality Study of the Ottawa River and Principal Tributaries

Allen, Auglaize, Hardin, Putnam and Hancock Counties

INTRODUCTION

Figure 1. Location of the Ottawa River watershed in northwest Ohio.

As part of the Total Maximum Daily Load (TMDL) process, an intensive ambient assessment of the Ottawa River watershed was conducted by the Ohio EPA during the 2010 field sampling season. The study area included the entire length of the Ottawa River, principal tributaries, and many remaining minor conveyances possessing a drainage area greater than three square miles (Figure 1). Eighty-five total stations were sampled. A subtotal of 80 biological stations was sampled throughout the catchment, evaluating 26 named and unnamed streams (Table 1). Ambient biology, physical habitat quality, and water chemistry were collected from all linked locations (Table 8). Diel water quality (DO, pH, conductivity, and temperature), bacterial data, sediment chemistry (metals, organics, and particle size), fish, and macroinvertebrate tissue were evaluated at selected stations. Cumulatively, 158.4 linear stream miles of the watershed were surveyed and assessed. Aquatic life assessments were completed for 79 of the 80 sites sampled.

A station list was derived from a systematic census of the watershed based upon drainage area. This method has proved rapid and efficient in generating an objective and comprehensive collection of potential sampling sites where an assessment of an entire catchment is desired. Higher order segments (or tributaries) were directly targeted to ensure an even distribution of sampling effort. Ohio EPA sampling resources were also allocated to evaluate public and private NPDES permitted entities. Lastly, areas that have been previously sampled and evaluated by the Ohio EPA were revisited for the purposes of trends assessment.

Specific sampling objectives included the following:

1) Systematically sample and assess the principal drainage network of the Ottawa River watershed in support of the TMDL process,

2) Gather ambient environmental information (biological, chemical, and physical) from undesignated water bodies to objectively prescribe an appropriate suite of beneficial uses (e.g., aquatic life, recreation, water supply),

3) Verify the appropriateness of existing and unverified beneficial use designations, and recommend changes where appropriate,

4) Establish baseline ambient biological conditions at selected reference stations to evaluate the effectiveness of existing and future pollution abatement efforts,

5) Evaluate wastewater treatments plants (WWTPs) and other NPDES permitted entities within the study area, and

6) Document any changes in the biological, chemical, and physical conditions of the study areas where historical information exists, thus expanding the Ohio EPA database for statewide trends analysis.

Components of the TMDL process supported by this survey are principally the identification of impaired waters, verification (and redesignation if necessary) of beneficial use designations, gathering ambient information that will factor into the wasteload allocation, ascribing causes and sources of use impairment, and the derivation of basin specific pollutant loading goals or restoration targets. These data are necessary precursors to the development of effective pollution control or abatement strategies.

SUMMARY

During the 2010 survey, the Ottawa River mainstem and 25 tributaries were sampled within the 365mi^2 watershed. A total of 158.4 stream miles were assessed in 2010 out of the 224 total perennial stream miles in existence for the selected streams sampled in the Ottawa River watershed. A total of 80% of assessed stream miles (126.2 miles) were found to fully support existing or recommended aquatic life uses (Figure 2). This was documented from 54 of 79 sites (68%) that biologically supported the existing and recommended aquatic life uses (Figure 3). Partial attainment was indicated for 23.0 stream miles (14%) and non-attainment for the remaining 9.2 stream miles assessed (6%). Total impaired miles, a combination of both partial and non-attainment, was 32.2 miles and comprised 20% of the linear stream study area (Figure 2). This represented 25 of the 79 (32%) survey sample sites that were biologically impaired (Figure 3). These impairments were identified in 9 streams (or segments) of the 26 individual waterbodies surveyed in 2010. Almost half (12) of the total impaired sites / segments sampled in the Ottawa River basin were located on the Ottawa River mainstem (Figures 2 and 3). A list of waters assessed as part of this survey, performance of community and habitat indices, by station or reach, and aquatic life attainment status for the Ottawa River watershed are presented in Table 1.

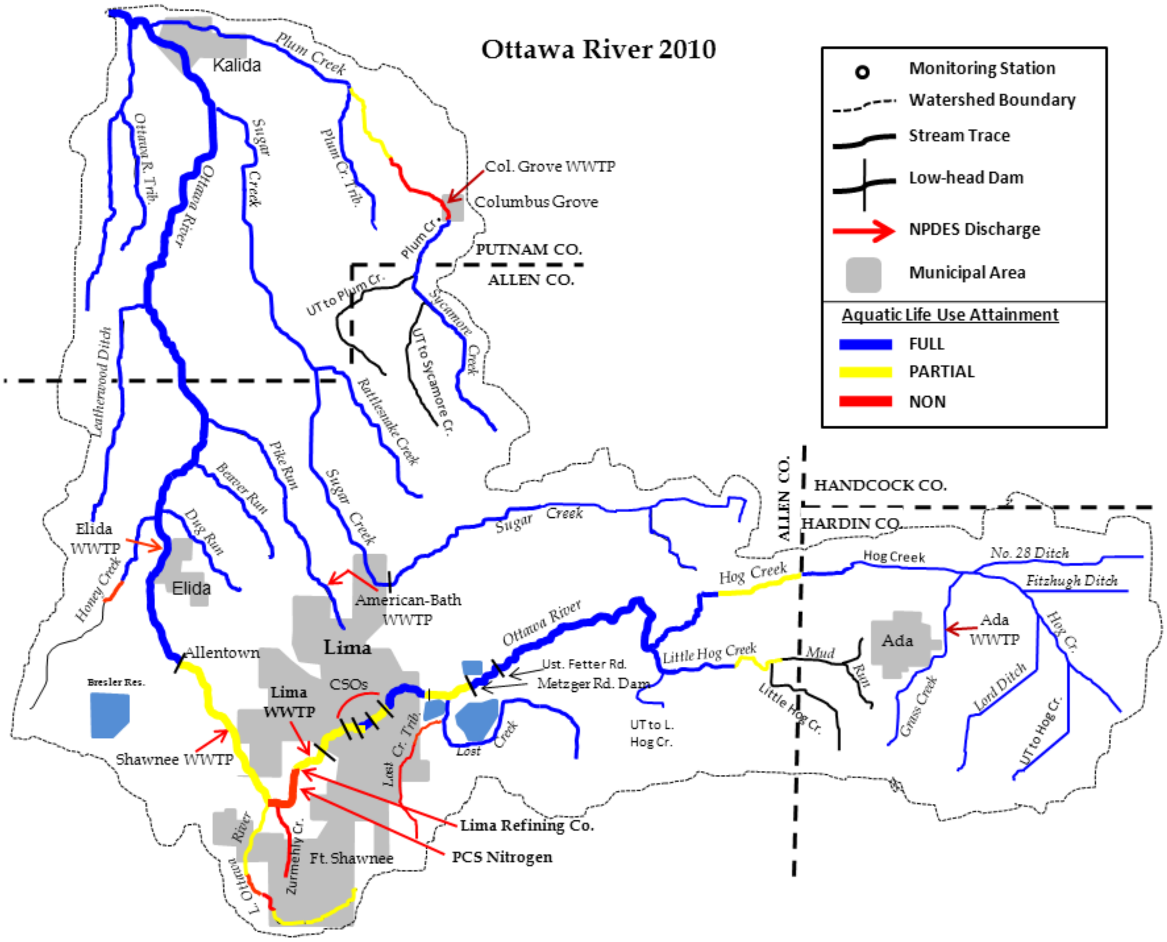

Figure 2. Map of surface waters of the Ottawa River basin, color coded to attainment status of sampled stream reaches compared to existing or recommended aquatic life use designation, 2010.

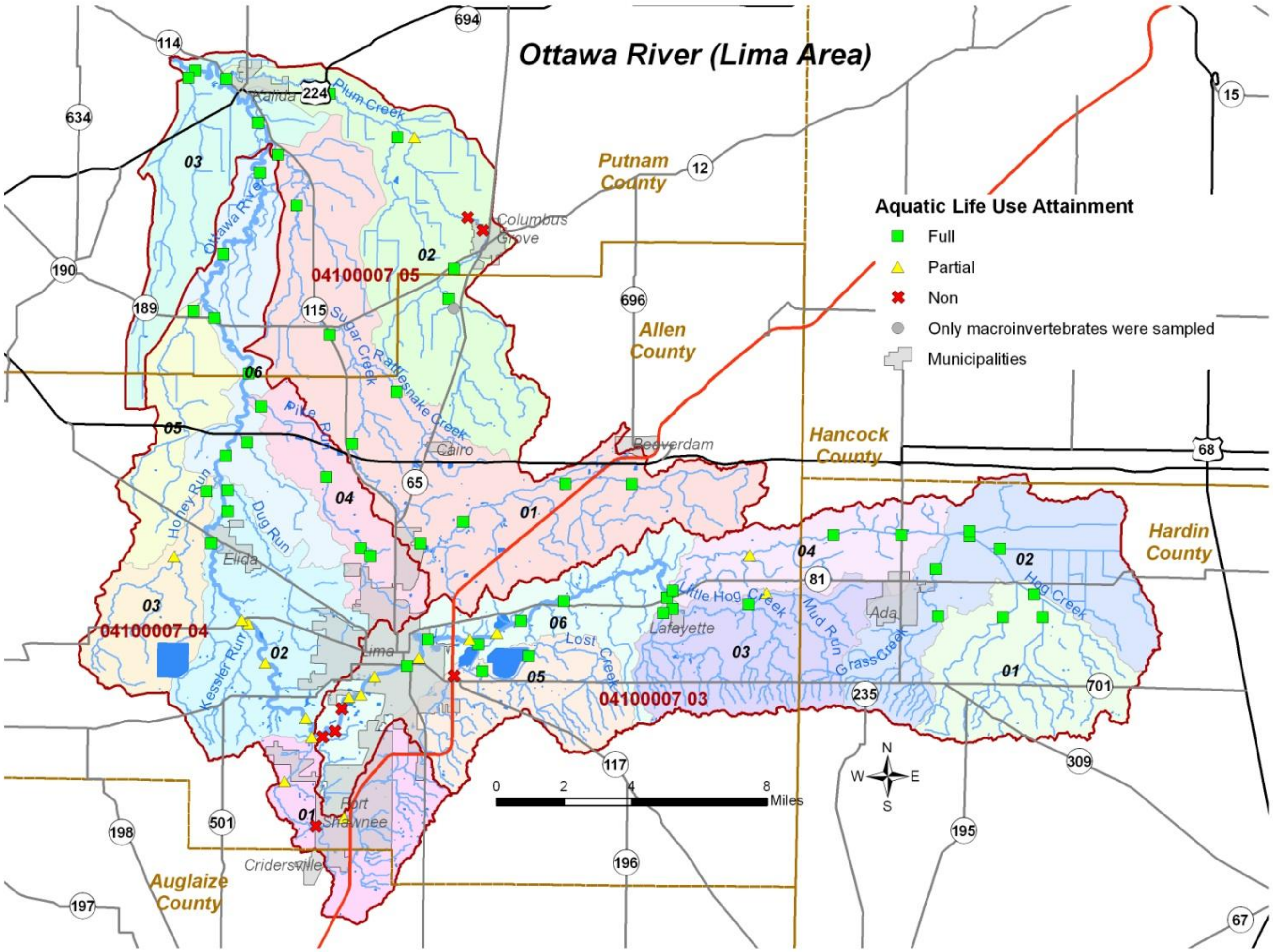

Figure 3. Attainment status of the Ottawa River basin biological sampling sites based on existing or recommended aquatic life use designations, 2010, and their relationship to USGS 10-digit and 12-digit Hydrologic Unit Code subwatersheds.

Table 1. Aquatic Life Use Attainment for stations sampled in the Ottawa River Watershed, June-Oct. 2010.

River Miles Fish/Invert.	IBI	MIwb	ICI[a]	QHEI[b]	Landmark	Attainment Status[c,d]	Cause(s)	Source(s)
Ottawa River mainstem (04-200) Eastern Corn Belt Plains **(ECBP) Warmwater Habitat (WWH)**								
46.1[W] / 46.0	37[ns]	8.7	48	81.0	Thayer Rd.	FULL	NA	NA
44.3[W]	39[ns]	9.4	46	70.0	Fetter Rd.	FULL	NA	NA
43.4[W] /43.45	35*	8.6	VG[b]	59.5	Dst. Metzger Dam	PARTIAL	Low Flow Alteration Nutrient / Eutrophication Biol. Indicators Nutrients	Flow Alteration from Water Diversions Impoundment Crop Production with Subsurface Drainage
42.5[B]	32*	9.0	38	61.3	Dst. Roush Rd.	PARTIAL	Low Flow Alteration Nutrient / Eutrophication Biol. Indicators Nutrients DO (Low, Range)	Flow Alteration from Water Diversions Impoundment Crop Production with Subsurface Drainage
41.3[W] / 41.2	44	9.1	44	71.3	Sugar St.	FULL	NA	NA
40.1[W]	35*	8.7	40	69.5	Dst. Lovers Lane Dam (dst. CSO)	PARTIAL	Nutrient/Eutrophication Biol. Indicators Nutrients DO (Range)	Sanitary Sewer Overflows (SSOs) Combined Sewer Overflows (CSOs)
39.6[W]/39.67	37[ns]	9.3	46	71.5	Dst. Elm St. Dam	FULL	NA	NA
38.6[B]/38.65	39[ns]	8.0 [ns]	Low Fair*	46.5	Collett St./ Erie RR Dam pool	PARTIAL	Direct Habitat Alteration Nutrient/Eutrophication Biol. Indicators DO (Low, Range) Organic Enrichment (Sewage) Biological Indicators	Impoundment CSOs
37.9[W]	35*	9.3	20*	74.0	Dst. Erie RR Dam Ust. Lima WWTP	PARTIAL	Nutrient / Eutrophication Biol. Indicators DO (Range) Organic Enrichment (Sewage) Biological Indicators Nutrients Other Anthropomorphic Substrate Alteration	CSOs Impoundment Historic Bottom Deposits

River Miles Fish/Invert.	IBI	MIwb	ICI[a]	QHEI[b]	Landmark	Attainment Status[c,d]	Cause(s)	Source(s)
Ottawa River mainstem (04-200) **(ECBP)** **WWH** (cont.)								
37.4 W/37.55	34*	9.0	20*	71.8	Dst. Lima WWTP	PARTIAL	Nutrient/Eutrophication Biol. Indicators Ammonia-N Nutrients	Municipal Point (Pt.) Source Discharges CSOs
37.0 W	31*	7.7*	20*	70.3	Dst. Husky Refinery	NON	Nutrient/Eutrophication Biol. Indicators Ammonia-N Nutrients Excess Algae Chronic Toxicity (Impairment unknown)	Municipal Pt. Source Discharge Industrial Pt. Source Discharge Source Unknown
36.1 W	31*	7.7*	26*	77.3	Dst. PCS Nitrogen	NON	Nutrient / Eutrophication Biol. Indicators Ammonia-N Nutrients DO (Range) Chronic Toxicity (Impairment unknown)	Municipal Pt. Source Discharge Industrial Pt. Source Discharges Source Unknown
34.6 W/34.55	29*	7.3*	36	69.3	Adj. Westfield Dr. (Shawnee CC/ Dst. major dischargers)	PARTIAL	Nutrient/Eutrophication Biol. Indicators DO (Minimum, Range) Nutrients Chronic Toxicity (Impairment unknown)	Municipal Pt. Source Discharge Industrial Pt. Source Discharges Source Unknown
31.1 B/ 30.75	31*	8.3	38	60.0	Elm St. / Dst. Shawnee WWTP	PARTIAL	Nutrient / Eutrophication Biol. Indicators DO (Minimum, Range) Nutrients Organic Enrichment (Sewage) Biol. Indicators	Sanitary Sewer Overflows Municipal Pt. Source Discharge (upst.) Industrial Pt. Source Discharges Urban Runoff / Storm Sewers
29.3 W	33*	8.3	38	69.5	Copus Rd.	PARTIAL	Nutrient / Eutrophication Biol. Indicators Nutrients Organic Enrichment (Sewage) Biological Indicators	SSOs Municipal Pt. Source Discharge Industrial Pt. Source Discharges

River Miles Fish/Invert.	IBI	MIwb	ICI[a]	QHEI[b]	Landmark	Attainment Status[c,d]	Cause(s)	Source(s)
Ottawa River mainstem (04-200) **(ECBP) WWH** (Allen Co. line to confluence) (cont.)								
28.9 B/28.85	32*	9.1	32ns	78.0	Allentown Dam Pool (SR 81)	PARTIAL	Nutrient / Eutrophication Biol. Indicators Nutrients Fish-Passage Barrier	SSOs Municipal Point Source Discharge Dam or Impoundment
25.8 W/25.75	42	8.2ns	40	63.5	Piquad Rd.	FULL	NA	NA
24.1 W/24.11	38ns	9.2	48	68.3	Dst. Elida WWTP	FULL	NA	NA
22.1 W / 22.2	43	8.2ns	42	54.3	Neff Rd./ recovery	FULL	NA	NA
18.8 W / 18.7	41	9.4	VG	66.0	Dst. Gomer/ Dst. Pike Run / SR 12	FULL	NA	NA
Ottawa River mainstem (04-200) Huron-Erie Lake Plains **(HELP) WWH**								
15.9 W / 16.0	45	9.5	42	68.8	@ Rimer/ SR 189	FULL	NA	NA
12.7 W	43	8.7	36	59.5	Dst Rimer(CRR17)	FULL	NA	NA
8.2 B / 7.75	38	9.5	50	55.5	Ust. Sugar Cr.	FULL	NA	NA
5.6	--	--	46	--	Ust. Kalida off SR115	(FULL)	NA	NA
3.7 W / 3.8	35	8.9	50	59.5	Kalida @ SR 224	FULL	NA	NA
1.2 B / 0.8	44	9.8	48	56.0	Dst. Kalida(CR19)	FULL	NA	NA
Ottawa River Tributaries								
Hog Creek (04-216) **(ECBP) Modified Warmwater Habitat (MWH)**[e] (headwaters to Hardin County line) **Confirmed**								
13.4 H/ 13.42	40	NA	High Fair	20.0	At TR 85	FULL	NA	NA
10.8 W/10.77	32	6.2	High Fair	24.0	CR 65	FULL	NA	NA
8.7 W / 8.72	36	8.1	32	45.0	SR 235 (dst. Ada inputs (Grass Cr.))	FULL	NA	NA
6.7 W / 6.6	30	7.9	32	55.3	St. Paul Rd.(T25)	FULL	NA	NA

River Miles Fish/Invert.	IBI	MIwb	ICI[a]	QHEI[b]	Landmark	Attainment Status[c,d]	Cause(s)	Source(s)
Hog Creek (04-216) **(ECBP) WWH** (Allen Co. line to confluence) **Confirmed**								
3.8 [W] / 3.9	24*	5.7*	46	63.5	Pevee Rd.	PARTIAL	Nutrient / Eutrophication Biol. Indicators Nutrients Sedimentation	Crop Production with Subsurface Drainage
0.3 [W] / 0.1	39[ns]	8.5	48	69.5	Swaney Rd.(mouth)	FULL	NA	NA
UT to Hog Creek at RM 13.71 (04-263) **(ECBP) MWH Recommended**[e]								
0.50 [H] / 0.52	36	NA	HF	20.0	TR 50	FULL	NA	NA
Lord Ditch (04-220) **(ECBP) MWH Recommended**								
1.2 [H] / -	32	NA	--	36.0	CR 50	(FULL)	NA	NA
Fitzhugh Ditch (04-219) **(ECBP) MWH Recommended**								
0.2 [H] / 0.4	32	NA	Fair	23.0	CR 65	FULL	NA	NA
No. 28 Ditch (04-218) **(ECBP) MWH Recommended**								
0.4 [H] / 0.37	36	NA	HF	18.0	CR 65	FULL	NA	NA
Grass Creek (04-217) **(ECBP) MWH Recommended**								
3.1 [H] / 2.57	30	NA	High Fair	39.8	CR 65/44 (Ust. Ada)	FULL	NA	NA
1.2 [H]	30	NA	MG	51.0	CR 65 (Dst. Ada)	FULL	NA	NA
Little Hog Creek (04-221) **(ECBP) WWH Confirmed**								
3.6 [H] / 3.62	30*	NA	MG[ns]	50.5	Pevee Rd.	PARTIAL	Direct Habitat Alteration Sedimentation TSS Nutrients	Crop Production with Subsurface Drainage Streambank Destabilization
0.6 [H] / 0.64	38[ns]	NA	G	55.5	Dst. Lafayette WWTP-Swaney Rd	FULL	NA	NA
0.2 [H]	37[ns]	8.7	46	60.5	Dst Lafayette-SR81	FULL	NA	NA

River Miles Fish/Invert.	IBI	MIwb	ICI[a]	QHEI[b]	Landmark	Attainment Status[c,d]	Cause(s)	Source(s)
Mud Run (04-222) **(ECBP) WWH Confirmed**								
0.6 [H] / 0.65	36[ns]	NA	Low Fair*	39.3	Dst. Bluffton Bentley Rd.	PARTIAL	Organic Enrichment (Sewage) Biological Indicators DO (Low) Nutrients	Home Septic Treatment System (HSTS)
UT to Little Hog Creek at RM 0.47 (04-294) **(ECBP) WWH Recommended**								
0.3 [H] / 0.1	40	NA	G	51.5	Napoleon Rd.	FULL	NA	NA
Lost Creek (04-214) **(ECBP) MWH Recommended (RM 4 to > 0.35)**								
3.6 [H] / 3.56	32	NA	Fair	33.0	Mumaugh Rd.	FULL	NA	NA
1.7 [H]	30	NA	High Fair	40.0	Fenway Drive	FULL	NA	NA
Lost Creek (04-214) **(ECBP) WWH Confirmed (RM 0.35 – mouth)**								
0.3 [H]	36[ns]	NA	G	72.0	E. High St (Lower Reservoir Rd.)	FULL	NA	NA
UT to Lost Creek at RM 1.15 (04-249) **(ECBP) MWH Recommended**								
0.6 [H] / 0.62	28	NA	VP*	43.0	Bryn Mawr Ave.	NON	Fish Kills Nutrients Organic Enrich.(Sewage) Biol. Ind.	Other Spill Related Impacts Urban Runoff / Storm Sewers
Zurmehly Creek (04-261) **(ECBP) WWH Confirmed**								
0.1 [H] / 0.03	30*	NA	HF*	65.0	Ust. Ft. Amanda Rd.	NON	Nutrients, Sedimentation Unknown	Urban Runoff / Storm Sewers Source Unknown
Little Ottawa River (04-213) **(ECBP) MWH** (Headwaters to RM 5.54) **Recommended**								
5.5 [H]	26	NA	Low Fair*	57.0	Old S. Dixie Highway	PARTIAL	Organic Enrichment(Sewage) Biol. Indicators Nutrients Biochem. O_2 Demand (BOD)	Unspecified Domestic Waste Package Plant
Little Ottawa River (04-213) **(ECBP) WWH** (RM < 5.54 to mouth) **Confirmed**								
4.5 [H] / 4.45	28*	NA	High Fair*	67.0	Ft. Shawnee Rd. / Dst. Cridersville WWTP	NON	Organic Enrich. (Sewage) Biol. Indicators Nutrients	HSTS Urban Runoff / Storm Sewers Munic. Pt. Source Discharge

River Miles Fish/Invert.	IBI	MIwb	ICI[a]	QHEI[b]	Landmark	Attainment Status[c,d]	Cause(s)	Source(s)
Little Ottawa River (04-213) **(ECBP) WWH** (RM < 5.54 to mouth) **Confirmed** (cont.)								
1.1 [H] / 1.85	26*	NA	MG[ns]	69.3	Zurmehly Rd. / Breese Rd.	PARTIAL	Organic Enrich. (Sewage) Biol. Indicators Nutrients Direct Habitat Alteration	HSTS Urban Runoff / Storm Sewers Historic Channelization
0. 1 [H] / 0.03	22*	NA	G	66.8	Ust. Ft. Amanda Rd.	PARTIAL	Organic Enrich. (Sewage) Biol. Indicators Nutrients	SSOs Urban Runoff / Storm Sewers
Honey Run (04-209) **(HELP) MWH Recommended**								
3.6 [H] / 3.58	26	NA	Low Fair*	41.0	Cremeans Rd.	PARTIAL	Nutrients DO (Minimum) (Range) Direct Habitat Alteration	Crop Production with Subsurface Drainage Channelization (County Stream Maintenance)
Honey Run (04-209) **(HELP) WWH Confirmed**								
0.9 [H] / 1.1	30	NA	G	46.5	Wapak Rd.	FULL	NA	NA
Dug Run (04-210) **(HELP) WWH Confirmed**								
0.2 [H] / 0.19	40	NA	G	65.0	Dutch Hollow Rd.	FULL	NA	NA
Beaver Run (04-293) **(HELP) WWH Recommended**								
0.5 [H] / 0.51	30	NA	G	42.5	Dutch Hollow Rd.	FULL	NA	NA
Pike Run (04-208) **(HELP) MWH Confirmed**								
8.3 [H] / 8.5	24	NA	High Fair	51.0	Ust. American Bath WWTP	FULL	NA	NA
7.6 [H] / 7.56	20	NA	High Fair	58.0	Cole Rd. (Dst. WWTP)	FULL	NA	NA
4.6 [H] / 4.61	26	NA	G	38.5	State Rd.	FULL	NA	NA
0.8 [H] / 0.84	30	NA	High Fair	41.0	Lima Gomer Rd.	FULL	NA.	NA
Leatherwood Ditch (04-207) **(HELP) WWH Confirmed**								
0.5 [H] / 0.48	36	NA	G	30.5	State Rd.	FULL	NA	NA

River Miles Fish/Invert.	IBI	MIwb	ICI[a]	QHEI[b]	Landmark	Attainment Status[c,d]	Cause(s)	Source(s)
Sugar Creek (04-203) **(ECBP) (Headwaters to RM 20) MWH Recommended**								
26.0 [H]	24	NA	HF	44.3	Napoleon Rd.	FULL	NA	NA
23.9 [H]/23.85	26	NA	HF	51.0	Thayer Rd.	FULL	NA	NA
20.1 [H]/20.05	26	NA	G	45.5	Stewart Rd.	FULL	NA	NA
Sugar Creek (04-203) **(ECBP) (RM 20 to dst. SR 65 - RM 17.0) WWH Confirmed**								
18.2 [W]/18.24	40	8.1[ns]	MG[ns]	65.5	Dst. Bluelick Rd (lower crossing)	FULL	NA	NA
Sugar Creek (04-203) **(HELP) (< RM 17.0 to Mouth) WWH Confirmed**								
13.4 [W] / 13.5	38[ns]	8.1[ns]	44	52.3	Ust. Old US 30 (Lincoln Highway)	FULL	NA	NA
8.8 [W] / 8.55	40	7.1[ns]	40	56.0	St. Rt. 115	FULL	NA	NA
3.6 [W] / 4.8[RR]	41	8.8	36	45.8	Co. Rd. Q	FULL	NA	NA
0.6 [W] / 0.64	39	8.9	36	60.9	Co. Rd. 16-O	FULL	NA	NA
Rattlesnake Creek (04-204) **(HELP) MWH Recommended**								
1.7 [H] / 1.74	28	NA	G	43.8	Hofferbert Rd.	FULL	NA	NA
Plum Creek (04-201) **(HELP) MWH Recommended**								
14.9 [H] /14.35	26[ns]	NA	G	39.5	Ust. Columbus Grove (TR 11-R)	FULL	NA	NA
12.9 [H] /12.95	16*	NA	VP*	60.5	Ust. Columbus Grove WWTP (Wayne St.)	NON	Toxicity (Unknown) Fish Kill Organic Enrich.(Sewage) Biol.Ind.	CSOs
12.1 [H] /12.14	12*	NA	VP*	37.5	Dst. Columbus Grove (WWTP) (TR 11)	NON	Nutrient / Eutroph. Biol. Ind. Organic Enrich.(Sewage) Biol.Ind. DO (low), CBOD Ammonia (Total), Nutrients	Municipal Point Source Discharge CSOs
8.1 [W] / 8.12	29	8.4	14*	40.0	Township Rd. O	PARTIAL	Nutrients Nutrient / Eutroph. Biol. Ind. DO (Low) Sedimentation (Sand)	Crop Production with Subsurface Drainage Channelization (Stream Maintenance)

River Miles Fish/Invert.	IBI	MIwb	ICI[a]	QHEI[b]	Landmark	Attainment Status[c,d]	Cause(s)	Source(s)
Plum Creek (04-201) **(HELP) Confirmed WWH**								
4.6 [W] / 4.62	30[ns]	8.8	44	29.8	TR M-10	FULL	NA	NA
0.2 [W] / 0.19	29[ns]	7.7[ns]	G	51.3	St. Rt. 114	FULL	NA	NA
Sycamore Creek (04-202) **(HELP) MWH Recommended**								
0.8 [H]	28	NA	MG	39.0	Dst. Searfoss Rd.	FULL	NA	NA
UT to Sycamore Creek at RM 0.85 (04-295) **(HELP) MWH Recommended**								
- / 0.26	--	NA	MG	--	Searfoss Rd.	--	NA	NA
UT to Plum Creek at RM 7.30 (04-229) **(HELP) WWH Recommended**								
0.4 [H]	34	NA	MG[ns]	35.3	TR O west of CR13	FULL	NA	NA
UT to Ottawa River at RM 0.70 (04-290) **(HELP) WWH Recommended**								
0.4[H]	36	NA	G	64.5	TR M-17	FULL	NA	NA

ECOREGIONAL BIOLOGICAL CRITERIA:

	Eastern Corn Belt Plains (ECBP)			Huron-Erie Lake Plains (HELP)		
INDEX – Site Type	WWH	EWH	MWH	WWH	EWH	MWH
IBI - Headwaters	40	50	24	28	50	20
IBI – Wading Sites	40	50	24	32	50	22
IBI – Boat Sites	42	48	24	34	48	20
Modified Index of Well-Being (MIwb) - Wading	≥ 8.3	≥ 9.4	≥ 6.2	≥ 7.9	≥ 9.4	≥ 5.6
Modified Index of Well-Being (MIwb) – Boat Sites	≥ 8.5	≥ 9.6	≥ 5.8	≥ 8.6	≥ 9.6	≥ 5.7
Invert. Community Index - ICI	36	46	22	34	46	22

* Significant departure from ecoregional biocriteria: poor and very poor results are underlined.

ns Nonsignificant departure from ecoregional biocriteria for WWH or EWH (≤ 4 IBI, ≤ 4 ICI, or ≤ 0.5 MIwb units).

NA Not applicable to headwater streams (≤ 20 mi.^{2}) or not applicable since site in FULL attainment - no Causes or Sources.

a Narrative evaluation in lieu of ICI: E=Exceptional; VG=Very Good; G=Good; MG=Marginally Good; LF=Low Fair; F=Fair; HF=High Fair; P=Poor; VP=Very Poor.

b	Quality Habitat Evaluation Index (QHEI) values based on Rankin (1989,1995)
c	Attainment is given for the proposed status when a change is recommended.
d	Attainment status based on one organism group is in parentheses ( ).
e	Modified Warmwater Habitat criteria for channel modified streams.
H	Headwater site (drainage area < 20mi^2) sampled with headwater methods and analyzed with only IBI biocriteria metrics calibrated for small streams.
W	Wading method used for fish sampling with particular IBI and MIwb biocriteria metrics calibrated for stream and rivers of intermediate drainage area.
B	Boat method used for fish sampling with particular IBI biocriteria and MIwb metrics calibrated for deeper rivers and those of larger drainage area.
RR	Regional Reference site

Ottawa River Mainstem

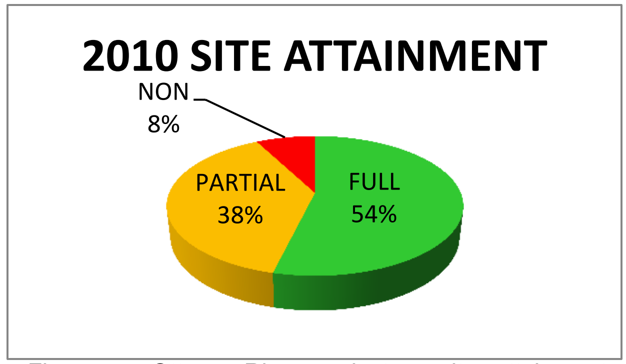

Figure 4. Ottawa River mainstem site attainment, 2010.

From the confluence of Hog and Little Hog creeks, the entire Ottawa River mainstem was assessed (RM 50.7 to the mouth) at 26 sites in the 2010 survey. Twenty sites were located in the Eastern Corn Belt Plains (ECBP) ecoregion with the most downstream (northern) six survey sites sampled in the Huron-Erie Lake Plains (HELP) ecoregion. Fourteen of 26 mainstem survey sample sites (54%) were attaining the designated Warmwater Habitat (WWH) aquatic life use biological criteria (Figure 4). Of the non-attaining sites, ten (38%) were in partial attainment and two (8%) were in non-attainment. The lower 28.8 river miles of the Ottawa River mainstem met the WWH ecoregional biological performance criteria. However, 46% (12 of 26) of Ottawa River mainstem sites / segments (in the middle and upper reaches) were impaired. Most were located within urban Lima or upstream near impoundments for public water withdrawal.

Figure 5. Hog Creek at TR 85 (RM 13.42) modified similarly to other streams in Hardin County also under stream maintenance.

A leading associated cause and source of the aquatic life use impairments in the Ottawa River mainstem reaches was nutrient enrichment / eutrophication from nonpoint source (NPS) nutrient inputs (through tile discharged to modified tributaries or surface runoff) (Table 1). These impairments occurred in the upper Ottawa River watershed, as many of the modified tributary streams expedited nutrient delivery downstream to Hog Creek, and ultimately, to the Ottawa River (Figure 5). The enrichment and excess algal production caused diel high and low dissolved oxygen (DO) fluctuations (and sometimes high pH values) that were exacerbated by chronic low flow conditions. The lower fish IBI scores near the public water supply reaches (RMs 43.4 and 42.5) were correspondent with the decreased stream discharge, as no flow was observed over or immediately below the Metzger dam, during both the July and August 2010 sampling events (Table 1 and Figure 77). The deleterious effects of diminished discharge (less dilutional flow and reduced current velocities) from Metzger Rd. to the Lima WWTP were compounded by a decline in macrohabitat quality related to historic channel modification, impoundment, nutrient enrichment / eutrophication, and to a lesser extent sedimentation (Table 1 and Figure 77).

Main causes of impairment in urban Lima were nutrient enrichment and organic enrichment with subsequent low DOs from urban sanitary/combined sewer overflow (SSO/CSO) inputs, and municipal and industrial discharges exacerbated by low flows from flow alteration (impoundments) and water withdrawals. Effects in urban Lima would be worse if not for daily intermittent quarry flows augmenting summer low flows (Table 1, Figures 6 and 7). Through urban Lima, a series of five dam pools with five major CSO discharges are contained within a three mile reach. All are in close proximity to one another and can form contiguous impoundments. During this and previous Ohio EPA surveys, these relief points in Lima's collection system have been significant sources of pollutant loads and have directly contributed to aquatic life use impairment (Ohio EPA 1992 and 1998) (Figures 6, 7, 114 and 132).

To varying degrees the entire segment through downtown appeared affected by the combined influences of CSOs and SSOs, habitat deficits (impoundment and others) and attendant nutrient enrichment (Figure 6). Relief points in the collection system (SSOs/CSOs) served as sources of nutrients which combined with the various hydromodifications to create optimal conditions for runaway productivity with observed toxic response signatures as defined by Yoder and Rankin (1995) (Table 20 and Figure 95).

Upon exiting downtown Lima, the Ottawa River receives treated effluent from three major NPDES permitted entities in a distance of just over one river mile: Lima WWTP (a municipal treatment works), Lima Refining Co. (AKA Husky Oil), and PCS Nitrogen (an industrial supplier of nitrogenous products). Any limitations or other water quality issues related to diminished stream flow are abruptly abated downstream from the Lima WWTP, as the discharge of the Ottawa River is significantly augmented by this 18.5 MGD facility. Fair quality conditions continued, as all three sites downstream from these dischargers failed to support WWH biological communities with different stressors at and among the sites (Figures 6 and 7). The condition of the fish assemblage downstream from the Lima Refining Co. at RM 37.0 was markedly diminished with a reduced IBI and MIwb well below the WWH standard (Table 1 and Figure 6). The number of sensitive fish species significantly decreased, the incidence of deformities, eroded fins, lesions and tumors (DELT) anomalies rose sharply, and overall fish community structure declined (Figures 101 and 102). Similar fair quality fish community conditions were found downstream from PCS Nitrogen, at RM 36.1, and at the next downstream station at RM 34.6 (adj. Westfield Dr./at Shawnee CC) (Figures 6, 101 and 102). Observed signature toxic responses continued among the macroinvertebrate community with the highest percentage of tolerant taxa documented from the Erie RR impoundment (RM 38.6) to downstream from each major discharger (RM 36.0) (Yoder and Rankin, 1995b, Tables 25 and 26, Figure 8).

There was partial and/or non-attainment of the WWH biocriteria downstream from and including the Collett St. dam pool (RM 38.6) to the Allentown dam pool (RM 28.85) (Table 1, Figures 6, 7). Partial recovery of the macroinvertebrate community occurred ~1.5 miles downstream from the three major dischargers at RM 34.55 with sensitive taxa totals still low (Figures 8, 125, 126 and 127).

Below Allentown dam the lower 28.8 river miles of the Ottawa River mainstem met the WWH ecoregional biological performance criteria for the fish and macroinvertebrate communities in 2010 (Table 1, Figures 6 and 7). The strong performance of the ICI, MIwb and the absence of poor IBI scores on the Ottawa River indicate that pollution abatement efforts to date have yielded meaningful improvements, leaving little doubt that the Ottawa River mainstem has entered a phase of strong environmental recovery.

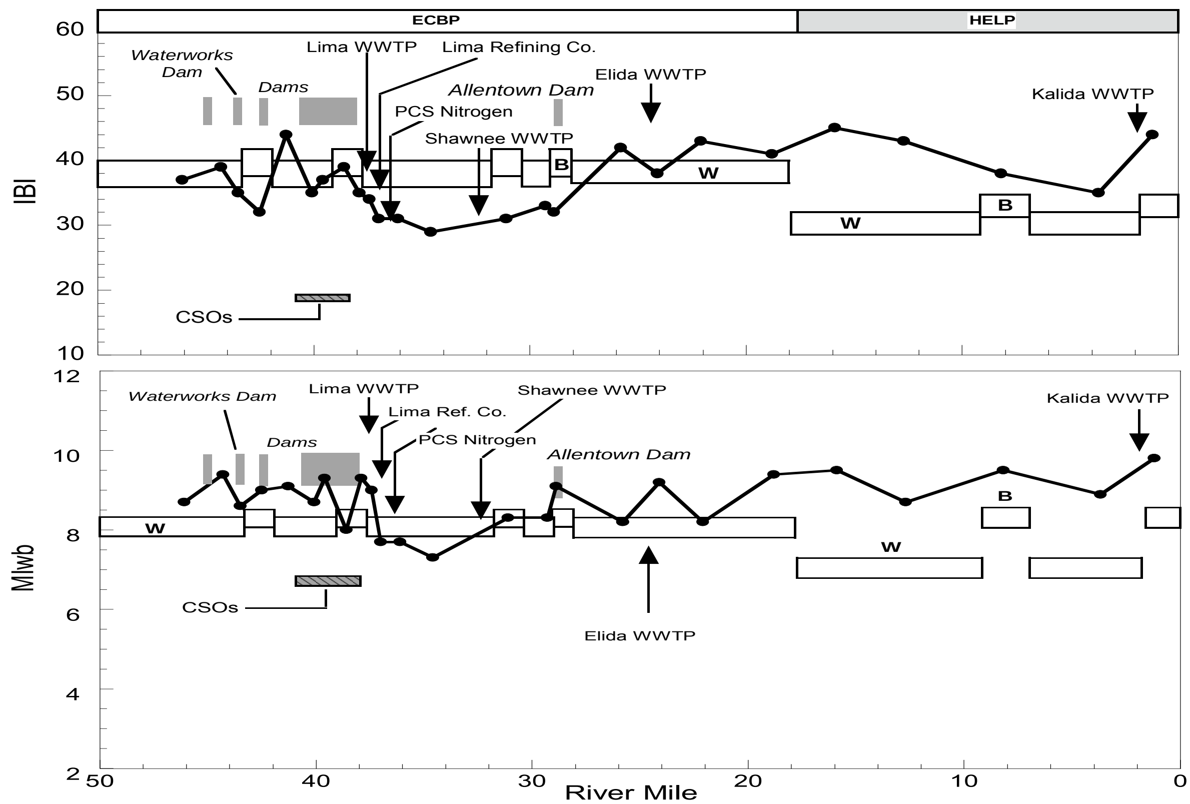

Figure 6. Longitudinal performance of the IBI, and the MIwb, Ottawa River (mainstem), 2010. Horizontal rectangles B and W represent the existing WWH biocriteria and areas of non-significant departure for Boat and Wading sites, respectively. Arrows identify significant direct points of discharge for NPDES permitted entities. Horizontal rectangles atop the figure demark the ecoregions through which the Ottawa River flows: ECBP and HELP (Omernik and Gallant 1988).

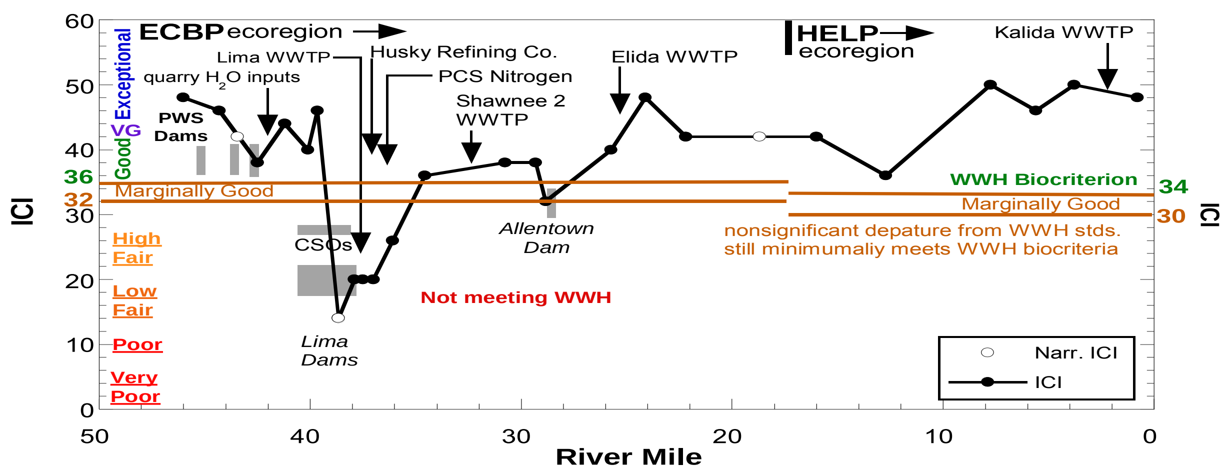

Figure 7. Macroinvertebrate ICI scores for the Ottawa River mainstem for the 2010 survey.

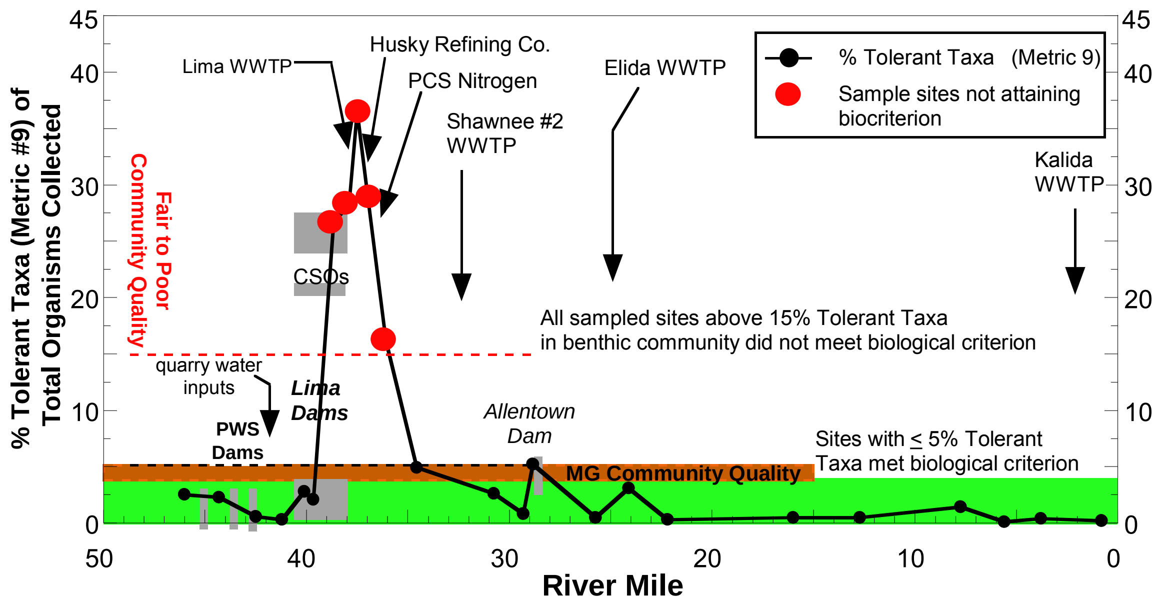

Figure 8. Percent tolerant taxa (ICI Metric 9) of quantitative sampled macroinvertebrate populations collected at each Ottawa River mainstem site during the Ottawa River 2010 survey.

Ottawa River Watershed Tributaries

Thirty ECBP and 23 HELP tributary sample sites were evaluated in the 2010 Ottawa River basin survey. There were 25 WWH sites and 28 Modified Warmwater Habitat (MWH) sites sampled among the ECBP and HELP ecoregions in Hardin, Allen, and Putnam counties (Figures 2 and 3, Tables 1 and 2). The site at RM 0.26 on the unnamed tributary to Sycamore Creek (RM 0.85) was unassessed. Forty of 53 tributary sites (75.5%) on 24 streams met their respective expected or recommended biological performance criteria (Tables 1 and 2).

The HELP WWH tributary sites all met the biological performance criteria (Tables 1 and 2). Most HELP ecoregion streams in the Ottawa River basin were modified (straightened or entrenched with riparian removal, etc.) decades ago. Many have partially recovered with improved stream habitat quality and WWH function. Others, on intermittent county stream maintenance, recovered sufficient habitat qualities to meet the WWH biocriteria (Tables 1 and 2). However, open canopies from maintenance activities exacerbated the nutrient enrichment conditions of several streams (Figure 5). Most of the modified streams had minimum DO exceedances, and nutrient loads in several MWH streams affected aspects of downstream WWH performance. There were higher percentages of facultative and filtering taxa with lower percentages of sensitive taxa from nutrient enrichment/algal production (e.g., Hog Creek in eastern Allen County and the upper Ottawa River) (Figure 98). Proactive maintenance options to diminish algal production and enhance fish and stream habitat quality could be utilized to ensure continued acceptable WWH biological performance.

Table 2. A summary of biological survey data with totals for attainment and non-attainment of ecoregional biological criteria for the Ottawa River tributaries in 2010.

Ecoregion	Total Sites	WWH	Criterion MET	NOT MET	MWH	Criterion MET	NOT MET
ECBP	**30**	**13**	**6 (46%)**	**7 (54%)**	**17**	**15 (88%)**	**2 (12%)**
HELP	**23**	**12**	**12(100%)**	**0**	**11***	**7 (64%)**	**4 (36%)**
Totals	**53**	**25**	**18**	**7**	**28**	**22**	**6**

* One HELP MWH site was not assessed as it went dry before biological sampling was completed.

Several MWH sites in the HELP ecoregion did not meet MWH performance standards due to nutrient enrichment from nonpoint source (NPS) nutrient inputs through tile discharges to modified tributaries or surface runoff (Table 1). These impairments occurred in the rural reaches of Ottawa River basin tributaries, particularly Hog Creek (RM 3.8), upper Honey Run and Plum Creek (RM 8.12) (Figures 2, 3, 138 and 152). Many of the modified streams expedite nutrient delivery downstream where enrichment and excess algal production appeared strongly influenced by the export of nutrients and sediment from the highly artificial conditions. This led to diel high and low DO fluctuations (and sometimes high pH values) exacerbated by low flow conditions (Table 6, Figures 138 and 152). Two other Plum Creek MWH sites further upstream were overwhelmed by urban impacts from the Columbus Grove WWTP and CSOs with excess nutrients, low DOs, fish kills and high *E. coli* bacterial counts (Table 6, Figures 110, 147, and 150, and Appendices C and D). The two non-attaining ECBP MWH sample sites were affected by urban spills, stormwater, and sewage inputs (UT to Lost Creek and upper Little Ottawa River at RM 5.5) (Table 1).

Seven impacted WWH ECBP sample sites were divided between rural and urban issues. Little Hog Creek and Hog Creek at Pevee Rd. were impacted by agriculture, nutrients, and/or habitat alterations. Mud Run was affected by malfunctioning home sewage treatment systems (HSTS) and low DO concentrations. Two urban streams, Little Ottawa River and Zurmehly Creek, were impacted by urban runoff / storm sewers and spills/kills (Tables 1 and 2, Appendices C and D).

Tributaries in urban areas (Little Ottawa River and UT to Lost Creek in Lima) had larger issues with organic enrichment from sewer inputs including SSOs and/or CSOs (Table 1, Appendices C and D). Grey water, deposits of black anoxic solids, sewage fungus, and active SSOs were all observed on the Little Ottawa River.

Trends Summary

Multiple data sets were available to assess ambient biological performance in the Ottawa River watershed through time. In one form or another, the Ottawa River has been regularly assessed by Ohio EPA since the early 1970s. Prior Ohio EPA field work has included all or portions of the mainstem and selected tributaries, supporting various water quality management goals (e.g.,NPDES, stream regionalization, use attainability analysis, and reference site monitoring). The first significant attempt to evaluate the entire basin was undertaken in 1996, where the majority of the mainstem and major tributaries were systematically sampled (Ohio EPA 1998). Earlier Ohio EPA field efforts, both large and small, were undertaken in 1974, 1976, 1977, 1985, 1989, 1990, 1991, and 1995.

Ottawa River Mainstem

The maximum area negatively influenced by the Ottawa River in the first half of the 20th Century extended downstream through the Auglaize River to include a portion of the Maumee River. By the mid-1970s through early pollution abatement efforts, impacts had contracted significantly to include only the Ottawa River, with an incipient recovery evident near the mouth (Ohio EPA 1979). However, water quality through the historically degraded reach downstream from Lima remained extremely poor, as the cumulative pollutant load continued to exceed the river's assimilative capacity. Specifically, biological impacts paralleled water quality standards violations for DO, ammonia, chromium, phenols, and surfactants, which were numerous and regularly observed downstream from all the major facilities near Lima. Localized toxicity associated with private dischargers and the Lima WWTP was also identified, as well as the deleterious effects of pollutant loads derived from Lima's CSOs and SSOs (Ohio EPA 1979). Improved waste treatment and stricter enforcement attending additional amendments to the Federal Water Pollution Control Act (AKA the Clean Water Act) resulted in additional water quality improvements and associated biological recovery through the 1980s and into the early 1990s, particularly when compared against the gross pollution identified in the previous decades. Despite the significant improvements achieved during this period of time, substantial pollution problems persisted through and downstream from Lima (USEPA 1984 and Ohio EPA 1992).

The longitudinal performance of biological community biometrics portrayed a trend of significant recovery in 2010 (Figures 7, 8, 114, and 132). However, these data results also clearly delineated impacted areas (and corresponding recovery through time), relative to major pollution sources, stressors or limiting factors on the Ottawa River. Prior to 2010, historical surveys portrayed significant and unambiguous depressions in community performance (indexes and other biometrics) both through and downstream from Lima, with a secondary depression evident well downstream from Lima, beginning in the vicinity of Elida and extending to Kalida. Persistent local departures from the associated biocriteria and diminutions of other biometrics were also documented immediately upstream from Lima as well.

By 2010, 37.5 miles (74%) of the 50.7 linear stream miles of the mainstem were found to support the appropriate biological assemblage (fish and macroinvertebrates) at least minimally consistent with WWH biocriteria (Figures 2, 7 and 8). The remaining 13.2 (26%) miles failed to support WWH assemblages. However, the magnitude of the departure or degree of impact was not great, as community performance below the fair range (i.e., poor to very poor) was not observed. Figures 9 and 10 illustrate the biological improvements over time (from 1985 – 2010 including the 1991 and 1996 surveys).

At the upstream regional reference site on the Ottawa River at Thayer Road (RM 46), ICI scoring trends indicated improvement and recovery to relatively stable exceptional macroinvertebrate community quality (Figure 11). Good quality communities were present in the 1970s which were still affected by past upstream channelization activities in most tributaries with associated sedimentation and/or lower quality WWTP treatment upstream. Improvements and upgrades in WWTP process quality (secondary and/or tertiary treatment) and some habitat stabilization allowed for increases in sensitive taxa diversity and thereby higher quality macroinvertebrate communities.

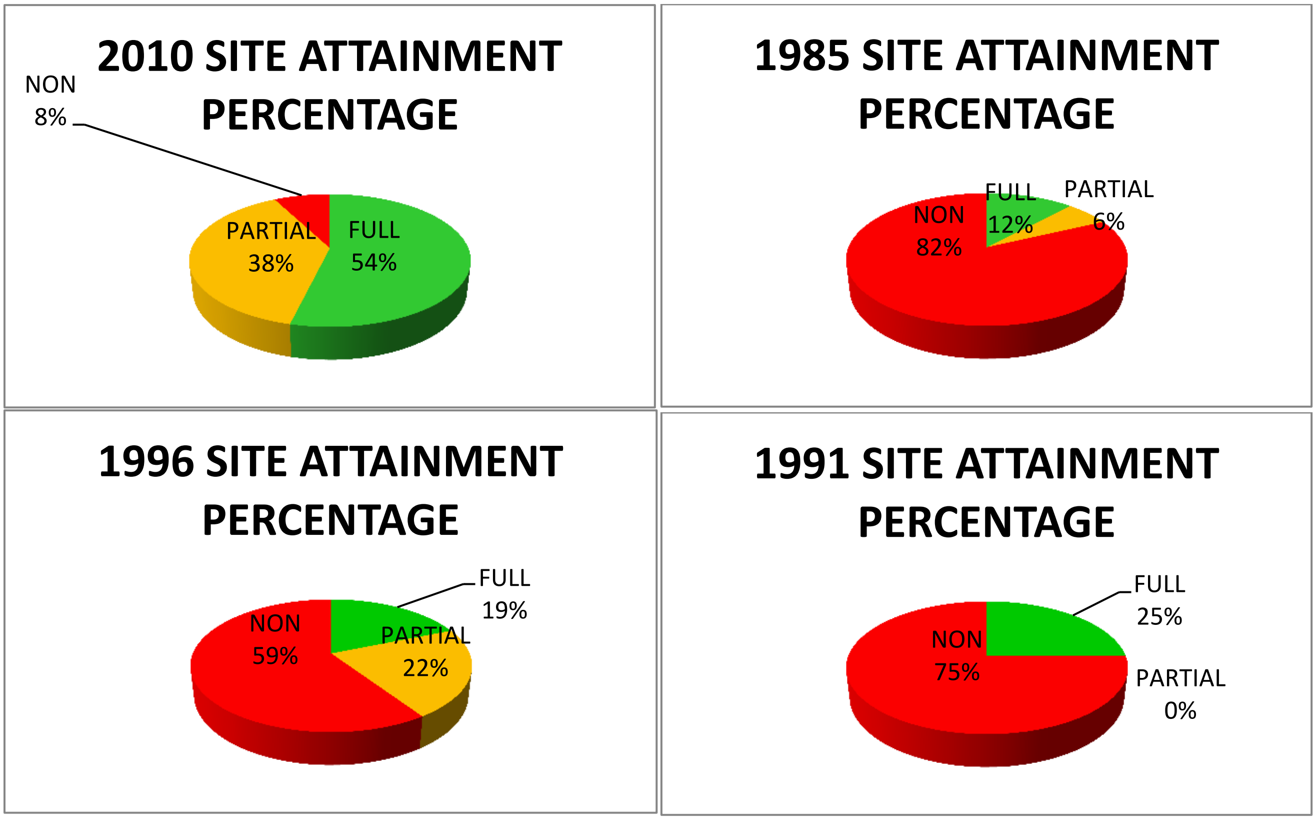

Figure 9. Site attainment percentage trends for the Ottawa River mainstem during 2010, 1996, 1991, & 1985 surveys.

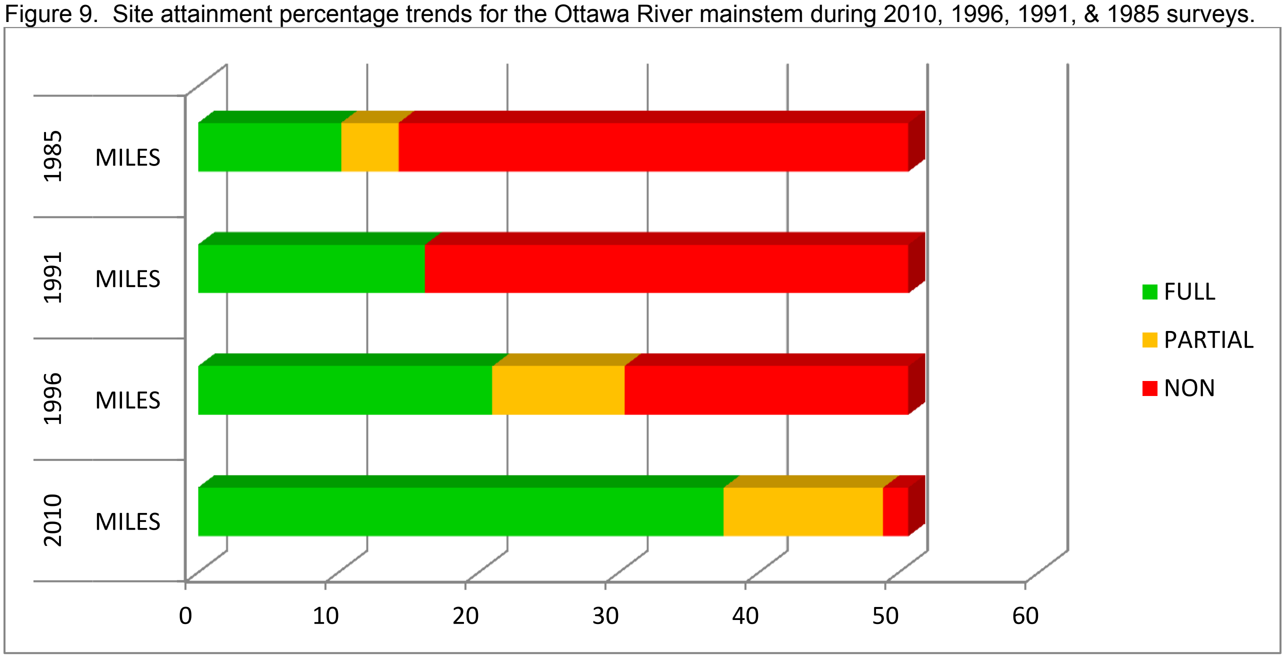

Figure 10. Attainment status in miles for the Ottawa River mainstem (50.7 river miles) during 2010, 1996, 1991, and 1985 surveys.

Downstream from Lima, long-term data collections on the Ottawa River at State Route 81 downstream from the Allentown dam indicated slow gradual improvement in the 1980s and 1990s. WWTP upgrades and lower permit chemical discharge limits during that time had addressed some of the acute toxicity associated with industrial inputs and low quality WWTP effluents Additional decreases in pollutant loadings associated with lower permit limits for ammonia, selenium, and lowered BOD loads improved industrial / municipal discharge quality. Thereby the overall less frequent toxic spikes / events with several CSO/SSO improvements since 1996 allowed for a dramatic improvement in water quality in 2010, and subsequently, improved macroinvertebrate community quality (Figures 12 and 13). There has been also less frequency of ammonia exceedances at higher concentrations (the abatement or lessoning of ammonia toxicity immediately downstream from PCS Nitrogen) (Ohio EPA 1998, Appendix A). Heavy metals (e.g., chromium, selenium) have decreased since 1996 with statistically significant instream selenium concentration reductions (p *value* < 0.0001) (Table 15).

The DO regime in the Ottawa River mainstem seemed to transition from one dominated by excess oxygen demand (organic enrichment – BOD) in 1991 and partially in 1996 to stimulated far field enrichment productivity (nutrient enrichment) in 2010 from urban inputs with less DO flux in the lower river reaches (Figures 78-81). In 2010, significant TKN and nitrate (NO_3-N) increases compared to 1996 values corresponded with this overall transition (p *values* < 0.002 *and* $= 0.01$, respectively) (Table 15). The mean DO concentration stability significantly improved overall. There were decreased DO criteria violations and/or exceedances from the 1991 to the 2010 mainstem survey. There were significantly lower mean DOs (decreased excess nutrients and less extremes) in the lower 29 miles in 2010 compared to 1996 (p *value* < 0.002) (Table 15). Fish community improvement lagged behind the macroinvertebrate community and was likely associated with lingering effects from municipal/industrial inputs along with impeded fish migration due to dams.

Water quality of the Ottawa River has also been influenced by selenium loads over time. Between 1985 and 1996, the incidence of DELT anomalies, a reliable indicator of community level chronic sublethal stress, remained highly elevated and among the highest in the state (Figures 113, 115, Ohio EPA 1987). A precipitous decline in the incidence of DELT anomalies was documented in 2010 and followed substantial selenium load decreases implemented in 2001-02 (monthly average of 12µg/L Se from previous limit of 27µg/L Se effluent limit in 1999) (Figures 18, 87, 113 and 115, and Appendix I). Fish anomalies (skeletal deformities) characteristic of selenium chronic toxic effects were readily observed in fish in the Ottawa River in 1996 and to a much lesser extent in 2010 (Ohio EPA 1998, Figures 18, 19, 87 and 102).

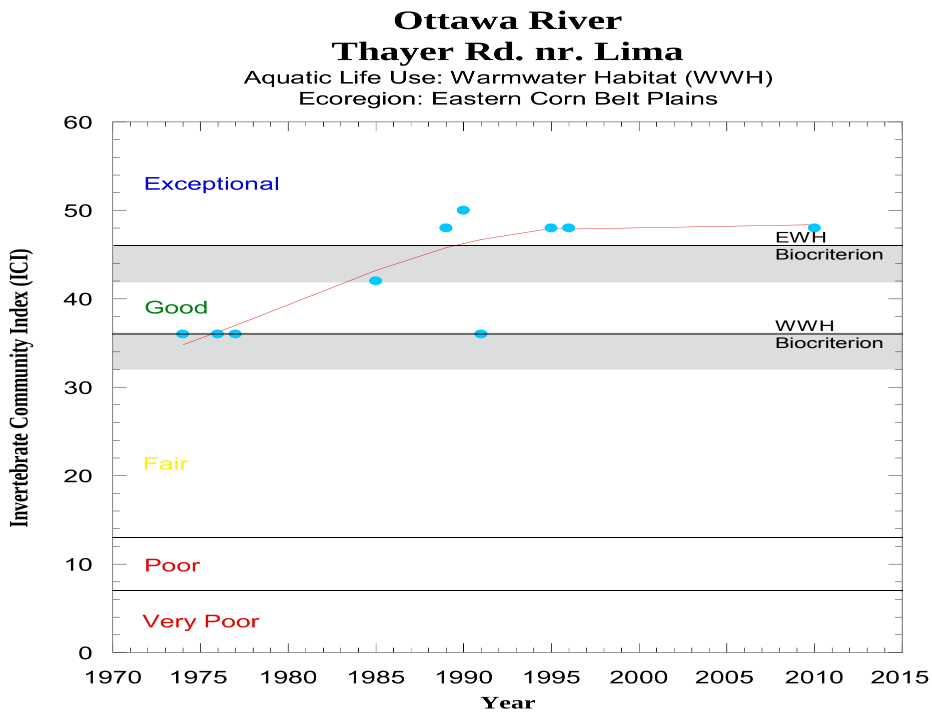

Figure 11. ICI trends at the Thayer Rd. (RM 46.0) ambient macroinvertebrate site the Ottawa River, 1970s to 2010.

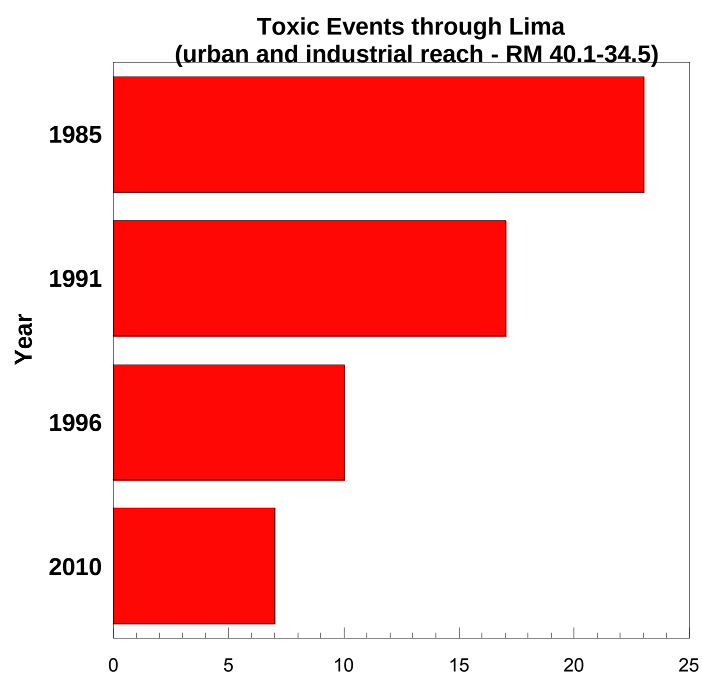

Figure 12. Number of toxic events in the Ottawa River mainstem through Lima (RMs 401-34.5), 1985-2010.

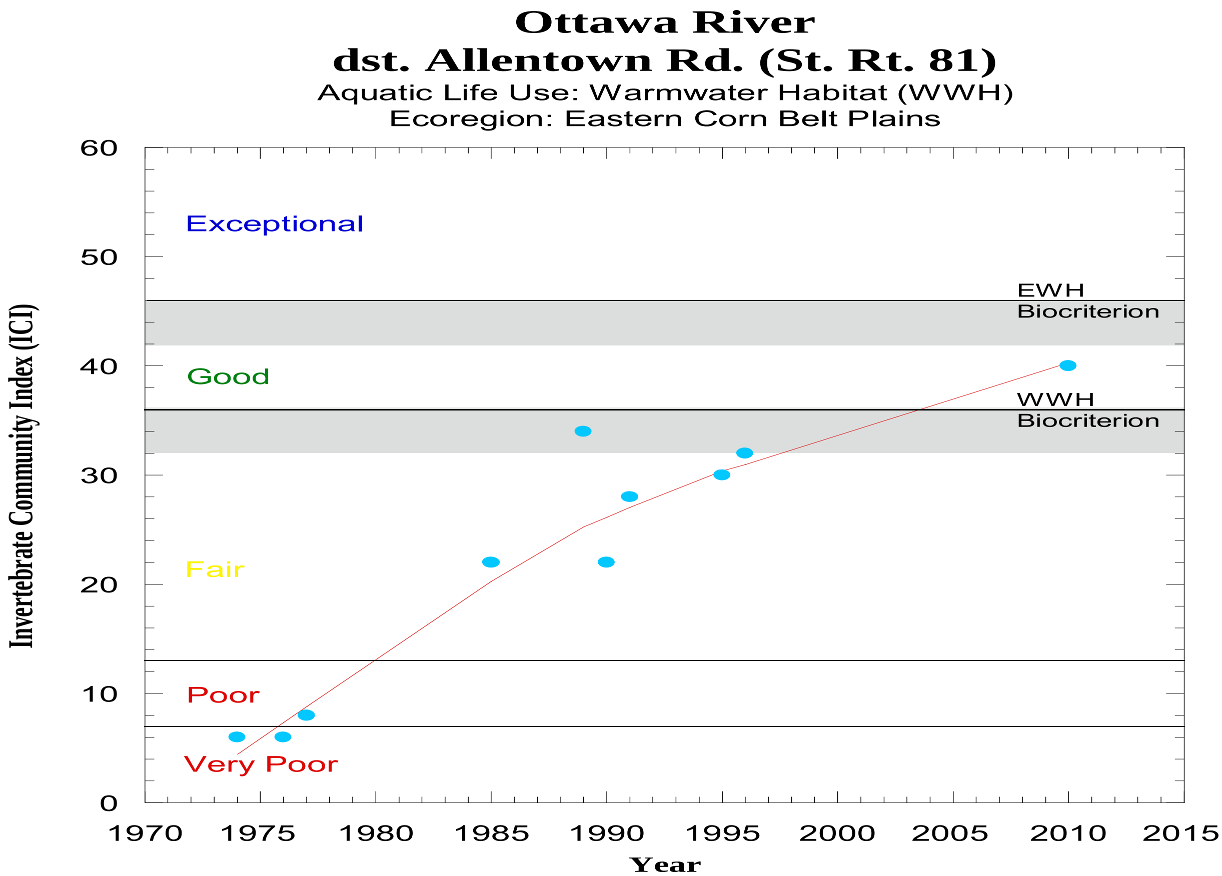

Figure 13. ICI trends at an ambient macroinvertebrate site downstream from Allentown dam at State Route 81 (RM 28.8) in the Ottawa River, 1970 to 1996. The 2010 macroinvertebrate sample location used for comparison was at RM 25.75 (Piquad Rd.).

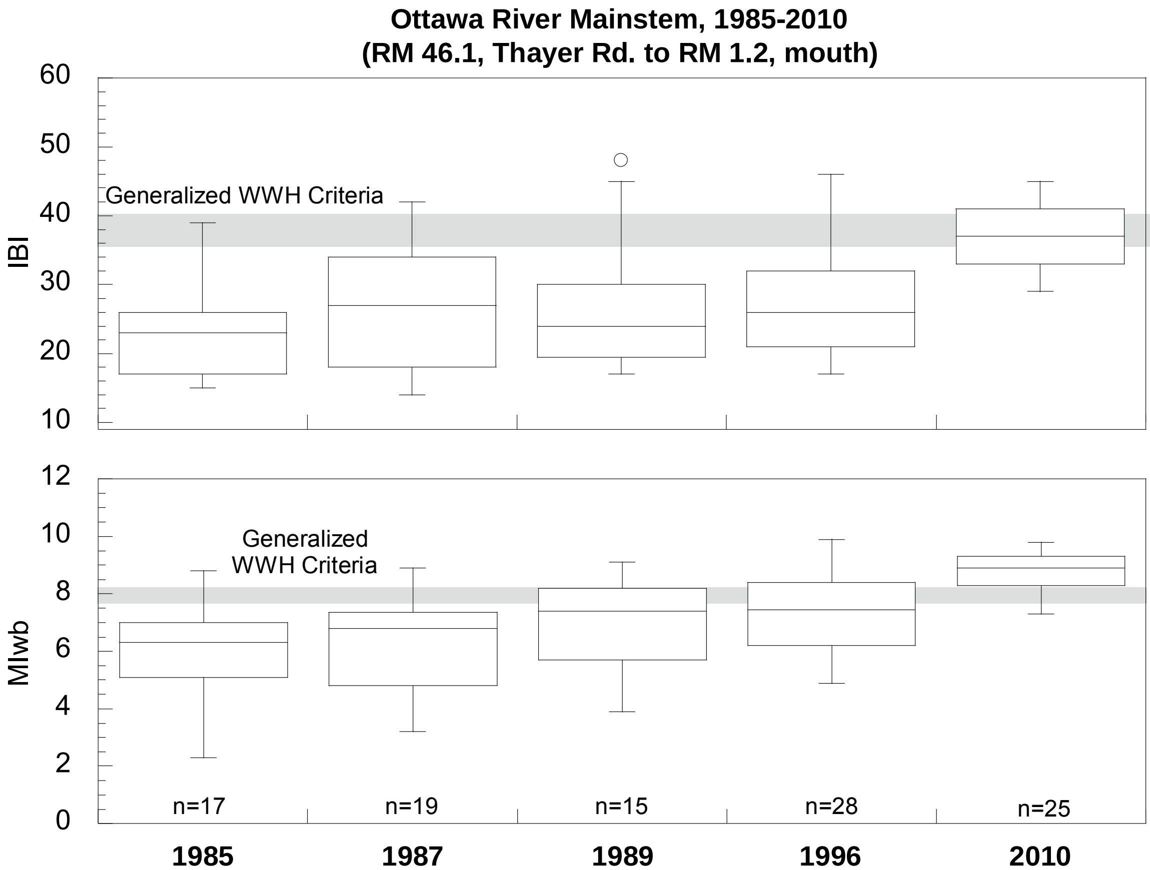

Figure 14. Cumulative performance of the IBI and MIwb, Ottawa River: 1985-2010. As these data are derived from monitoring stations contained in both HELP and ECBP ecoregions, and were generated with a mix of wading and boat sampling gear, a generalized criteria or benchmark is indicated by shaded areas for a point of reference and not for attainment.

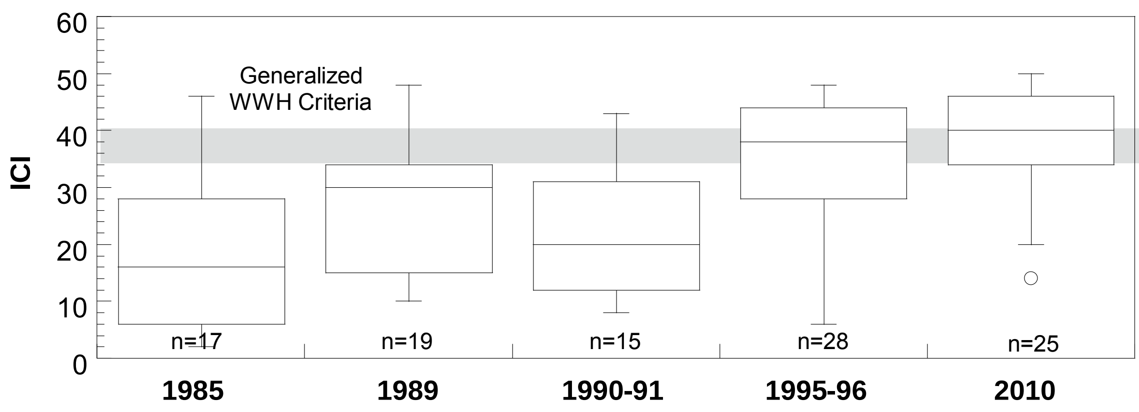

Figure 15. Cumulative performance of the ICI during Ottawa River surveys: 1985-2010. As these data are derived from monitoring stations contained in both HELP and ECBP ecoregions, a combined criteria or benchmark is indicated by shaded areas for a point of reference and not for attainment.

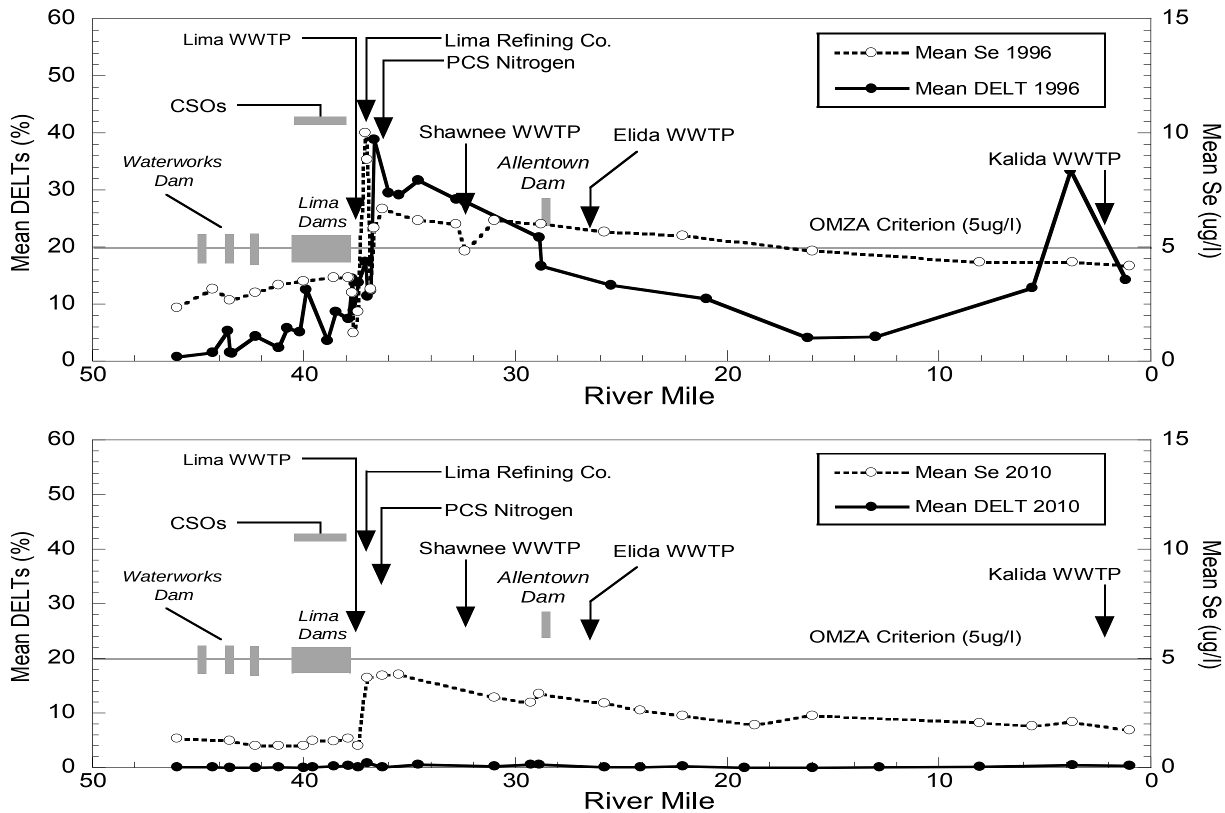

Figure 16. Longitudinal station mean DELTs plotted against average Total Recoverable Selenium (TR Se) for the Ottawa River, separately for 1996 and 2010, respectively.

In 2010, selenium was still persistent (bioaccumulation) at lower concentrations despite decreased loads (≥ 2.0 µg/lSe TMDL threshold toxic effect concentration of concern) (Lemly 2001, Figures 16, 17, 18, and 87). In addition, the selenium in fish tissue equaled or exceeded the 97th percentile of concentrations reported statewide in 1996 and was similar in 2010 due to its persistence in the environment (Lemly 2001, Appendix I). Instream total concentrations of ≥ 2.0 µg/lSe can cause food-chain bioaccumulation, and eventually, can result in reproductive failure in fish and aquatic birds exposed to selenium in aquatic ecosystems (Lemly 2001, 2002, and 2004).

Current selenium loads downstream from the Lima Husky Refinery resulted in summer average instream concentrations at or below the current ambient criterion. The instream selenium concentrations were statistically significantly lower in 2010 compared to 1996, as the 1996 ambient selenium concentrations were markedly and consistently higher throughout the entire 37 river miles of the Ottawa River downstream from the refinery (p value < 0.0001) (Table 15, Figures 17, 18, 87, 88, 89 and 90). The only non-violation excursions were two individual sampling events in 2010 from two separate monitoring stations in close proximity to the refinery (Figures 17 and 18). The total Se exceedances in 2010 (n=3) were statistically different from the large number of Se exceedances during the 1996 survey (p value < 0.0001 using Kolmogorov-Smirnov Two Sample) (Figures 17 and 18).

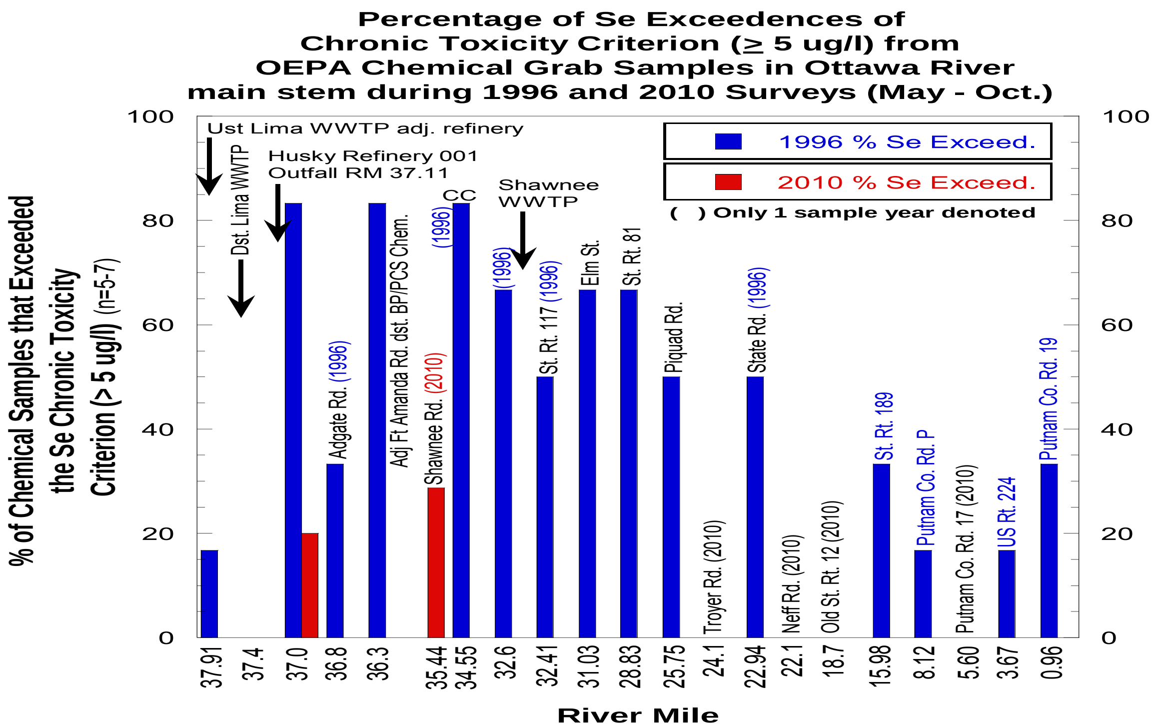

Figure 17. Percentage of Se exceedances of chronic toxicity threshold (> 5ug/l) from Ohio EPA chemical grab samples in the Ottawa River mainstem from May – October, 1996 and 2010.

The percent fish deformities at the 1996 and 2010 fish survey sites, apportioned out of the overall DELT totals (possibly directly attributed to selenium inputs), were compared with the 1996 and 2010 selenium exceedances (Figure 18). The differences in percent deformities between the survey years of 1996 and 2010 were statistically significant at $p < 0.0062$. The 1996 percent fish deformities and selenium exceedances were statistically different from the much lower 2010 deformities and selenium exceedance totals at $p= 0.073$ Analysis of Variance (ANOVA) (Figure 18).

The selenium load reductions were concurrent with systematic improvements in the fish and macroinvertebrate communities on the Ottawa River mainstem between 1996 and 2010, particularly through the historically degraded reach beginning at the Lima WWTP. The extent and magnitude of aquatic life use impairment has decreased significantly, as nearly every biological measure displayed improvement, including decreased DELT anomalies and deformities that can be associated with excess selenium, through the historically impacted 11 mile segment downstream from the Lima Refinery (Figures 16 - 18).

The level of selenium contamination documented in 1996 was a contributing determinant regarding aquatic life use impairment. Elevated DELTs and the poor performance of related indicators of surface water quality coupled with selenium's known toxicological characteristics (including teratogenic effects) would suggest that higher selenium loads and resulting instream concentrations were, at a minimum, a contributory factor to aquatic life use impairment, including highly elevated DELTs and higher percent deformities, documented in 1996 (Figures

16-18). Furthermore, the significant, yet incomplete recovery documented in 2010 can be at least partially attributable to the diminution of selenium effects, as well as other pollution abatement actions mentioned which caused other water quality changes to occur and/or were on-going over the same period time.

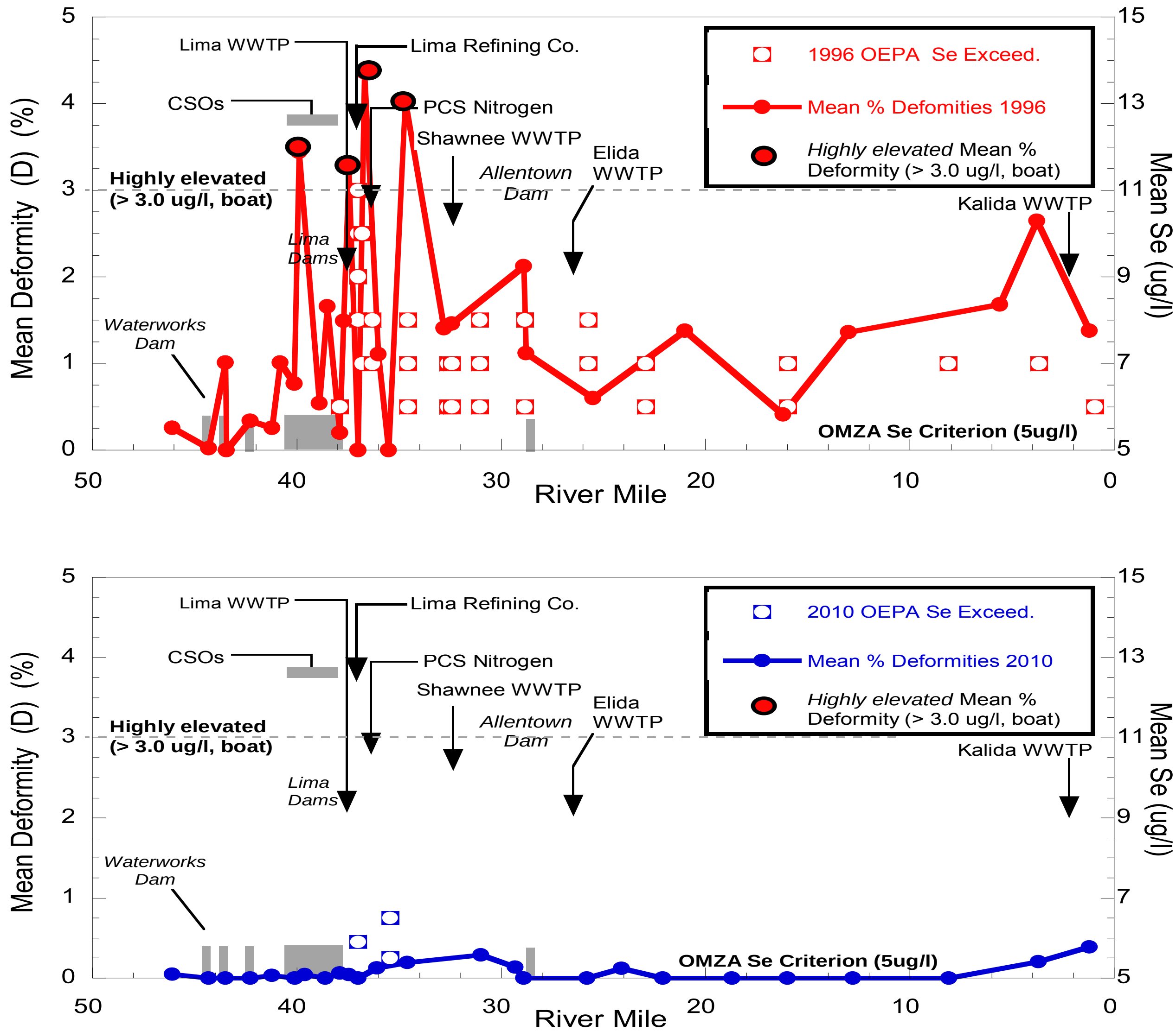

Figure 18. Plot of mean deformities (%) and Se exceedances of chronic toxicity threshold (> 5ug/l) from Ohio EPA chemical grab samples in the Ottawa River mainstem in May – October, 1996 and 2010, respectively.

Ohio EPA cannot precisely allocate or apportion the degree to which selenium did contribute to the complex impact, including extremely elevated DELTs, documented in 1996. At that time the affected portion of the Ottawa River was profoundly degraded by multiple, varied, and interactive pollution sources (e.g., municipal, industrial, CSOs, SSOs, spills, legacy and diffuse). Ammonia, organic enrichment, and unknown toxicity (the latter indicated by a response signature in the biota) were identified as the overarching stressors, with petroleum contamination, chromium, and nitrogenous wastes being identified as having significant, but localized effects. Load reductions and related abatement actions for these primary causes of aquatic life use impairment were specified and recommended as part of the findings from the 1996 biosurvey (Ohio EPA, 1998).

Over the period of 1987-1996, community indexes and related measures portrayed a mix of incremental improvement or relative stability. Specifically, the IBI in 1996 paralleled or tightly tracked 1987 results for the upper 33 miles of the Ottawa River mainstem. The 2010 survey results represent the most comprehensive effort to date, extending sampling coverage well beyond all previous efforts, both in terms of spatial coverage and station density. As indicated by the condition of the resident aquatic biology, environmental conditions of surface waters that constitute the Ottawa River catchment have gradually improved through time (Figures 14 and 15).

As the effects of pollution abatement efforts are realized or otherwise manifest in aquatic communities, the MIwb is often the leading indicator of recovery on formerly degraded larger waterbodies. Often lagging behind the MIwb by a full reporting cycle (5-10 years), the IBI is typically the last biological index employed by Ohio EPA to achieve its respective biocriterion. The increased MIwb scores and the absence of poor or very poor IBI or ICI scores on the Ottawa River mainstem in 2010 indicate that pollution abatement efforts to date have yielded improvements and leave little doubt that the Ottawa River has entered a phase of strong environmental recovery (Figures 14 and 15).

Ottawa River Tributaries

Regarding the environmental conditions of the principal tributaries that comprise the Ottawa River catchment, the 2010 survey represents the most thorough effort to date. All waters of consequence were surveyed and assessed in this single field year. Although much historical data does exist for these waters, previous sampling efforts were not necessarily concurrent or coordinated with past basin-wide efforts. As a result, the multiple and varied historical data collected by Ohio EPA was utilized for trends assessment, and included results from Hog Creek, Little Hog Creek, Lost Creek, Zurmehly Creek, Little Ottawa River, Pike Run, Sugar Creek, and Plum Creek.

Hog Creek and Little Hog Creek: 1991-2010

Available historical fish community data on Hog Creek was limited to a small, two station effort as part of the 1991 Ottawa River survey (Ohio EPA 1992). At that time, community performance appeared strongly influenced by macrohabitat quality. In 2010, the aquatic communities appeared to reflect improved macrohabitat quality achieved through natural fluvial processes (Figures 116, 136 and 138). As observed within many other rural streams statewide, Hog Creek has very likely benefited from modern tillage practices that have reduced overland erosion and thus the delivery of fine sediment to surface waters. However, nutrient delivery (via tiles, NPS inputs including Ada) and subsequent enrichment with elevated pH and ammonia concentrations with low DOs measurements overwhelmed the biological community in the WWH designated reach in Allen County.

Little Hog Creek: 1991-2010
A single station on lower Little Hog Creek was also evaluated as part of the 1991 survey. Little Hog Creek appeared stable, as WWH communities were conserved through time.

Lost Creek: 1988-2010
At stations common to both 1988 and 2010 surveys, the condition of the fish assemblage was improved, including WWH attainment on the lower reach. Recovery of the IBI to WWH near the mouth was a result of increased species richness and improved functional organization, namely reduced proportion of ecological generalists (omnivores) with a proportional increase in specialized feeding guilds (insectivores). These changes likely reflected improved macrohabitat achieved through natural fluvial processes and more favorable water quality from less frequent urban inputs.

The macroinvertebrate community quality improved as well, as the upstream site met the MWH biocriteria and in the lower reach the EPT totals doubled with a substantial increase in total sensitive taxa. The high percentage of tolerant taxa at RM 0.3 (25% in 2010 as compared to 56% in 1988) was likely still related to less frequent small upstream spills, SSO releases, and other urban stormwater inputs.

Zurmehly Creek: 1996-2010
A single station on Zurmehly Creek near the mouth was evaluated as part of the 1996 Ottawa River survey (Ohio EPA 1998). Zurmehly Creek possessed physical habitat attributes that were consistent with the designated WWH use. As reflected by the fish and macroinvertebrate community in both surveys (narratively, high fair quality), the environmental conditions on Zurmehly Creek appeared stable. The biological community continued to labor under the influence of an urban or otherwise developed catchment (diffuse pollutant sources, documented spills, flashy hydrology, etc.). Much of the watershed is industrialized (petroleum fuel storage tank farms and historic war products manufacturing, etc.) and likely is subject to storm event scouring and sedimentation (Appendix D).

Little Ottawa River: 1996-2010
A single station on the lower Little Ottawa River was evaluated as part of the 1996 Ottawa River survey (Ohio EPA 1998). As reflected by the fish community, the environmental conditions on the Little Ottawa River appeared stable, in that the fish community continued to labor under the effects of SSOs and the sundry effects attendant to an urban or otherwise developed catchment (Appendices A, C, and D).

Some decreases in stormwater runoff, fewer SSO and WWTP episodes lessened the volume and frequency of toxic impacts and allowed more stability at least in the benthic community compared to a 1996 sample site near the mouth (RM 0.4). Sensitive taxa improved from one in 1996 to nine in 2010, and the number of EPT taxa increased from 8 in 1996 to 14 in 2010. Marginally good conditions in 1996 improved to good quality in the 2010 survey – a reflection of infrastructural improvements, but not enough for fish community quality changes.

Pike Run: 1991-2010
Historical fish community data were available for Pike Run from both 1991 and 1996 surveys of the Ottawa River basin (Ohio EPA 1992 and 1998). The 2010 results portrayed significant recovery in comparison with previous survey results. Nearly every community biometric was

improved, including a decrease in both the frequency and magnitude of diseased fish, which reached levels characterized as highly elevated in 1996. Presently, all sites were found to support a fish assemblage fully consistent with Pike Run's existing MWH aquatic life use designation. These improvements were directly attributable to the American-Bath WWTP being installed in 1996. As observed elsewhere, natural macrohabitat improvement may have contributed to use recovery on Pike Run, but given the nature of the historical impact (pathogens from CSOs and municipal point source), this appeared secondary or tertiary (Ohio EPA 1998).

Despite MWH attainment in 2010, the macroinvertebrate community quality condition in Pike Run declined significantly in Gomer at the Lima–Gomer Rd. bridge (RM 0.48). High *E. coli* bacteria concentrations exceeding the PCR criterion (max. = 7700 cfu/ml with mean of 3144 cfu/ml) were documented in Pike Run at Gomer (Appendix C). As the result of septic inputs from the unsewered community of Gomer, total EPT and sensitive taxa diversity decreased by ≥ 50% (Figure 108). Pike Run nutrient and sewage inputs from Gomer contributed to nutrient inputs into the Ottawa River downstream.

Sugar Creek: 1984-2010

Historic macroinvertebrate sample sites were collected in the lower reaches of Sugar Creek in 1984, 1996, and 1997. The general trend in the macroinvertebrate community in Sugar Creek was continued attainment over time, though nutrient enrichment and low diel DO events dampen the ability of the aquatic community to improve further.

Ample historical fish community data exists for the lower Ottawa River tributary of Sugar Creek. To varying degrees, Sugar Creek has been regularly surveyed since 1984. The entire length of Sugar Creek, a reach nearly identical to the 2010 effort, was surveyed and assessed as part of the 1996 Ottawa River study (Ohio EPA 1998). Monitoring efforts on Sugar Creek through the mid-1980s found much of the stream impaired relative to existing and recommended aquatic life uses, as nearly every station failed to support communities consistent with the prescribed biocriteria. These data portrayed a significant impact or depression in community performance downstream from the Ford Motor Co. (Lima Engine Plant). In addition, several minor septic discharges well up and downstream from "Ford" tributary combined with diffuse sources of urban-industrial pollution through the lower 1.2 miles (e.g., scrapyard and automotive finisher) contributed to the fair to poor community performance. By 2010, nearly every biometric improved, including a significant reduction in the incidence of DELTs, increased species richness and the accrual of environmentally sensitive taxa through the reach formerly affected by Ford Motor Co. Presently, all sites support communities fully consistent with the existing and recommended aquatic life use designations. In addition to pollution abatement, both the recovery of macrohabitat through natural fluvial processes, sediment reduction achieved through modern tillage practices and the diminution of urban-industrial NPS likely contributed to overall improved ambient biological performance documented in 2010.

Plum Creek: 1996-2010

The entire length of Plum Creek, a reach nearly identical to the 2010 effort, was surveyed and assessed as part of the 1996 Ottawa River study (Ohio EPA 1998). First surveyed by Ohio EPA in 1996, Plum Creek represents the only waterbody showing significant declines in comparison with the 2010 results. However, negative deviation from previous results was not universal, in that both positive and negative trends were observed. Worsening conditions were documented on Plum Creek in 2010 at Columbus Grove. Although the WWTP was upgraded in 2000, and additional upgrades are on-going, CSO by-passes rendered Plum Creek septic and nearly devoid of fish at the sites immediately up and downstream from Columbus Grove's point of final discharge. However, far-field effects documented in 1996 appear abated, as the lower eight miles of Plum Creek recovered to WWH levels in 2010. The general benefits of modest natural improvement to macrohabitat and reduced sedimentation may have contributed to the recovery documented on the lower eight miles.

Plum Creek macroinvertebrate communities were sampled in 1996 and 2010 at similar locations. Columbus Grove CSOs (with low DO, NH_3, and fecal coliform bacteria inputs) were issues since before 1996, but the WWTP was operating more efficiently during the 1996 survey. As such, benthic community quality improved to MG conditions in 1996 downstream from Columbus Grove and met the HELP ecoregion WWH biocriterion from RM 11.0 to the mouth. In 2010, recovery did not occur in Plum Creek from Columbus Grove until < 5 miles from the mouth due to poor quality WWTP and CSO discharges exacerbated by additional NPS agricultural nutrient inputs (Appendices A, C and D). Downstream from Kalida, macroinvertebrate quality was negatively influenced from either NPS agriculture inputs or Kalida stormwater runoff in 1996. In 2010, significant improvements in the macroinvertebrate community were noted and are detailed in the macroinvertebrate tributary trends section of this report.

RECOMMENDATIONS

Status of Aquatic Life Uses

Nearly all waterbodies contained within the Ottawa River watershed were originally designated for aquatic life use(s) in the 1978 and 1985 state water quality standards. The techniques in use at that time did not include standardized approaches to the collection of instream biological data or numeric biocriteria. This study represents the first comprehensive use of these types of ambient biological data to inform the use designation process. While some of the recommendations may appear to constitute "downgrades" (e. g., EWH to WWH) or "upgrades" (e. g., WWH to EWH) any change should not be construed as such because these, in most instances, constitute the first application of an objective and robust data driven process to ascertain the appropriate aquatic life use designation. Ohio EPA is obligated by a 1981 public notice to review and evaluate all aquatic life use designations outside of the WWH use prior to basing any permitting actions on the existing, unverified use designations. Thus, some of the following aquatic life use recommendations constitute a fulfillment of that obligation. Confirmed existing and recommended aquatic life use(s) resulting from the 2010 intensive survey are summarized in Table 3 and discussed in detail in the following text.

Ottawa River Mainstem

Community performance was found consistent with the existing aquatic life use designation of Warmwater Habitat (WWH) for the entire Ottawa River mainstem (Table 1). QHEIs in flowing reaches of the Ottawa River ranged from 54.3 to 81.0 – consistent with WWH use potential.

- Ottawa River mainstem, WWH (affirmed)

Ottawa River Watershed Tributaries

Several Ottawa River watershed tributaries demonstrated biological community performance consistent with warmwater habitat and were recommended to be designated WWH aquatic life use streams. Most recommended WWH streams contained sufficient WWH habitat and adequate commensurate QHEI scores, especially within the ECBP ecoregion. However, WWH aquatic community expectations within the HELP ecoregion are lower because of the regional calibration of WWH performance for that ecoregion and therefore it is not unusual to have substandard habitat scores with acceptable WWH biological performance. Sampled streams or portions of streams that are recommended / confirmed as WWH are listed below.

Ottawa River basin sampled streams recommended or confirmed to be WWH

ECBP streams

- Hog Creek RM 5.63 (downstream Allen Co. line) to mouth (QHEI=63.5 and 69.5)
- Little Hog Creek (QHEI=50.5-60.5 with mean=55.5)
- Unnamed Tributary (UT) to Little Hog Creek @ RM 0.47 (QHEI=60.5)
- Mud Run RM 1.7 (Ada Lafayette Rd.) to mouth (QHEI=39.3)
- Lost Creek RM 0.35 (Dst. E. High St. – Reservoir Rd.) to mouth (QHEI=72.0)
- Zurmehly Creek (QHEI=65.0)
- Little Ottawa River RM < 5.54 (dst. CS&T RR trestle) (QHEI=66.8-69.3 with mean=67.7)
- Sugar Creek (ECBP) RM 20 (dst. Stewart Rd.) to RM 17 (dst. SR 65) (QHEI=65.5)

HELP streams

- Dug Run RM 1.0 (ust. Sherrick Rd.) to mouth (QHEI=65.0)
- Honey Run RM 1.2 (ust. Billy Mack Rd.) to mouth (QHEI=46.5)
- Beaver Run RM 1.7 (dst. Gomer Rd.) to mouth (QHEI=42.5)
- Leatherwood Ditch RM 1 (ust. SR 189) to mouth (QHEI=30.5)
- Sugar Creek RM 17 to mouth (QHEI=45.8-60.9 with mean=53.8)
- Plum Creek from RM 5.0 (ust. TR M10) to mouth (confirmed) (QHEI=29.3 and 51.3)
- Unnamed Tributary (UT) to Plum Creek @ RM 7.30 (confirmed) (QHEI=35.3)
- Unnamed Tributary (UT) to Ottawa River @ RM 0.70 (confirmed) (QHEI=64.5)

Widespread, active county ditch maintenance programs noted at the vast majority of monitoring stations were the driving factors for the recommendation of the MWH aquatic life use in the majority of streams in Hardin, Allen, and Putnam Counties. These streams are channelized, open ditched, deeply entrenched, and monotonous channels maintained as agricultural conveyances with little habitat diversity and limited substrates besides sediment and hardpan. There were 8 – 11 modified habitat attributes that were predominant in these maintained ditched streams from the individual QHEI evaluations (see physical habitat section). Streams that possessed consistently substandard habitat quality with past/present channelization under historical or regular routine county maintenance and further confirmed by low biological performance are recommended for the MWH aquatic life use designation and are listed below.

- Hog Creek (ECBP) RM 16 (CR 60) to RM ≥5.63 (Hardin/Allen Co. line) (QHEI mean = 36.1)
- Unnamed Tributary (UT) to Hog Creek @ RM 13.71 (ECBP)
- Lord Ditch (ECBP) (QHEI=36.0)
- Fitzhugh Ditch (ECBP) (QHEI=23.0)
- No. 28 Ditch (ECBP) (QHEI=18.0)
- Grass Creek ECBP) (QHEI=39.8 and 51.0)
- Lost Creek (ECBP) RM 3.6 to RM >0.35 (ust. E. High St.) (QHEI=33.0 and 40.0)
- Unnamed Tributary (UT) to Lost Creek @ RM 1.15 (ECBP) (QHEI=43.0)
- Little Ottawa River (ECBP) ≥ RM 5.54 (ust. CS&T RR trestle)
- Honey Run (HELP) RM >1.2 (ust. Billy Mack Rd.) to headwaters (QHEI=41.0)
- Pike Run (HELP) (QHEI=38.5-58.0 with mean=47.1)
- Sugar Creek (ECBP) RM 27.98 to RM >20 (dst. Stewart Rd.)
- Rattlesnake Creek (HELP) (QHEI=43.8)
- Plum Creek (HELP) RM 15.8 to RM >5.0 (dst. TR 14L)
- Sycamore Creek (HELP) (QHEI=39.0)
- Unnamed Tributary (UT) to Sycamore Creek @ RM 0.85 (HELP)

Status of Non-Aquatic Life Uses

The current Industrial and Agricultural Water Supply use designations for the Ottawa River and designated tributaries should remain in place. The Primary Contact Recreation use designation (Class A for Ottawa River and Class B for all others) is recommended for waterbodies evaluated as part of the 2010 Ottawa River survey.

Future Monitoring Needs

- Reevaluate survey sites to continue to document positive water quality improving trends, including reaches with CSO/SSO improvements (as appropriate).

- Recommend a water budget study regarding how new reservoir could alleviate summer low flow concerns in the Ottawa River mainstem through Lima.

- Conduct a follow-up survey in Plum Creek watershed after improvements occur at Columbus Grove WWTP and associated infrastructure (limiting CSO impacts).

- Continuing monitoring of stream sediments adjacent to and upstream from L5 landfill (to downstream from Erie RR dam) to ensure continued containment of any new sediment deposition of oils.

- Investigate if there are any essential purposes or function (e.g., water intake) for the small impoundment on Sugar Creek at Bluelick Rd. (~RM 18.25) and ascertain the viability of removal (improvement of stream habitat and fish migration).

Table 3. Existing and recommended beneficial use designations for the Ottawa River basin. All recommendations based on 2010 monitoring and assessment results.

Water Body Segment	Use Designation													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Ottawa River Basin														
Ottawa River mainstem														
-at RM 43.45(upstream of low head dam at Metzger Rd.		+						+	+	+		+		PWS intake Lima
-at Roush Rd. (RM 42.60)		+						+	+	+		+		PWS intake – Lima (alternate)
-all other segments		+							+	+		+		Existing
UT to Ottawa River (@ 0.70)		-/+							-/+	-/+		-/+		Verified
Plum Creek														
-RM 15.8 (source – UT to Plum Cr. & Sycamore Cr.) to RM > 5.0 (dst. TR 14L)		+/-		▲					+	+		+		County Maintained
-RM 5.0 (ust. TR M10) to mouth		+							+	+		+		County Maintained
UT to Plum Creek (@ 7.30)		-/+							-/+	-/+		-/+		Verified
Sycamore Creek		*/-		▲					*/+	*/+		*/+		County Maintained
UT to Sycamore Creek @ 0.85				-/+					-/+	-/+		-/+		County Maintained
Sugar Creek														
-RM 27.98 (source – confluence of Cotner Ditch and Huber Ditch) to RM 20 (dst. Stewart Rd.)		*/-		▲					*/+	*/+		*/+		Past maintenance **Channelization**
-RM 20 to mouth		*/+							*/+	*/+		*/+		Verified
Rattlesnake Creek		*/-		▲					*/+	*/+		*/+		County Maintenance
Ford Trib. (Sugar Cr. @ 18.82)		+							*	*			+	Historical data
Huber Ditch		*							*	*		*		Unverified
Cotner Ditch		*							*	*		*		Unverified
Leatherwood Ditch		*/+							*/+	*/+		*/+		County Maintenance
Pike Run				+					+	+		+		County Maintenance
Beaver Run		-/+							-/+	-/+		-/+		Verified

Water Body Segment	Use Designation														Comments
		Aquatic Life Habitat							Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Honey Run															
- RM > 1.2 (ust. Billy Mack Rd.)				▲					*/+	*/+		*/+		Verified
- RM ≤ 1.2 (ust. Billy Mack Rd.)		*/+							*/+	*/+		*/+		Verified
Dug Run		*/+							*/+	*/+		*/+		Verified
Kessler Run		*							*	*		*		Unverified
Swalley Ditch		*							*	*		*		Unverified
Little Ottawa River															
- RM ≥ 5.54 (ust. CS&T RR bridge)		+/-		▲					+	+		+		County Maintenance
- RM < 5.54 (dst. CS&T RR bridge)		+							+	+		+		Verified
Zurmehly Creek		+							+	+		+		Existing
Lost Creek															
- RMs 3.6 to >0.35 (ust. E. High St.)		*/-		▲					+	+		+		County Maintenance
- RM ≤ 0.35 (dst. E. High St.)		*/+							*/+	*/+		*/+		Verified
Crosley Ditch		*							*	*		*		
UT to Lost Creek @ 1.15				-/+					-/+	-/+		-/+		Co. / Private Maintenance
Hog Creek															
-headwaters to Hardin-Allen County line (RM 5.63)				+					+	+		+		County Maintenance
-Hardin-Allen Co. line (RM 5.63) to mouth		+							+	+		+		Verified
Grass Creek		*/-		▲					*/+	*/+		*/+		Verified
Number (No.) 28 Ditch		*/-		▲					*/+	*/+		*/+		Verified
Fitzhugh Ditch		*/-		▲					*/+	*/+		*/+		Verified
Lord Ditch		*/-		▲					*/+	*/+		*/+		Verified
UT to Hog Creek @ RM 13.71				-/+					-/+	-/+		-/+		Verified
Little Hog Creek		+							+	+		+		Verified

Water Body Segment	Use Designation													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
UT to Little Hog Creek @ RM 0.47		-/+							-/+	-/+		-/+		Verified
Mud Run		*/+							*/+	*/+		*/+		Verified

* Unverified existing or recommended Use Designation

\+ Verified Use Designation

▲ New recommendation and verified use designation based on the findings of this report.

*/+ Verification of an existing yet unverified use designation based on the findings of this report.

-/+ Field verified recommendation for a previously unlisted, and therefore, undesignated stream

*/- Unverified existing use not appropriate

a Water bodies so identified were not surveyed or assessed as part of 2010 sampling effort.

Ohio WQS Beneficial Uses

SRW = state resource water.
WWH = warmwater habitat.
EWH = exceptional warmwater habitat.
MWH = modified warmwater habitat.
SSH = seasonal salmonid habitat.
CWH = coldwater habitat.
LRW = limited resource water.
PWS = public water supply.
AWS = agricultural water supply.
IWS = industrial water supply.
BW = bathing water.
PCR = primary contact recreation.

STUDY AREA DESCRIPTION

Location and Scope

The Ottawa River rises in northern Hardin County at the confluence of Hog and Little Hog Creeks and flows west/southwest through Lima. Near the southwest edge of Lima and the eastern side of Shawnee Township it turns north and flows into western Putnam County (Figure 1). After traveling 57 miles it joins the Auglaize River between the villages of Kalida and Cloverdale. The nine primary tributaries of the Ottawa River are Grass Creek, Little Hog Creek, Lost Creek, Little Ottawa River, Honey Run, Dug Run, Pike Run, Sugar Creek and Plum Creek (Ottawa River Coalition, 2008). The Ottawa River watershed covers an area of approximately 365mi^2 and is a subwatershed of the Maumee River Basin.

History

The Ottawa River is named for the Ottawa tribe of Native Americans who inhabited the area in the 18th century. It is one of two rivers in northwestern Ohio, along with the Ottawa River in Toledo, that share the same name. The Ottawa River is also known locally as "Hog Creek". The origin of this name is ascribed to the following legend: "Alexander McKee, the British Indian Agent who resided at the Machachac towns on Mad River during the incursion of General Logan from Kentucky in 1786, was obliged to flee with his effects. He had a large lot of swine which were driven on to the borders of this stream, and when the Indians (Shawnee) came on they called the river Koshko Sepe, which in the Shawnee language signified 'The Creek of the Hogs', or 'Hog Stream'" (Howe 1889).

Ecoregions

The study area spans two distinct ecoregions, the Eastern Corn Belt Plain (ECBP) and the Huron-Erie Lake Plains (HELP) (Omernik 1987). The transition to the HELP ecoregion from the ECBP ecoregion occurs approximately at RM 17.5 on the Ottawa River mainstem in Allen County. Sample sites and stream reaches are identified by ecoregion in Table 1.

Beneficial Uses

Beneficial use designations within the watershed include those for aquatic life, recreation and public water supply. The effective use designations for the majority of streams in the Ottawa River watershed include Warmwater Habitat (WWH) or Modified Warmwater Habitat (MWH), Primary Contact Recreation (PCR), Agricultural Water Supply (AWS) and Industrial Water Supply (IWS). The mainstem of the Ottawa River is a Class A recreation stream and also a public water supply upstream of Lima at RMs 43.45 and 42.60.

Geology/Soils

Soils in the watershed can be classified by ecoregion location with the ECBP till plain soils being derived from glacial till material and HELP lake plain soils being formed of lacustrine sediments. Soils in the Morely-Blount-Pewamo association are found in the upland areas of Hardin and Allen Counties. They are characterized as light colored, somewhat poorly drained fertile soils of the till plains and end moraines. Hog Creek Marsh is located on the extreme west edge of the watershed near Dola in Hardin County. In this area, poorly drained darker soils of the Milford-Patton association are present that formed in medium textured lacustrine sediment on lake plains. In the HELP ecoregion of northern Allen County and into Putnam County, the soils migrate from Blount-Pewamo clays to the Hoytville-Nappanee association. These are the darker, very poorly drained soils of the glacial lake plains. Beach ridge soils in the Haskin-Mermill-Millgrove association are found in southern Putnam County along SR 12 between Columbus Grove and Gomer (USDA 2013).

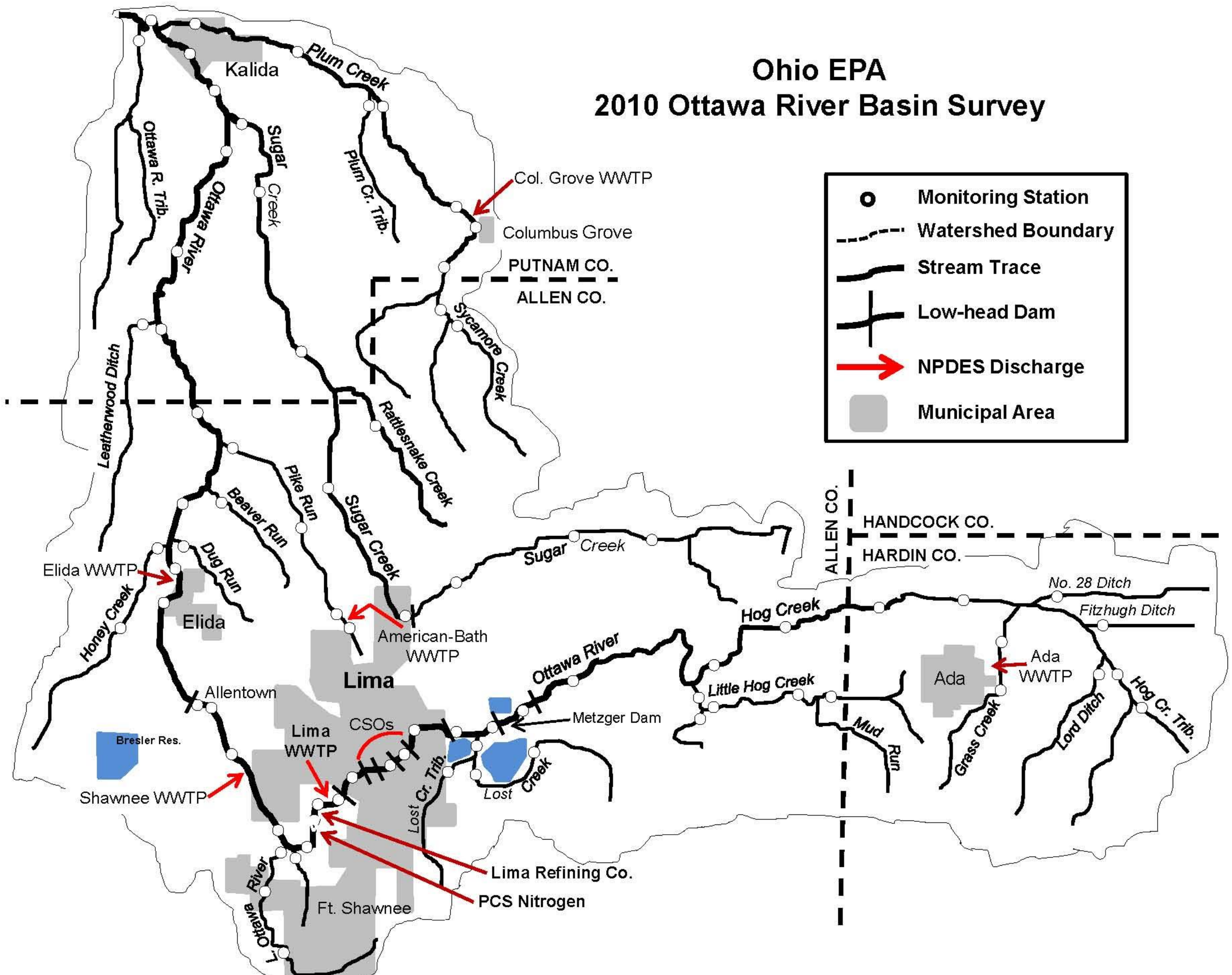

Figure 19. Sample locations for the Ottawa River watershed survey, 2010.

Table 4. Environmental monitoring stations in the Ottawa River study area, 2010. The river miles listed in the table are the STORET location Point of Record (POR) identifiers. Sample type collection locations (RM) may vary slightly from the POR listing. Sample codes include the following: F-fish community, M-macroinvertebrate community, C-water column chemistry, O-water column organic chemical sampling, D-diel water chemistry (Datasonde), DWS-drinking water supply chemical analysis, Sed-sediment metals and organics, E- *E. coli* bacteria samples, FC-field chemistry, FT-fish tissue or MT- fish tissue.

Station Code	River Mile	Sample Codes[a]	Location Description	Latitude	Longitude	County	HUC 12
Ottawa River (04-200)							
500270	45.97	Sed,C,F,M,D,E,FT,MT	OTTAWA R. UPST. LIMA @ THAYER RD. (Ref Site)	40.7656	-84.0131	ALLEN	041000070306
500230	44.26	F,M	OTTAWA R. E OF LIMA @ FETTER RD.	40.7569	-84.0372	ALLEN	041000070306
204307	43.60	Sed	OTTAWA R. E OF LIMA, UPST. DAM	40.7533	-84.0472	ALLEN	041000070306
P04W23	43.45	DWS,F,M,D,C	OTTAWA R. DST. METZGER RD. DAM	40.7514	-84.0506	ALLEN	041000070306
P04S26	42.3	C,D,F,M,FT	OTTAWA R. UPST. LIMA, DST. ROUSH RD.	40.7478	-84.0711	ALLEN	041000070306
P04K04	41.16	E,C,D,F,M,FT	OTTAWA R. AT LIMA @ SUGAR ST.	40.7481	-84.0894	ALLEN	041000070306
301609	40.21	FT	OTTAWA R. AT LIMA, UPST.LOVERS LANE DAM @ HIGH ST.	40.74255	-84.09259	ALLEN	041000070306
P04K03	40.04	C,D,F,M,E	OTTAWA R. AT LIMA, DST. Lovers Lane DAM (Elm St. Dam Pool), DST. LOVERS LANE CSO (tailwaters)	40.7400	-84.0950	ALLEN	041000070306
P04W08	39.58	C,D,F,M,E	OTTAWA R. AT LIMA at/ust. CENTRAL AVE. and RR bridge and dst. Elm St. dam tailwaters (riverine reach)	40.7367	-84.1009	ALLEN	041000070306
P04S14	38.63	Sed,C,D,F,M,E,FT	OTTAWA R. AT LIMA @ COLLETT ST. (in Erie RR /Collett St. Dam Pool that extends above Collett St.)	40.7319	-84.1192	ALLEN	041000070306
P04P19	37.91	C,D,F,M,FT	OTTAWA R. UPST. LIMA WWTP @ ROAD DST. Erie RR DAM	40.7242	-84.1267	ALLEN	041000070306
P04S30	37.47	Sed,C,D,F,M,FT,MT	OTTAWA R. AT LIMA, DST. LIMA WWTP	40.7228	-84.1333	ALLEN	041000070306
P04S10	37.11	C,O	HUSKY REFINERY 001 OUTFALL TO OTTAWA R.	40.7196	-84.1371	ALLEN	041000070306
P04S09	37.00	Sed,C,O,D,F,M,FT,MT	OTTAWA R. UPST PCS NITROGEN, DST HUSKY REFINERY	40.7178	-84.1375	ALLEN	041000070306
P04S07	36.3	Sed,O,D,F,M,FT	OTTAWA R. AT LIMA, ADJ. FORT AMANDA RD. (Dst PCS Nitrogen OUTFALLS)	40.7083	-84.1411	ALLEN	041000070306

Station Code	River Mile	Sample Codes[a]	Location Description	Latitude	Longitude	County	HUC 12
P04S28	35.44	E,C,O,D	OTTAWA R. Dst Lima outfalls at Shawnee Rd	40.7064	-84.1514	ALLEN	041000070306
P04S06	34.55	F,M,FT	OTTAWA R. DST. LIMA @ WESTFIELD DRIVE (Shawnee Country Club)	40.7136	-84.1575	ALLEN	041000070402
P04S27	31.03	C,D, F,M	OTTAWA RIVER AT ELM STREET (DST. SHAWNEE #2 WWTP, Seriff Rd. Landfill)	40.7369	-84.1803	ALLEN	041000070402
P04P01	29.26	E,C,D,F,M,MT	OTTAWA R. AT ALLENTOWN @ COPUS RD.	40.7536	-84.1908	ALLEN	041000070402
500050	28.85	C,D,F,M,Sed,FT,MT	OTTAWA R. AT ALLENTOWN @ ST. RT. 81 (in dam pool)	40.7550	-84.1947	ALLEN	041000070402
P04P32	25.75	C,D,F,M	OTTAWA R. W OF ELIDA @ PIQUAD RD.	40.7878	-84.2125	ALLEN	041000070402
300939	24.11	C,F,M	OTTAWA R. DST. ELIDA WWTP (Troyer Rd. or adj. Dutch Hollow Rd.)	40.8017	-84.2038	ALLEN	041000070402
P04P14	22.14	E,C,D,F,M	OTTAWA R. N OF ELIDA @ NEFF RD.	40.8253	-84.2053	ALLEN	041000070406
P04P33	18.68	C,D, F,M	OTTAWA R. NW OF GOMER @ OLD ST. RT. 12	40.8608	-84.1931	PUTNAM	041000070406
P04P15	15.98	C, E,D,F,M,FT	OTTAWA R. AT RIMER @ ST. RT. 189	40.8842	-84.2131	PUTNAM	041000070406
P04K01	12.75	D,F,M	OTTAWA R. N OF RIMER @ CO. RD. R-17	40.9117	-84.2089	PUTNAM	041000070406
P04S03	8.12	C,E,F,M	OTTAWA R. S OF KALIDA @ CO. RD. P (near TR 107)	40.9469	-84.1889	PUTNAM	041000070406
204299	5.60	C,D,F,M	OTTAWA R. SW of KALIDA at farm field rd. off SR 115	40.9683	-84.1906	PUTNAM	041000070503
P04W21	3.67	E,C,F,M,Sed,FT	OTTAWA R. AT KALIDA @ U.S. RT. 224	40.9803	-84.2031	PUTNAM	041000070503
500150	0.96	C,D,F,M,Sed	OTTAWA R. NEAR KALIDA @ CO. RD. 19	40.9900	-84.2267	PUTNAM	041000070503
Hog Creek (04-216)							
301040	13.42	C,F,M	HOG CREEK at TR 85	40.7717	-83.7478	HARDIN	41000070301
300937	12.03	E only	HOG CREEK at TR 75	40.7854	-83.7661	HARDIN	41000070302
P04S42	10.77	C,E,F,M,D	HOG CREEK at CR 65	40.7963	-83.7848	HARDIN	41000070302
500370	8.72	C,F,M,D	HOG CREEK NEAR ADA at St. Rt. 235 hist C site	40.7962	-83.8232	HARDIN	41000070304
301006	6.67	C,F,M,D	HOG CREEK at St. Paul Rd. (TR 25) (Hardin Co.)	40.7958	-83.8617	HARDIN	41000070304
500410	3.8	C,F,M,D	HOG CREEK at Peevee Rd.	40.7867	-83.9086	ALLEN	41000070304
P04P18	0.27	E,C,F,M,D	HOG CREEK N OF LAFAYETTE@ Swaney Rd.	40.7708	-83.9517	ALLEN	41000070304
UT to Hog Creek @ RM 13.71 (04-263)							
301042	0.52	F,M	UT to Hog Creek @ RM 13.71 at TR 50	40.761851	-83.74282	HARDIN	041000070301

Station Code	River Mile	Sample Codes[a]	Location Description	Latitude	Longitude	County	HUC 12
Lord Ditch (04-220)							
301041	1.2	C,F,M	LORD DITCH *(Trib. to Hog Creek @ RM 12.8)* at CR 50	40.7616	-83.7652	HARDIN	41000070301
Fitzhugh Ditch (04-219)							
301039	0.4	C,F,M,D	FITZHUGH DITCH *(AKA Ireton Ditch) dst.* CR 75 & Airport Rd. toward mouth	40.7670	-83.7910	HARDIN	41000070302
No. 28 Ditch (04-218)							
301038	0.37	F,M	No. 28 DITCH at CR 65	40.7982	-83.7848	HARDIN	41000070302
Grass Creek (04-217)							
P04P13	2.57	C,F,M,D	GRASS CR. UPST. ADA WWTP @ Lincoln St. (CR 44)	40.7692	-83.8108	HARDIN	41000070302
P04K22	1.24	E,C,F,M,D	GRASS CR. DST. ADA WWTP @ Van Atta Rd. (TR55)	40.7819	-83.8036	HARDIN	41000070302
Little Hog Creek (04-221)							
P04P11	3.62	C,F,M,D	L. HOG CREEK at Peevee Rd.	40.7656	-83.9086	ALLEN	41000070303
P04S43	0.64	C,E,F,M	L. HOG CREEK dst Lafayette (WWTP) at Swaney Rd.	40.7631	-83.9515	ALLEN	41000070303
204312	0.2	F,M,D	L. HOG CREEK dst. Lafayette at SR 81 by confluence	40.7678	-83.9550	ALLEN	41000070303
Mud Run (04-222)							
301043	0.65	C,F,M	MUD RUN at Bluffton Bentley Rd.	40.7704	-83.8989	ALLEN	41000070303
UT to Little Hog Creek @ RM 0.47 (04-294)							
301044	0.3	C,F,M	UT to Little Hog Creek @ RM 0.47	40.7612	-83.9569	ALLEN	41000070303
Lost Creek (04-214)							
P04K16	3.56	C,F,M	LOST CREEK E OF LIMA @ Mumaugh Rd.	40.7419	-84.0322	ALLEN	41000070305
204311	1.7	C,F,M	LOST CREEK AT LIMA @ Fenway Drive	40.7350	-84.0583	ALLEN	41000070305
P04K15	0.35	E,C,F,M,D	LOST CREEK AT LIMA @ E High St. (Reservoir Rd.) (Lower Crossing)	40.7454	-84.0609	ALLEN	41000070305
UT to Lost Creek @ RM 1.15 (04-249)							
P04K19	0.62	C,F,M	UT TO LOST CREEK (@ 1.15) @ Bryn Mahr Ave.-Lima	40.7328	-84.0744	ALLEN	41000070305
Zurmehly Creek (04-261)							
P04W20	0.03	C,F,M	ZURMEHLY CREEK AT LIMA @ FT. Amanda	40.7058	-84.1481	ALLEN	41000070306

Station Code	River Mile	Sample Codes[a]	Location Description	Latitude	Longitude	County	HUC 12
			Rd.				
Little Ottawa River (04-213)							
301010	5.5	C,F,M	L. OTTAWA R. adj. Old S Dixie Rd.	40.6716	-84.1347	ALLEN	41000070401
P04P09	4.45	C,F,M	L. OTTAWA R. dst Cridersville WWTP @ FORT SHAWNEE RD.	40.6675	-84.1510	ALLEN	41000070401
301005	1.38	F,M	L OTTAWA R at Breese Rd.	40.6863	-84.1687	ALLEN	41000070401
500420	0.03	E,C,F,M,D	L. OTTAWA R. NEAR LIMA @ FT. AMANDA RD.	40.7056	-84.1539	ALLEN	41000070401
Dug Run (04-210)							
P04K10	0.19	C,F,M,D	DUG RUN @ DUTCH HOLLOW RD.	40.8107	-84.2040	ALLEN	41000070402
Honey Run (04-209							
301003	3.58	C,F,M	HONEY RUN at Cremeans Rd.	40.7819	-84.2333	ALLEN	41000070403
300938	0.9	E,C,F,M,D	HONEY RUN at Wapak Rd.	40.8099	-84.2160	ALLEN	41000070403
Beaver Run (04-200)							
301037	0.51	C,F,M	BEAVER RUN at Bussert Rd.	40.8311	-84.1934	ALLEN	41000070406
Pike Run (04-208)							
P04P24	8.21	C,F,M	PIKE RUN UPST. AMERICAN BATH WWTP	40.7836	-84.1225	ALLEN	41000070404
301009	7.56	C,F,M	PIKE RUN DST. AMERICAN BATH WWTP at Cole Rd.	40.7867	-84.1280	ALLEN	41000070404
510160	4.61	C,F,M,D	PIKE RUN NEAR LIMA at State Rd.	40.8170	-84.1483	ALLEN	41000070404
P04P10	0.84	E,C,F,M,D	PIKE RUN AT GOMER at Lima Gomer Rd.	40.8467	-84.1858	ALLEN	41000070404
Leatherwood Ditch (04-202							
301007	0.48	C,F,M,D	LEATHERWOOD DITCH W OF RIMER at TR 19	40.8871	-84.2253	Putnam	41000070405
Sugar Creek (04-203)							
301002	26.03	C,F,M	SUGAR CREEK at Napoleon Rd.	40.8162	-83.9759	ALLEN	41000070501
301001	23.85	C,F,M	SUGAR CREEK at Thayer Rd.	40.8159	-84.0134	ALLEN	41000070501
P04S20	20.05	C,F,M,D	SUGAR CREEK NEAR LIMA @ STEWART RD.	40.7989	-84.0706	ALLEN	41000070501
P04K09	18.24	C,F,M	SUGAR CREEK N OF LIMA at/dst. Bluelick Rd. (LOWER)	40.7892	-84.0944	ALLEN	41000070501
P04S16	13.41	C,F,M	SUGAR CREEK at Old US Rt. 30 Lincoln Hwy	40.8314	-84.1342	ALLEN	41000070501
301004	9.27	C,F,M	SUGAR CREEK at SR 115 ust Vaughnsville	40.8779	-84.1478	Putnam	41000070501
P04S18	3.51	C,F,M	SUGAR CREEK SE OF KALIDA at CR Q	40.9331	-84.1681	Putnam	41000070501

Station Code	River Mile	Sample Codes[a]	Location Description	Latitude	Longitude	County	HUC 12
P04S02	0.64	C,F,M,D	SUGAR CREEK SE OF KALIDA @ CO. RD. 16-O near mouth	40.9545	-84.1791	Putnam	41000070501
Rattlesnake Creek (04-204)							
301000	1.74	C,F,M	RATTLESNAKE CREEK NW of Cairo near mouth at Hofferbert Rd.	40.8536	-84.1095	ALLEN	41000070501
Plum Creek (04-201)							
P04W13	14.92	C,F,M,D	PLUM CREEK SW (UPST) OF COLUMBUS GROVE at TR 11-R	40.9072	-84.0783	Putnam	41000070502
P04P03	12.95	C,F,M	PLUM CREEK @ Wayne St UPST. COLUMBUS GROVE WWTP	40.9239	-84.0625	Putnam	41000070502
P04K07	12.14	C,F,M	PLUM CREEK DST. COLUMBUS GROVE WWTP @ TR 11	40.9288	-84.0721	Putnam	41000070502
P04W15	8.12	C,F,M,D	PLUM CREEK NW OF COLUMBUS GROVE @ TR O	40.9627	-84.1021	Putnam	41000070502
P04W16	4.62	C,F,M,D	PLUM CREEK E OF KALIDA @ TWP. RD. M-10	40.9811	-84.1504	Putnam	41000070502
P04W17	0.19	C,F,M,D	PLUM CREEK NEAR KALIDA @ ST. RT. 114	40.9867	-84.2092	Putnam	41000070502
Sycamore Creek (04-202)							
301074	0.65	F,M,FC	SYCAMORE CR. upstream Searfoss Rd. (Morris Rd.)	40.8942	-84.0811	ALLEN	41000070502
UT to Sycamore Creek @ RM 0.85 (04-295)							
301008	0.2	C,F,M	UT to Sycamore Cr. @ RM 0.85 upstream Searfoss Rd.	40.8913	-84.0802	ALLEN	41000070502
UT to Plum Creek @ RM 7.30 (04-229)							
P04P04	0.41	C,F,M	UT to Plum Creek @ RM 7.30 at TR O west of CR 13	40.9628	-84.1120	Putnam	41000070502
UT to Ottawa River @ RM 0.7 (04-290)							
300999	0.33	C,F,M,D	UT to OTTAWA R @ RM 0.7 at TR M-17	40.986947	-84.23037	Putnam	41000070503

Hydrology

The Ottawa River watershed covers 238,000 acres of Wisconsinan glaciated till plain and lake plain land. Underlying bedrock of Silurian limestone and dolomite is exposed at various locations in the river and elsewhere is covered by several to more than two hundred feet of glacial drift material (Omernik 1987, ODNR 2001).

The ECBP ecoregion is a rich agricultural area that covers the upper (eastern) portion of the watershed in Allen and Hardin Counties. The relief in this part of the watershed is nearly level to gently rolling, with steeper areas along streams and the three end moraines which traverse the region from east to west. These end moraines are among the areas where soil erosion in greatest in the watershed (Omernik 1987). Local relief is greater than in the HELP ecoregion and the streams have a steeper slope. Little Hog Creek and the Little Ottawa River have gradients of 11.7 feet per mile and 8.6 feet per mile respectively (ODNR 2001).

The HELP ecoregion in the lower areas of the watershed (northern Allen and Putnam counties) is characterized by a broad almost level lake plain crossed by low moraines and beach ridges (Omernik 1987). Local relief is generally only a few feet and streams have a lower gradient. Plum Creek and Sugar Creek have flow gradients of 3.5 and 5.5 feet per mile, respectively (ODNR 2001).

A flow hydrograph representing the stream discharge for the Ottawa River is presented in Figure 20 and includes the dates when biological, chemical and datasonde studies were conducted in the watershed. The lack of stream flow in the warm, dry summer months contributed to stresses on the biological communities and decreased the stream's ability to assimilate nutrient and other pollutant loads especially in the middle segment of the Ottawa River mainstem as it flows through the City of Lima and is affected by CSOs and wastewater discharges from 4 major facilities. Water withdrawals for Lima's public drinking water system exacerbate the effects of low flow during the rest of the year.

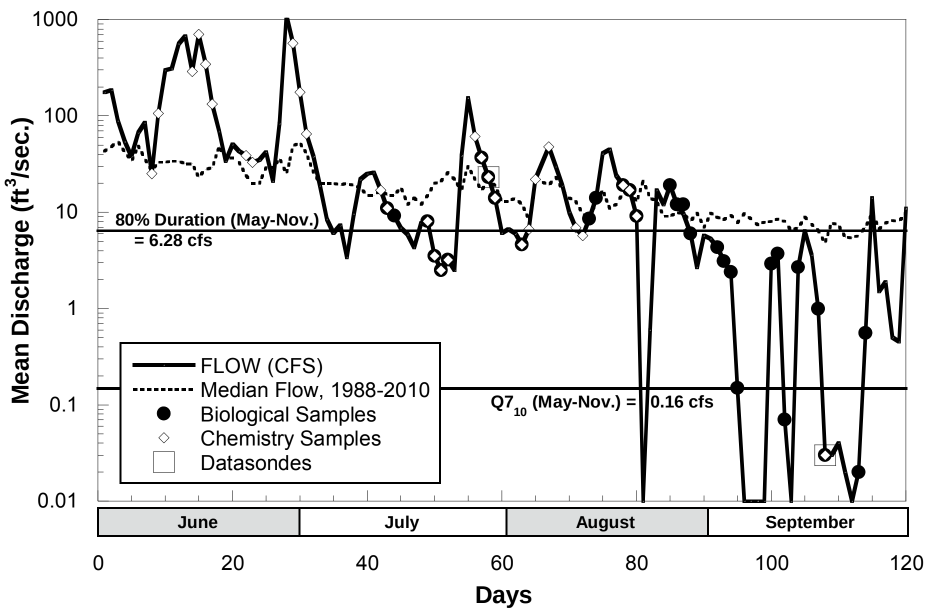

Figure 20. Flow hydrograph for Ottawa River (RM 37.8) showing daily mean discharge and historical median discharge, 1988-2010 (USGS 2007). Symbols indicate days of Ohio EPA sampling visits.

The City of Lima relies on surface water from the Ottawa River as their public drinking water supply. Water is pumped from the river upstream of the city during certain times of year for storage in a series of upground reservoirs. Water withdrawal records for 2010 indicate that a total of 4.39 billion gallons of river water was pumped into the Metzger and Lost Creek Reservoir system on 193 days during the year. No surface water was withdrawn from the Ottawa River between July 1 and October 31, 2010 (City of Lima, 2010).

Land Use

Portions of twelve townships, and the municipal area of Lima along with the smaller villages of Ada, Lafayette, Fort Shawnee, Cairo, Elida, Columbus Grove, and Kalida, are located in the Ottawa River watershed (US Census Bureau 2011). Figures 21-23 are individual maps showing land use in the three watershed assessment units of this study area (Fry et al. 2011).

Grain farming is the predominant land use in the watershed and since most soils are poorly drained, an extensive artificial drainage system must be maintained to make row crop farming possible. Many small streams have been extensively channelized to support the tile and drainage ditch systems throughout the watershed (ODNR 2008). Aggregated land use across these watersheds approximated 69.2% agricultural and nearly 2.2% pasture lands, with 18.9% developed for urban or residential use. Other land uses included 6.9% forest, 1.7% grassland, 0.85% open water and 0.3% wetland (Fry et al. 2011). While row crop and livestock production remains the dominant land use, the long term trend has shown the loss of farmland to urban growth and residential sprawl, particularly around the urban area of Lima. The watershed supports a resident population of approximately 100,000, with the City of Lima's population at about 37,600 (US Census, 2010).

Protected Lands

The Johnny Appleseed Metropolitan Park District was created in June, 1972. The Park District is a comprehensive park system of natural areas and preserves designed to enhance the quality of life of the citizens of Allen County by providing passive outdoor recreational and educational opportunities while conserving and protecting the natural resources of the area for future generations.

The Park District currently has 12 park areas with over 1,200 acres that provide opportunities for hiking, picnicking, interpretive programs and guided nature walks. The Ottawa River Metro Park offers camp sites and swimming for visitors, while Lima Lake Reservoir offers daily fishing and boating activities. Horseback riding is available at the Allen County Farm Park bridle trail, and bicyclists may enjoy the 13 mile Rotary Riverwalk which links Heritage Park with Collett Street Recreation Area (Johnny Appleseed Metropolitan Park District, 2011).

Ground Water Supply

Many rural residents in Ohio depend on ground water wells as their source of drinking water. Outside of the service area of City of Lima, residents and businesses rely on wells for potable water. The villages of Ada, Columbus Grove, Kalida, and Cridersville use ground water for their public drinking water supply.

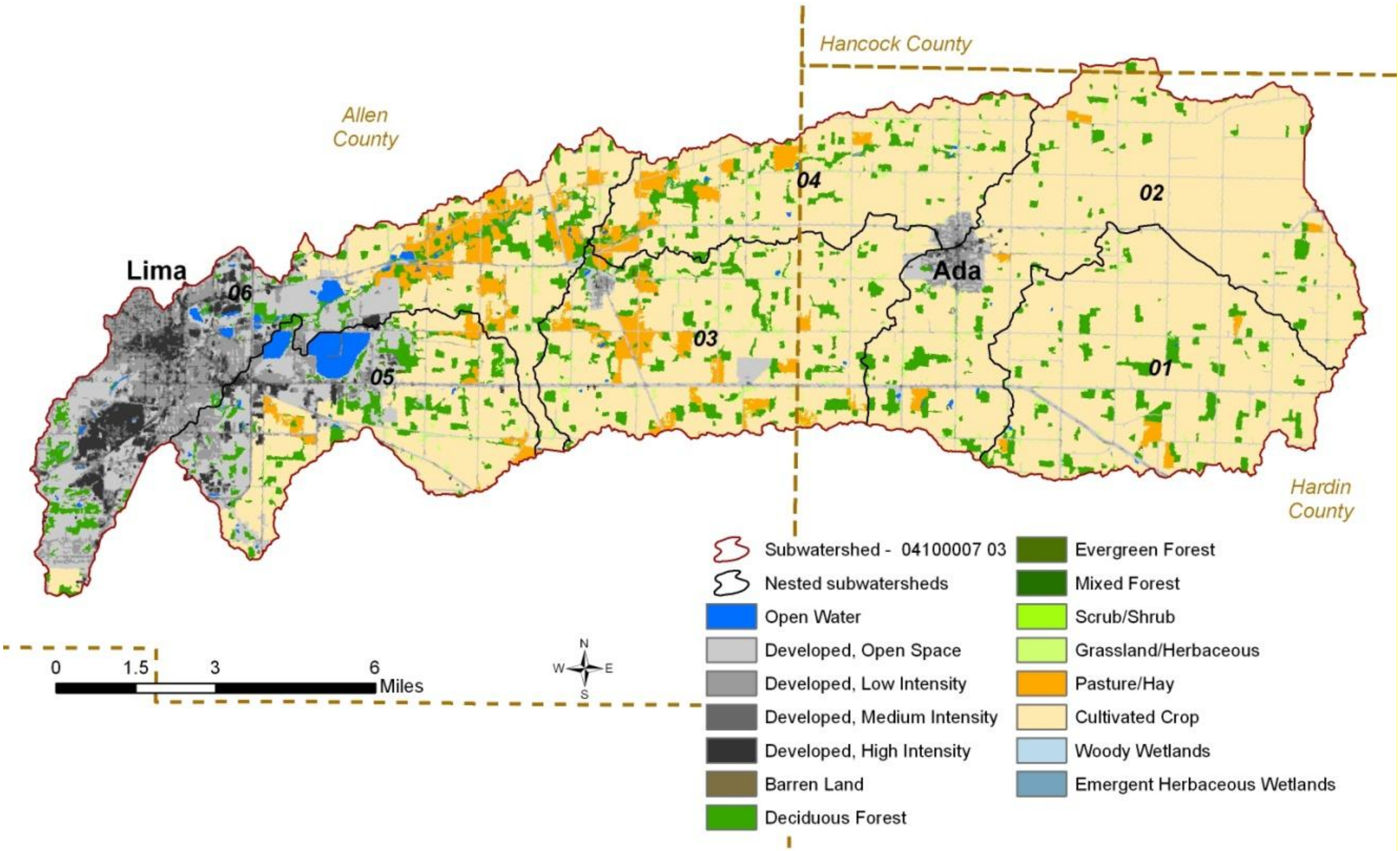

Figure 21. Land use in the upper Ottawa River watershed (Fry et al. 2011).

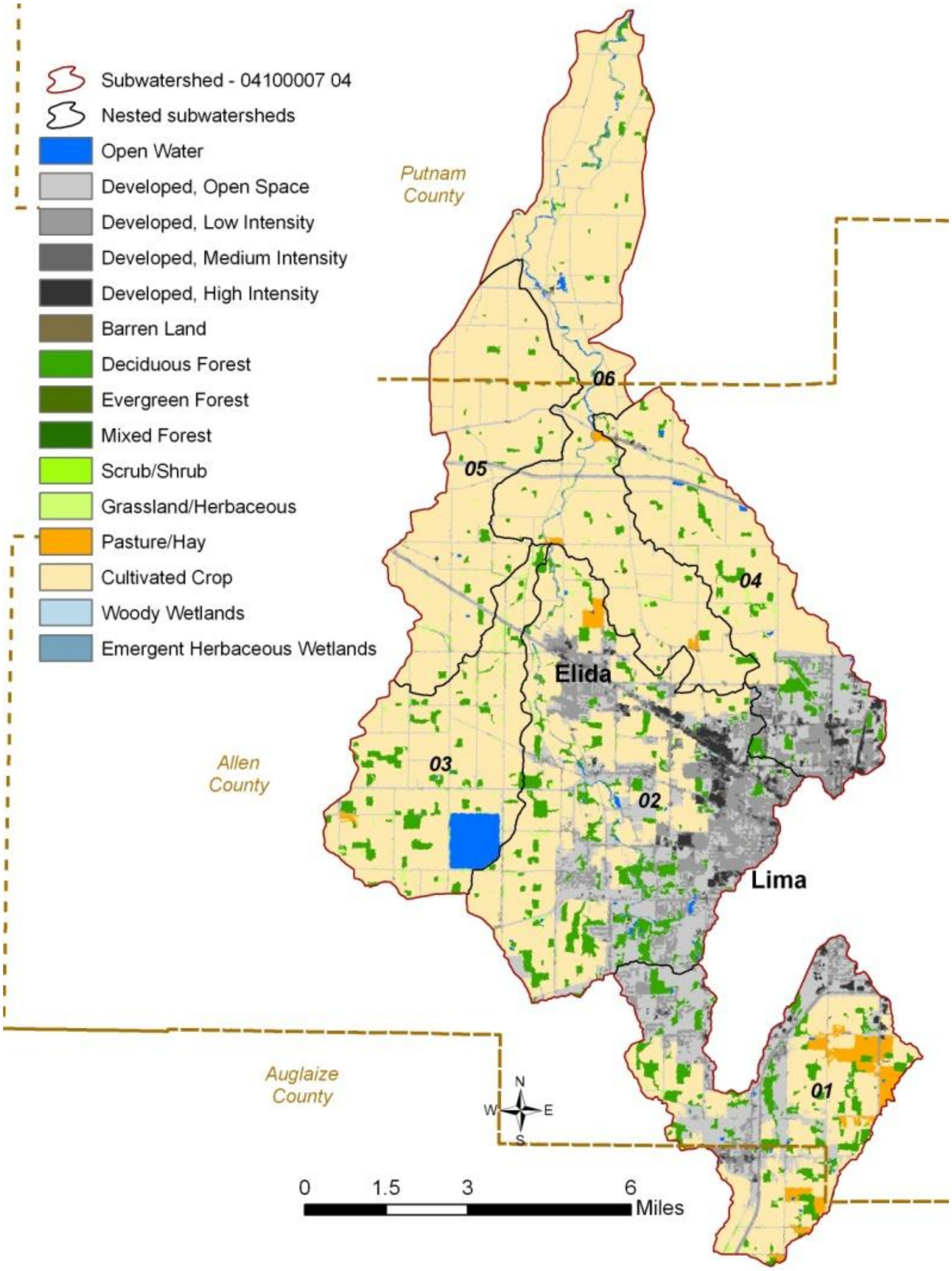

Figure 22. Land use in the middle Ottawa River watershed (Fry et al. 2011).

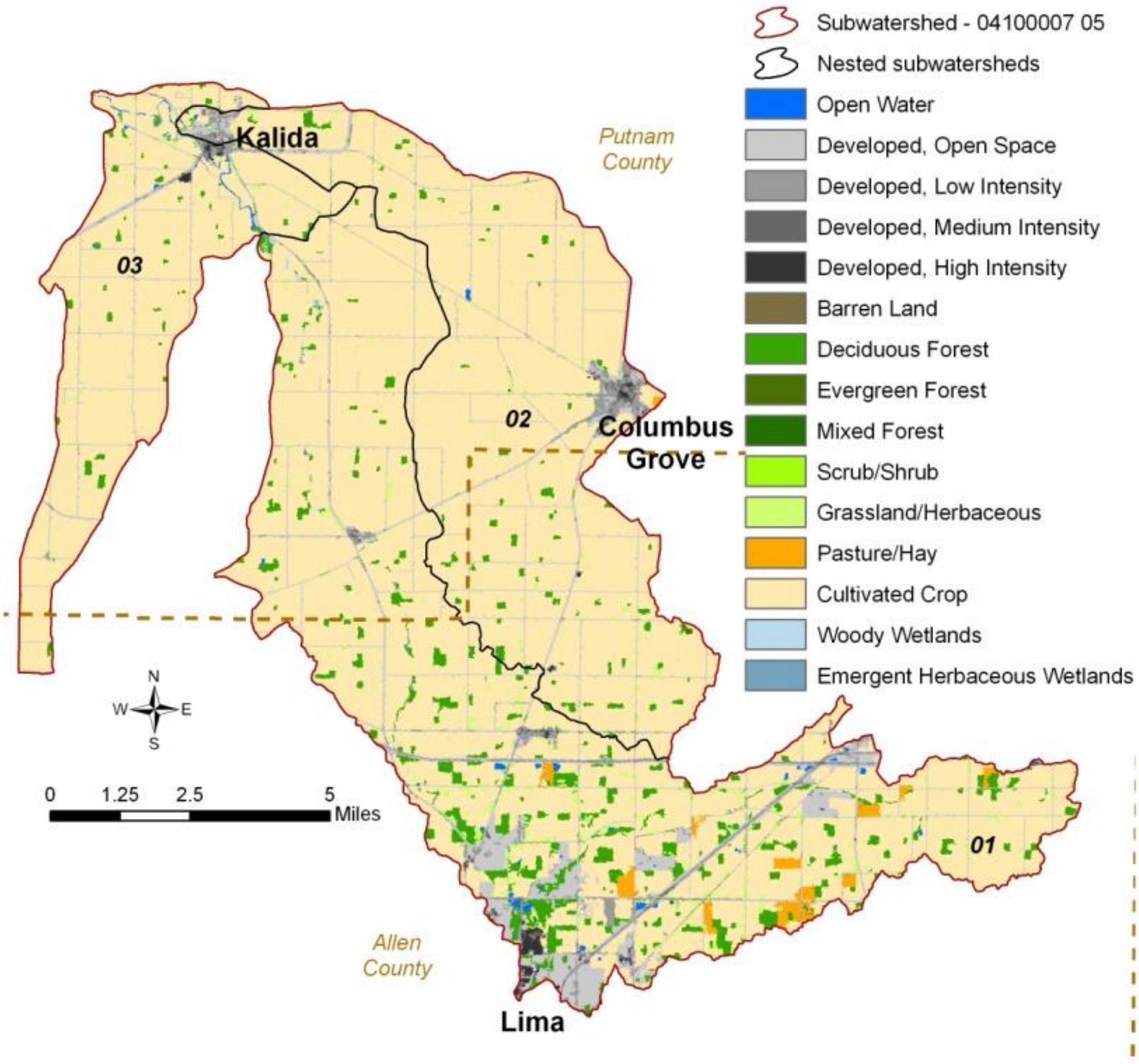

Figure 23. Land use in the lower Ottawa River watershed (Fry, et al. 2011).

Surface Water Supply and Drinking Water Quality

The City of Lima uses several upground reservoirs to store drinking water. The East Reservoir Complex includes Ferguson Reservoir, Metzger Reservoir and Lost Creek Reservoir. They are located in Section 32-34 of Bath Township, Allen County. They are connected in a series and the water flows between them by gravity. The water ultimately reaches either the water treatment plant or Twin Lakes Reservoir which is located next to the plant. Source water is obtained from the Ottawa River via a pump station located at river mile 43.45. The lakes are open to the public for fishing but swimming is not allowed. The four reservoirs were built between 1886 (Twin Lakes) and 1959 when Ferguson reservoir was added to the complex. The combined total storage capacity is 4.25 billion gallons.

The status of the public drinking water supply use is summarized in the Ohio 2010 Integrated Water Quality Monitoring and Assessment Report. Sampling conducted in 2010 and 2011 to determine the support of the drinking water use designation is discussed in detail in the Public Drinking Water Supply section of this report. Additional information on the drinking water sources can be found in the Drinking Water Source Assessment for the City of Lima at the following website http://www.epa.ohio.gov/ddagw/swap_publications.aspx .

Point Source Issues

Lima and portions of Auglaize and Allen County are designated as Phase 2 Storm Water entities. They are required to prepare and implement storm water pollution prevention plans to address construction sediment and erosion control measures and urban runoff issues. There are individual stormwater permits for eight petroleum pipeline/storage facilities, six light industrial companies and three privately owned package plants for a mobile home park, a golf course and a business. Additional information regarding the storm water requirements in this area is available at the following website http://epa.ohio.gov/dsw/storm/index.aspx.

In a stretch of seven river miles, the Ottawa River receives effluent discharges from two major municipal and two major industrial facilities. The City of Lima, Lima Refining Co, and PCS Nitrogen discharge between RM 37.9 and 35.4 and the Shawnee #2 WWTP is located at RM 32.5.

Industrial discharges from the Lima Refining Company potentially negatively influenced water quality as it released selenium, ammonia, total dissolved solids, and occasionally cyanide into the Ottawa River. The City of Lima WWTP has a wastewater treatment bypass in addition to multiple CSOs and SSOs. The Shawnee #2 WWTP has significant inflow to the sewer system that results in plant operation problems and SSOs affecting the Ottawa River. The Columbus Grove WWTP negatively impacts Plum Creek for several miles, nearly to the confluence with the Ottawa River. The Cridersville WWTP effluent and SSOs from the Shawnee sewer system also negatively influence the water quality of the Little Ottawa River. Additional details regarding these point sources are provided in the NPDES section of this report.

Nonpoint Source Issues

The most common nonpoint sources negatively affecting water quality throughout the study area included fertilizer runoff, failing home sewage treatment systems, sedimentation from agricultural crop production and urban storm water runoff. Agricultural practices including channelization and routine maintenance of streams and ditches and the drainage of farm fields through subsurface tiles caused habitat and flow alteration impairments in the headwater and small tributary streams.

Drainage alterations were also found where floodplains and wetlands were crossed by numerous highways and railroads, as well as in urban areas where development has encroached or filled in natural wetlands. All of the counties in the study area had programs for drainage maintenance (ODNR, 2008). Recreational use impairment was also attributed to unsanitary conditions in several rural communities that do not have centralized wastewater collection and treatment. Unsewered areas include Gomer, Rimer and Vaughnsville.

Watershed Groups

The Ottawa River Coalition (ORC) is a nonprofit organization established in 1993 in response to increasing attention to water quality issues. It represents the collaborative efforts of 45 member and partner organizations. The ORC is committed to promoting public awareness and education regarding the benefits of improving water quality. The ORC attempts to work with the public to collectively understand and protect water quality while continuing to study and monitor the river system. They seek an adequate financial base to maintain operations of the organization and providing a forum for stakeholders representing the varying viewpoints and uses of the watershed. The mission of the organization is to promote the wise use and management of the Ottawa River and its watershed as a valuable community resource. For more information regarding the ORC, visit their website, http://www.thisismyriver.org/ (Ottawa River Coalition, 2008).

RESULTS

NPDES Permitted Facilities

Facilities within the study areas that are regulated by an individual NPDES permit are listed in Table 5. A total of 33 NPDES permitted facilities discharge sanitary, industrial process, and/or industrial storm water into the Ottawa River watershed and its tributaries. Included in this list is one confined animal feeding operation (CAFO), four major and six minor municipal WWTPs, two major and three minor industrial facilities, three package plants, six facilities with individual storm water and eight petroleum pipeline or tank farm facilities with individual storm water permits. Each facility is required to monitor their discharges according to sampling and monitoring conditions specified in their NPDES permit and report results to the Ohio EPA in a Discharge Monitoring Report (DMR). Each permit includes a detailed list of each parameter to be monitored and the specific limits for both concentration and loading rate. The permit also includes monthly average limits and daily or weekly maximum limits, depending on the monitoring requirements. DMR data can be used to track compliance as well as to evaluate historical trends.

A general NPDES permit is a potential alternative to an individual NPDES permit and affords coverage to new and existing dischargers that have similar operations and types of discharges and can meet the eligibility criteria. There were 11 general permits for household sewage treatment systems issued in the watershed as of 2010. General permits are also used to cover other types of discharges that will have a minimal effect on the environment. Facilities or sites within the study area that are regulated by a construction storm water general NPDES permit may be found by visiting http://www.epa.ohio.gov/dsw/permits/gpfact.aspx#background

Table 5. Facilities regulated by an individual NPDES permit in the Ottawa River watershed, 2010.

Facility Name	Ohio EPA Permit	Receiving Stream	Description
Ada WTP	2IW00320	Grass Creek	Lime sludge settling lagoons
Ada WWTP	2PB00050	Grass Creek	0.82 MGD Activated Sludge, Trickling Filter
Lafayette WWTP	2PA00049	Little Hog Creek	0.1 MGD Activated Sludge
Lima WWTP	2PE00000	Ottawa River	18.5 MGD Activated Sludge
Lima Refining Company - Husky	2IG00001	Ottawa River	8.6 MGD Dissolved Air flotation and Advanced WWTP
PCS Nitrogen	2IF00004	Ottawa River	Storm water outfalls, Non-contact cooling water, cooling tower blow down
Colonial Golfers Club	2PR00195	UT Little Hog Creek	0.0075 MGD package plant
Sheldon Farms	2IK00042	Hog Creek	Storm water permit
Buckeye Pipeline Co – Lima Station	2II00013	UT Ottawa River	3 outfalls from spill containment basins, storm water, hydrostatic test water
Buckeye Terminals – Lima North	2II00006	Ottawa River	1 outfall from tank draw water, storm water, hydrostatic test water
Buckeye Terminals – Lima South	2IG00011	UT Ottawa River	4 storm water outfalls from tank farm, hydrostatic test water
Chemtrade Logistics - Cairo Sulfur Products	2IF00008	UT Arnold Ditch	Non-contact cooling water, storm water, filter backwash, R.O. reject water
County Line Investments	2PW00018	UT Lost Creek	0.003 MGD package plant
Ernst Enterprises Lima Division	2IN00105	Ottawa River	Storm water sedimentation basin
Lima Refinery – Buckeye Rd Tank Farm	2IG00018	UT to Ottawa River	Tank draw water, storm water, hydrostatic test water
Marathon Ashland Petroleum LLC-Lima	2IG00025	UT Ottawa River	Storm water pond and tank draw water, hydrostatic test water
Marathon Pipeline Lima Transfer Station	2II00023	UT Little Ottawa River	Tank draw water, storm water, hydrostatic test water
Mid-Valley Pipeline Co Lima Transfer Station	2II00002	UT Ottawa River	Tank draw water, storm water, hydrostatic test water
National Lime & Stone Co Lima	2IJ00013	Ottawa River	2.0 MGD sedimentation pond, storm water/ground water
Guardian Lima Holdings, LLC	2IN00238	UT Lost Creek	Storm water detention pond
Proctor & Gamble Manufacturing Co	2IN00038	UT Ottawa River and Lost Creek	5 storm water outfalls
Shelly Materials Lima Tank Farm	2IN00232	UT Ottawa River	Storm water retention pond, hydrostatic test water
Superior Forge and Steel Corp	2ID00012	Storm sewer tributary to Ottawa River	Storm water retention pond, cooling water
US Dept. Defense Joint Systems Mfg.	2IO00000	UT Ottawa River	13 outfalls for storm water, non-contact cooling water, fire protection system test, coal pile runoff and general surface runoff
Cridersville WWTP	2PB00048	UT Little Ottawa River	0.8 MGD Activated Sludge
Shawnee #2 WWTP	2PK00002	Ottawa River	2.0 MGD Sequencing Batch Reactor

Facility Name	Ohio EPA Permit	Receiving Stream	Description
American Bath WWTP	2PH00007	Pike Run	1.5 MGD Oxidation Ditch
American #2 WWTP	2PH00006	Dug Run	1.2 MGD Sequencing Batch Reactors
Elida WWTP	2PB00046	Ottawa River	0.5 MGD Trickling Filter
Indian Village MHP	2PY00001	Freed Ditch	0.035 MGD package plant
Columbus Grove WWTP	2PC00004	Plum Creek	0.820 MGD Trickling Filter
Kalida WWTP	2PA00047	Ottawa River	0.2 MGD Continuous discharge lagoon system
National Lime & Stone Co – Rimer Plant	2IJ00053	Ottawa River	3 storm water outfalls

Point Source Pollutant Loadings

Normally, only major NPDES permitted facilities are described in detail in this section. However, there are multiple WWTPs throughout the watershed that are collectively contributing to the overall water quality of the Ottawa River, so more background information will be presented here. Several major discharges through the City of Lima are interactive between RMs 38 - 32 of the Ottawa River, so a waste load allocation was completed as part of the permit renewal process in 2010-2011. The NPDES permits may be found by visiting:
http://wwwapp.epa.ohio.gov/dsw/gis/npdes/index.php .

Concentrations and respective calculated pollutant loads from NPDES dischargers in the Ottawa River watershed were available from 1996 through 2010. These data are gathered and reported to Ohio EPA by the permit holders. The data were screened for compliance with permit requirements, and further analyzed for trends in magnitude and variability over time. Summaries of results by individual facilities follow the general overview.

Because of the interactive nature of these discharges, graphs showing the mean concentrations of ammonia, selenium and total dissolved solids are presented in Figures 24-26. In addition, the pie graphs in Figure 27 show median concentration percentages of ammonia-nitrogen and total phosphorus comprising the four major discharges on the Ottawa River mainstem in Lima. The significant contributions of the four major dischargers are discussed in detail below followed by the remaining point sources.

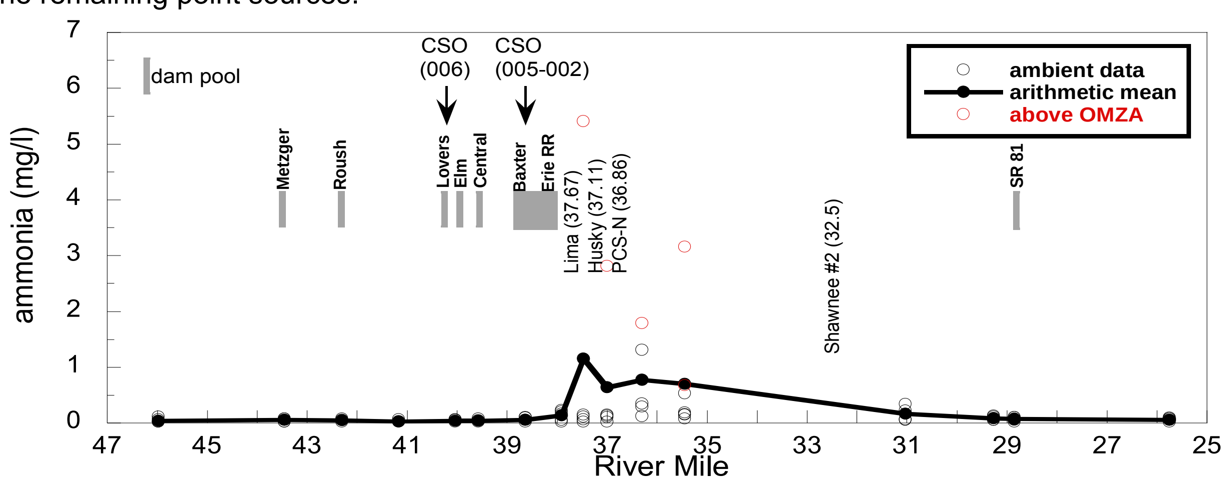

Figure 24. Longitudinal mean ammonia concentrations in effluent and ambient samples for the upper Ottawa River mainstem, 2010.

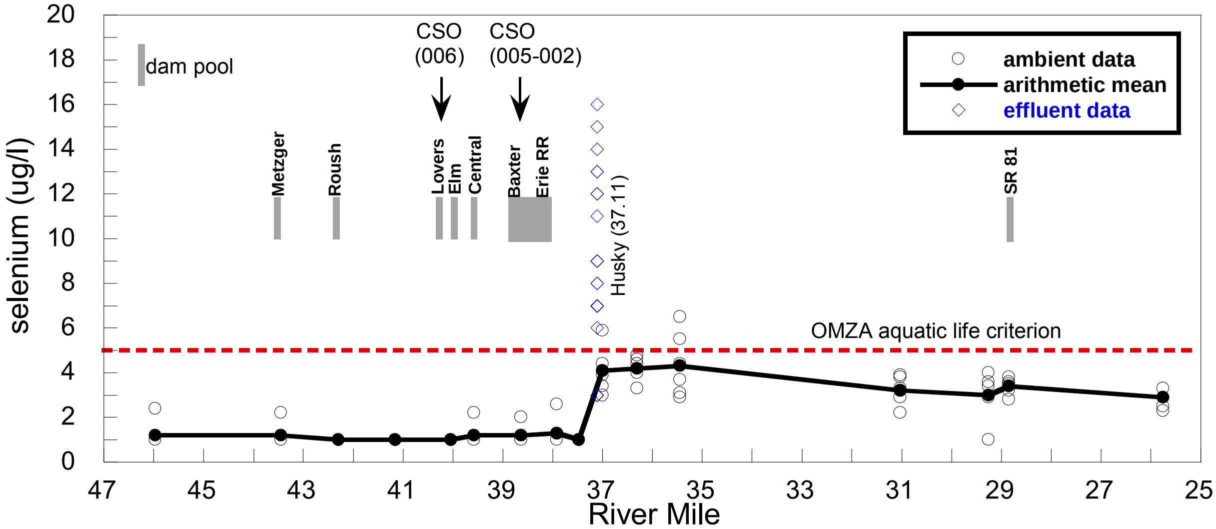

Figure 25. Longitudinal mean selenium concentrations in effluent and ambient samples for the upper Ottawa River mainstem, 2010.

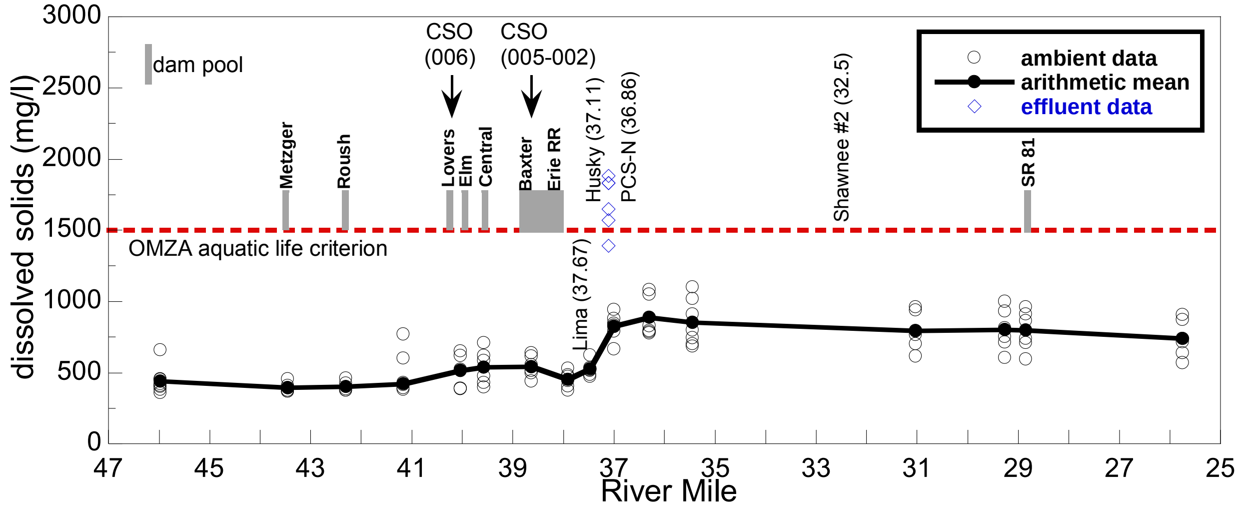

Figure 26. Longitudinal mean dissolved solids concentrations in effluent and ambient samples for the upper Ottawa River mainstem, 2010.

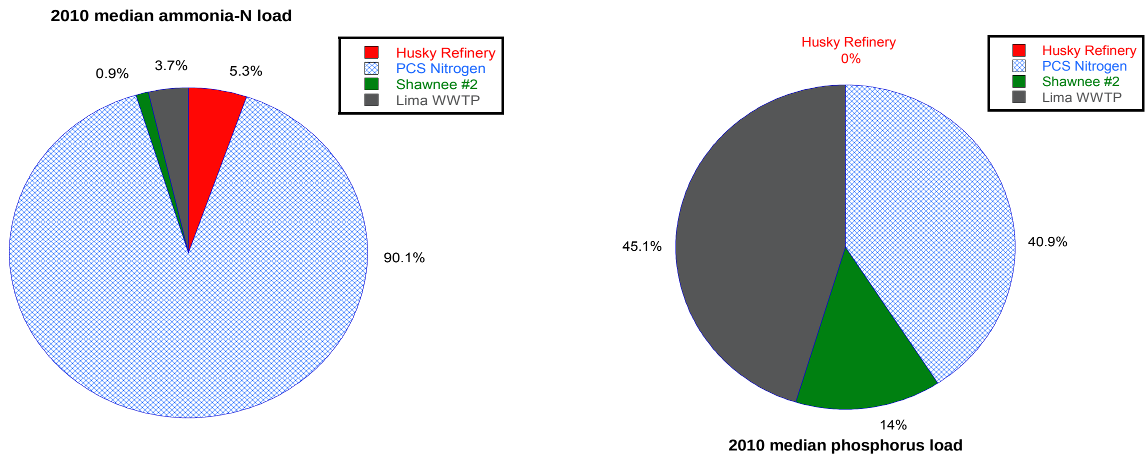

Figure 27. Percentage of median ammonia-N and median phosphorus loads coming from the four Ottawa River mainstem dischargers, 2010.

City of Lima WWTP (2PE00000)

A major municipal facility that discharges to the Ottawa River at RM 37.6, the Lima WWTP is an activated sludge plant with an average daily design flow of 18.5 MGD and a hydraulic capacity of 45 MGD. Wet stream processes include screening and grit removal, phosphorus removal using ferrous chloride and polymer addition, primary settling, activated sludge aeration, secondary clarification, nitrification using trickling filters, disinfection by chlorination, and dechlorination. Solid stream processes are sludge thickening, stabilization by anaerobic digestion, dewatering by belt filter press, alkaline stabilization, and sludge disposal at a landfill and by marketing.

Lima's treatment plant has three bypasses: Outfall 057 is a bypass of the entire plant; Outfall 602 is a bypass of the secondary treatment system; Outfall 603 is a bypass of tertiary treatment (nitrification process). Outfalls 602 and 603 are in-plant outfalls that are blended with the fully treated effluent (outfall 604) prior to discharge. Lima monitors treatment-system control parameters (cBOD, suspended solids, ammonia-nitrogen and phosphorus) at outfall 604. Treatment technology limits are imposed at this outfall. Water quality based limits for these parameters and metals are also applied at this point because this outfall represents the final discharge during low-flow conditions. Outfall 001 represents the final discharge of the fully treated effluent and the in-plant bypasses. All flows at Outfall 001 receive disinfection. Water quality based limits for bacteria parameters and chlorine are applied at this location.

During the last five years the plant bypass has not been used. The secondary bypass was used 19 times with an average duration of 5.5 hours per month. The tertiary system was bypassed 384 times for an average of 10 hours per month.

Lima's collection system is comprised of combined sewers (approximately 80 percent) and separate sanitary sewers. There are 19 overflows on the combined portion of the system, five of which are mechanically controlled by a computer system to maximize in-line storage. All of the CSOs are regulated under this NPDES permit. The previous Long Term Control Plan (LTCP) approved in December 1999 is not valid since U.S. EPA took over the enforcement case and is negotiating a new CSO LTCP and SSO elimination schedule with the city.

The separate portion of the system includes 27 lift stations and 42 SSOs none of which are mechanically controlled or metered. The SSOs were the subject of Director's Final Findings and Orders (DFFO) issued in February 1994 and a general plan for elimination that was approved on January 1996. The City completed phases 1 and 2 of the general plan, eliminating 9 SSOs before the U.S. EPA also took on the enforcement case.

Lima implements an Ohio EPA approved industrial pretreatment program. According to the 2009 annual program report, six categorical industrial users and ten significant non-categorical industrial users discharge wastewater to the Lima WWTP.

Facility DMRs from 2006 to 2010 were evaluated. The final effluent exceeded limits for low level mercury limit on 1/1/08. In August and early September, 2008 discharges of high strength wastewater led to ammonia, cBOD5 and total suspended solids violations. There was one violation of oil and grease on 3/2/09 and two cBOD5 weekly average violations at the final outfall in the first half of March 2010. During some high flows when secondary and or tertiary treatment was bypassed, there were violations of the chlorine residual limit on 5/26/06, 7/11/09, 5/10/10, and 5/15/10.

Ohio EPA conducted 48 hour screening bioassays at the facility in September 2008 and October 2008 as part of the toxics evaluation prior to permit re-issuance. The effluents were not acutely toxic in either the September 23 or the October 20 tests. Fathead minnow (*Pimephales promelas*) mortality was ten percent in the October effluent grab, and daphnia (*Ceriodaphnia dubia*) mortality was five percent in the same sample. No other mortality or adverse effects were observed in the ambient waters and remaining effluents. Additional bioassays should be conducted to further demonstrate the absence of unacceptable toxic conditions associated with this discharge. These did not address the possibility of chronic toxicity and discharge data for Lima WWTP and the Ottawa River should be evaluated to determine if chronic toxicity is a concern.

Pollutant loadings from the Lima WWTP between 2000 and 2010 were evaluated and annual statistics for ammonia, nitrate+nitrite and total phosphorus are displayed below in Figures 28, 29, and 30. The plant discharged a fairly consistent level of nutrients during the evaluation period. The load of ammonia-N has decreased over time while the annual nitrate+nitrite loadings have remained fairly steady with noted increases in 2001 and 2007. Phosphorus loads appear stable over time. Several upgrades to the plant and collection system were done during and immediately after the 2010 stream survey. Most plant improvements were done to repair or replace aging equipment. This included repairing leaks in aeration system pipes and replacing aeration diffusers. Also, the scum collection mechanisms in the final tanks were replaced.

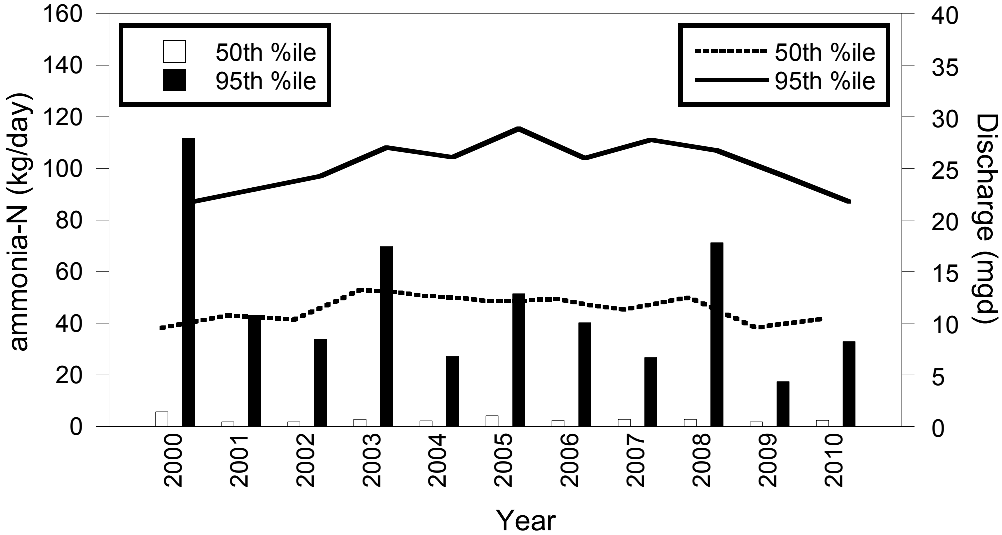

Figure 28. Annual ammonia-N loadings for the City of Lima WWTP from 2000-2010.

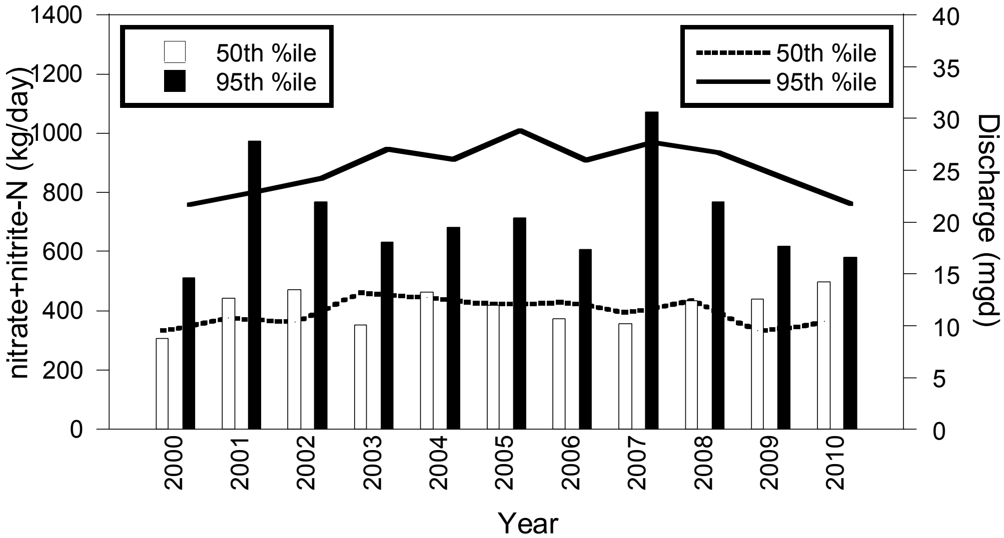

Figure 29. Annual nitrate+nitrite loadings for the City of Lima WWTP from 2000-2010.

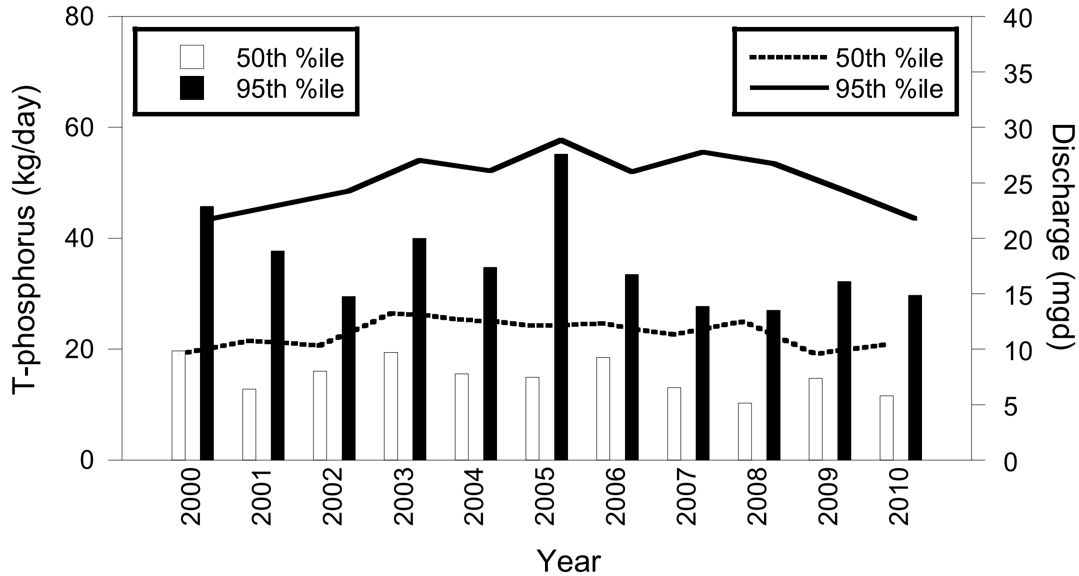

Figure 30. Annual total phosphorus loadings for the City of Lima WWTP from 2000-2010.

Lima Refining Company (Husky Refinery) (2IG00001)

A major industrial facility which discharges at RM 37.1 to the Ottawa River via Outfall 001, the Lima Refining Company produces a variety of products from crude oil including gasoline, diesel fuel, jet fuel, liquid propane gas, coke, benzene, toluene and trolumen (oxidized asphalt). Process operations include crude distillation, crude desalting, fluid catalytic cracking, hydrocracking, delayed coking and catalytic reforming.

The process operations performed at this facility are classified by the Standard Industrial Classification (SIC) code 2911, “Petroleum Refining”. Discharges resulting from process operations are therefore subject to Federal Effluent Guideline Limitations for the Petroleum Refining Point Source Category, contained in Chapter 40 of the Code of Federal Regulations, Part 419, and Subpart B – Cracking Subcategory.

The Lima Refinery treatment plant also receives wastewater from an adjacent organic chemical plant. This plant manufactures acrylonitrile, acrylonitrile catalysts, Barex resin, and recovers and purifies acetonitrile and hydrogen cyanide as co-products.

The refinery obtains its potable water from the City of Lima water system. The facility’s process and cooling water is taken from wells or the Bresler Reservoir, which is untreated municipal water.

The total discharge volume from outfall 001 averages approximately 4.3 MGD. The effluent is comprised of process wastewater, cooling tower blowdown, boiler blowdown, sanitary wastewater, tank draw waters from the adjacent oil storage terminal, organic chemical wastewaters from the adjacent chemical plant and storm water. Outfall 002 is an emergency overflow from D-Pond, which is a holding pond for storm water and tank draw waters. This partial bypass is used only when there is no feasible alternative to discharge, as determined by company studies approved by Ohio EPA. The data for the last permit cycle shows that Outfall 002 discharged only two days during that permit cycle. These discharges occurred during a flooding rain event in August 2007 that affected most of Northwest Ohio. The discharge was done according to the no-feasible-alternative procedure and was authorized under the permit.

All flows from outfall 001 are treated by the on-site advanced wastewater treatment facility (AWWT) which has a total treatment flow capacity of 6000 gallons per minute (8.64 MGD). The oily process water, cooling water, boiler water, storm water and tank draw waters are routed to the API/Dissolved Air Flotation separator system before reaching the equalization tank and the AWWT. Waste streams that contain greater than 10 ppm of benzene are collected in a segregated sewer system that is blanketed with nitrogen (Benzene NESHAP sewer). The higher benzene wastewaters flow into a corrugated plate separator to the induced gas flotation unit to the equalization tank and AWWT. The benzene removed in the two separators is incinerated.

Sanitary wastewater from the Lima Refining Company and process water from the chemical plant flow directly to the equalization tank, and then enter the AWWT. The AWWT consists of activated sludge aeration, flocculation, chemical conditioning, gravity thickening, rapid sand filtration and polishing. The solids generated in the AWWT are aerobically digested, flocculated and gravity thickened and processed through a biological belt press. The solids are land-applied.

The Lima Refining Company stores storm water so that it can be run through the treatment plant at a consistent rate whenever possible. The facility has an average storm water flow rate of 365 gpm (0.525 MGD), and has a total storm water impoundment capacity of 5 million gallons (G-tank). The secondary impoundment is a pond with a capacity of 19 million gallons (D-pond). The storm water is gradually fed back into the AWWT at approximately 1000 gpm (1.44 MGD). Any overflows are discharged via outfall 002. Outfall 002 had only two days of overflow during July 2005-August 2010. These were associated with severe flooding that occurred throughout northwest Ohio in August 2007.

DMR data were reviewed for the period 2006 to 2010. The facility experienced persistent ammonia nitrogen violations of both concentration and loading limits in May 2006, but no problems since then. Selenium monthly average violations were documented in five months each during 2007 and 2008, once in March, 2009 and in March and April 2010. Chronic toxicity limits for both *Ceriodaphnia* and *Pimephales* were exceeded in January 2006 and just the *Pimephales* in April 2008. There was also one violation each of total suspended solids in March 2006 and free cyanide in April 2007.

From July 2005 to July 2010, the facility conducted 21 acute and 21 chronic toxicity tests on effluent from outfall 001. The Ohio EPA also conducted an acute screening bioassay on April 28, 2009 and the effluents were not acutely toxic. The results of all these tests indicate that the refinery effluent does not exhibit acute toxicity however, effluent exceeded chronic toxicity for both daphnia and fathead minnows in January 2006 and for minnows in April 2008.

Pollutant loadings from the Lima Refining Company between 1999 and 2010 were evaluated and annual statistics for selenium, total phosphorus, ammonia and total dissolved solids loadings are displayed in Figures 31, 32 and 33. The spike in selenium load shown in 2007 was likely due to a new source of crude oil with higher selenium content. The facility pilot tested a selenium removal system and installed a full scale system in 2008 after it proved to be effective. The downward trend in ammonia load since 2008 may be a fringe benefit of the selenium removal unit.

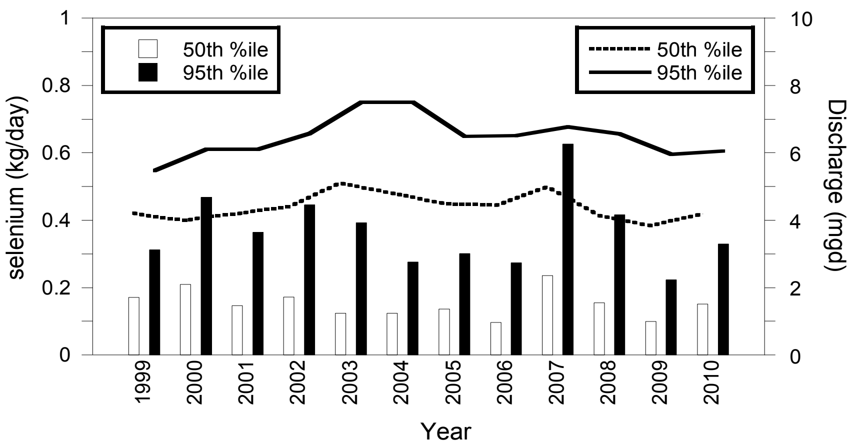

Figure 31. Annual selenium loadings for the Lima Refining Company from 1999-2010.

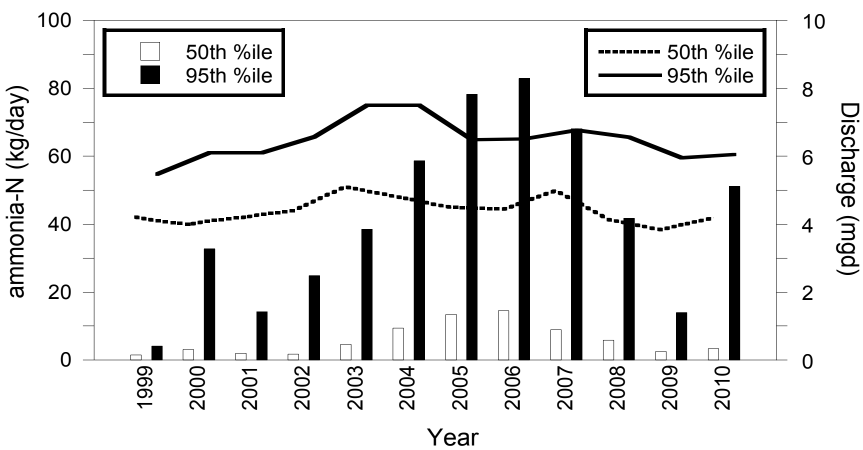

Figure 32. Annual ammonia-N loadings for the Lima Refining Company from 1999-2010.

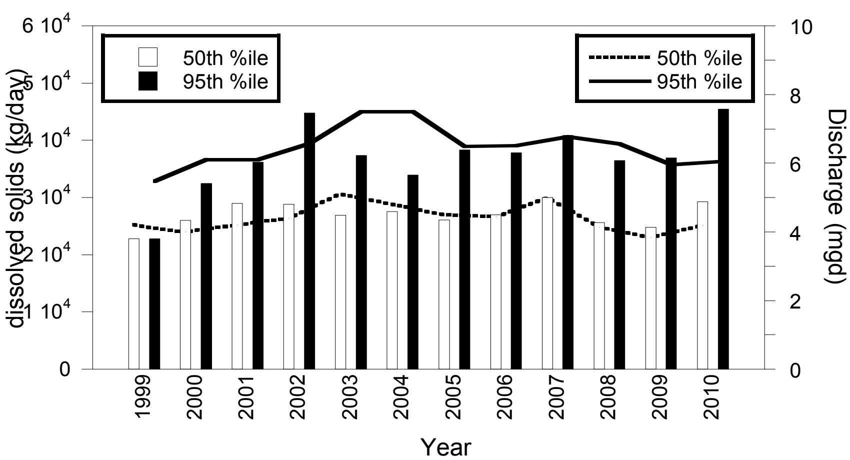

Figure 33. Annual total dissolved solids loadings for the Lima Refining Company from 1999-2010.

PCS Nitrogen (2IF00004)

A major discharger, PCS Nitrogen has four outfalls that discharge to the Ottawa River at river mile (RM) 36.9. PCS Nitrogen manufactures ammonia and several other products that use ammonia as a raw material. Ammonia, urea, nitric acid, ammonium nitrate, and nitrogen fertilizer solutions are manufactured at the Lima facility. In addition, carbon dioxide is produced as a co-product of ammonia manufacturing, and is processed by BOC Gas, Inc.

The process operations at PCS Nitrogen are classified under the Standard Industrial Classification (SIC) categories SIC 2873 (nitrogenous fertilizers) and SIC 2819 (industrial inorganic chemicals, not elsewhere classified). The process wastewaters generated from these operations are regulated under the multiple subparts in the Code of Federal Regulations (40 CFR), Part 418, “Fertilizer Manufacturing Point Source Category”.

On an adjacent property, Ineous USA LLC manufactures acrylonitrile, acrylonitrile catalyst, butanediol, Barex resin, and recovers and purifies acetonitrile and hydrogen cyanide as co-products of acrylonitrile manufacturing. Process wastewaters from these facilities are routed to treatment systems at the Husky Lima Refinery, which are covered under Ohio EPA Permit Number 2IG00001. Non-contact cooling waters from Ineous USA LLC are discharged under the PCS Nitrogen permit at outfall 001.

The facility obtains its water from three sources. The City of Lima provides potable water and untreated reservoir water. PCS Nitrogen also obtains water from wells.

Outfall 001 consists of process wastewater from the facility’s fertilizer production, non-contact cooling water, cooling tower blowdown, steam generator blowdown, and storm water. Non-contact cooling water, cooling tower blowdown, and steam generator blowdown from the adjacent BP Chemicals plant mix with treated process wastewater from PCS Nitrogen and discharge through PCS Nitrogen’s outfall 001. The process and storm water discharged from outfall 001 is treated using ammonia stripping and ion exchange. The non-contact cooling water, cooling tower blowdown and steam generator blowdown undergo neutralization and sedimentation prior to being discharged through outfall 001. The discharge from the process wastewater treatment system is monitored at internal station 603. Compliance with the applicable federal effluent guidelines for this facility is required at station 603.

Outfalls 002, 003, and 004 discharge storm water from the facility site. The majority of storm water which is discharged from these outfalls is collected in storage ponds and treated through an ion exchange unit and then recycled. Sanitary wastewater is pretreated prior to being sent to the Lima Refinery wastewater treatment facilities.

Discharge Monitoring Report (DMR) data were reviewed for the period 2005 to 2010. Since 2005, the PCS Nitrogen facility has reported relatively few sample results which were violations of permit limits. The majority of the pH violations (four violations of the pH minimum limit and four violations of the maximum limit) occurred in 2005 while violations for total residual oxidants (seven violations) occurred in 2007, 2009 and 2010. There were also seven violations for ammonia.

PCS Nitrogen conducted five acute toxicity tests from 2006 through 2009. The March 16, 2009 test resulted in 16.7 percent mortality for fathead minnows for one of the grab samples, while the April 27, 2009 composite test showed 5 percent mortality for daphnia. The other tests conducted by PCS Nitrogen showed no evidence of toxicity.

Ohio EPA conducted screening bioassays in 2009, with the March test resulting in acute toxicity for both species based upon one of the grab samples (the composite sample showed toxicity for only fathead minnows) and the April test resulting in no evidence of toxicity. The tests conducted in 2009 by PCS Nitrogen were based upon splitting the samples collected by Ohio EPA.

Pollutant loadings from the PCS Nitrogen facility between 1996 and 2010 were evaluated using the PEQ application. Annual statistics for ammonia, nitrate and total phosphorus loadings are displayed in Figures 34, 35, and 36. The plant discharged a fairly consistent level of nutrients during the evaluation period, although nitrate does show a slight decreasing trend since the early 2000s. No known process changes have been done during this time frame and it’s not likely that the storm water pond added in 2007 would have an impact. The improvement may likely be the results of more efficient operation of the treatment system.

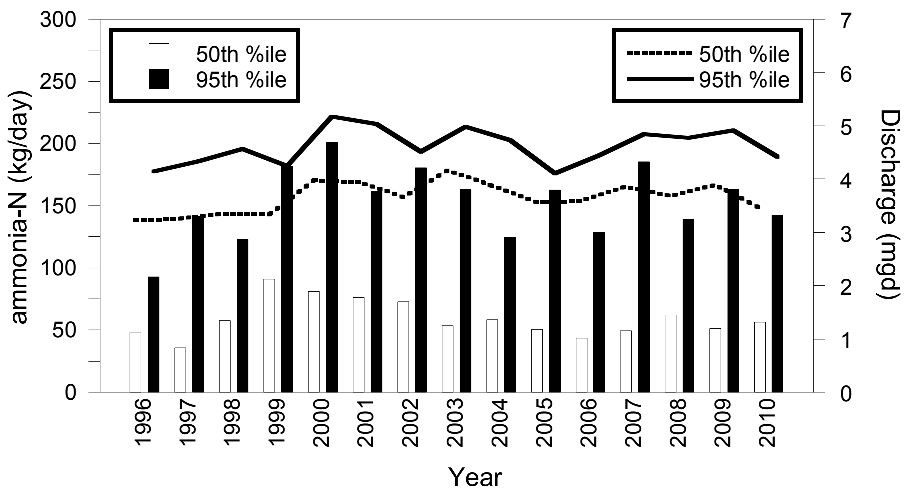

Figure 34. Annual ammonia-N loadings for PCS Nitrogen from 1996-2010.

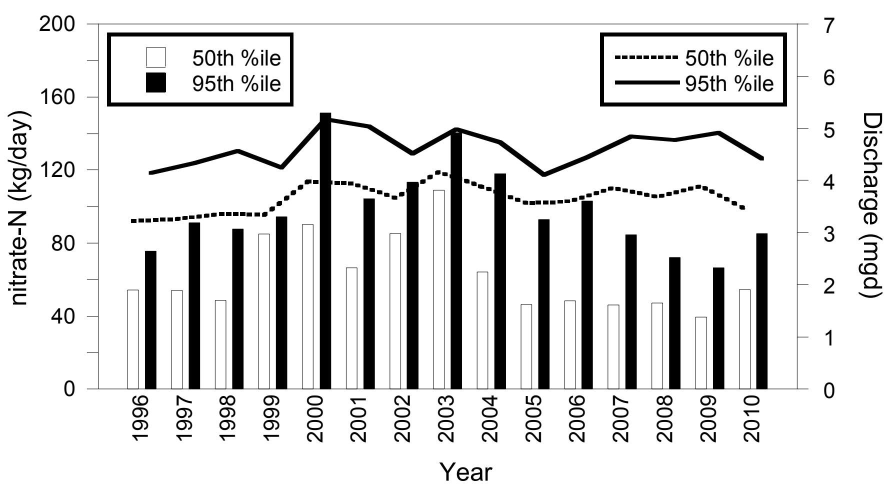

Figure 35. Annual nitrate+nitrite loadings for PCS Nitrogen from 1996-2010.

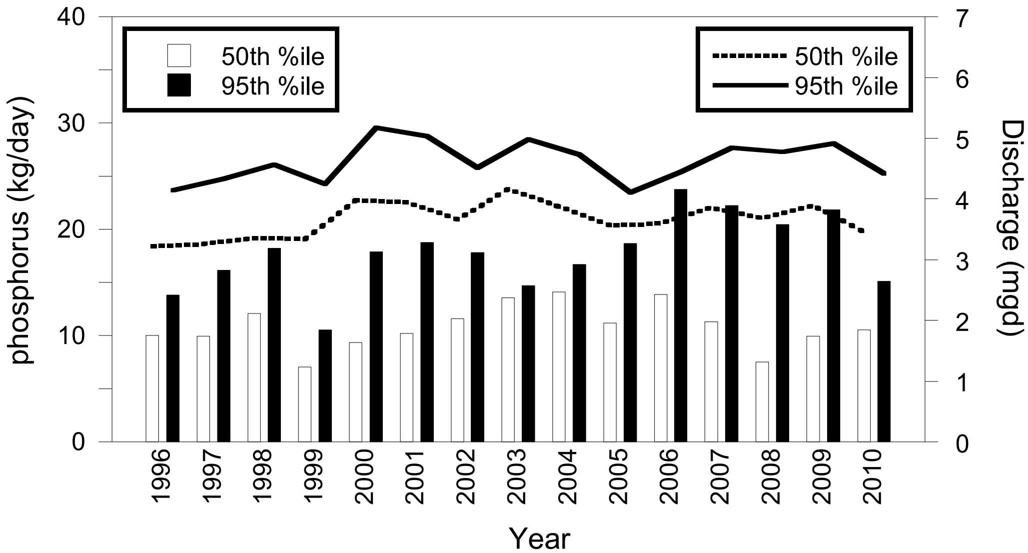

Figure 36. Annual total phosphorus loadings for PCS Nitrogen from 1996-2010.

Shawnee #2 WWTP (2PK00002)

A major municipal discharger to the Ottawa River at RM 32.5, the Shawnee #2 WWTP is designed to treat an average daily flow of 2.0 MGD. The sequencing batch reactor plant replaced the original facility and was constructed in 1994. There have been no major modifications to the plant since that time. Treatment plant processes include bar screening, comminuting, sequencing batch reactors, alum addition, chlorination, de-chlorination, and post-aeration.

Sludge is processed with aerobic digestion, gravity belt thickening, and ultimately disposed by land application and transfer to another WWTP.

The collection system, which serves a population of 9,000 in Shawnee Township, consists of 100 percent separate sanitary sewers. The estimated inflow and infiltration rate is 0.5 MGD. The water supply sources for the service area are residential wells and a surface water reservoir. There are no industrial users which discharge into the collection system, and the County does not operate an industrial pretreatment program for this system

In 2005, Director's Findings and Orders (F&Os) were issued to address SSOs continuing to occur in the collection system. The permittee has submitted a System Evaluation Capacity Assurance Plan (SECAP) to satisfy a requirement of the F&Os. As part of the plan to eliminate SSOs, the SECAP includes proposals to expand and upgrade the WWTP and also construct interceptor sewers within the collection system. There are six SSOs in the collection system. The F&Os requires all SSOs to be eliminated by December 31, 2015. Overflows range in quantity and volume from nine events totaling 470,000 gallons up to 328 events of over 141.8 million gallons reported from 2006 through September 2010. The trend has been toward lower volume and number of overflow events since 2006.

Facility DMRs from 2006 through September 2010 were reviewed and Shawnee #2 WWTP reported a total of only six sample results which violated permit limits. Three ammonia samples in 2007 and one in 2008 exceeded permit limits, while one phosphorus sample exceeded limits in 2008. The total residual chlorine limit was exceeded once in 2010.

Allen County conducted eight effluent toxicity tests at the Shawnee #2 WWTP during 2005 and 2006, and Ohio EPA conducted two acute tests in September and October 2008. One acute test conducted by the County was above the detection level. Given the magnitude of this test result and because all the other tests were below detection, Ohio EPA believes that the test result for fathead minnows on August 19, 2005 was not representative of effluent quality.

Pollutant loadings from the Shawnee #2 WWTP between 1996 and 2010 were evaluated using the PEQ application. Annual statistics for ammonia, nitrate+nitrite and total phosphorus loadings are displayed in Figures 37, 38, and 39. The plant discharged a consistent level of nutrients during the evaluation period. Ammonia loads increased in 2007, but have trended downward since. The ammonia spike was likely caused by problems experienced with the decanter in 2007 and the sequencing batch reactor mixing pumps in 2008. Both issues have been corrected.

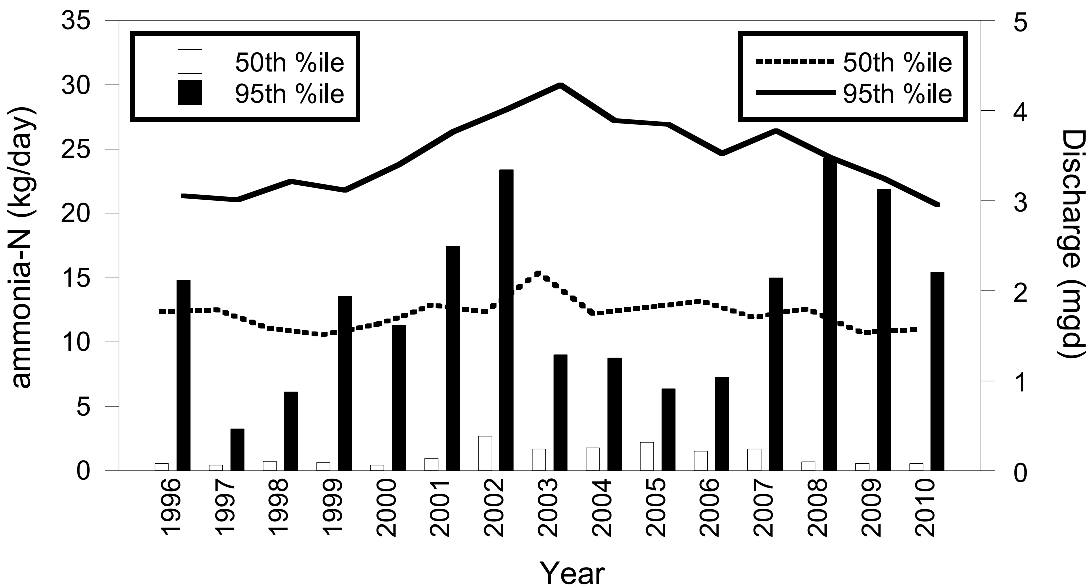

Figure 37. Annual ammonia-N loadings for Shawnee #2 WWTP from 1996-2010.

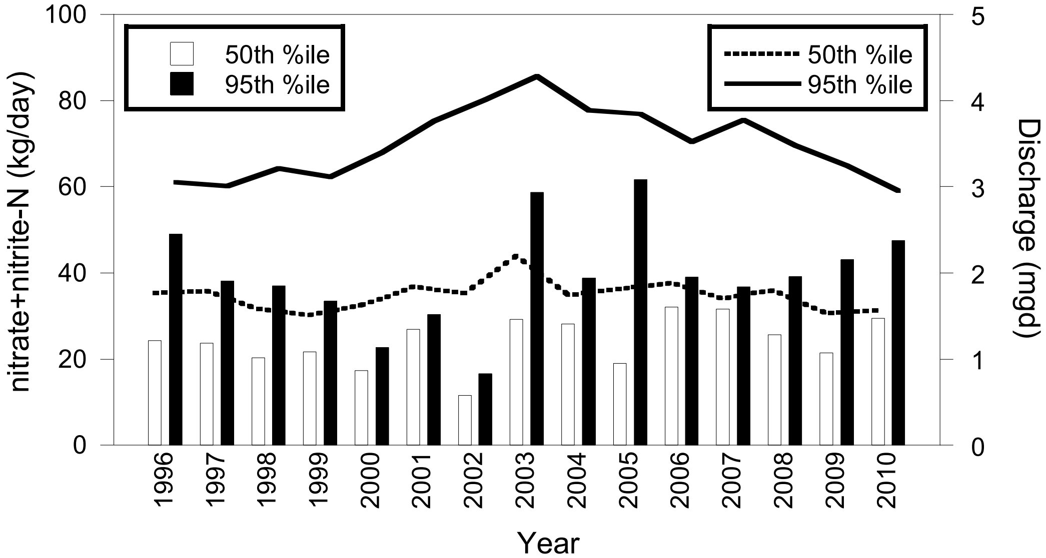

Figure 38. Annual nitrate+nitrite loadings for Shawnee #2 WWTP from 1996-2010.

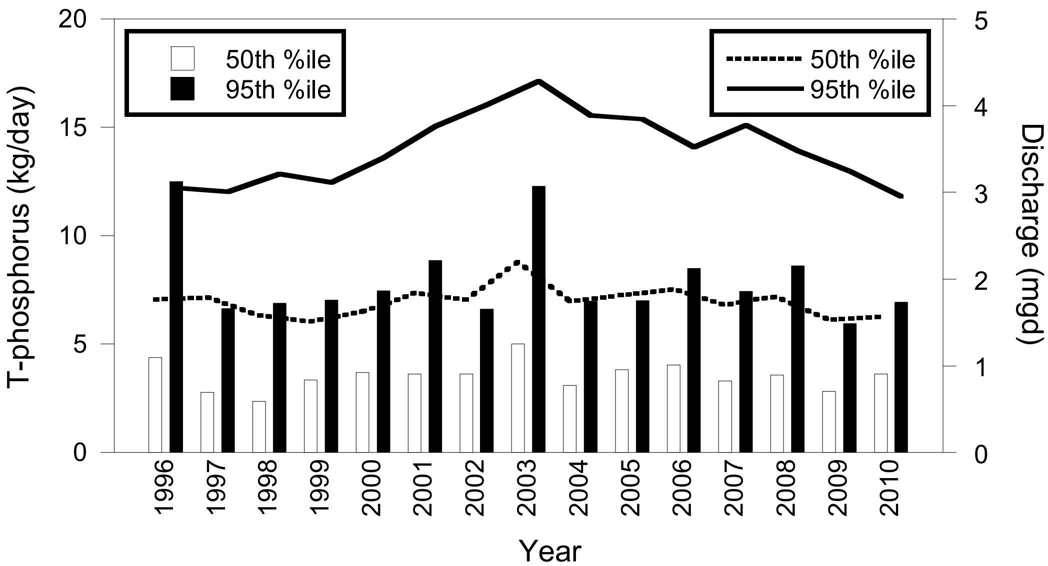

Figure 39. Annual total phosphorus loadings for Shawnee #2 WWTP from 1996-2010.

Village Of Ada WWTP (2PB00050)

This facility was built in 1955 and discharges to Grass Creek at RM 2.4. It has a design flow of 0.82 MGD and consists of grit removal, comminuting, primary settling, activated sludge, biological nitrification (trickling filters), final clarification, chlorination and dechlorination which was installed in 1999. Sludge is handled in anaerobic and aerobic digesters, dewatered on drying beds and land applied. The collection system is 100% separate sanitary sewers and there are no overflows from the sewers or the pump stations.

Facility DMRs from 2005 through 2010 were evaluated. The plant has been operating at influent rates above the design flow for several years and this has led to significant and persistent violations of daily and monthly average ammonia nitrogen permit limits over the six year period. Ammonia nitrogen summer and winter average load limit violations were reported during seven months in 2010, the 30 day average for suspended solids was exceeded in March and May, and the chlorine residual was high on several days in June and August 2010. The renewal permit issued in August 2010 has a compliance schedule which requires the Village to conduct a plant performance evaluation to achieve compliance with final effluent limitations, specifically ammonia nitrogen.

Village of Lafayette (2PA00049)

This facility was built in 1981 and discharges to Little Hog Creek at RM 0.85. It has a design flow of 0.1 MGD and consists of a bar screen and comminutor, followed by an activated sludge plant with final settling, fixed media clarifiers and chlorination. Dechlorination facilities were added in 1998. Further treatment plant improvements in 2003 allowed the plant to more consistently meet ammonia limits and the effluent polishing pond was taken out of active service. Sludge is handled in an aerobic digester, two drying beds and land applied or land filled. The collection system is 100 percent separate sanitary sewers with no overflows or pump station bypasses.

Facility DMRs from 2005 to 2010 were evaluated. Although the plant continued to experience ammonia nitrogen violations during summer 2005, the frequency tapered over the next couple of years and there has been only one monthly average ammonia violation since January 2009. High chlorine residual was a consistent problem in May 2007 and throughout the entire summer of 2008, coupled with monthly average fecal coliform violations from June through October 2008. Total suspended solids and cBOD5 load violations began to occur in 2008 and continued on a sporadic basis through the summer of 2010.

Village of Cridersville WWTP (2PB00048)

This facility was constructed in 1983 with a current design flow of 0.8 MGD, and the plant discharges to an unnamed tributary (RM 4.68) to Little Ottawa River at RM 0.90. The activated sludge treatment system consists of a bar screen and comminutor, primary settling tanks, aeration tanks, final settling in one clarifier and two polishing lagoons with chlorine disinfection and dechlorination. In 2009, a permit to install was issued for improvements to the plant that included new positive displacement blowers for both aeration tanks, two sludge holding tanks and a sludge belt filter press. Final sludge disposal is at the landfill. Prior to these upgrades, sludge was aerobically digested and land applied to farm fields. The aerobic digester was converted back to an aeration tank. The collection system is 100% separate sanitary sewers with no overflows or pump station bypasses.

Facility DMRs from 2005 to 2010 were evaluated. The plant experienced frequent and sometimes significant load limit violations for total suspended solids and ammonia nitrogen between January 2005 and July 2007. In December 2007, March 2008 and October 2008, the total recoverable copper loading or concentration limits were exceeded each month. There were a total of eight exceedances of permit limits for dissolved oxygen, fecal coliform, oil and grease, pH and low level mercury from January 2009 through June 2010.

American Bath WWTP (2PH00007)

The American Bath WWTP was completely replaced in 1996 and serves eastern American Township, western Bath Township and the Village of Cairo. The plant has a design flow of 1.5

MGD, a peak hydraulic capacity of 4 MGD and the effluent discharges to Pike Run at RM 8.2. The current system includes mechanical bar screening, phosphorus removal by alum addition, oxidation ditch aeration, final settling and ultraviolet disinfection. Sludge is aerobically digested, dewatered in a gravity belt thickener, and land applied at agronomic rates. The American Bath WWTP collection system is 100% separate sewers and there are no industrial users discharging to the wastewater treatment system.

The Ohio EPA conducted two bioassay tests on the plant's final effluent on March 28 and April 26, 2008. The effluents were not acutely toxic and no mortality or other adverse effects were exhibited in the Pike Run receiving stream waters or plant effluents.

Facility DMRs from 2005 to 2010 were evaluated and there was only one total suspended solids load violation in February 2008. Compliance has been consistent since the plant was completely replaced in 1996.

American #2 WWTP (2PH00006)

The plant has a design flow of 1.2 MGD and discharges to Dug Run at RM 3.1. A completely new WWTP was placed online in April 2008. The treatment process now consists of bar screens, comminutor, alum addition, sequencing batch reactors with cannibal interchange tanks for the sludge transfer/feed process and ultraviolet disinfection. Sludge is aerobically digested, and land applied or hauled to another plant. The plant is served by a 100% separate sanitary sewer system.

Facility DMRs from 2006 to 2010 were evaluated. Prior to the new plant coming on line, the permit limits were only exceeded three times in May 2006 (fecal coliform), July 2006 (oil and grease) and December 2007 (cBOD5). During plant start-up for the new sequencing batch reactor system, there were numerous permit violations of cBOD5, suspended solids and ammonia nitrogen between March and November 2008. Once the plant was adjusted, the only violations have been of the phosphorus seven day loading limit in February 2009 and phosphorus seven day concentration limit in July 2009.

Village of Elida WWTP (2PB00046)

This facility has a design flow of 0.5 MGD and discharges to the Ottawa River at RM 24.2. The facility was built in 1966 and the treatment process includes comminutor, alum addition to remove phosphorus, primary settling, trickling filter, final clarifier and disinfection. A storm water equalization basin was constructed in 1993 and the final clarifier was replaced in 2002 when ultraviolet disinfection was also installed to replace the chlorination system. Sludge is treated with aerobic digestion and drying beds, followed by land application. The collection system is comprised of 100 percent separate sanitary sewers, with no overflows or pump station bypasses.

Facility DMRs from 2006 to 2010 were evaluated. The facility had monthly average loading limit violations of total suspended solids in January and April 2007 and February 2008. The cBOD5 monthly average loading limits were exceeded in January 2007 and during December 2007 through April 2008 and then again in January and March 2009.

Village of Columbus Grove WWTP (2PC00004)

The facility was constructed in 1934 and last upgraded in 2000. The plant has a design flow of 0.820 MGD and discharges to Plum Creek at RM 12.80, which flows into the Ottawa River at RM 2.67. The treatment process consists of grit removal, primary settling, trickling filters, final clarifiers, chlorination and dechlorination. Sludge is pumped to a holding tank, dewatered on the repaired sand filter beds and then transported to the landfill. The facility continues to provide poor treatment and is in need of major renovations. Improvements to the WWTP began in the fall of 2011 and are now in operation. The improvements included the construction of a head works building including a mechanical fine screen and a vortex grit removal system, replacement of sludge pumps and trickling filter recirculation pumps, a new chemical building with flow proportional disinfection equipment, replacement of both trickling filter rotary distributors, and repairs to the sludge sand drying beds. However, the facility has been in significant non-compliance (SNC) for *E. coli* for the last quarter of 2012 and has ongoing issues with mercury. As part of the general plan process control measurements will be performed before and after the trickling filters to evaluate if additional treatment will be needed.

In addition, until the sewers are completely separated, the WWTP will likely continue to be hydraulically overloaded at the plant during precipitation events which will create treatment issues. The collection system is made up of 80% combined sanitary sewer with only 20% separated. There are four overflows in the combined portion of the sewer system. The village has an approved long term control plan that will eliminate CSOs through complete sewer separation by 2018. Phase one of sewer separation was completed in 2012. Three more phases of separation are yet to be completed.

Facility DMRs from 2006 to 2010 were evaluated. Numerous permit limit violations for multiple parameters including pH, ammonia nitrogen, cBOD5, suspended solids and fecal coliform were noted throughout the period 2006 through 2008. There were also sporadic exceedances of the monthly average for lead, cadmium and hexavalent chromium. The frequency and persistence of ammonia and cBOD5 concentration violations increased during 2009 and 2010, especially during summer months. Fecal coliform limits were consistently exceeded throughout the summer of 2009.

Village of Kalida WWTP (2PA00047)

This facility was constructed in 1981 with a design flow of 0.20 MGD and discharges to the Ottawa River at RM 2.65. The treatment process consists of a series of two aerated lagoons and one settling lagoon with a continuous discharge. An ultraviolet disinfection system was installed in 1993. The sanitary sewer system in Kalida is 100% separated with no overflow or lift station bypass. There is one categorical industrial discharger, Unverferth Manufacturing, which is regulated by an indirect discharge permit, 2PD00084.

Facility DMRs from 2006 to 2010 were evaluated. The plant had relatively few problems throughout the 5 year reporting period. The monthly average concentration for cBOD5 violations occurred in May and June 2007 and the average fecal coliform limit was exceeded in October 2007. There were some minor pH exceedances in July 2008 and one weekly loading violation in March 2009.

Chemical Water Quality

Surface water grab samples were collected from the Ottawa River watershed at 76 locations five times between June 8 and August 19, 2010. Monthly grab water samples were also collected at six sentinel sites within the watershed from June 8, 2010 through September 15, 2011. Sampling locations were established in free-flowing sections of the streams and were primarily collected from bridge crossings.

A United States Geological Survey (USGS) gage station is located on the Ottawa River just upstream of the Lima WWTP and was used to show flow trends for the summer of 2010 (Figure 40). Dates when chemistry and biology samples were collected in the Ottawa River watershed are noted on the graph. Flow conditions during the 2010 sampling season fell below the historical monthly median flows beginning in mid-July and were consistently below the 7Q10 threshold for drought conditions from late August through September.

Surface water samples were analyzed for metals, nutrients, bacteria, suspended and dissolved solids, semi-volatile organic compounds, volatile organic compounds and pesticides (Appendices A, and C). Parameters which exceeded Ohio WQS criteria are reported in Table 6. Bacteriological samples were collected from 20 locations and the results are reported in the Recreation Use Section.

Semi-volatile organic compound (SVOC) analyses were conducted two times on water samples collected from five locations on the mainstem. In addition, volatile organic compound (VOC) samples were collected one time at the same five locations. Bis(2-ethyl)hexylphthalate was the only SVOC compound detected in the first sampling event at the Ft. Amanda Road site. Phthalates are commonly detected in urban areas because they are used to manufacture plastic materials. All other analyses for SVOC compounds were reported as not detected in both sampling events. Chloroform, a VOC, was detected in samples at three sites between the Lima WWTP and Shawnee Road, and bromodichloromethane, another VOC, was only detected at the site immediately downstream of Lima WWTP. These compounds are disinfection byproducts and are commonly detected where chlorine is used in wastewater treatment.
Herbicide samples were collected once at the public drinking water intake near Metzger Road. Four herbicides were detected, but only Atrazine exceeded the public water supply maximum contaminant level of 3.0 µg/l (Table 6). Atrazine is a common agricultural herbicide. Metals were measured at 26 locations, with 17 parameters tested. Exceedances of selenium were found in the Ottawa River mainstream downstream of the Husky Lima Refining Company discharge and Shawnee Road (Table 6). No other metals exceedances were observed in the Ottawa River basin (Appendix A).

Datasonde™ studies on July 28 and September 15 indicated eight locations on the Ottawa River mainstem with DO swings that exceeded the reasonable potential to affect aquatic life (7.0 mg/l). Results for the Ottawa River mainstem are displayed in Figure 41 and Table 7. Parameters that did not meet WQS criteria during the 2010 assessment are listed below in Table 6.

Datasonde™ studies in selected tributaries recorded values below the minimum and average DO criteria for Plum Creek. Hog Creek showed a DO swing with a range greater than 7.0 mg/l. Although Sugar Creek had multiple low DO episodes in the headwaters and lower nine miles, the July study did not reveal a DO swing range greater than 7.0 mg/l and the lower 18 miles were in full attainment of WWH criteria.

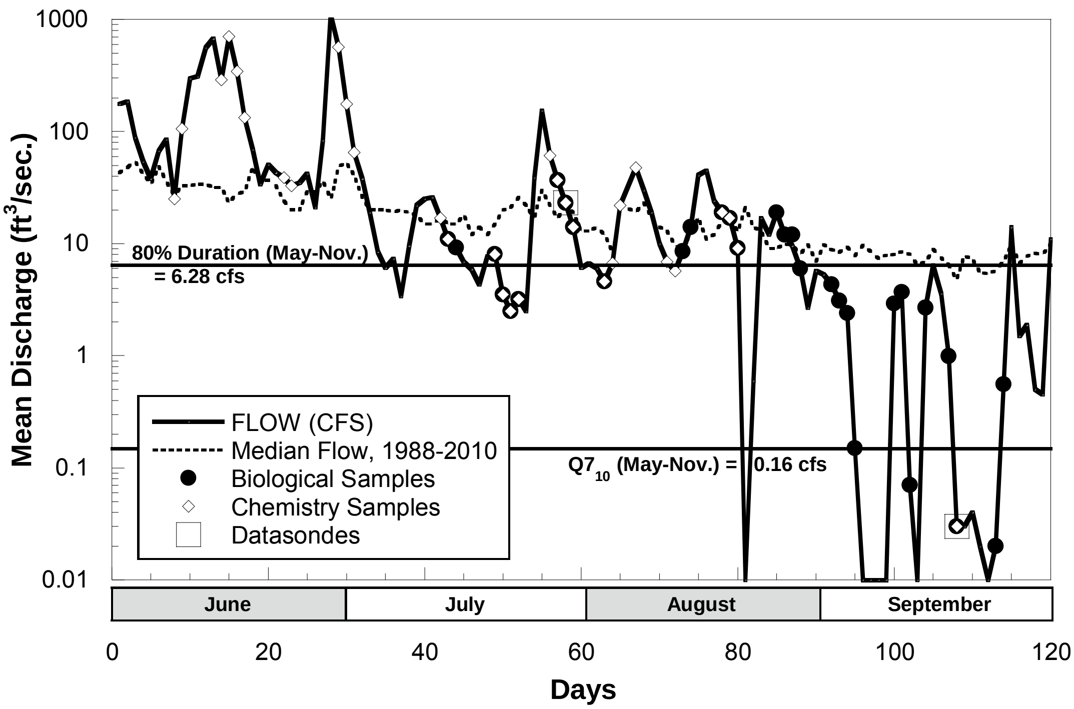

Figure 40. Flow hydrograph for the Ottawa River during June through September, 2010.

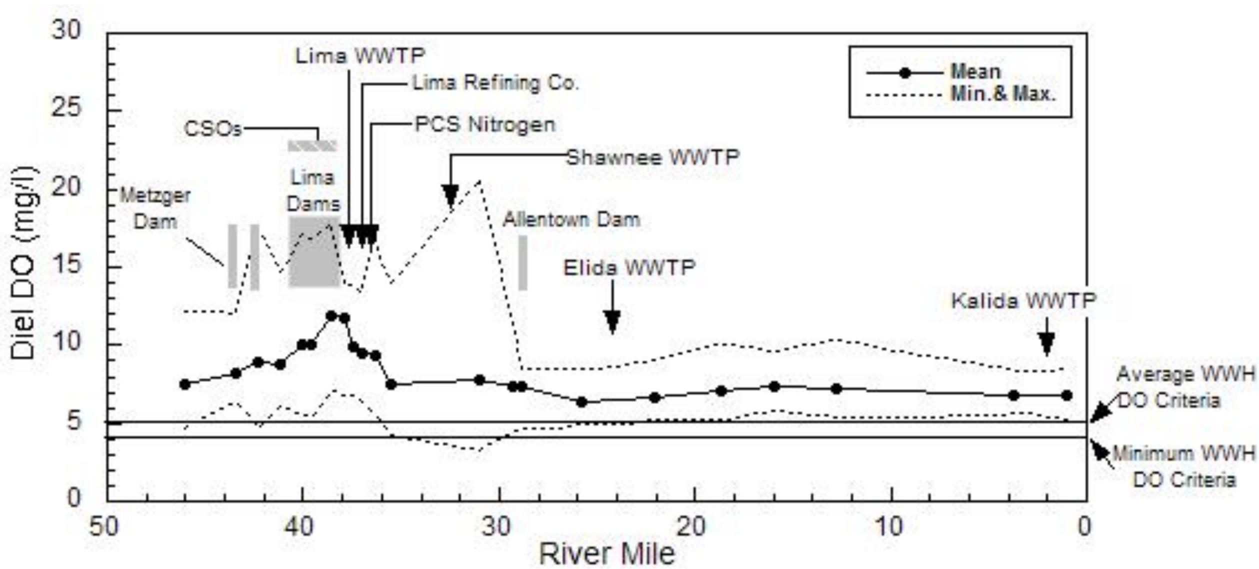

Figure 41. Longitudinal mean, maximum, and minimum diel DO concentrations from continuous monitoring units for the Ottawa River from July 23-25, 2010. Solid horizontal lines represent average and minimum WWH DO criteria, 5 and 4 mg/l, respectively.

Table 6. Exceedances of Ohio Water Quality Standards criteria (OAC3745-1) for chemical/physical parameters measured in the Ottawa River watershed, 2010. Bacteria exceedances are presented in the Recreation Use section. Data is evaluated for both the existing use and recommended use where applicable. Number of samples (N) is five unless indicated.

Location with River Mile (RM)	Parameter (value – mg/l unless noted)
WWH sites in the Ottawa River watershed	
Ottawa River @ Thayer Rd (RM 45.97)	pH (SU) – 9.09[1] (N=6)
Ottawa River @ Dst Metzger Dam (RM 43.45)	pH (SU) – 9.36[1] (N=6), Nitrate-nitrite – 21.9[3], Iron – 1960, 685, 353, 722, 904[3] , Atrazine – 3.38 ug/l[3] (N=1)
Ottawa River @ Roush Rd (RM 42.30)	Dissolved oxygen (mg/l) – 4.93[1] (N=6), Nitrate-nitrite – 12.0[3], Iron – 1600, 389, 668, 475[3]
Ottawa River @ Collett St (RM 38.63)	Dissolved oxygen (mg/l) – 4.53[1] (N=6)
Ottawa River @ Dst Lima WWTP (RM 37.47)	Ammonia – 5.41[1]
Ottawa River @ Dst Husky Refinery (RM 37.00)	Ammonia – 2.81[1], Selenium – 5.9[1] ug/l, Temp (ºC)-27.81[1] (N=6)
Ottawa River Adj. Ft. Amanda Rd (RM 36.3)	Ammonia – 1.79[1]
Ottawa River @ Shawnee Rd (RM 35.44)	Ammonia (mg/l) – 3.16[1], 0.67[1], (N=7), Selenium – 5.5[1], 6.5[1] ug/l
UT to Hog Creek @ RM 13.71 at TR 50 (RM 0.52)	Dissolved Oxygen - 3.96[2], 2.71[2], 4.02[1]
Lord Ditch @ CR 50 (RM 1.2	Dissolved Oxygen – 3.86[2], 3.63[2]
Fitzhugh Ditch @ CR 75 (RM 0.4)	Dissolved Oxygen – 4.85[1], 4.76[1], 4.56[1], 4.60[1], 3.19[2]
Grass Creek @ CR 44 upst Ada WWTP (RM2.57)	Ammonia – 0.56[1]
Grass Creek @ CR 65 dst Ada WWTP (RM 1.24)	Ammonia – 0.876[1]
Mud Run @ Bentley Rd (RM 0.65)	Dissolved Oxygen – 3.76[2]
Hog Creek @ Peevee Rd (RM 3.8)	Ammonia – 0.25[1]
Hog Creek @ Swaney Rd (RM 0.27)	pH (SU) – 9.07[1], Ammonia 0.13[1]
Honey Run @ Cremean Rd (RM 3.58)	Dissolved Oxygen – 4.05[1], 4.98[1]
Honey Run @ Wapak Rd (RM 0.9)	Dissolved Oxygen – 4.29[1], 4.01[1]
Leatherwood Ditch @ TR 19 (RM 0.48)	Dissolved Oxygen – 4.23[1]
Beaver Run @ Bussert Rd (RM 0.51)	Dissolved Oxygen – 4.32[1]
Sugar Creek @ Napoleon Rd (RM 26.03)	Dissolved Oxygen – 4.24[1]
Sugar Creek @ Thayer Rd (RM 23.85)	Dissolved Oxygen – 4.70[1]
Sugar Creek @ Stewart Rd (RM 20.05	Dissolved Oxygen – 4.98[1]

Location with River Mile (RM)	Parameter (value – mg/l unless noted)
Sugar Creek @ SR 115 (RM 9.27)	Dissolved Oxygen – 4.03[1], 4.92[1]
Sugar Creek @ CR Q (RM 3.51)	Dissolved Oxygen – 4.41[1]
Sugar Creek @ CR 16-O (RM 0.64)	Dissolved Oxygen – 4.56[1], 4.42[1]
Rattlesnake Creek @ Hofferbert Rd (RM 1.74)	Dissolved Oxygen – 3.91[2]
Plum Creek @ TR 11-R (RM 14.92)	Dissolved Oxygen – 3.91[2]
Plum Creek @ TR 11 (RM 12.14)	Dissolved Oxygen – 3.05[2], Ammonia – 7.92[1]
Plum Creek @ SR 114 (RM 0.19)	Dissolved Oxygen – 4.62[1], 4.60[1]
Sycamore Creek @ Searfoss Rd (RM 0.65)	Dissolved Oxygen – 4.88[1]
UT to Plum Creek @ TR O (RM 0.41)	Dissolved Oxygen – 4.17[1], 4.28[1]
UT to Ottawa River @ TR M-17 (RM 0.33)	Dissolved Oxygen – 3.96[2]
MWH Sites in the Ottawa River watershed	
Hog Creek @ TR 85 (RM 13.42)	Dissolved Oxygen – 3.53[1], 3.01[1], 3.69[1]
UT to Hog Creek @ TR 50 (RM 0.52)	Dissolved Oxygen – 3.96[1], 2.71[2]
Hog Creek @ CR 65 (RM 10.77)	Dissolved Oxygen – 3.98[1]
Hog Creek @ TR 25 (RM6.67)	Dissolved Oxygen – 4.45[1]
Fitzhugh Ditch @ CR 75 (RM 0.4)	Dissolved Oxygen – 3.19[1]
Rattlesnake Creek @ Hofferbert Rd (RM 1.74)	Dissolved Oxygen – 3.91[1]
Plum Creek @ TR 11 (RM 12.14)	Dissolved Oxygen – 3.05[1], Ammonia – 7.92

1 Exceedance of the aquatic life Outside Mixing Zone Average water quality criterion (below **24 hour** average for D.O).
2 Exceedance of the aquatic life Outside Mixing Zone Maximum water quality criterion (below minimum for DO).
3 Exceedance of the Human Health drinking water and non-drinking water criterion.

Table 7. Summary of hourly dissolved oxygen measurements (mg/L) recorded by automatic meters deployed in the Ottawa River on July 28 and September 15, 2010. Values highlighted in bold indicate either a violation of the outside mixing zone 24 hr. average criterion (5.0), outside mixing zone minimum criterion (4.0) or a range that exceeds reasonable potential to affect aquatic life (7.0).

River Mile	Mean		Median		Minimum		Maximum		Range	
	7/28	9/15	7/28	9/15	7/28	9/15	7/28	9/15	7/28	9/15
04100007 03 06: Ottawa River below Little Hog Creek to above Little Ottawa River										
45.97	7.74	6.81	6.60	6.47	5.34	5.02	12.12	9.25	6.78	4.23
43.45	7.95		7.98		6.57		9.87		3.30	
42.30	9.56	7.25	7.37	6.59	5.41	5.37	17.43	10.56	**12.02**	5.19
41.16	8.47	7.70	8.29	7.46	6.94	6.32	10.51	9.80	3.57	3.48
40.04	10.06	10.70	9.02	10.33	5.79	6.91	16.21	15.05	**10.42**	**8.14**
38.63	11.87	**4.73**	10.94	4.25	5.42	**3.58**	19.61	7.06	**14.19**	3.48
37.91	11.47	6.77	11.31	5.79	8.03	4.75	15.95	10.35	**7.92**	5.60
37.47	9.90		9.70		7.73		12.52		4.79	
37.00	9.48	7.71	9.06	7.62	6.84	7.11	13.14	8.41	6.30	1.30
36.30	9.73	7.03	8.32	6.17	6.00	5.35	16.97	10.40	**10.97**	5.05
35.44	7.96	6.43	6.82	6.03	4.75	4.99	14.02	8.86	**9.27**	3.87
04100007 04 03: Ottawa River below Little Ottawa River to below Dug Run										
34.30		7.21		7.08		4.95		10.09		5.14
32.60		7.75		7.09		5.74		10.79		5.05
31.03	9.03	7.55	6.22	7.19	**3.71**	6.10	20.69	9.61	**16.98**	3.51
30.12		7.81		7.43		6.37		10.03		3.66
29.26	7.54	8.03	6.20	7.64	4.59	6.28	11.40	11.08	6.81	4.80
28.85	7.20	8.03	6.11	7.60	4.89	6.37	10.23	10.76	5.34	4.39
25.75	6.18	7.76	5.94	7.47	4.93	6.44	8.12	9.41	3.19	2.97
04100007 04 06: Ottawa River below Dug Run to above Sugar Creek										
22.14	6.84		6.37		5.49		9.06		3.57	
18.68	7.16	9.02	6.68	8.56	5.48	6.11	10.08	12.89	4.60	6.78

Table 13. (cont.)										
River Mile	Mean		Median		Minimum		Maximum		Range	
	7/28	9/15	7/28	9/15	7/28	9/15	7/28	9/15	7/28	9/15
15.98	7.50		6.98		6.02		9.65		3.63	
12.75	7.33	8.75	6.75	8.49	5.72	5.93	10.34	12.38	4.62	6.45
River Mile	Mean		Median		Minimum		Maximum		Range	
	7/28	9/15	7/28	9/15	7/28	9/15	7/28	9/15	7/28	9/15
04100007 05 03: Ottawa River below Sugar Creek to Auglaize River										
5.60	7.00		6.70		6.17		8.43		2.26	
0.96	6.77		6.70		5.76		8.12		2.36	

Upper Ottawa River (HUC 04100007-03)

The Ottawa River mainstem was generally free of water quality standards exceedances along the 46 mile stretch from Thayer Road to the mouth. There were a couple of elevated pH values and two low dissolved oxygen readings between Thayer Road and the Collett Street dam pool at RM 38. In the zone between RMs 37.5 and 35.5, from Lima WWTP to Shawnee Road, there were multiple sites with selenium and/or ammonia exceedances. The City of Lima reported an ammonia upset at their WWTP over a period of several days in July that was detected in stream samples that were collected on July 21, 2010 (Tables 6 and 7).

The land use in the upper Ottawa River hydrologic unit area speaks directly to the condition and health of the streams. In the headwaters of Hog Creek, agricultural production is only possible due to the network of artificially drained fields. Small streams have been extensively channelized to support the tile and ditch drainage system, which contributes to nutrient and sediment runoff. The lack of riparian shade led to sustained low DO levels in Hog Creek and some headwater tributaries. Low head dams through the city prevent flow movement which exacerbates nutrient enrichment and adds to low dissolved oxygen stress on aquatic life (Tables 6 and 7).

Elevated nutrient concentrations are typically associated with either farming, animal husbandry or the treatment of wastewater. The Ottawa River between Thayer Road and the Lima WWTP exhibited only occasional exceedances of the total phosphorus and nitrate-nitrite benchmark values. However, an increased frequency of elevated values for both nutrients was noted beginning downstream of the Lima CSOs and WWTP discharge. This trend persisted all the way to the mouth of the river near Kalida. Total phosphorus never dropped below 0.22 mg/l and nitrate-nitrite levels remained around 3.0 mg/l, although the aquatic life use recovered to full attainment of WWH criteria near RM 25.8 at Piquad Road (Appendix A). Longitudinal displays of results for ammonia, total phosphorus and nitrate+nitrite are shown for the Ottawa River mainstem in Figures 42-46 below.

In the upper tributaries of the Ottawa River, particularly in the smaller headwater streams and maintained ditches of the watershed, there were numerous sites with DO values that fell below the level needed for the protection of the designated WWH ALU (average of 5.0 mg/l and minimum of 4.0 mg/l). Even in Fitzhugh Ditch and the unnamed tributary of Hog Creek, which will be recommended for the MWH use designation (average of 4.0 mg/l and minimum of 3.0 mg/l), there were DO readings below 4.0 mg/l. Grass Creek and Hog Creek each had one ammonia exceedance during the survey. The predominant agricultural land use in the rural areas upstream and downstream of Lima contributed nutrients which often resulted in the DO issues.

Nutrient levels in some locations were elevated and could be attributed to point source discharges. The Ada WWTP had chronic ammonia exceedances which impacted water quality in Grass Creek. Several medium size livestock operations and failing home septic systems also likely contribute to elevated nutrient levels in Hog Creek. Total phosphorus and nitrate in most of the tributary streams was not elevated to levels that caused biological non-attainment, but there were visual signs of enrichment in the form of algae. Farming activity is more prevalent in the eastern (upper) section of the watershed and several streams lacked any form of riparian or instream habitat and exhibited low DO levels during the late summer.

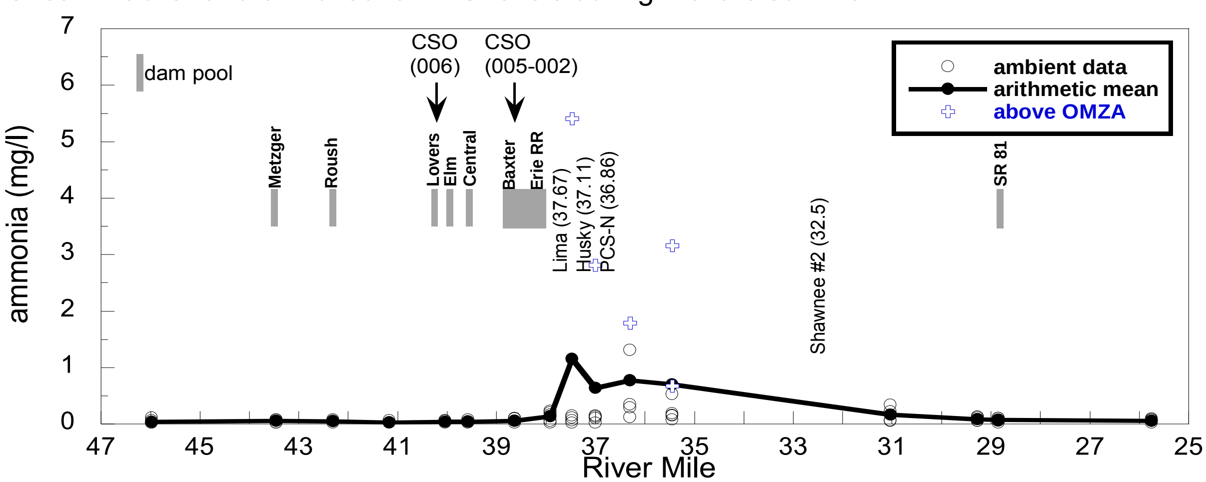

Figure 42. Longitudinal mean ammonia concentrations in ambient samples within the Ottawa River mainstem between Thayer Road and Piquad Road, 2010.

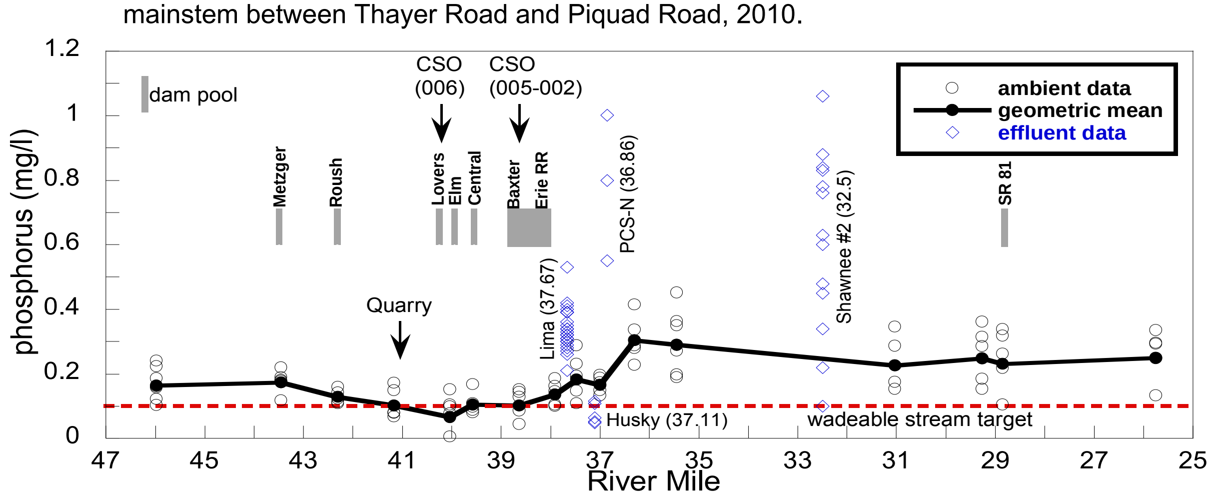

Figure 43. Longitudinal mean phosphorus concentrations in ambient samples within the Ottawa River mainstem between Thayer Road and Piquad Road, 2010.

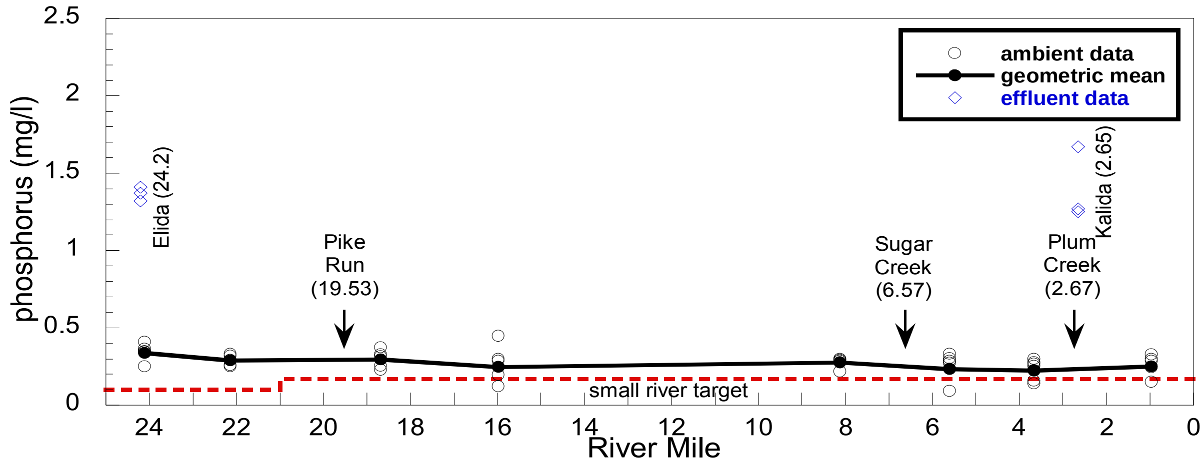

Figure 44. Longitudinal mean phosphorus concentrations in ambient samples within the Ottawa River mainstem from downstream Elida WWTP to the mouth, 2010.

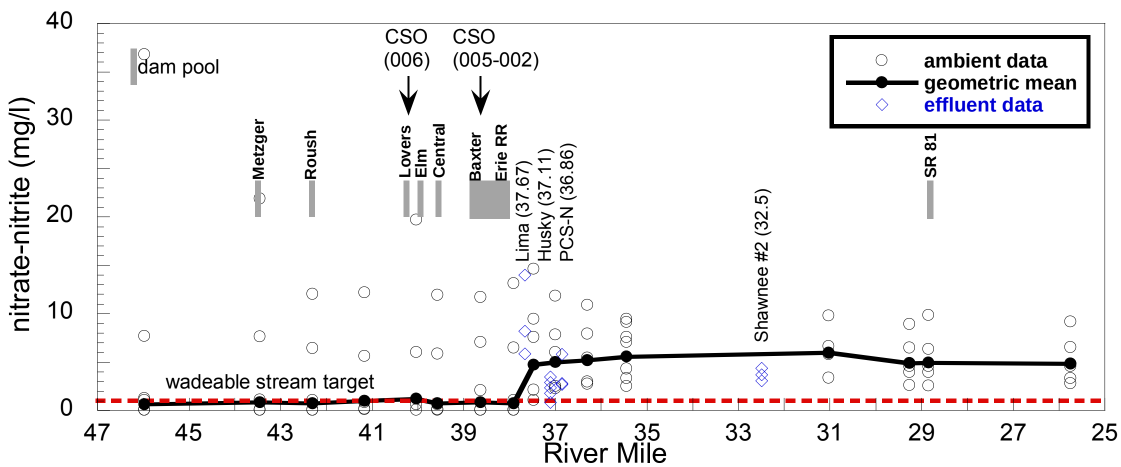

Figure 45. Longitudinal mean nitrate+nitrite concentrations in ambient samples within the Ottawa River mainstem between Thayer Road and Piquad Road, 2010.

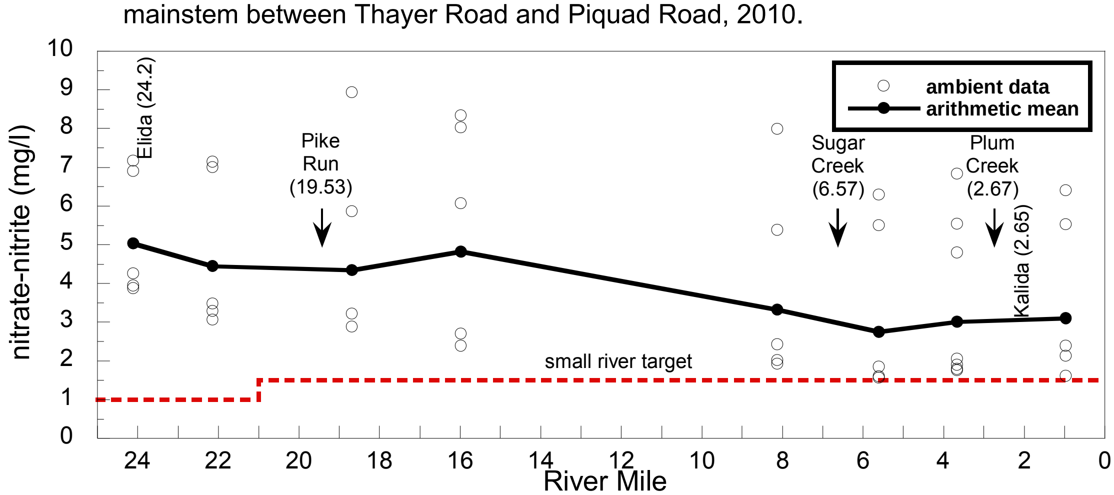

Figure 46. Longitudinal mean nitrate+nitrite concentrations in ambient samples the Ottawa River mainstem, from downstream Elida WWTP to the mouth, 2010.

Middle Ottawa River (HUC 04100007-05)

The mainstem of the Ottawa River leaving Lima carries the signature of industrial and municipal discharges and urban storm water runoff for several miles. Nutrients, total dissolved solids, ammonia and selenium remained elevated most of the way to Kalida, although the number of fish DELTs has greatly diminished since the 1996 survey due to lower concentrations of pollutants and less exceedances of water quality criteria (Table 6).

In the middle tributaries of the Ottawa River, agricultural nutrients and a lack of riparian shade on many streams that are maintained for agricultural drainage led to widespread low dissolved oxygen levels in late summer. Sites on Honey Run, Leatherwood Ditch and Beaver Run had DO values that fell below the level needed for the protection of the designated WWH aquatic life use (average of 5.0 mg/l and minimum of 4.0 mg/l) (Table 6).

Nutrient levels in some locations were elevated and could be attributed to point source discharges. The Cridersville WWTP impacted the water quality in Little Ottawa River. The unsewered community of Rimer and failing home septic systems also likely contribute to elevated nutrient levels in the Ottawa River and tributaries.

Lower Ottawa River 04100007-05

The lower Ottawa River subwatershed is predominantly agricultural land and exhibits the typical problems associated with row crop production and tile drainage practices, however it enjoyed the highest level of aquatic life use attainment for the three 10-digit HUCs in this survey.

In the lower tributaries of the Ottawa River, agricultural nutrients and a lack of riparian shade on some streams that are maintained for agricultural drainage lead to pervasive low dissolved oxygen levels in the warm, dry months of the survey. There were numerous sites on Sugar Creek, with DO values that fell below the level needed for the protection of the designated WWH aquatic life use (average of 5.0 mg/l and minimum of 4.0 mg/l) (Table 6). Even in Rattlesnake Creek, Sycamore Creek and portions of Plum Creek which will be recommended for the MWH use designation (average of 4.0 mg/l and minimum of 3.0 mg/l); there were DO readings below 4.0 mg/l (Table 6). Plum Creek also had one ammonia exceedance during the survey which was collected downstream of the Columbus Grove WWTP and was significantly elevated.

Nutrient levels in some locations were elevated and could be attributed to point source discharges. The Columbus Grove WWTP impacted the water quality in Plum Creek. The unsewered communities of Gomer and Vaughnsville and failing home septic systems also likely contribute to elevated nutrient levels in Pike Run and Sugar Creek respectively.

Chemical Water Quality Trends

Significant water pollution has been identified and investigated on the Ottawa River since the late 19^{th} century. In modern times, multiple state sponsored water quality surveys of the Ottawa River have been under taken at regular intervals since the mid-1950s. In addition to these, and through the same period, pollution problems on the Ottawa River have been the subject of numerous and varied studies performed by non-state actors (scholars, academics and scientific/engineering contractors, etc.). Although vast, a detailed review of this wealth of historical environmental information is well beyond the scope and purposes of this report. However, it is important to note all of the early investigators found the Ottawa River through and downstream from Lima grossly polluted or otherwise profoundly degraded by a combination of municipal and industrial wastes.

Therefore, a very brief summary of the salient findings of these sundry studies will prove both efficient and useful in describing, in general terms, the environmental conditions on the Ottawa River prior to contemporary pollution controls.

Between the 1950 and 1960s, extremely high and toxic concentrations of ammonia were consistently observed downstream from Lima, with peak values from 122 to 136 mg/l, and concentrations between 60-63 mg/l commonly observed (Patrick et al. 1956 and US Department of the Interior 1966). Instream oxygen demand was extremely high, evidenced by both elevated demand parameters and consistently deficient DO. From Lima to the mouth, the Ottawa River DO was typically below 2.0 mg/l, with selected sites at times indicating complete depletion (Ohio Department of Health 1966 and Stuckey and Wentz 1969). Concurrent visual observation and related descriptions were equally compelling as the Ohio Department of Health (1953) found that evidence of industrial discharge was at all times present "in the form of oil slicks, color, and sludge deposits". Stuckey and Wentz (1969) observed, "Oil is much in evidenced in the water, on the water, and along banks" adding that "strong petrochemical and phenolic odors are present over the stream" during summer low flow periods. Numerous published observations made near the turn of the 20th century painted an equally grim picture of the Ottawa at that time, but were obviously not supported by what is now considered the basic suite of modern chemical measures of water quality.

Environmental impacts described above were not limited to the Ottawa River, as reaches of both the Auglaize River and its receiving stream, the Maumee River, were at times similarly affected. Thus, during periods of peak pollution, three major water bodies comprising approximately 112 linear river miles were impacted or otherwise negatively affected to varying degrees by pollutant loads from the suite of major dischargers on the Ottawa River (US Department of the Interior 1966, ODNR 1966).

Through early pollution abatement efforts the maximum impacted area had contracted significantly by the mid-1970s to include the Ottawa River alone, with an incipient recovery evident near the mouth (Ohio EPA 1979). However, water quality through the historically degraded reach downstream from Lima remained extremely poor as the cumulative pollutant load continued to exceed the river's assimilative capacity. Specifically, water quality standards violations for DO, ammonia, chromium, phenols, and surfactants were numerous and regularly observed downstream from all the major facilities near Lima. Localized toxicity associated with the Lima WWTP was also identified, as well as the deleterious effects of pollutant loads derived from Lima's CSOs (Ohio EPA 1979). Improved waste treatment and stricter enforcement attending additional amendments to the Federal Water Pollution Control Act (AKA the Clean Water Act) resulted in additional water quality improvements through the 1980s and into the early 1990s, particularly when compared against the gross pollution identified in the previous decades. Despite the significant improvements achieved during this period of time, substantial pollution problems persisted through and downstream from Lima (USEPA 1984 and Ohio EPA 1992).

To serve the purposes of this report, the assessment of trends in water quality of the Ottawa River will focus primarily on a comparison between the results from the 1996 and 2010 intensive surveys, with selected water column chemistry data from prior field years (1991 and 1989), employed as needed. Data analysis will take several forms including, but not limited, to longitudinal ordination, basic statistical treatments (descriptive and testing), summary of water quality standards violations and exceedances through time, regulatory history, and regional and locale hydrologic and climatic data pertaining to water resources of the study area.

In terms of spatial coverage and station density, both the 1996 and 2010 surveys were by far the most robust. Each of these efforts evaluated the entire 46 plus miles of the Ottawa River mainstem (Thayer Rd. to the mouth) with a high degree of actual or functional correspondence between and among sites. Due to the continuity of effort through time, these data were subjected to basic parametric and non-parametric analysis, to discern gross statistical differences in aggregate water quality between 1996 and 2010. Limited in scope, the 1989 and 1991 results were examined and compared against those from 1996 and 2010, through the historically impacted mainstem river segment between the Erie RR dam/upstream Lima WWTP (RM 37.9) to the Allentown dam pool (RM 28.8).

Data ordination took three basic forms: 1) longitudinal plots of selected water quality parameters for the entire length of the mainstem, 1996-2010, 2) longitudinal plots of selected parameters for the historically impacted reach between Erie RR dam and the Allentown dam pool, 1989-2010, and 3) box plots of the same data set (Lima to Allentown, 1989-2010).

Hydrology and Regional Climate

As surface discharge is among the most significant and consequential of environmental variables affecting nearly every aspect of water quality management, an attempt has been made to gather and collate basic hydrologic and regional climatic metrics to describe and attempt to account for their effects on water quality of the Ottawa River between 1989 and 2010. To that end, a combination of regional and locale measures of precipitation, river discharge, and drought severity for the summer months corresponding to that last four state sponsored water quality surveys of the Ottawa River are presented in Table 8 and Figures 47 and 48.

In general terms, the Ottawa River labored under various stages of drought for the years 1989 and 1991. Monthly discharge of the Ottawa River for both these years were consistently below the monthly averages derived from the period of record. Reasonable correspondence between local discharge and regional measures of drought and precipitation was evident, particularly in 1991. In terms of overall severity and alignment of climatic and hydrological indicators, 1991 was by far the driest of the four survey years. The years 1996 and 2010 shared high flows and regional precipitation above normal in June, but diverged strongly through the remainder of their respective summers. Normal flows and precipitation prevailed through the summer of 1996, while in 2010 drought conditions emerged and worsened as the summer progressed. Through a short period in August and through nearly all of September, the Ottawa River discharge was found below 7Q10, with protracted periods of zero discharge or otherwise having no discernible surface flow. Late summer flows on the Ottawa in 2010 are among the lowest on record.

Table 8. Summary statistics and measures of relative discharge, precipitation, and drought severity of northwest Ohio, and the Ottawa River discharge for 1989, 1991, 1996, and 2010.

Year Month	Palmer Index NW Ohio [a]	Precipitation NW Ohio (% of Normal)[a]	Ottawa R. discharge at Lima (cfs)[b]	Maumee R., discharge at Waterville (% of Normal)[a]	Palmer Index Narrative [a]
2010					
June	-0.1	156	212.3	215	Normal
July	-0.9	77	21	57	Incipient Drought
August	-1.3	62	14	96	Mild Drought
September	-1.4	59	2.5	50	Mild Drought
October	-2.0	45	-	27	Moderate Drought
Average	*-1.1*	*79.8*	*62.4*	*89*	***Mild Drought***
1996					
June	+0.1	118	156.8	453	Normal
July	+0.9	119	62.3	112	Incipient Moist
August	-0.4	51	15.8	265	Normal
September	-0.4	99	15.5	73	Normal
October	+0.4	91	-	99	Normal
Average	*+0.1*	*95.6*	*62.6*	*200.4*	***Normal***
1991					
June	-2.0	28	10.4	238	Moderate Drought
July	-3.3	74	7.58	51	Severe Drought
August	-3.9	123	11.3	107	Severe Drought
September	-4.3	57	10.5	106	Extreme Drought
October	-2.0	248	-	649	Moderate Drought
Average	*-3.1*	*106*	*9.9*	*230.2*	***Severe Drought***
1989					
June	-0.6	110	39.7	480	Incipient Drought
July	-1.3	133	22	125	Mild Drought
August	-1.3	89	12.2	164	Mild Drought
September	-0.9	131	14.5	528	Incipient Drought
October	-0.4	63	-	112	Normal
Average	*-0.9*	*105.2*	*22.1*	*218.8*	***Incipient Drought***

a - ODNR, Division of Water, Monthly Water Reports June-October, 1988, 1991, 1996, and 2010.
b - USGS gauge, Ottawa River at Lima, monthly mean discharge, 1988-2011 (Q7,10 and 80% duration are 0.16 and 6.28, respectively).

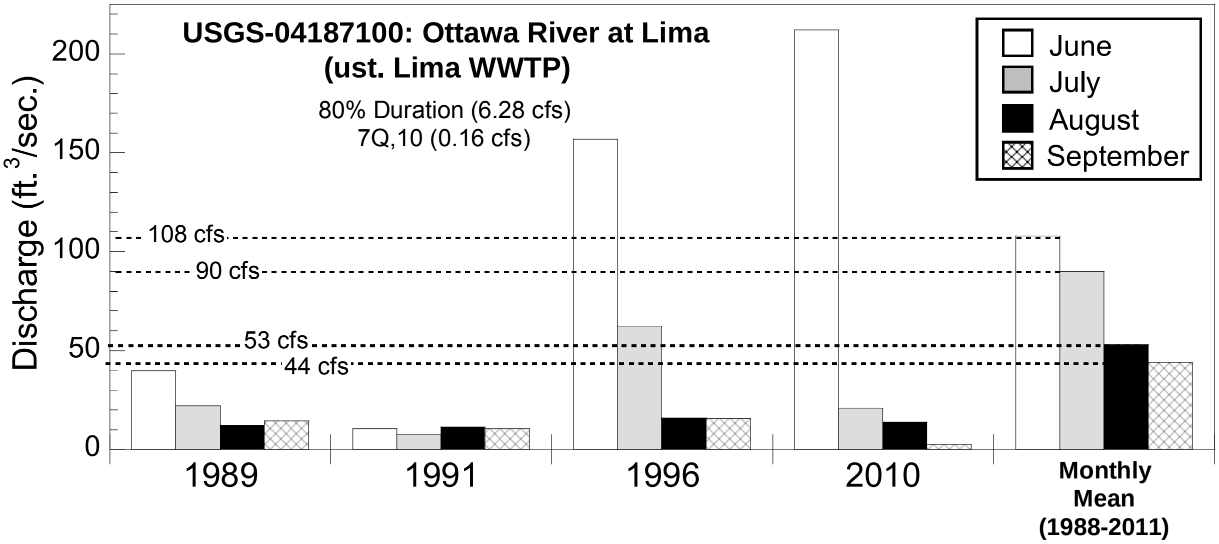

Figure 47. Average monthly discharge, Ottawa River, for the selected years and through the period of record (USGS gauge 14087100).

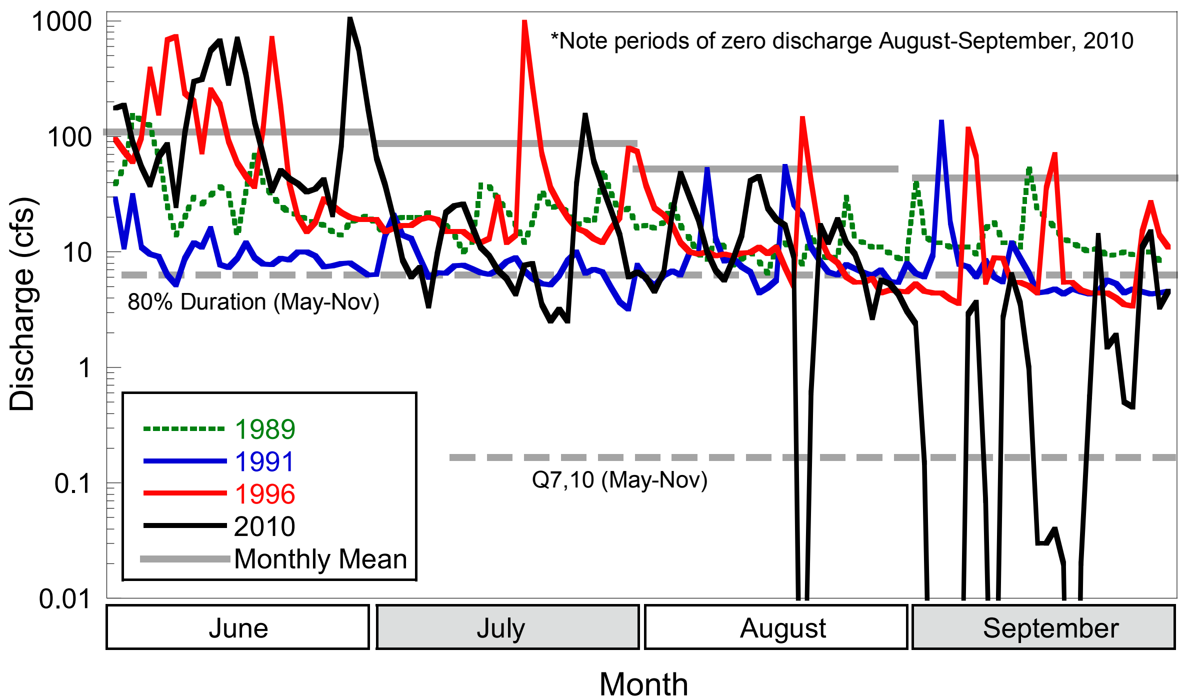

Figure 48. Daily average discharge of the Ottawa River, at Lima, for selected years (USGS gauge 14087100). May-November Q7, 10 and 80% duration are 0.16 and 6.28cfs, respectively.

Dissolved Oxygen and Oxygen Demand

Data for trends in DO and oxygen demand for the Ottawa River were drawn from the results of chemical and physical sampling, part of four integrated water quality surveys undertaken by Ohio EPA between 1989 and 2010. DO data were derived from two methodologies: daytime field measurements made at an associated station during the various survey years (1989-2010) and diel DO monitoring (48-72 hrs.) from selected stations between late-July and mid-August 1991, 1996, and 2010. Five-day Biochemical Oxygen Demand (BOD_5) is no longer a standard Ohio EPA water quality parameter, thus 2010 results are absent from the assessment of trends of oxygen demand.

Based upon daytime field measurements, remarkably few DO criteria exceedances or violations have been observed on the Ottawa River over the past 19 years (Ohio EPA 1991, 1998). Normalized by effort, the frequency of DO criteria excursions declined in recent years: 7.1%, 6.9%, and 1.4% from the survey years, 1991, 1996, and 2010, respectively. Actual violations of the minimum WWH DO criterion (values less than 4 mg/l) were limited to a subset of exceedances from 1991 and 1996.

Statistical analysis of station average DO samples failed to demonstrate a strong and significant difference between 1996 and 2010 results, as both parametric (t-test) and non-parametric (Wilcox-Mann-Whitney Rank Sum) tests yielded t-probabilities and approximated p values greater than 0.05 (Table 9). However, longitudinal ordination of these data clearly indicated important spatial discontinuity. Specifically, these data show an abrupt and strong divergence of ambient DO between these field years through the lower 29 river miles, beginning at the Allentown Dam (Figure 49). Station averages were markedly and consistently greater through this reach in 1996 when compared with 2010 results. Subdivided at the point of divergence (Allentown) and reanalyzed, these data showed a significant difference between 1996 and 2010 through the lower segment (p values<0.002) and no significant difference through the river reach upstream form Allentown (p values>0.05).

The biases and limitations of daytime DO monitoring are, however, brought into stark relief through a comparison of data generated with concurrent diel DO measurements made by continuous monitoring units (i.e., Datasonde). The summer DO regime of any temperate lotic system is centered around a 24 hour period and in general terms, driven by both a persistent oxygen demand associated with the aggregate respiration and oxygen produced by sestonic and attached algae and/or macrophytes during daylight hours. Although a wide range of abiotic and biotic factors can mediate this primary ecological feature, the circadian nature of DO is consistent. As such, diel measurements are far superior and more representative than those resulting from multiple daytime, hand measurements made over the course of a summer.

The diel DO regime of the Ottawa River has been monitored through three survey cycles, 1991, 1996, and 2010. The 2010 effort included the deployment of continuous monitoring units at selected sampling stations through the entire length of the Ottawa River mainstem. With only slight variation, both the 1991 and 1996 efforts were limited to the upper half of the Ottawa River, terminating at Allentown or a few miles downstream at the village of Elida, respectively. As is typical, diel DO monitoring was performed in mid-summer, between late-July and mid-August, for all years, with each unit being deployed between 48 and 72 hours (Figure 50).

Table 9. Statistical comparison of selected water quality parameters of the Ottawa River, 1996 and 2010. Unless otherwise noted, analysis includes entire length of the Ottawa River.

T-Test (parametric)							**Wilcox-Mann-Whitney Rank Sum** (non-parametric)			
Year-Parameter	**Trans.**[a]	**Distrb.**[b]	**No.**	**Mean**[c]	**2SD**[c]	***p***	**50th**	**75th**	**25th**	***p***
2010 DO (mg/l) 1996 DO (mg/l)	Log_{10}	Normal	142 144	7.42 7.96	1.6822 2.2844	*0.0697*	7.37 7.95	8.02 8.57	6.65 7.12	*0.0778*
Upper-2010 DO[d] Upper-1996 DO[d]	Log_{10}	Normal	90 108	7.93 7.55	1.5109 1.4278	*0.338*	7.93 7.7	8.31 8.0	7.45 7.0	*0.4368*
Lower-2010 DO[e] Lower-1996 DO[e]	Log_{10}	Normal	52 36	6.786 9.178	1.091 2.7556	***0.0019***	6.64 8.7	7.04 9.1	6.45 8.6	***0.0026***
2010 NH_3-N (mg/l) 1996 NH_3-N (mg/l)	–	Non-normal	125 144	0.2015 0.1781	0.6199 0.6690	–	0.06 0.05	0.16 0.18	0.05 0.25	*0.3367*
2010 TKN (mg/l) 1996 TKN (mg/l)	Log_{10}	Normal	125 144	1.2179 0.8504	1.0761 1.0854	***0.0024***	1.03 0.72	1.39 1.03	0.83 0.52	***0.0014***
2010 NO_3-N (mg/l) 1996 NO_3-N (mg/l)	Log_{10}	Normal	125 144	5.4763 4.4408	2.7259 3.1869	***0.0105***	5.26 4.28	6.73 5.84	4.53 3.08	***0.0320***
2010 TP (mg/l) 1996 TP (mg/l)	GM, Log_{10}	Normal	125 144	0.2196 0.2263	0.1521 0.2483	*0.3021*	0.24 0.21	0.28 0.27	0.15 0.12	*0.6798*
2010 TDS (mg/l) 1996 TDS (mg/l)	Log_{10}	Normal	149 144	629.70 702.92	299.30 263.45	*0.0625*	593.8 715.5	781 817	516 561	*0.1123*
2010 pH (SU) 1996 pH (SU)	–	Non-normal	142 144	8.0929 7.9721	0.2791 0.4738	–	8.08 8.00	8.21 8.14	7.98 7.79	*0.0627*
2010 Temp. (°C) 1996 Temp. (°C)	–	Non-normal	142 144	24.883 21.844	1.8793 2.5222	–	25.25 21.98	25.6 22.5	24.0 21.1	***<0.0001***
2010 TR Se (ug/l) 1996 TR Se (ug/l)	GM, Log_{10}	Normal	127 144	2.1857 4.5833	2.1742 3.2482	***<0.0001***	2.0 4.33	2.85 5.96	1.17 3.08	***<0.0001***

a - Transformation(s) employed to normalize WQ data: geometric mean (GM), base 10 logarithm, or both.
b - Kolmogorov-Smirnov normality test. If sundry transformations failed to yield normal distribution, parametric test was not attempted.
c - Arithmetic means and standard deviations (SDs) are derived from untransformed data.
d - Analysis exclusive to upper Ottawa River: Thayer Rd. to Allentown.
e - Analysis exclusive to lower Ottawa River: Allentown to mouth.
f – The p values in **bold** were statistically significant at $\leq$ 0.05 and **red** were statistically significantly at $\leq$ 0.01.

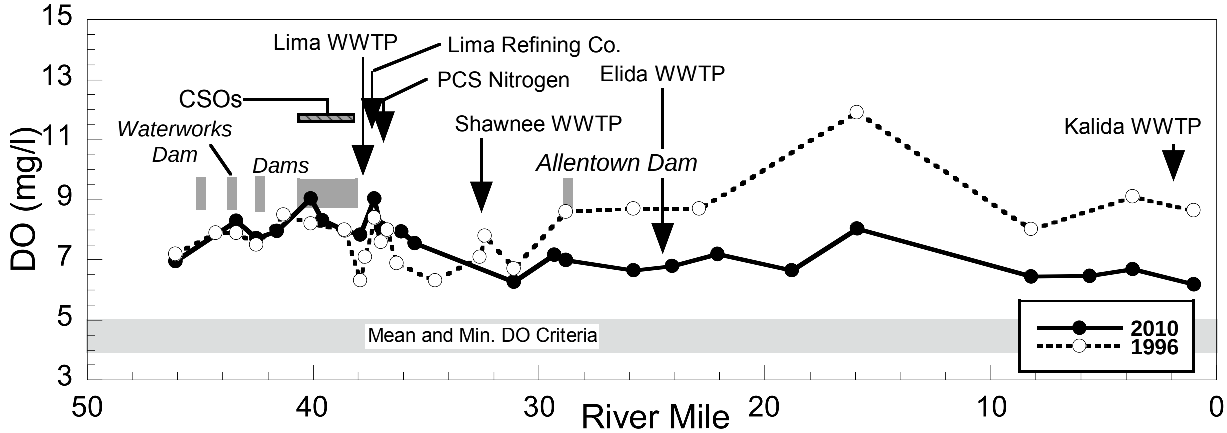

Figure 49. Longitudinal station average DO for Ottawa River, 1996 and 2010.

Upstream from Lima, the DO regime through time appeared controlled by the interplay of nutrient loads from diffuse upstream sources, hydrology, and impoundments, with the added effects of lost surface flow due to municipal water demand. At stations common among the field years, average DO values tended to modestly increases through time, but the spread between minimum and maximum values increased substantially, particularly between 1996 and 2010 (Figure 50). Peak values as high a 14.7 mg/l were observed in 2010, with corresponding lows that included multiple excursions below the average WWH criteria. Even larger diel spreads (12.8 mg/l variation) were documented in 2010 at intervening stations not previously monitored. These results would suggest that instream productivity upstream from Lima was highly stimulated in 2010, and less so in previous years (Figure 50, Table 9).

Downstream from Lima, diel DO monitoring appears to have captured or otherwise described both spatial and temporal shifts of impact types and the restoration of an expected or otherwise normal DO regime through the lower Ottawa River over the past 19 years. Unlike daytime field sampling, mid-summer diel monitoring in 1991 documented numerous violations of the WWH minimum DO criterion, including values as low as 2.3 mg/l observed immediately downstream from Lima's CSOs at the Erie RR dam spillway. In fact, minimum values at five of the seven monitoring stations located between the Erie RR dam spillway (downstream Lima CSOs) and the Allentown dam pool were below 4 mg/l, with mean values typically hovering above the average criterion. These data were indicative of a DO regime still depressed by excessive oxygen demand from the combined waste loads derived from CSOs bypasses, and municipal and industrial sources located on this segment (Figure 50).

The effects of putrescible waste loads from Lima's CSOs appeared reduced in 1996, as the DO regime was much improved immediately downstream from the Erie RR dam spillway (downstream Lima's CSOs). Other stations too showed signs indicative of reduced oxygen demand, as the numerous violations of the WWH minimum DO criterion observed in 1991 were, by and large, replaced with non-violation exceedances of the average criterion in 1996, and in nearly every instance, station averages were greater in 1996 than in 1991 (Figure 50). Maximum values, as well as the DO spread, also increased with increasing distance from Lima, particularly reaches affected by the lessor WWTPs of Shawnee and Elida. The 1996 diel DO monitoring results appeared to portray a transition from a DO regime controlled by oxygen demand (organic enrichment) in 1991, to a DO regime increasingly controlled by stimulated productivity (nutrient enrichment). Although 1996 diel monitoring did not extend much past Elida, an incipient rising DO trajectory was evident. As stated previously, daytime field measurements in 1996 portrayed a marked rise in average DO concentrations beginning just upstream from Elida at Allentown, which persisted through the lower Ottawa River. Considered synoptically (diel and daytime measurements), the rising average DO, as measured by daytime sampling through the lower Ottawa, appeared to represent, albeit imperfectly, far field enrichment effects, resulting from the mineralization of organic forms of nitrogen and phosphorus from Lima and other municipal and industrial sources upstream (Figures 49 and 50).

By 2010, diel monitoring revealed a DO regime downstream from Lima that appeared controlled by highly stimulated instream productivity, suggesting an abatement or significant diminution of the effects of excessive oxygen demand documented in the past. Peak maximum DO values reached a remarkable 20.7 mg/l, with a corresponding DO spread of over 17 mg/l (Figure 50). At sites common to the 1991, 1996, and 2010 monitoring efforts, maximum values were consistently and substantially higher in 2010, with low or minimum values constituting WWH DO exceedances reduced by 25%. In contrast, the DO regime of the lower Ottawa appeared to have recovered and stabilized by 2010. Between Allentown and the mouth, DO concentrations were significantly, but not detrimentally, reduced. Through the lower 29 miles, average values ranged between 6.7 and 7.3 mg/l, with a moderate or otherwise typical diel DO flux ranging between 3.2 and 4.9 mg/l. These values are more characteristic of unimpacted streams of the size and form of the Ottawa River (Figure 50).

Direct measurement of the oxygen demand, through time, supported the interpretation and inferences drawn from the DO data (Figure 51). Although BOD_5 results were not available for 2010, this parameter showed a strong declining trend between 1989 and 1996, for the affected segment of the Ottawa River downstream from Lima (Figures 51 and 52). Diel pH measurements concurrent with diel DO monitoring from 2010 offered an additional line of evidence of the hyper eutrophic conditions between Lima and Allentown, and normal or non-stimulated conditions for the stream reach from Allentown to the mouth. Like DO, pH follows a circadian rhythm in temperate lotic systems, increasing and decreasing with photosynthesis. The pH regime through and downstream from Lima indicated highly stimulated instream productivity (Figure 53). Wide diel pH swings and elevated station averages were evident through this segment, including peak values in violation of the WWH maximum pH criterion (pH>9.0). The pH regime from Allentown to the mouth appeared normal and relatively stable, lacking the wide swings common up river.

In summary, the performance of these data through time portrays significant spatial and temporal shifts in water quality downstream from Lima. In general terms, the Ottawa River labored under the effects of the excessive oxygen demand (organic enrichment), with a corresponding depressed DO regime during the early 1990s. Based upon both direct measurement and inference drawn from the 1996 monitoring results, oxygen demand and its attendant effects were lessoned, but still consequential immediately downstream from Lima, with evidence of stimulated instream productivity (nutrient enrichment) emerging with increasing distance from Lima. Nutrient enrichment through the lower river very likely reflected instream mineralization of organic forms of nitrogen and phosphorus from upstream municipal and industrial sources. By 2010, compelling evidence of excessive loads of oxygen demanding waste immediately downstream from Lima was absent. On the contrary, classic demand related impacts of the past appeared supplanted by hyper eutrophic conditions with related nutrient enrichment near Lima, and the eutrophic conditions identified through the lower Ottawa in 1996 appeared more abated.

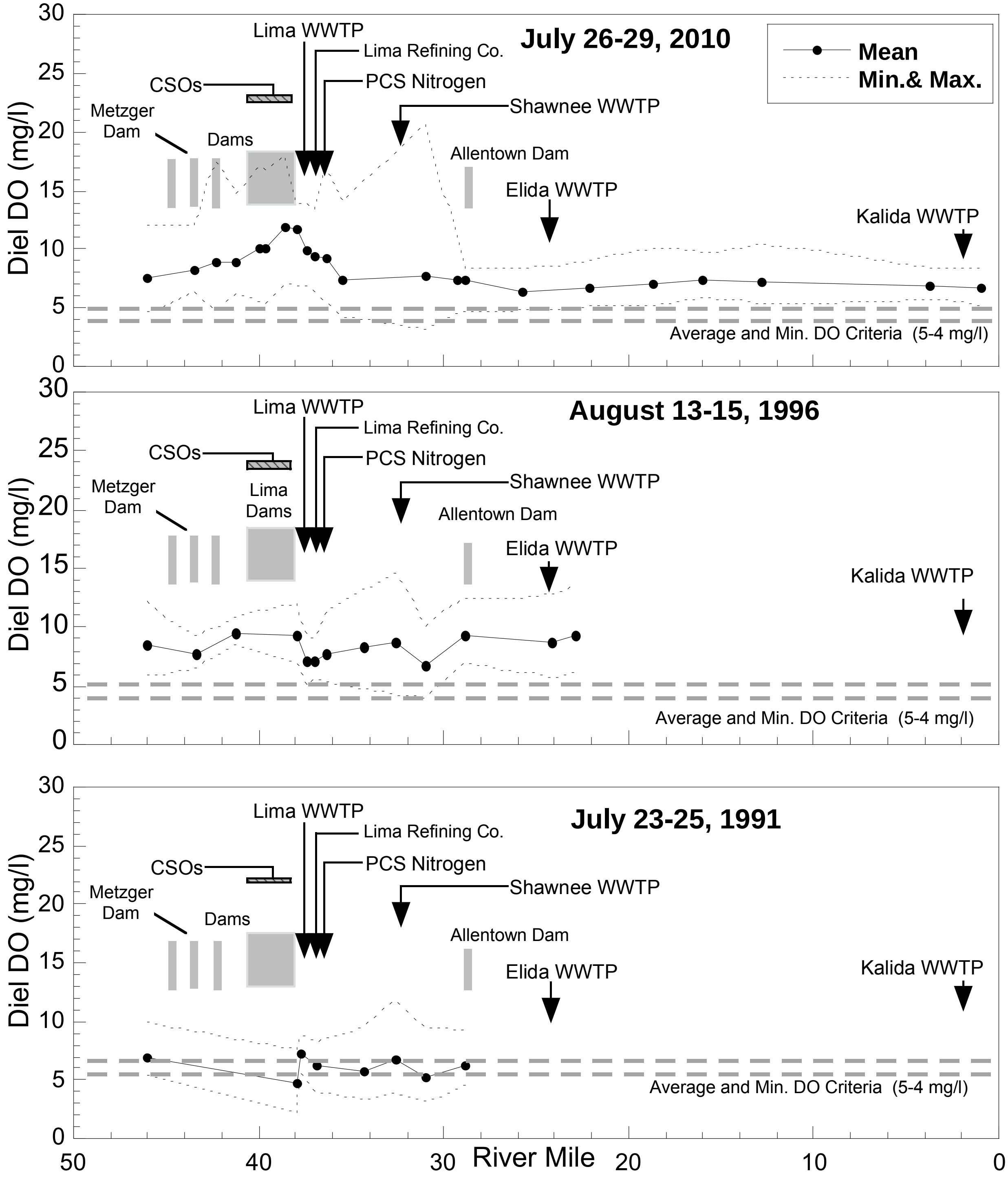

Figure 50. Station average, minimum and maximum DO from continuous monitoring units (Datasonde), Ottawa River: 1991, 1996, and 2010.

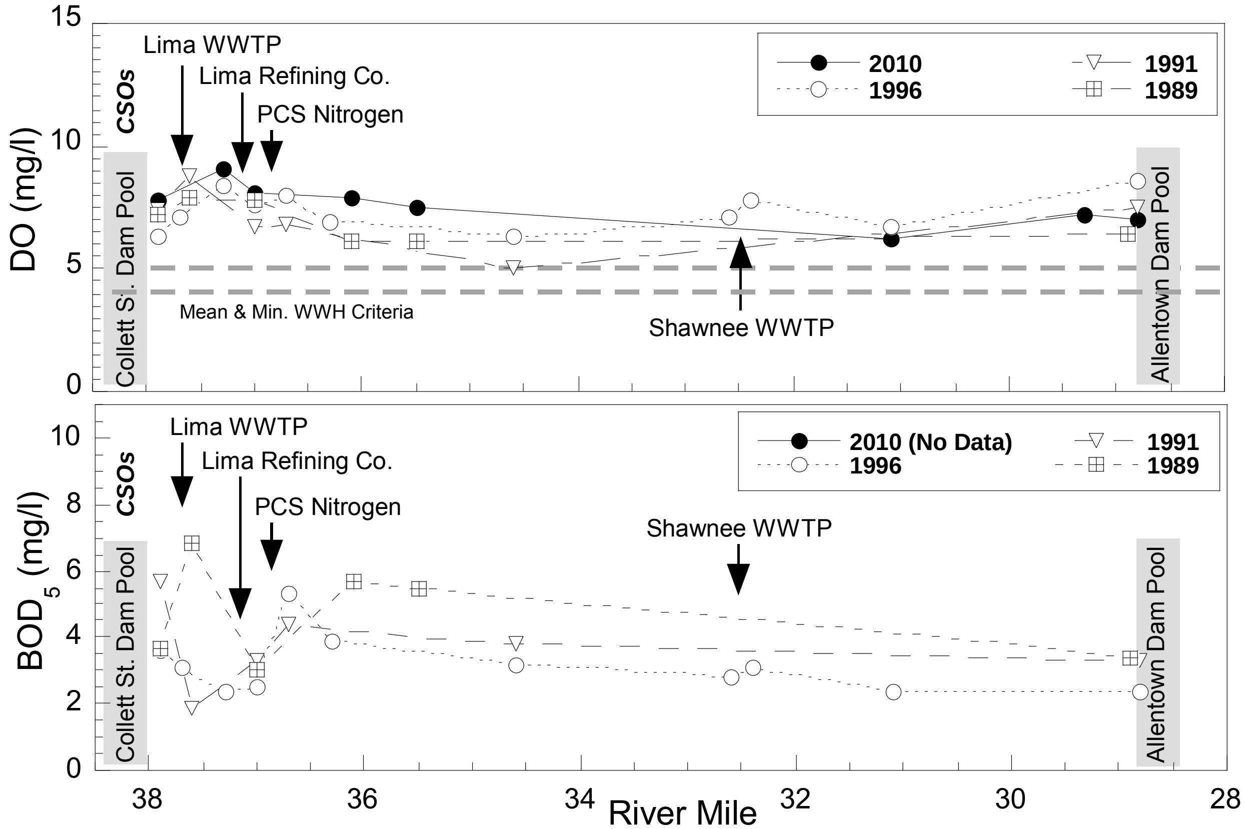

Figure 51. Longitudinal station average DO and BOD_5 through the historically impacted river reach between Erie RR Dam (RM 37.9, upstream Lima WWTP) and the Allentown Dam (RM 28.9) on the Ottawa River, 1989, 1991, 1996, and 2010.

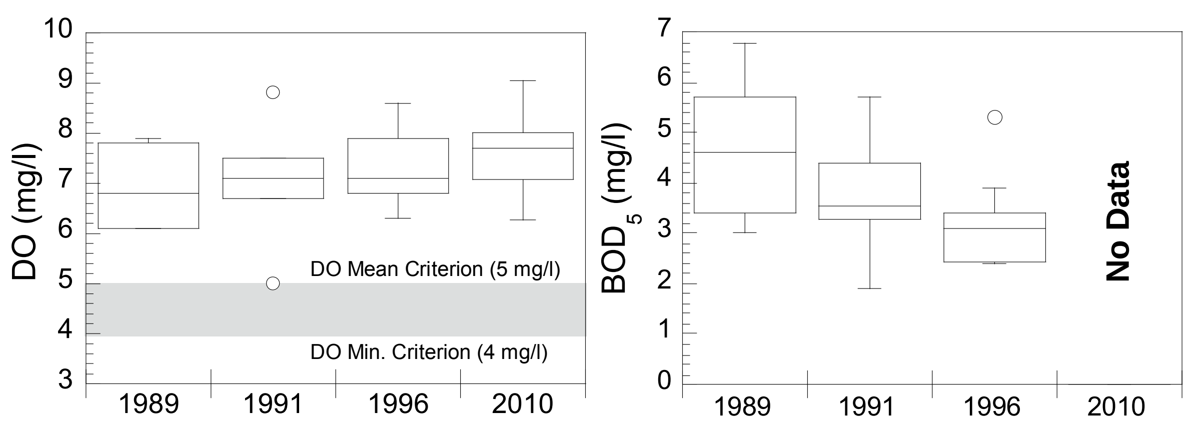

Figure 52. Box plot of DO and BOD_5 through the historically impacted river reach between Erie RR Dam (RM 37.9, upstream Lima WWTP) and the Allentown Dam (RM 28.9), Ottawa River: 1989, 1991, 1996, and 2010.

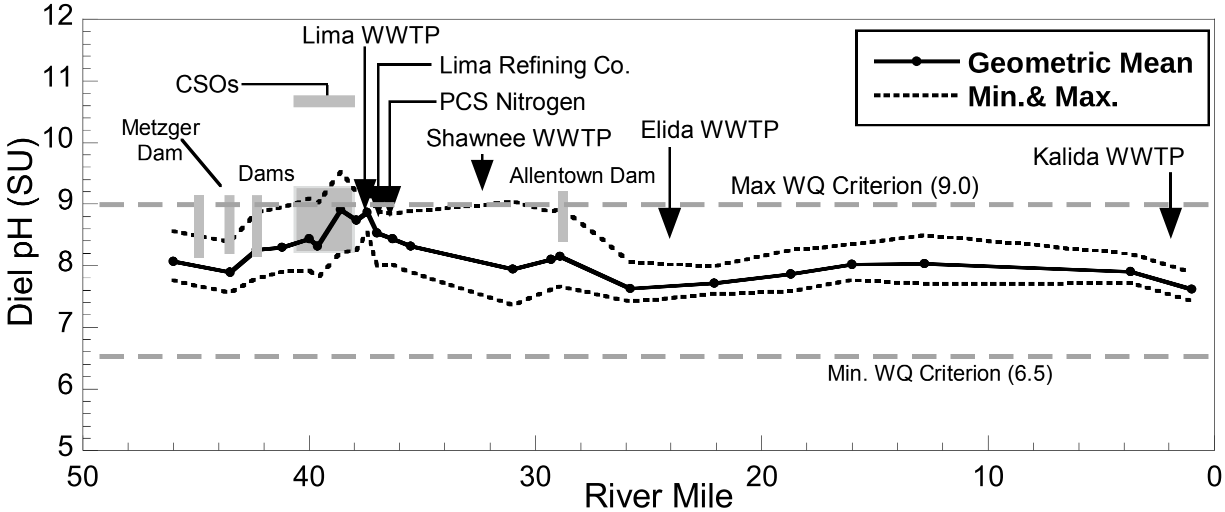

Figure 53. Geometric mean, minimum and maximum pH from continuous monitoring units (Datasonde), Ottawa River, 2010. Dashed lines identify WWH maximum (upper) and minimum (lower) pH criteria.

Nitrogenous Parameters and Phosphorus

Trends of nitrogenous parameters and phosphorus for the Ottawa River were drawn from the results of chemical and physical sampling of four integrated water quality surveys undertaken by Ohio EPA between 1989 and 2010. All of these data were derived from daytime hand collections, with stations typically visited five to six times over the course of a given survey year. Longitudinal ordinations and box plots of these data, through time, are presented in Figures 54, 55, and 56.

Statistical analysis of station averages failed to demonstrate a strong and significant difference in ammonia concentrations between 1996 and 2010 results. However, due to a predominance of ambient ammonia values at the analytical Method Detection Limit (MDL), the resulting aggregated data could not be made to fit a normal distribution, despite multiple transformations (e.g., geometric mean and log rhythmic). Thus, parametric statistical analysis was not attempted for ammonia, and the determination of gross statistical differences between the 1996 and 2010 results was drawn from a non-parametric analysis, which yielded approximated $p > 0.3$ (Table 9). Visual inspection of the longitudinal ordination of these data affirms this statistic, as the only obvious discontinuity between 1996 and 2010 results was a shift in the apparent source of peak values (Figures 54 and 55).

Normalized by effort, the frequency of ammonia criteria exceedances were 9.5%, 2.1%, and 4.0% from the survey years 1991, 1996, and 2010, respectively. These results would suggest a gross reduction through time, however, over this 19 year period, excursions above the water quality criteria were confined to a 1.6 mile river segment, demarcated by monitoring stations at RMs 37.0 (downstream Lima WWTP) and 35.4 (at Shawnee Rd.). These data can be further proscribed, as all ammonia exceedances identified in 1991 and 1996 were limited to a single sampling station located at RM 36.8 (downstream PCS Nitrogen), with roughly half of the six sampling events for each year yielding criteria excursions ranging between 0.84 and 4.1 mg/l. In contrast, ammonia peaks in 2010 was observed beginning downstream from the Lima WWTP, with one to two criteria exceedances at the three consecutive downstream monitoring stations (RM 37.0, 36.3, and 35.4), totaling five in all (Figures 54 and 55). Four of the five peak values occurred on July 22 and were associated with a temporary up-set at the Lima WWTP. The remaining exceedance occurred nine days later on July 29th, at RM 36.3, downstream from PCS Nitrogen. Ammonia exceedances in 2010 ranged between 0.67 and 5.41 mg/l (Table 6, Appendix A).

When paired down to include data from the historically affected stream reach, the frequency of ammonia exceedances through time appeared similar among the field years or perhaps suggested a modest increasing trend (Table 9, Figure 56). This conclusion, however, would represent a gross oversimplification, as it ignores two important observations: 1) the abatement or lessoning of ammonia toxicity immediately downstream from PCS Nitrogen, and 2) the anomalous nature of at least four of the five ammonia exceedances documented in 2010; the latter substantiated by consistently low and non-violation ammonia levels observed below both the Lima WWTP and Lima Refining Company between 1989 and 1996. Furthermore, excluding high values associated with the WWTP upset on July 22, 2010, but still including the exceedance on the 29th, the station average ammonia at RM 36.8, immediately downstream from PCS Nitrogen, would have represented a reduction of over 60% (Figures 54 and 55, Appendix A).

Although reduced from recent historical highs, the result from far field monitoring through time, found that ammonia continued to be elevated (above background) downstream from the suite of major dischargers below Lima (Figure 56). Ammonia levels upstream from Lima and through the lower 28 miles (Allentown to the mouth) have remained typically at or near analytical MDL. Statistical analysis of station average Total Kjeldahl Nitrogen (TKN) found a strong and significant difference between the 1996 and 2010 results, as parametric and non-parametric tests yielded t-probabilities and approximated p values less than 0.05 (Table 9). Station means were consistently higher in 2010 by an average of about 0.4 mg/l. These statistics comport with a visual inspection of the longitudinal ordination of these data. In 1996 and 2010, TKN largely paralleled ammonia and the two parameters were well-correlated in both years (Figure 57). As ammonia is one of many possible constituents of TKN, a high degree of correlation is not unexpected, particularly on the Ottawa River with its multiple sources of ammonia beginning downstream from Lima. The association between TKN and ammonia appeared stronger between middling and high concentrations of ammonia and less so at lower ammonia concentrations, particularly in 1996. Both the inter and intra-year variations may reflect a combination of several factors: 1) statistical artifacts due to the loss of low-end resolution associated with the MDL for ammonia, 2) changes in the source(s) and/or quantity of organic nitrogen delivered to the Ottawa River and 3) spatial and temporal changes to instream productivity. Regardless of these factors, these data show ammonia continues to constitute a significant portion of the organic nitrogen (measured as TKN) of the Ottawa River.

As the primary nutrients of temperate lotic systems, trends in nitrate+nitrite-N (henceforth referred to as “nitrate”) and Total Phosphorus (TP) will be discussed in tandem. Statistical analysis of station averages of these parameters found significant difference between 1996 and 2010 results for nitrate alone ($p < 0.05$) (Table 9). Longitudinal ordination of these data affirmed the statistical conclusions for TP (no significant difference), as in nearly every instance, station averages remained comparable through time (Figures 54, 55, and 56). The only exceptions to this being peak and anomalously high station average TP values in 1996, observed at two sites: immediately downstream from all major dischargers in the Lima area (RM 38.6), and Piquad Rd. (RM 25.7). It must be noted that the high station average at RM 25.7 was the result of a single sample (one of six), associated with a high rainfall event and thus likely represented the influence of diffuse, intermittent source(s) (Ohio EPA 1998). By 2010, station average TP at these two sites was reduced to concentrations comparable to those at adjacent sites or through adjacent reaches.

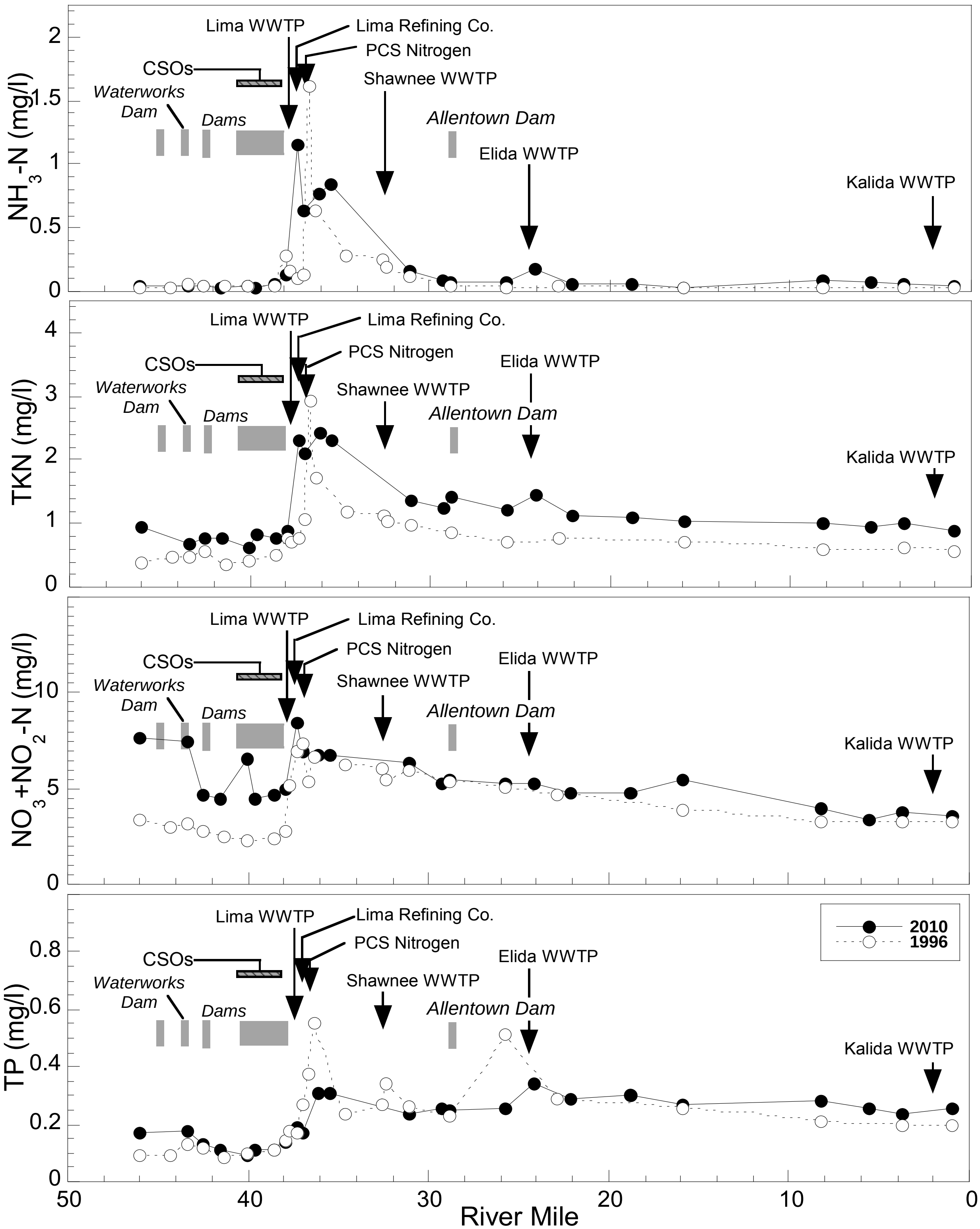

Figure 54. Longitudinal station average of NH3-N, TKN, NO3+NO2-N, and TP from the Ottawa River, 1996 and 2010.

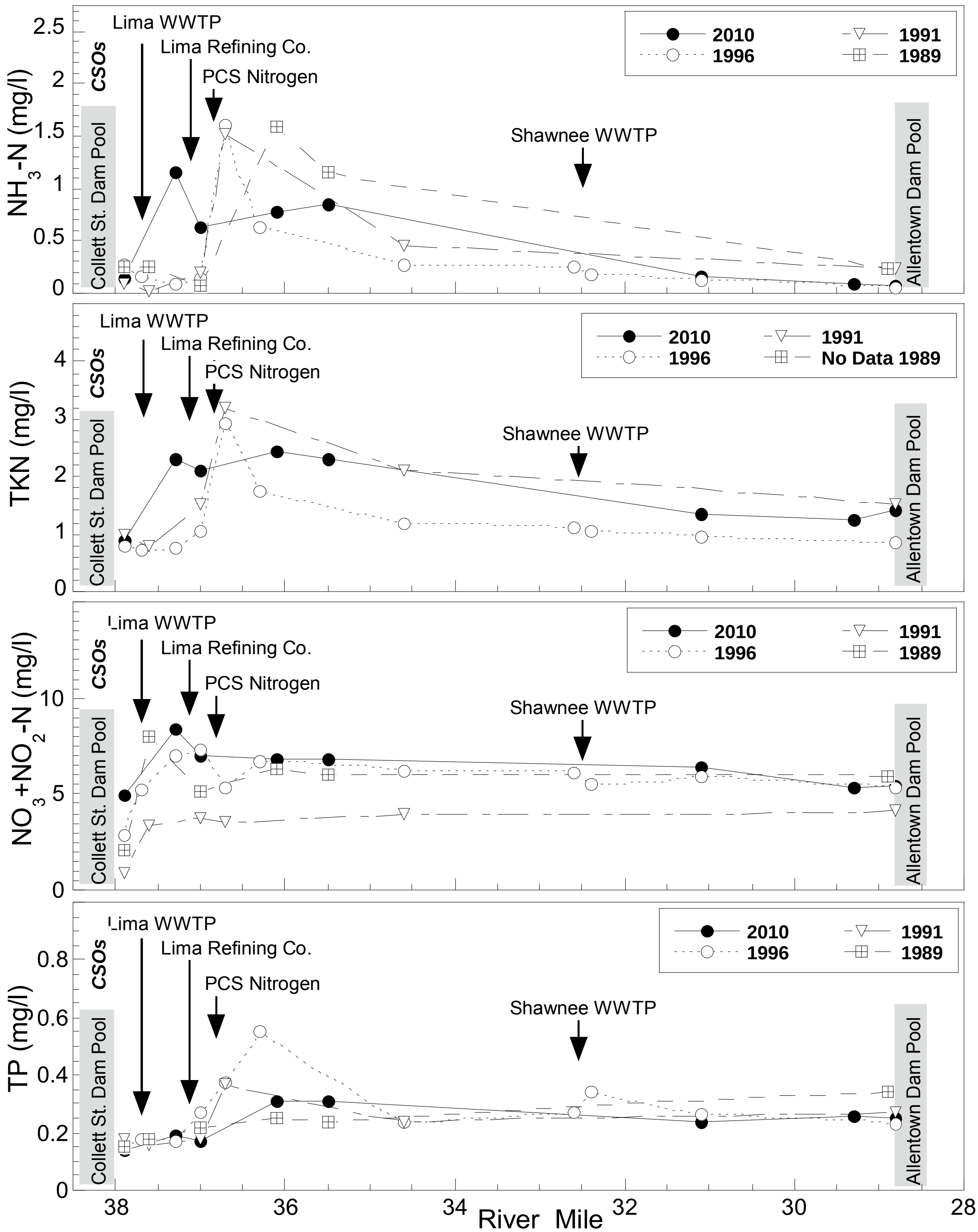

Figure 55. Longitudinal station average of NH_3-N, TKN, NO3+NO2-N, and TP through the historically impacted river reach from Eire RR Dam to the mouth, 1989, 1991, 1996, 2010.

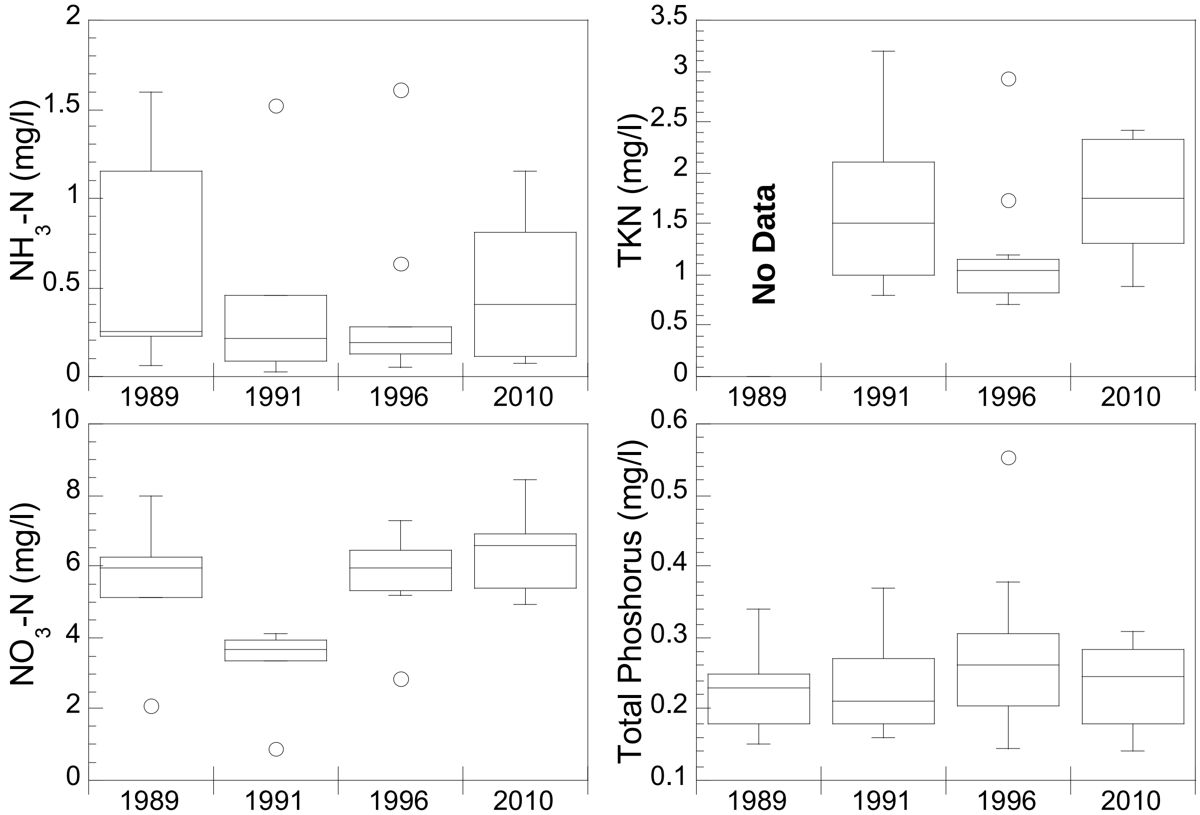

Figure 56. Box plot of NH_3-N, TKN, NO_3+NO_2-N, TP through the historically impacted river reach between Erie RR Dam (RM 37.9, upstream Lima WWTP) and the Allentown Dam (RM 28.9) of the Ottawa River, 1989, 1991, 1996, and 2010.

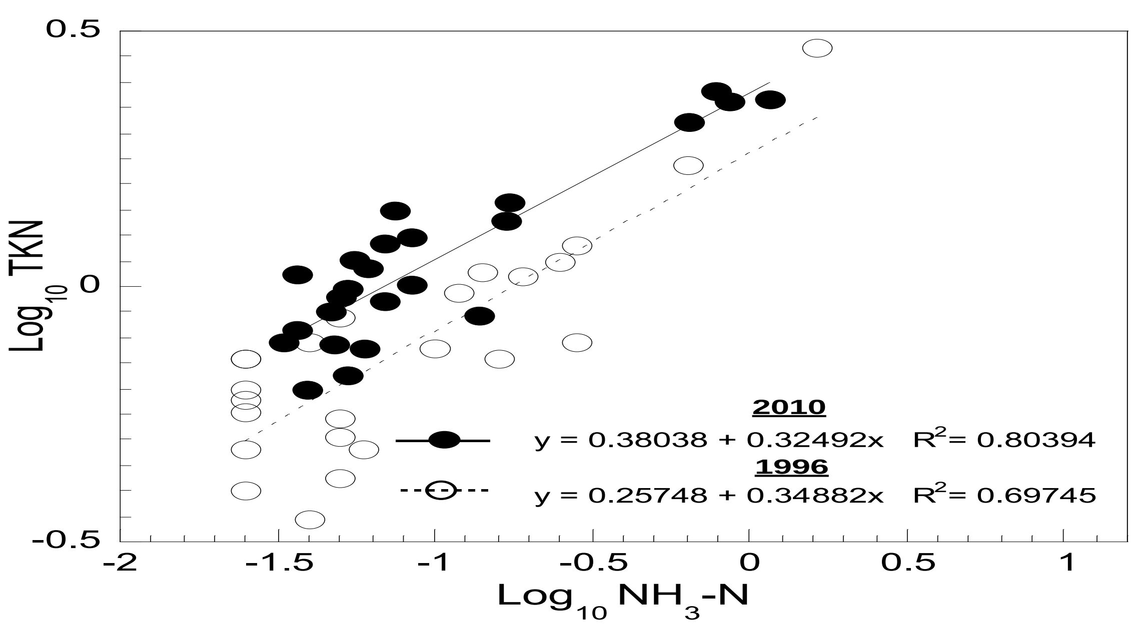

Figure 57. Linear regressions of TKN and NH_3-N from the Ottawa River, 1996 (open data points and dashed line) and 2010 (black data points and solid line).

Regarding nitrate, ambient concentrations were consistently and significantly greater in 2010 through the reach upstream from and through Lima (Thayer Rd. to Erie RR Dam) (Figures 54 and 55). In fact, discontinuity through the upper Ottawa River was sufficient to affect or otherwise drive both parametric and non-parametric statistics, as average nitrate concentrations through the lower river remained comparable between 1996 and 2010 (Table 9). Examining data as far back as 1989, the 2010 results from the most upstream monitoring station at RM 46.0 (Thayer Rd.) yielded both the highest station average (7.6 mg/l) and the highest single value (36.8 mg/l) observed on the Ottawa River upstream from Lima. Over this twenty-one year period, nitrate loads, as reflected in ambient concentrations, varied considerably through the upper Ottawa River, apparently controlled by the combination of diffuse agricultural sources and run-off patterns (Figure 54). Although these data did not fully comport with regional measures of drought, precipitation, or river discharge, some of these metrics aligned with instream nitrate values. Station averages at Thayer Rd. appeared in most years (2010, 1996, and 1989) controlled by high to extremely high concentrations from sampling runs collected early in each survey. In most instances, these corresponded with the higher flow and thus higher run-off events. Conversely, average nitrate at Thayer Rd. in 1991 was the lowest of the four survey years, with a station average of 0.21 mg/l. Between June and July, regional precipitation was well-below normal and moderate to severe drought conditions were indicated for northwest Ohio (Table 8, Figures 47 and 48). These regional metrics corresponded with the monthly average discharge of the Ottawa River of 9.6 and 11.5 cfs, for June and July, respectively. Although surface discharge remained above the 80% duration mark (May-November), these values were well below seasonal norms through the period of record. Lacking the otherwise typical spring and early summer run-off pulse, non-point source loadings of nitrate appeared substantially lower in 1991 than more typical years (Figures 54-56). Although not directly accounted for here, changes in tillage practices on agricultural lands may have also affected nitrate loads through time.

Upon receiving the large volume of treated wastewater discharged daily from Lima's 18 MGD WWTP, the lower Ottawa River becomes instantaneously effluent dominated, and remains so for most of its length. As such, the nitrate load of the affected segment is largely controlled by the Lima WWTP, though other major entities near Lima provide non-trivial contributions. As stated previously, between 1996 and 2010, nitrate levels through the lower Ottawa River (downstream Lima WWTP) appeared stable and comparable. However, nitrate monitoring results prior to 1996 showed a generally increasing trend, reflecting improved nitrification at the WWTP and corresponding reductions in ammonia loads (Ohio EPA 1998).

Water Column Heavy Metals

Trends in Total Recoverable (TR) heavy metals for the Ottawa River were drawn from the results of chemical and physical sampling associated with four integrated water quality surveys undertaken by Ohio EPA between 1989 and 2010. All of these data were derived from daytime, hand collections, with stations typically visited five to six times over the course of a given survey year. This trends assessment included the following heavy metals: Selenium (Se), Arsenic (As), Lead (Pb), Zinc (Zn), Chromium (Cr), Cadmium (Cd), and Copper (Cu). Longitudinal ordinations and box plots of these data, through time, are presented in Figures 58-61.

Analysis of gross statistical difference in TR metals between 1996 and 2010 was undertaken for Se alone. Both parametric and non-parametric tests indicated a very strong difference in mean Se concentration between 1996 and 2010, yielding t-probabilities and approximated $p < 0.0001$ (Table 8). Longitudinal ordination of Se data affirms this conclusion, as in nearly every instance, station average concentrations of Se were consistently lower in 2010. This was particularly evident below the Lima Refining Co., where in 1996 ambient values as high as 11 µg/l were observed, with average Se concentrations from nine of the ten monitoring stations downstream from the refinery greater than the 5 µg/l ambient criterion with many exceedances (Figures 58 and 59). The affected segment accounts for over 14 river miles (30.4%) of the Ottawa River mainstem. By 2010, selenium loads to the Ottawa River below the refinery were significantly reduced following the imposition of a lower monthly average water quality-based effluent limit in 1999 (implemented between 2001 and 2002). Current selenium loads downstream from the Lima Husky Refinery resulted in summer average instream concentrations at or below the current ambient criterion. Non-violation excursions were limited to only three individual sampling events from two separate monitoring stations located in close proximity to the refinery. Ranging between 5.5 and 6.5 µg/l, these values represented peak 2010 concentrations, well-below the peak values documented in 1996.

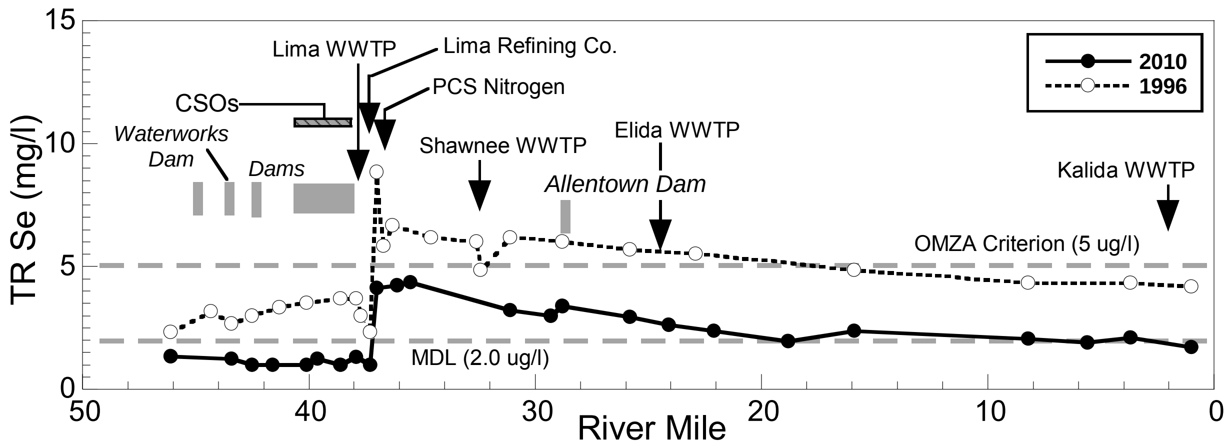

Figure 58. Longitudinal station average TR Se from the Ottawa River for 1996 and 2010. Dashed lines indicate average ambient criteria (upper) and analytical MDL (lower).

However, 62 of 80 (77.5%) water chemistry samples below the Lima Husky Refinery discharge either exceeded or equaled the 2.0 µg/ITMDL threshold toxic effect concentration of concern for selenium with twelve samples $\geq$ 4 µg/l(Lemly 2001). The instream total concentrations of 2.0 µg/g Se can cause food-chain bioaccumulation and reproductive failure in fish and aquatic birds. Fish and aquatic birds are exposed to selenium in aquatic ecosystems through diet. Fish anomalies (skeletal deformities) characteristic of selenium chronic toxic effects were observed in fish in the Ottawa River. These were still lower totals than 1996, as 100% of instream selenium concentrations downstream from the refinery were above 2 µg/land 71 of 84 samples (84.5%) were > 4 µg/lSe (Ohio EPA 1998).

In comparison with the 1996 results, Se through the upper Ottawa River was also significantly reduced in 2010 (Figures 58, 59, and 61, Table 8). As there are no major permitted point sources of Se upstream from Lima, the 1996 results would at first suggest that station averages were perhaps skewed by samples collected during periods of high flow following heavy precipitation, the resulting pulse of contaminated run-off from diffuse rural and/or urban sources yielding anomalously high values. However, this pattern was not evident in the 1996 data. Of the 60 sampling events in 1996 distributed through the upper ten monitoring stations (six events per site), only seven yielded Se concentration below the MDL. The remaining 53 samples yielded mean sites concentrations from 2 to 4 µg/l well upstream from Lima, with concentrations generally increasing by 1-2 µg/l as the river entered the city's impounded, urban center (Ohio EPA 1998).

Station averages were not obviously affected by one or two anomalously high values, rather, they appeared to reflect a modest, but persistent background Se load in 1996, the source of which remains unknown. The source(s) of Se through the upper Ottawa were either inactive in 2010 or abated (natural or otherwise) over the past 14 years, as monitoring results from 2010 found the overwhelming majority (87%) of samples below the MDL, and the few actual detections of Se did not exceed 2.6 µg/l (Appendix A).

Statistical analysis comparing the remaining TR heavy metals from 1996 and 2010 surveys was not attempted due to two confounding factors: a very high frequency of analytical results at the MDL, resulting in truncated data that have an irretrievably non-normal distribution; and shifting MDLs, associated with improved analytical methods for selected parameters. Instead, selected historical and contemporary heavy metals monitoring data were screened for violations or exceedances of associated water quality criteria so as to examine the distribution and frequency of said excursions through time. This coupled with the use of other relevant information, as needed, will constitute this narrative trends assessment.

For the remaining heavy metals (As, Pub, Zn, Cr, Cd, and Cu), remarkably few violations or exceedances of their respective ambient water quality criteria were observed on the Ottawa River between 1991 and 2010. In fact, a single Zn exceedance (one of six samples) at RM 37.9 (upstream Lima WWTP/downstream Eire RR dam) in 1991 represented the only criteria excursion (Ohio EPA 1992) observed during this period (Figures 59-61).

Between 1991 and 2010, longitudinal concentrations of As, Pb, and Zn have shown a declining trend among and downstream from the suite of major dischargers immediately below Lima. At stations common to all efforts, the 2010 results for these parameters were typically the lowest. With few exceptions, concentrations of TR Cd, Cr, and Cu were found very near or below their respective MDL, and all were found well-below their respective water quality criterion between 1991 and 2010 (Figures 59-61).

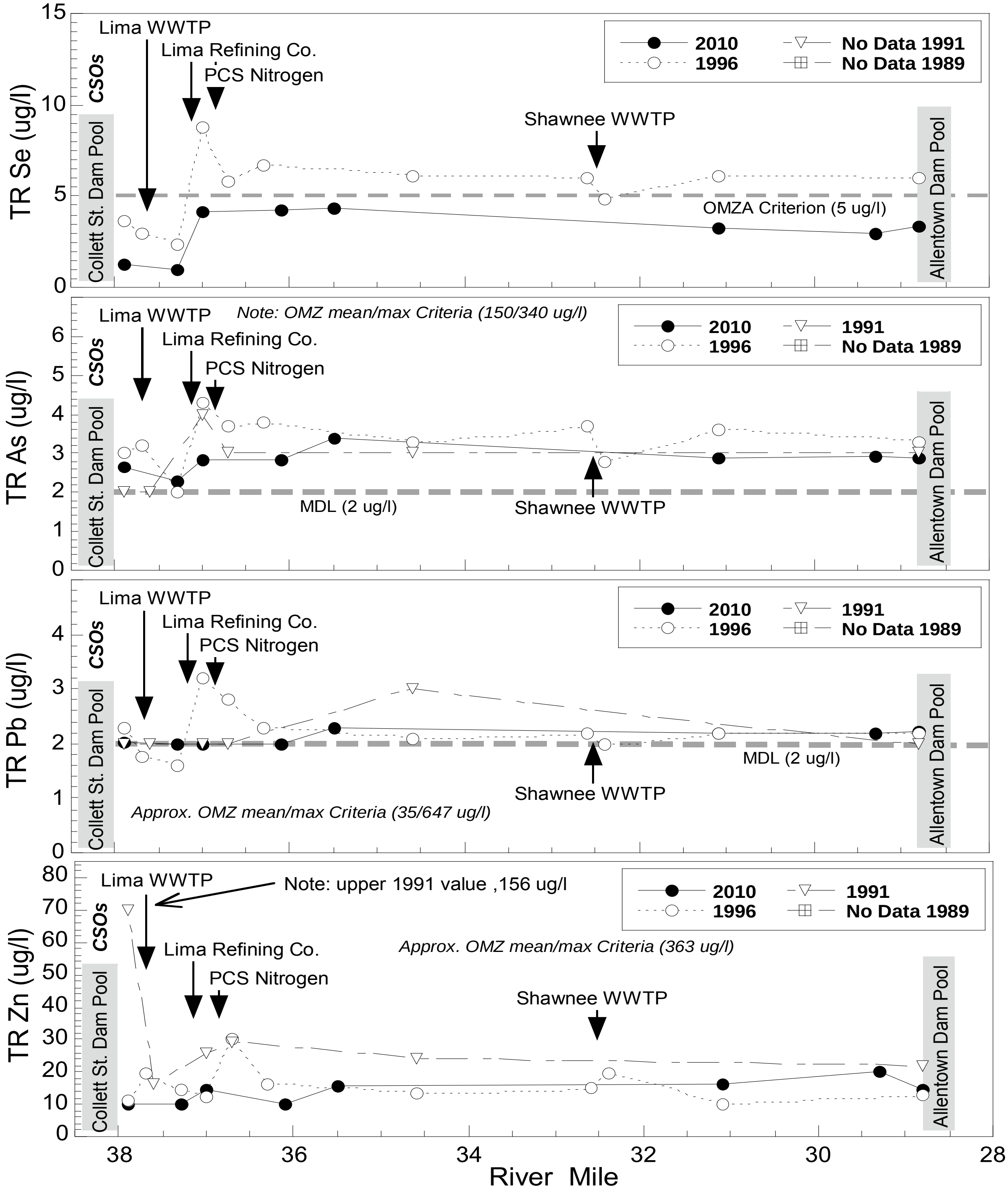

Figure 59. Station average of Total Recoverable (TR) water column metals: Se, As, Pb, and Zn, through the historically impacted river reach between the Erie RR Dam (RM 37.9, upstream Lima WWTP) and the Allentown Dam (RM 28.9), for the Ottawa River, 1989-2010. Where water quality criteria vary based upon ambient hardness, an "approximate" or generalized mean and maximum criteria are indicated on each longitudinal plot to provide context to the associated values. Generalized criteria were derived from the stream segment's average hardness. Unless otherwise indicated, dashed lines represent the analytical MDL for each metal.

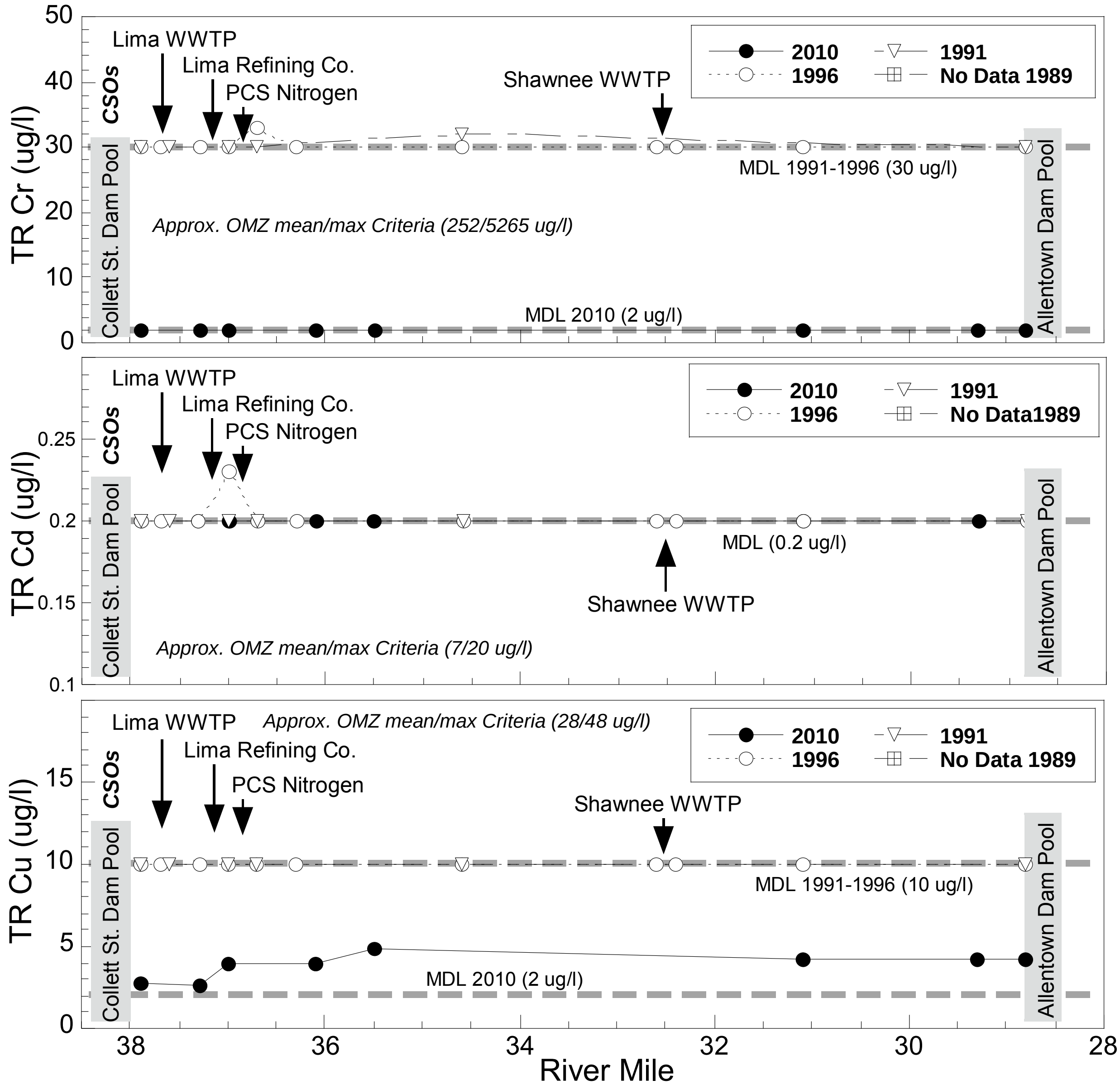

Figure 60. Longitudinal station average of TR water column metals: Cr, Cd, and Cu, through the historically impacted river reach between the Erie RR Dam (RM 37.9, upstream Lima WWTP) and the Allentown Dam (RM 28.9) for the Ottawa River, 1989, 1991, 1996, and 2010. Where water quality criteria vary, based upon hardness, an “approximate” or generalized mean and maximum criteria are indicated on each longitudinal plot to provide context to the associated values. Generalized criteria were derived from the stream segment’s average hardness. Unless otherwise indicated, dashed lines represent the analytical MDL for each metal species. Advances in analytical techniques have resulted in lower MDL in recent years for Cr and Cu.

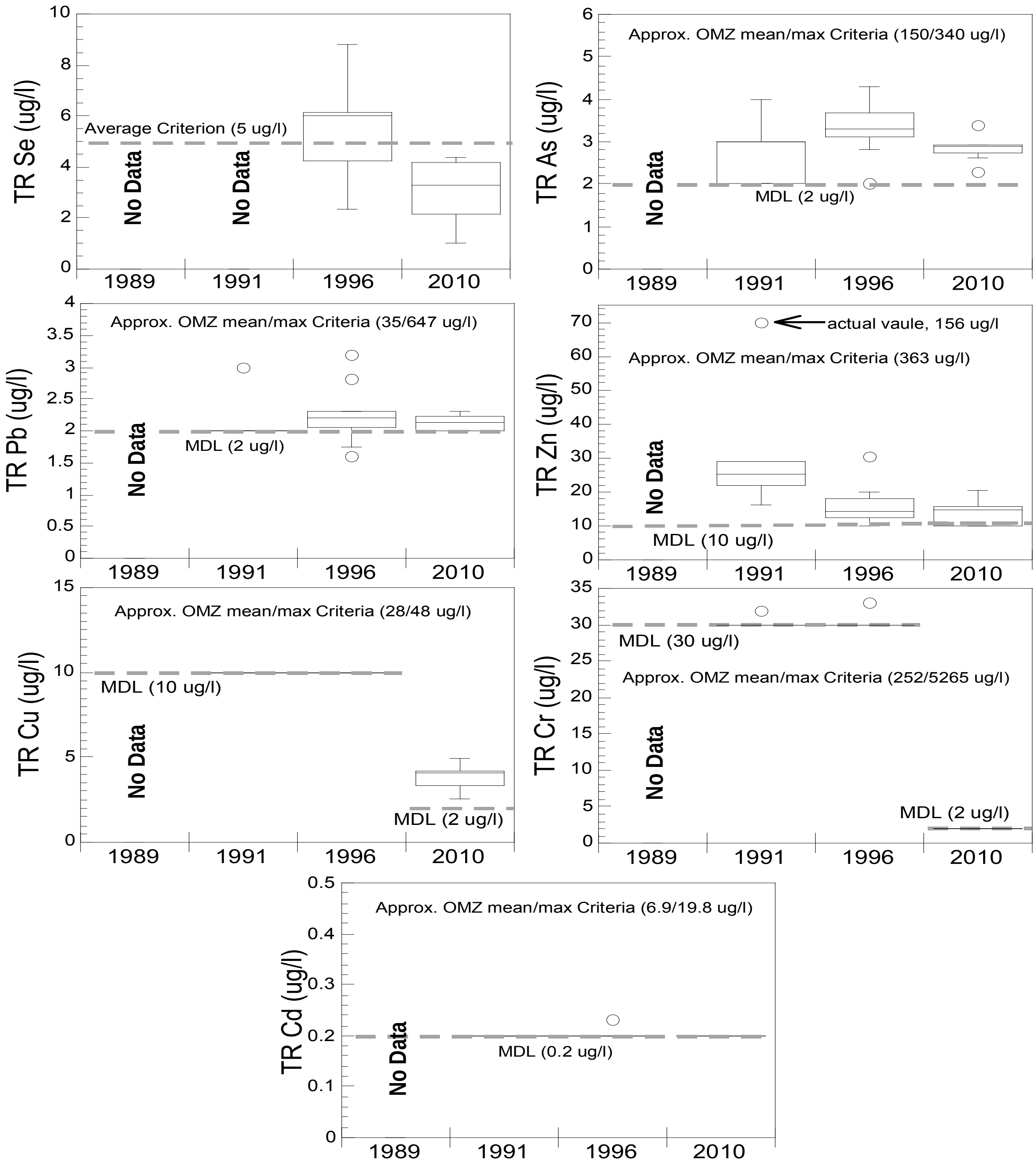

Figure 61. Box plots of TR water column metals: Se, As, Pb, Zn, Cu, Cr, and Cd through the historically impacted river reach between the Erie RR Dam (RM 37.9, upstream Lima WWTP) and the Allentown Dam (RM 28.9), for the Ottawa River, 1989-2010. Where water quality criteria vary based upon ambient hardness, an "approximate" or generalized mean and maximum criteria are indicated on each longitudinal plot so as to provide context to the associated values. Generalized criteria were derived from the stream segment's average hardness. Unless otherwise indicated, dashed lines represent the analytical MDL for each metal species.

Recreation Use Assessment

Water quality criteria for determining attainment of recreation uses are established in the Ohio Water Quality Standards (Table 7-13 in OAC 3745-1-07) based upon the prevalence of the *Escherichia coliform* (*E. coli)* bacteria indicator in the water column. *E. coli* bacteria are microscopic organisms that are present in large numbers in the feces and intestinal tracts of humans and other warm-blooded animals. *E. coli* typically comprises approximately 97 percent of the organisms found in the fecal coliform bacteria of human feces (Dufour, 1977), but there is currently no simple way to differentiate between human and animal sources of coliform bacteria in surface waters, although methodologies for this type of analysis are becoming more practicable. These microorganisms can enter water bodies where there is a direct discharge of human and animal wastes, or may enter water bodies along with runoff from soils where these wastes have been deposited.

Pathogenic (disease causing) organisms are typically present in the environment in such small amounts that it is impractical to monitor them directly. Fecal indicator bacteria by themselves, including *E. coli*, are usually not pathogenic. However, some strains of *E. coli* can be pathogenic, capable of causing serious illness. Although not necessarily agents of disease, fecal indicator bacteria such as *E. coli* may indicate the potential presence of pathogenic organisms that enter the environment through the same pathways. When *E. coli* are present in high numbers in a water sample, it invariably means that the water has received fecal matter from one source or another. Swimming or other recreational-based contact with water having a high fecal coliform or *E. coli* count may result in ear, nose, and throat infections, as well as stomach upsets, skin rashes, and diarrhea. Young children, the elderly, and those with depressed immune systems are most susceptible to infection.

The streams of the Ottawa River watershed evaluated in this survey are designated as a Primary Contact Recreation (PCR) use in OAC Rule 3745-1-24. Water bodies with a designated recreational use of PCR "...are waters that, during the recreation season, are suitable for one or more full-body contact recreation activities such as, but not limited to, wading, swimming, boating, water skiing, canoeing, kayaking and SCUBA diving" [OAC 3745-1-07 (B)(4)(b)]. There are three classes of PCR use to reflect differences in the potential frequency and intensity of use. Streams designated PCR Class A typically has identified public access points and support primary contact recreation. Streams designated PCR Class B support, or potentially support, occasional primary contact recreation activities. The Ottawa River mainstem is designated Class A PCR waters except for the reach from the confluence of Hog Creek and Little Hog Creek to Thayer Road which is Class B PCR; all other streams assessed during this survey are designated Class B PCR waters. The *E. coli* criteria that apply to PCR Class A and B streams include a geometric mean of 126 and 161 cfu/100 ml, and a maximum value of 298 and 523 cfu/100 ml, respectively. The geometric mean is based on two or more samples and is used as the basis for determining attainment status when more than one sample is collected (Table 10).

Summarized bacteria results are listed in Table 10, and the complete dataset is reported in Appendix C. Twenty locations in the Ottawa River study area were sampled for *E. coli* nine to twelve times, from May 12 – October 13, 2010. Evaluation of *E. coli* results revealed none of the twenty locations attained the applicable geometric mean criterion, and thus all were in non-attainment of the recreation use.

Table 10. A summary of E. coli data for locations sampled in the Ottawa River watershed, May 12 – October 13, 2010. Recreation use attainment is based on comparing the geometric mean to the PCR Classes A or B geometric mean water quality criterion of 126 or 161 cfu/100 ml (Ohio Administrative Code 3745-1-07). All values are expressed in colony forming units (cfu) per 100 ml of water. Gray shaded values exceed the applicable PCR Class A or B geometric mean criterion.

Location	River Mile	Use	# of Samples	Geometric Mean	Maximum Value	Recreation Attainment Status	Probable Source(s) of Bacteria
Ottawa River @ Thayer	45.97	PCR-A	9	336	1200	NON	Unknown
Ottawa River@ Sugar	41.16	PCR-A	9	>223	>2400	NON	Lima CSOs
Ottawa River@ Shawnee	35.44	PCR-A	9	549	2400	NON	Lima CSOs
Ottawa River@ Copus	29.26	PCR-A	9	299	2420	NON	Shawnee SSOs, HSTS (Piquad Rd)
Ottawa River@ Neff	22.14	PCR-A	9	150	2420	NON	Unknown
Ottawa River@ SR 189	15.98	PCR-A	9	224	1600	NON	Unsewered community (Rimer)
Ottawa River@ CR- P	8.12	PCR-A	9	>326	>2420	NON	Unknown
Ottawa River@ U.S. 224	3.67	PCR-A	9	>270	>2420	NON	Unknown
Hog Creek	12.03	PCR-B	12	457	7700	NON	CAFO
Hog Creek	10.77	PCR-B	12	432	7300	NON	Unknown
Grass Creek	1.24	PCR-B	12	>905	>24000	NON	Ada WWTP
Little Hog Creek	0.3	PCR-B	12	332	20000	NON	HSTS, Lafayette WWTP
Hog Creek	0.27	PCR-B	12	337	7700	NON	Unknown
Lost Creek	0.35	PCR-B	12	>717	3000	NON	Lima SSOs
Little Ottawa River	0.03	PCR-B	11	637	3900	NON	Package plant, Shawnee #2 WWTP SSO's, Cridersville WWTP
Honey Run	0.9	PCR-B	11	>946	3100	NON	Unknown
Pike Run	0.84	PCR-B	11	3144	7700	NON	Unsewered community (Gomer)
Leatherwood Ditch TR 19	0.48	PCR-B	4	816	1700	NON	HSTS
Leatherwood DitchTR19	1.5	PCR-B	5	546	1500	NON	CAFO
Sugar Creek	0.64	PCR-B	9	1052	2900	NON	Unsewered community (Vaughnsville)
Plum Creek	0.19	PCR-B	12	707	2800	NON	Columbus Grove WWTP and CSOs

Most of the streams in the study area had elevated bacteria levels during the higher flow periods in May and June. Four sites on the mainstem of the Ottawa River reported maximum results for nine samples on May 12, 2010. Thirteen of the twenty sites, mostly on the tributaries, had their highest reported *E.coli* counts following several rain events in June (Tables 8 and 10).

The mainstem of the Ottawa River is impaired for the recreational use in several areas. Probable sources of bacteria are CSOs from the Lima municipal treatment/collection system, SSOs in the Shawnee #2 collection system and discharges from the Elida WWTP (Table 10). All three sites on Hog Creek had maximum *E.coli* counts > 7,000 cfu/100ml in the last two weeks of June. The subwatershed is largely rural above the confluence of Grass Creek and the stream is likely impaired by multiple sources including failing home septic systems and livestock manure. The downstream site on Hog Creek is likely impaired by lingering effects of Ada and Lafayette as well as general unknown bacteria sources in the rural areas of the watershed (Table 10). Grass Creek was impaired by the Village of Ada WWTP discharge. The maximum *E.coli* count was >24,000 cfu/100ml on June 28, 2010. Little Hog Creek had a very elevated maximum sample of 20,000 cfu/100ml on June 28 and may have been impacted by the Lafayette WWTP or an unknown bacteria source. In August 2010, HSTS issues from nearby home(s) were documented on Mud Run (Trib. to Little Hog Creek) during biological sampling (Table 10). Lost Creek is impaired by Lima SSOs and the Little Ottawa River was impaired by a combination of poorly treated effluent from the Cridersville WWTP, and Shawnee #2 WWTP SSOs on the southeast side of Lima. One source of bacteria will be eliminated when the package plant serving Indian Village Mobile Home Park is connected to the Lima sanitary sewer system (Table 10). Pike Run had the highest geometric mean in the study area with a count of 3,144 cfu/100ml for eleven samples. The main source of bacteria is the unsewered Allen County community of Gomer which is located on Pike Run at the sample location. Plum Creek was primarily affected by CSO discharges from the Village of Columbus Grove WWTP (Table 10).

Other probable sources that contributed to the recreational impairment included two communities that do not have wastewater treatment facilities. Rimer is located on the mainstem Ottawa River at State Route 189 in Putnam County and Vaughnsville, also in Putnam County, discharges to Sugar Creek. These villages have storm sewers which carry combined sewage and storm water directly to their respective streams.

There are several WWTPs that land apply digested sewage sludge at agronomic rates on approved farm fields in the watershed. Ohio EPA investigated whether any of the fields have experienced problems with the land application process that resulted in runoff to the receiving stream, but did not find any conclusive evidence. It is not likely that sludge applied in accordance with conditions of an NPDES permit will negatively impact these streams. Municipal treatment plants that are approved to land apply sludge include, Ada, American Bath, Elida, Lafayette, and Shawnee #2. Sludge from the permitted package plants in this area is hauled to a municipal treatment plant for disposal.

In addition to the twenty sampling locations, two additional locations in the watershed were sampled in response to complaints during the 2010 survey season. One sample was collected on June 29, 2010 from a tributary to Sugar Creek at SR 65 north of Lima. The lab result of 9,900 cfu/100ml was attributed to either animal waste, human waste or both. Possible sources of fecal contamination were a dairy farm on SR 65 and/or a small subdivision north of Lutz Rd. that both drain to this tributary. The Allen County health department subsequently confirmed that all homes in the area are connected to the sanitary sewer. We referred the farm runoff situation to the Allen County Soil and Water Conservation District and ODNR.

A sample was collected from the Ottawa River at Piquad Road (RM 25.75) on July 13, 2010. The lab result of >24,200 cfu/100ml and visual observation of a grey septic discharge indicated unsanitary conditions attributed to at least one of the four homes in an unsewered area just south of Elida. The Allen County Health Department was informed of this nuisance situation and they began an investigation.

Public Drinking Water Supply Use Attainment

Lima, with a population near 40,000 people, obtains its drinking water from several sources (see Table 11). The City of Lima uses several upground reservoirs to store drinking water. The "East Reservoir Complex" is comprised of Ferguson Reservoir, Metzger Reservoir and Lost Creek Reservoir. The reservoirs are connected in a series and water flows from one to the next by gravity. Source water is obtained from the Ottawa River via an automated pump station located at Metzger Road (RM 43.45) and a seldom-used back-up pump located at Roush Road (RM 42.3). There is also a manual pump station located on Lost Creek that can pump water directly into Lost Creek Reservoir. The manual pump is only used if the water level in the reservoirs is low and flow in the creek is high enough to be pumped. Water from Lost Creek Reservoir can flow directly to the water treatment plant or be further stored in Twin Lakes Reservoir located next to the plant. The lakes are open to public fishing, but swimming is not allowed. Ferguson and Metzger have primitive boat ramps and Lost Creek is accessible by carry-in boat. Only electric motors are permitted. Fish management activities include routine stocking, population monitoring, angler harvest studies and tissue analysis.

Table 11. Public drinking water supply (PDWS) use information from the 2012 Integrated Report.

Name/Community	Stream	Nitrate Status	Atrazine Status	Impairment (Y/N)
Lost Creek (04100007 03 05)				
Lima	Lost Creek	None	None	Insufficient data to assess
Lima Reservoir-Ottawa River (04100007 03 06)				
City of Lima	Ottawa River	None	None	Insufficient data to assess
Honey Run (04100007 04 03)				
City of Lima	Ottawa River	None	None	Insufficient data to assess

The PDWS use was evaluated based on Safe Drinking Water Act maximum contaminant levels (MCLs) for nitrate (10 parts per million [ppm]) and atrazine (3 parts per billion [ppb]). None of the lake samples exceeded any of these levels. These compounds were also tested in source water from the Ottawa River. A sample collected during late spring of 2010 had very high levels of nitrate (36.8 ppm) and atrazine slightly above the MCL (3.38 ppb). Pumping under these conditions should be avoided.

A whole water phytoplankton sample from the lake collected in the fall of 2010 was enumerated to assess the need to test liver and nerve toxins produced by Cyanobacteria (blue green algae). Toxin samples were submitted when results showed a dominance of Cyanobacteria. Levels of *Cylindrospermopsin* and *Saxitoxin* were below their respective reporting limit and *Microcystin* was detected at 1.2 ppb. No toxin was detected in a complimentary finished water sample. *Microcystin* was also detected in a toxin sample submitted in the fall of 2011 at 0.61 ppb. At that time of the sampling, Ohio EPA did not have established thresholds for *Microcystin,* but the World Health Organization drinking water criterion was 1.0 ppb.

Sediment Chemistry Quality

Sediment sampling locations were selected in the study plan to determine background sediment quality, assess the impact from point sources and urban non-point runoff and evaluate downstream transport and recovery. Samples were collected following the *Sediment Sampling Guide and Methodologies* (Ohio EPA, 2001). The goal was to collect a representative sample composed of >30% silt and clay particles. These fine grained particles are much more physically, chemically and biologically reactive because they hold more interstitial water and have unbalanced electrical charges that can attract contaminants.

Most of the Ottawa River contains little in the way of fine grained sediment in large enough volumes to have much of an ecological impact. This is due in part to a largely intact natural stream morphology and suitable gradient. Fine particles are often deflected into the floodplain or washed downstream. Exceptions to this include impounded segments, isolated eddies and in the headwaters where feeder streams are channelized.

A total of nine sediment samples were collected in the Ottawa River between Thayer Rd (RM 45.97) and Putnam CR 19 (RM 0.96). Sediment samples were analyzed for metals, s-VOCs, PAHs, PCBs and pesticides (organo-chlorine insecticides). Samples below the Lima WWTP and Husky Refinery were also analyzed for VOCs. No PCBs, pesticides or VOCs were detected in any of the samples.

Sediment sample results were evaluated using Tier I procedures for aquatic life described in the *Guidance on Evaluating Sediment Contaminant Results* (Ohio EPA, 2010). Numeric Sediment Quality Guidelines (SQGs) that were used included Ohio Sediment Reference Values (SRVs) for metals contained in the *Ecological Risk Assessment Guidance* (Ohio EPA, 2008) and toxicity values in the *Development and Evaluation of Consensus-based Sediment Quality Guidelines for Freshwater Ecosystems* (MacDonald et.al, 2000). When contaminants are at concentrations above the SQGs either appropriate treatment options should be explored to remediate the problem or consideration should be given to investigate if bioavailability affects toxicity. This would likely require further studies to be done.

A summary of parameters measured above SQGs is presented in Table 12. Metals that were above their TEC, but that did not exceed their SRV are not displayed. Heavy metals and PAHs are common contaminants in urban areas because of vehicular emissions, asphalt pavement and their use in industrial processes. For example, mercury is used in the production of chlorine gas and caustic soda and in the manufacture of batteries and compact fluorescent light bulbs. It is also common in the atmosphere from coal burned to produce electricity. Besides urban storm water runoff and atmospheric deposition, other likely sources include municipal and industrial wastewater and CSOs in the Lima sewage collection system, since there are several categorical industries that use the collection system. Another potential source is oily waste escaping from the L-5 landfill, although this load should be much reduced since retaining wall and rip-rap were installed to contain leachate. There are also legacy pipelines in the area that occasionally leak oily waste.

Table 12. Chemical parameters measured above SQGs in surficial sediment samples collected by Ohio EPA in the Ottawa River during 2010. Harmful effects are unlikely below the threshold effect concentration (TEC) and likely above the probable effect concentration (PEC).

Parameter	**Result (mg/kg)**	**SRV (mg/kg)**	**TEC (mg/kg)**	**PEC (mg/kg)**
HUC 12 (04100007-03-06) Lima Reservoir-Ottawa River				
Ottawa River @ Thayer Road (RM 45.97)				
No exceedances				
Ottawa River @ Metzger Road dam pool (RM 43.60)				
Cadmium	1.17	0.90	0.99	4.98
Ottawa River @ Collett Street dam pool (RM 38.63)				
Cadmium	1.15	0.90	0.99	4.98
Copper	46.9	34.0	31.6	149
Zinc	191	160	121	459
Total PAH	37.36	---	1.61	22.8

Ottawa River downstream Lima WWTP (RM 37.47)				
Cadmium	1.37	0.90	0.99	4.98
Copper	49.2	34.0	31.6	149
Mercury	0.177	0.12	0.18	1.06
Zinc	269	160	121	459
Total PAH	33.42	---	1.61	22.8
Ottawa River downstream Husky Refinery (RM 37.0)				
Cadmium	1.50	0.90	0.99	4.98
Copper	84.1	34.0	31.6	149
Lead	61.7	47.0	35.8	128
Mercury	0.252	0.12	0.18	1.06
Zinc	283	160	121	459
Total PAH	25.59	---	1.61	22.8
Ottawa River downstream PCS Nitrogen (RM 36.3)				
Cadmium	1.52	0.90	0.99	4.98
Copper	71.4	34.0	31.6	149
Lead	155	47.0	35.8	128
Mercury	0.627	0.12	0.18	1.06
Zinc	277	160	121	459
Total PAH	23.94	---	1.61	22.8
HUC 12 (04100007-04-03) Dug Run – Ottawa River				
Ottawa River @ Allentown Road dam pool (RM 28.85)				
Cadmium	1.11	0.90	0.99	4.98
Copper	40.7	34.0	31.6	149
Mercury	0.14	0.12	0.18	1.06
Zinc	215	160	121	459
HUC 12 (04100007-05-03) Kalida – Ottawa River				
Ottawa River @ US Route 224 (RM 3.67)				
No exceedances				
Ottawa River @ Putnam Co Rd 19 (RM 0.96)				
No exceedances				

All Ottawa River selenium sediment concentrations sampled by the Ohio EPA were less than the detection limits (Appendix B). However, the detection limits for Se analysis conducted by Ohio EPA were too high to adequately measure ambient sediment concentrations in the Ottawa River. Selenium sediment concentrations in the Ottawa River were also documented in 2009 in the report, *Ottawa River Biological and Water Quality Study and Ecological Risk Assessment,* completed by CH2MHILL for the Lima Refining Company (Lima Refining Company, 2010). Five different sediment samples were collected in each of six sample zones on 9-10 September 2009 and were analyzed with an MDL of 0.5 mg/kg. Zone 1 (Thayer Rd. at RM 45.9 - background) had one selenium sediment concentration of 0.6 mg/kg Se while four others were below the detection limits. Downstream from the Lima WWTP (Zone 2 at RM 37.4), two samples had Se sediment concentrations of 0.5 mg/kg and three others were below the detection limits. Downstream from the Lima Refining Company (RM 37.0 – the primary source of Se into the Ottawa River), all five Zone 3 sediment samples were analyzed above detection with a Se sediment concentration range of 0.6 – 0.9 mg/kg (mean of 0.78 mg/kg). Eight miles downstream from the Lima Refining Co. on the Ottawa River in the Allentown dam pool (Zone 4 at RM 29.0), the maximum and mean Se sediment concentrations were slightly higher (a maximum 1.0 mg/kg value from three different sediment samples with a mean of 0.88 mg/kg) in this depositional area. At Rimer (RM 15.9 – Zone 5), Se sediment concentrations were still consistently between 0.6 and 0.9 mg/kg (mean of 0.7 mg/kg). Finally at Kalida (RM 3.6), the Se sediment concentrations decreased to similar background levels documented upstream from Lima (0.6 mg/kg with only one sample above the detection limit). All values were less than the Se SRV for the ECBP ecoregion (2.3 mg/kg) or the HELP ecoregion SRV (1.4 mg/kg) (Ohio EPA, 2008).

However, sediment concentrations of selenium were consistently present and bioavailable in most of the Ottawa River mainstem because of the presence of persistent surface water inputs of selenium. The Ottawa River water chemistry grab samples collected during summer low-flow conditions upstream from Lima near Thayer Rd. (RM 45.97 - background conditions) documented one Se concentration in surface water (n=7 with an MDL of 2.0 ug/l) of 2.4 µg/l which persisted two miles downstream at Metzger Rd. (2.2 ug/l) (Appendix A). Consultant water chemistry sample data at Thayer Rd. from 2009 documented two Se samples with 0.4µg/l and 0.6 µg/l concentrations using lower minimum detection limits (Lima Refining Company, 2010). These documented lower Se concentrations inferred consistent but lower background Se concentrations with periodic higher concentrations (noted in the Ohio EPA data) in the upstream Ottawa River reach. Upstream Se inputs (e.g., Thayer Rd.) likely originated from periodic high surface water flows in the upper watershed conveying trace Se loads from herbicides/pesticide use.

Lower Se concentrations in surface water continued through downtown Lima (0.5 µg/lSe downstream Lima WWTP documented in 2 of 2 samples from 2009 consultant data) (CH2MHILL, 2010). There were occasional increased Se concentrations from urban stormwater and CSO inputs; two detections of 2.2 and 2.6 µg/l in five grab sampling events were measured at sites in city dam pools and below the dams upstream from the WWTP (Appendix A).

Downstream below the Husky Refinery discharge, Se was consistently present (2.3-4.4 ug/l) with some surface water exceedances over 5 µg/l at RM 37.0 (dst. Husky Refinery – one of five grab samples) and at Shawnee Rd. (5.5 and 6.5 µg/l– two of seven grab samples) along with several monthly average loading violations reported (Appendix A, and Table 6). Fish populations have started to recover closer to these sources (with generally lower Se inputs from periodic pulses), as no sediment samples exceeded the sediment toxic effect concentration of 2.0 µg/g dry weight (DW). However, the selenium in the sediment continued to bioaccumulate up the food web (Chapman et al. 2010 and Sorenson 1991).

Fish Tissue Quality Assessment

Ohio EPA has been sampling streams annually for sport fish contamination since 1993. Fish are analyzed for contaminants that bioaccumulate in fish and that could pose a threat to human health if consumed in excessive amounts. Contaminants analyzed in Ohio sport fish include mercury, PCBs, DDT, mirex, hexachlorobenzene, lead, selenium, and several other metals and pesticides. Other contaminants are sometimes analyzed if indicated by site-specific current or historic sources. For more information about chemicals analyzed, how fish are collected, or the history of the fish contaminant program, see the State of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program, Ohio EPA, January 2010 (http://www.epa.state.oh.us/portals/35/fishadvisory/FishAdvisoryProcedure10.pdf).
Fish contaminant data are primarily used for three purposes: 1) to determine fish advisories; 2) to determine attainment with the water quality standards; and 3) to examine trends in fish contaminants over time.

Fish advisories
Fish contaminant data are used to determine a meal frequency that is safe for people to consume (e.g., two meals a week, one meal a month, do not eat), and a fish advisory is issued for

applicable species and locations. Because mercury mostly comes from nonpoint sources, primarily aerial deposition, Ohio has had a statewide one meal a week mercury advisory for most fish since 2001. Most fish are assumed to be safe to eat once a week unless specified otherwise in the fish advisory, which can be viewed at the following website, http://www.epa.state.oh.us/dsw/fishadvisory/index.aspx.

The minimum data requirement for issuing a fish advisory is three samples of a single species from within the past ten years. For the Ottawa River, common carp, rock bass, smallmouth bass, and yellow bullhead met this requirement. For all other species, the statewide advisories apply, which are: two meals a week for sunfish (e.g., bluegill) and yellow perch, one meal a week for most other fish, and one meal a month for flathead catfish 23" and over, and northern pike 23" and over. Common carp are in the one meal a week category due to levels of lead, mercury, and PCBs. Rock bass and smallmouth bass are in the one meal a month advisory category due to mercury. Yellow bullhead are in the one meal a week category due to mercury. Fish tissue data collected from the Ottawa River in support of the advisory program is listed in Table 13.

Fish tissue/human health use attainment

In addition to determining safe meal frequencies, fish contaminant data are also used to determine attainment with the human health water quality criteria pursuant to OAC Rules 3745-1-33 and 3745-1-34. The human health water quality criteria are presented in water column concentrations of µg/l, and are then translated into fish tissue concentrations in mg/kg. In order to be considered in attainment of the water quality standards, the sport fish caught within a HUC12 must have a weighted average concentration of the geometric means for all species below 0.35 mg/kg for mercury, and below 0.023 mg/kg for PCBs. For further details of this conversion, see Ohio's 2010 Integrated Report, Section E (http://www.epa.state.oh.us/portals/35/tmdl/2010IntReport/Section_E.pdf).

Fish tissue data were adequate to determine partial attainment status for one of four HUC12s in the Ottawa River watershed. At least two samples from each trophic level, three and four, are needed, and of the four Ottawa River HUC12s, only 04100007 03 06 (for fish tissue, from upstream Thayer Road to downstream Adgate Road) met that data requirement. For mercury, the weighted mean fish tissue concentration for the HUC12 is 0.309 mg/kg. That meets both the water quality criterion-based threshold for attainment of 0.35 mg/kg, and U.S. EPA's fish tissue criterion for methylmercury of 0.3 mg/kg to one significant figure. For PCBs, the weighted mean fish tissue concentration for the HUC12 ranged between 0.008 mg/kg and 0.054 mg/kg, depending on whether zero or one-half the reporting limits (0.025 mg/kg per Aroclor) for PCBs are used. Because of the uncertainty associated with the reporting limits, attainment status related to PCBs could not be determined.

Fish contaminant trends

Fish contaminant levels can be used as an indicator of pollution in the water column at levels lower than laboratory reporting limits for water concentrations but high enough to pose a threat to human health from eating fish. Most bioaccumulative contaminant concentrations are decreasing in the environment because of bans on certain types of chemicals like PCBs, and because of stricter permitting limits on dischargers for other chemicals. However, data show that PCBs continue to pose a risk to humans who consume fish, and mercury concentrations have been increasing in some locations because of increases in certain types of industries for which mercury is a byproduct that is released to air and/or surface water.

Table 13. Select fish tissue data from 2009 Ottawa River sampling (mg/kg). The shading indicates the advisory category that applies. Green = two meals per week, yellow = one meal per week, orange = one meal per month. Unshaded cells had reporting limits above the one meal per week threshold, and so could not be determined.

Year Collected	Location	River Mile	Species	Lead	Mercury	PCBs
2009	Ottawa River upstream St. Rt. 224 Bridge (Kalida)	3.6	Common Carp	<0.040	0.199	<0.1
2009	Ottawa River upstream St. Rt. 189, adjacent Rimer	16.2	Common Carp	<0.040	0.087	<0.1
2009	Ottawa River upstream Allentown Dam	29	Common Carp	<0.040	0.212	0.319
2009	Ottawa River downstream Adgate Rd.(dst. refinery & PCS)	36.7	Common Carp	1.33	0.055	<0.1
2009	Ottawa River upstream pipeline, downstream Lima WWTP	37.25	Common Carp	<0.039	0.346	0.213
2009	Ottawa River downstream dam, upstream Lima WWTP	37.85	Common Carp	<0.039	0.137	0.051
2009	Ottawa River upstream Collett St. Dam	38.6	Common Carp	<0.040	0.16	0.219
2009	Ottawa River upstream Collett St. Dam	38.6	Common Carp	<0.040	0.087	<0.1
2009	Ottawa River upstream Baxter St. Dam	38.9	Common Carp	<0.040	0.173	0.198
2009	Ottawa River upstream Roush Rd.	42.1	Common Carp	<0.040	0.192	<0.1
	Averages for Common Carp			**0.151**	**0.165**	**0.125**
2009	Ottawa River upstream St. Rt. 224 Bridge (Kalida)	3.6	Rock Bass	<0.039	0.25	<0.05
2009	Ottawa River upstream St. Rt. 189, adjacent Rimer	16.2	Rock Bass	<0.039	0.197	<0.05
2009	Ottawa River upst. Allentown Dam	29	Rock Bass	<0.040	0.148	<0.05
2009	Ottawa River downstream Lima WWTP, upstream recycler	37.4	Rock Bass	<0.039	0.153	<0.05
2009	Ottawa River downstream dam, upstream Lima WWTP	37.85	Rock Bass	<0.040	0.332	<0.05
2009	Ottawa River upst. Baxter St. Dam	38.9	Rock Bass	<0.039	0.305	<0.05
2009	Ottawa River downstream North St. (dam pool)	40.3	Rock Bass	<0.040	0.281	<0.05
2009	Ottawa River upstream Sugar St.	41.2	Rock Bass	<0.039	0.208	<0.05
2009	Ottawa River upstream Roush Rd.	42.1	Rock Bass	<0.040	0.26	<0.05
2009	Ottawa River upstream Thayer Rd.	46.1	Rock Bass	<0.039	0.378	<0.05
	Averages for Rock Bass			**<0.039**	**0.251**	**<0.05**
2009	Ottawa River upstream St. Rt. 224 Bridge (Kalida)	3.6	Smallmouth Bass	<0.039	0.413	<0.05
2009	Ottawa River downstream Lima WWTP, upstream recycler	37.4	Smallmouth Bass	<0.039	0.244	<0.05
2009	Ottawa River downstream dam, upstream Lima WWTP	37.85	Smallmouth Bass	<0.039	0.420	<0.05
2009	Ottawa River downstream North St. (dam pool)	40.3	Smallmouth Bass	<0.039	0.374	<0.05
2009	Ottawa River upstream Sugar St.	41.2	Smallmouth Bass	<0.040	0.343	<0.05
2009	Ottawa River upstream Thayer Rd.	46.1	Smallmouth Bass	<0.039	0.510	<0.05

Year Collected	Location	River Mile	Species	Lead	Mercury	PCBs
2009	Ottawa River upstream Thayer Rd.	46.1	Smallmouth Bass	<0.039	0.611	<0.05
	Averages for Smallmouth Bass			**<0.039**	**0.416**	**<0.05**
2009	Ottawa River upstream St. Rt. 189, adjacent Rimer	16.2	Yellow Bullhead	<0.040	0.208	<0.05
2009	Ottawa River upst. Allentown Dam	29	Yellow Bullhead	<0.040	0.230	<0.05
2009	Ottawa River adjacent Shawnee Country Club upstream Ford	34.7	Yellow Bullhead	<0.040	0.118	<0.05
2009	Ottawa River downstream Adgate Rd. (dst. refinery & PCS)	36.7	Yellow Bullhead	0.285	0.171	<0.05
2009	Ottawa River downstream Adgate Rd. (dst. refinery & PCS)	36.7	Yellow Bullhead	0.112	0.123	<0.05
2009	Ottawa River upstream pipeline, downstream Lima WWTP	37.25	Yellow Bullhead	<0.040	0.134	<0.05
2009	Ottawa River downstream Lima WWTP, upstream recycler	37.4	Yellow Bullhead	<0.040	0.157	<0.05
2009	Ottawa River upst. Baxter St. Dam	38.9	Yellow Bullhead	<0.040	0.188	<0.05
	Averages for Yellow Bullhead			**0.065**	**0.166**	**<0.05**

For this reason, it is useful to compare the results from the survey presented in this TSD with the results of the previous survey(s) done in the study area. Recent data can be compared against historical data to determine whether contaminant concentrations in fish tissue appear to be increasing, decreasing, or staying the same in a water body or watershed.

Fish tissue had previously been collected in the Ottawa River in 1993 and 1996. Fish were collected along approximately the same stretch of river in 2009, from upstream of Thayer Road at RM 46.1 to the State Route 224 bridge near Kalida at RM 3.6. Mercury levels in fish appear to have risen in the Ottawa River since 1993-1996, from an average of 0.148 mg/kg to 0.319 mg/kg in 2009 (Table 13).

PCB levels appear to have decreased in the Ottawa River, from an average of 0.028 mg/kg in 1993-1996 to 0.013 mg/kg in 2009. However, PCBs were found only in fish upstream from the Baxter Street Dam (RM 38.9), to upstream of the Allentown Dam (RM 29) in 2009. Fish downstream of Allentown Dam did not contain detectable levels of PCBs in 2009 (Table 13).

Levels of selenium in fish tissue have remained similar, 0.932 mg/kg in 1993-1996 to 0.915 mg/kg in 2009. The Se concentration for the Ottawa River in Lima was at or above the 97th percentile for Se in rivers and streams in the state (1993-2007) via bioaccumulation in the food web despite lower overall Se inputs (with periodic pulses) compared to historic inputs (Sorenson, 1991).

In regards to historical selenium fish tissue data, four of the six whole body (WB) dry weight (DW) fish tissue samples collected in 1996 by Ohio EPA downstream from the Lima (then BP Oil) Refinery (RM 36.8) exceeded the Se toxicity threshold benchmark of 4 µg/g (Lemly 2001). While the Se fish tissue concentrations ranged from 4.28 to 21.08 µg/g, the samples immediately downstream from the Lima Refinery and near Allentown dam (RM 28.9) had values of 7.68 µg/g which can cause juvenile fish mortality and associated reproductive failure (Lemly 2001).

In 2010, WB fish tissue samples were collected and split for analysis between Husky Refinery and Ohio EPA. Two of the four samples at RM 36.9 (downstream from Husky Refinery discharge) contained Se values greater than the ecological safety benchmark of 4 µg/g (4.3-6.0 µg/g), while one of the four split samples near the Allentown dam pool (RM 29) exceeded the tissue toxicity threshold guidelines for skin-off fillet of 8 µg/g with a result =8.6 µg/g (Lemly 2001).

In 2009, Lima Refinery consultants collected 48 WB fish tissue samples (including 1 duplicate sample in five of six sampling zones) in the Ottawa River mainstem. Over 70% of the WB fish tissue samples exceeded the toxicity threshold of 4.0 µg /g. From the 2009 and 2010 Ottawa River mainstem fish tissue data collectively, eight different fish species (creek chub, white sucker, common carp, sand shiner, rock bass, longear sunfish, bluegill sunfish, and green sunfish) were documented to have bioaccumulated excess selenium in their tissue above the toxicity benchmark (Table 14). The highest median Se fish tissue concentrations were found downstream from the Lima Husky Refinery to the Allentown dam.

Table 14. Husky Oil 2009 consultant WB fish tissue sample total selenium data for the Ottawa River mainstem. The TMDL fish tissue matrix toxicity threshold benchmark is 4µg/g (Lemly 2001). All units are ug/g.

Sampling Zone[a]	Number of Fish Tissue Samples	Number of Fish Species	Selenium Range (median)	Number of samples exceeding 4.0 ug/g toxicity threshold (mean exceedance ratio)	% fish tissue samples > threshold
1	11	5	3 to 5.5 (4.3)	8 (1.175X)	72.7%
2	10	4	2.3 to 8.4 (4.2)	7 (1.10X)	70%
3	8	4	4.7 to 7.6 (6.1)	8 (**1.56X**)	100%
4	5	5	5.1 to 7.4 (7.0)	5 (**1.67X**)	100%
5	7	5	3.7 to 5.8 (5.0)	6 (1.28X)	86%
6	7	3	3.9 to 5.6 (5.3)	6 (1.26X)	86%

a - Zone 1 was upstream from Lima (Thayer Rd.) to upstream Lima WWTP. Zone 2 was downstream from the Lima WWTP discharge. Zone 3 was downstream Lima Husky Refinery. Zone 4 was from the Allentown dam upstream to above Copus Rd. Zone 5 was from downstream the Allentown dam to downstream near Rimer. Zone 6 is the lower reaches of the Ottawa River nearer the mouth.

Macroinvertebrate Tissue Analysis for Selenium

Macroinvertebrate sample collection for tissue analysis for selenium was conducted on September 21st and 22nd, 2010 within four sample reaches: Zones 1, 2, 3 and 4 (Table 15). The macrobenthos collected in each sample reach were composited in glass sample jars (total of ≥ 10 grams wet weight / sample), chilled in ice water immediately after sampling, and frozen at the end of the day. The approximate percentages of identified stream macroinvertebrate groups/taxa were documented (Table 15).

All macroinvertebrate tissue samples contained Se (Table 15). The five highest macroinvertebrate Se tissue concentrations were from the 2009 consultant data and ranged between 4.73 - 12 µg/g (Lima Refining Company, 2010). The sites with the two highest Se concentrations were downstream from the Lima Husky Refinery (RM 37.0) and in the Allentown Dam pool (RM 28.8) with values of 10 µg/g and 12 µg/g, respectively (Table 15). The other 2009 sites with elevated Se tissue concentrations were in zone 4 (RM 29.2) with a Se range between 3.63 - 4.73 ug/g, in zone 5 (dst. SR 81 to Rimer) with a range between 5.8 – 6.1 µg/g, and in zone 6 (near the mouth) with a Se value of 6.4 µg/g (Table 15). All 2009 macroinvertebrate tissue data exceeded the Lemly's recommended TMDL selenium threshold toxic effect concentration guideline of 3 µg/g dry weight for macroinvertebrates. Levels >3 µg/g can cause toxic fish health effects, reproductive, teratogenic, or survival effects in fish based on selenium concentrations in fish tissue (Lemly 2001, 2002). All but one 2009 macroinvertebrate selenium tissue sample concentration exceeded the upstream control (RM 45.9) (Table 15).

Table 15. Macroinvertebrate tissue analysis for selenium concentrations collected in sample zones in the Ottawa River mainstem, September 21-22, 2010 compared to Husky Oil 2009 consultant data. TMDL aquatic invertebrate threshold toxic effect concentration (Conc.) = 3.0 µg/g (Lemly 2001). Tissue concentrations > 3.0 µg/g or > control are in **bold** with the associated exceedance ratio **(**ER**)**.

Location and Sample Description	% Solids	Macroinvertebrate groups and taxa with percent composition	Se tissue Conc. (ER of threshold)	Mean zone Conc. (ER of threshold)	Se Tissue Conc. (ER of control)
ZONE 1 – Upstream from Thayer Rd. (RM 45.9)					
Lotic Riffle Composite	24.0	Caddisflies (Hydropsychids and Philopotamids) *95%* Riffles beetles 2.5% Moth larvae (*Petrophila* sp.) 1% Fingernail clams (*Sphaerium* sp.) 1% Mayflies, midges, and Turbellaria 0.5%	**4.21 (1.40X)**	**3.70 (1.23X)**	NA[a]
Lotic Run – Glide/Margin Composite (Comp.)	39.5	Crayfish 90% River snails (*Elimia* sp.) and water pennies 9% Spiral-cased caddisflies (*Helicopsyche* sp.) 0.5% *Argia* damselflies, heptageneid mayflies, & midges 0.5%	**3.20 (1.066X)**		No
Lima Refinery 2009	ND[b]		ND	NA	NA
ZONE 2 – Downstream from Lima WWTP (RM 37.47)					
Lotic Riffle Composite	33.8	Hydropsychids 55% Turbellaria 30% Fingernail clams (*Sphaerium* sp.) 10% River snails (*Elimia* sp.) and *Argia* sp. Damselflies 4% Midges 1%	2.24	1.88	No
Lotic Run/Margin Composite	53.0	River snails (*Elimia* sp.) 65% Fingernail clams (*Sphaerium* sp.) 30% Midges and *Argia* sp. damselflies 4% Dragonflies 1%	1.51		No
Lima Refinery 2009	ND		2.7	2.7	No
ZONE 3 – Downstream from Husky Oil Refinery (RM 37.0)					
Lotic Riffle Composite	58.0	Hydropsychids 50% Fingernail clams (*Sphaerium* sp.) 25% Baetid mayflies 15% River snails (*Elimia* sp.) 8% Midges 1% Turbellaria 1%	2.19	2.33	No

Location and Sample Description	% Solids	Macroinvertebrate groups and taxa with percent composition	Se tissue Conc. (ER of threshold)	Mean zone Conc. (ER of threshold)	Se Tissue Conc. (ER of control)
Lotic Run/Margin Comp.	39.1	River snails (*Elimia* sp.) 40% Fingernail clams (*Sphaerium* sp.) 30% Crayfish 25% *Argia* sp. damselflies 5%	2.47		No
Lima Refinery 2009	ND		**10 (3.33X)**	**10 (3.33X)**	**Yes (2.37X)**
ZONE 4 (Lotic Reach) - Upstream from Copus Rd. (RM 29.2)					
Lotic Riffle Composite	36.3	Hydropsychids 62% Baetid/heptageneid mayflies 17% Fingernail clams (*Corbicula* & *Sphaerium* sp.) 15% Midges 3% *Argia* sp. damselflies 2% Turbellaria & leeches 1%	**4.73 (1.58X)**	**4.18 (1.39X)**	**Yes (1.12X)**
Lotic Run/Margin Composite	31.4	Crayfish 70% Fingernail clams (*Corbicula* & *Sphaerium* sp.) 15% Mayflies (baetids, heptageneids, & *Caenis* sp.) 7% *Argia* sp. damselflies 5% Water pennies 2% Midges 1%	**3.63 (1.21X)**		No
ZONE 4 (Lentic Reach) – In Allentown Dam Pool (RM 28.8)					
Lentic Slow Run-Pool/Margin Composite	38.3	Crayfish 75% Damselflies 20% Mayflies (baetids, heptageneids, & *Caenis* sp.) 2% Scuds 1% Dragonflies 1% Midges & water pennies 1%	2.57	2.57	No
Lima Refinery 2009	ND		**12 (4.0X)**	**12 (4.0X)**	**Yes (2.85X)**
ZONE 5 – Downstream from Allentown Dam Pool to near Rimer					
Lima Refinery 2009	ND		**5.8-6.1 (1.93X-2.03x)**	**5.95 (1.98x)**	**Yes (1.4X-1.45X)**
ZONE 6 – Downstream in Ottawa River near the mouth					
Lima Refinery 2009	ND		**6.4 (2.13X)**	**6.4 (2.13X)**	**Yes (1.52X)**

a - NA = Not Applicable. Ohio EPA Zone 1 Lotic Riffle macroinvertebrate tissue sample is control (4.21 μg/g).
b - ND = No Data

Lakes Assessment

Metzger Reservoir is part of a series of lakes used by the City of Lima to store drinking water. It is an upground reservoir constructed in 1946 that covers a surface area of 157 acres with a maximum depth of about 33 feet. Source water is pumped from the Ottawa River and the watershed drains 103mi^2. Most land in the watershed is used for row crop agriculture. The lake is open to public fishing and there is a primitive boat launch, but only electric motors are allowed and swimming is prohibited.

Ohio EPA has implemented a sampling strategy that focuses on evaluating chemical conditions near the surface and physical conditions in the water column of inland lakes. Physical profile measurements are summarized either for the entire water column or the epilimnion depending on thermal stratification. The sampling target consists of an even distribution of a total of ten sampling events divided over a two-year period and collected during the index period of May 1 – September 30. Key parameters used to determine the attainment status of lakes include chlorophyll a, ammonia, dissolved oxygen, pH, total dissolved solids and various metals. Other parameters used to evaluate the degree of support or non-support include secchi depth, total phosphorus and total nitrogen. Details of the sampling protocol are outlined in Appendix 1 of the Ohio EPA Surface Water Field Sampling Manual, available on Ohio EPA's web page at; http://www.epa.ohio.gov/portals/35/inland_lakes/Lake_Sampling_Procedures.pdf

Water Quality Standards for the Protection of Aquatic Life in Lakes

Presently, lakes in Ohio are designated as Exceptional Warmwater Habitat (EWH) with respect to the aquatic life habitat use designation. Revisions to Ohio's WQS that would change the aquatic life use from EWH to Lake Habitat (LH) were proposed for adoption in December, 2011, but were subsequently withdrawn. A future rulemaking is anticipated but the timeframe is unknown. A primary reason for this revision is that in Ohio, a set of biological criteria applies to rivers and streams, whereas no biocriteria apply to lakes. The numeric chemical criteria to protect the LH use will remain the same as the criteria to protect the EWH use that currently applies to lakes, with a suite of nutrient criteria added. A set of numeric criteria that applies to all surface waters for the protection of aquatic life, regardless of specific use designation, also apply to inland lakes and are referred to as "base aquatic life use criteria" in the proposed WQS rules. The base aquatic life use criteria will be the same aquatic life numeric criteria that currently apply to lakes. Examples include various metals such as copper, lead, and cadmium as well as organic chemicals such as benzene and phenol. Specific details concerning the progress of revisions to Ohio's Water Quality Standards involving the proposed Lake Habitat aquatic life use and associated criteria can be found at the following Ohio EPA web site as information becomes available: http://www.epa.ohio.gov/dsw/rules/draftrules.aspx. Details of the proposed use designation, draft criteria and assessment methodology are previewed in the Ohio EPA 2012 Integrated Water Quality Monitoring and Assessment Report, available on Ohio EPAs web page at; http://epa.ohio.gov/dsw/tmdl/OhioIntegratedReport.aspx

Results for the proposed Lake Habitat criteria are presented in Table 16. Some of these parameters (chlorophyll *a*, total phosphorus, total nitrogen and secchi depth) are first evaluated by calculating a median value from the two year dataset and then comparing this value to the appropriate numeric criteria depending on lake type and ecoregion. The other parameters (dissolved oxygen, pH and ammonia) are evaluated in a manner similar to the base aquatic life parameters, except the numbers compared for dissolved oxygen and pH are average and median values, respectively, calculated from measurements taken in either the epilimnion or the entire water column if the lake isn't stratified. If chlorophyll *a*, dissolved oxygen, pH or ammonia doesn't meet criteria the Lake Habitat use is impaired. Metzger Reservoir would be considered impaired because of both chlorophyll *a* and pH based on the draft criteria and assessment methods (Table 16). The elevated nutrient levels and limited water clarity would trigger a watch list designation.

A surface sediment sample was analyzed for metals, nutrients, semi-volatile organics, insecticides and polychlorinated biphenyls. The metals were compared to ecoregional reference values for Ohio streams. These values should be appropriate for lakes because reference conditions are mainly influenced by parent geology. Copper was at a level slightly above reference condition, likely due to the use of copper based algaecides. No organic compounds were detected in the sample.

Even though swimming is not allowed in the lake, the recreation use was evaluated by measuring levels of *E.* coli at the boat ramp. Colony counts ranged from below detection to 52 cfu/100 ml and the geometric mean calculated from 10 samples collected over two years was 5 cfu/100 ml. This is well below the bathing water criterion of 126 cfu/100ml.

The PDWS use was evaluated based on Safe Drinking Water Act maximum contaminant levels (MCLs) for nitrate (10 ppm) and atrazine (3 ppb). None of the lake samples exceeded any of these levels. These compounds were also tested in source water from the Ottawa River. A sample collected during late spring 2010 had very high levels of nitrate (36.8 ppm) and atrazine slightly above the MCL (3.38 ppb). Pumping under these conditions should be avoided. A whole water phytoplankton sample from the lake collected in the fall of 2010 was enumerated to assess the need to test liver and nerve toxins produced by Cyanobacteria (blue green algae). Toxin samples were submitted when results showed a dominance of Cyanobacteria. Levels of *Cylindrospermopsin* and *Saxitoxin* were below their respective reporting limit, and *Microcystin* was detected at 1.2 ppb. No toxin was detected in a complimentary finished water sample. *Microcystin* was also detected in a toxin sample submitted in the fall of 2011 at 0.61 ppb.

Based on fish tissue data there is no need for a water body specific consumption advisory.

Table 16. *Assessment of lake data collected from Metzger Reservoir, using the proposed Lake Habitat aquatic life use and associated draft criteria. Note - As of the finalization of this report, the proposed Lake Habitat use and the associated nutrient criteria have not been adopted into the Ohio Water Quality Standards and the assessments provided in this table should be considered as examples of how the adopted use and criteria would be applied.*

Proposed Lake Habitat Aquatic Life Use							
Parameter	Chl. *a* (µg/L)	Secchi depth (m)	T-Nitrogen (µg/L)	T-Phosphorus (µg/L)	DO (mg/L)	pH (SU)	NH_3 (mg/l)
Draft Criteria	**6.0**	**2.60**	**1225**	**18**	**6.0**	**6.5>pH<9.0**	**(WQS)**
05/09/10	11.1	1.35	4141	29	8.55	8.19	0.06 (0.8)
06/08/10	4.5	4.07	1610	49	9.54	8.67	0.14 (0.3)
07/13/10	8.3	2.9	-	-	9.89	8.64	-
07/29/10	32.1	0.9	2510	20	9.50	8.83	<0.05 (0.2)
08/23/10	24.0	1.86	1220	12	7.61	9.33	<0.05 (0.1)
09/16/10	61.6	1.05	1010	27	6.81	8.49	0.06 (0.2)
05/08/11	2.4	0.8	3570	38	9.50	7.76	<0.05 (0.4)
06/14/11	6.0	3.6	3120	17	10.1	8.85	<0.05 (0.2)
07/07/11	2.4	4.5	2460	<10	9.03	8.88	<0.05 (0.1)
08/02/11	14.7	1.35	1610	13	10.4	9.06	<0.05 (0.1)
09/12/11	243	0.57	1540	137	5.10	7.89	<0.05 (0.1)
Median values of proposed Lake Habitat criteria and number of samples exceeding the base aquatic life OMZA criterion. (% Exceeded)	11.1	1.35	2035	23.5	1 of 11	2 of 11	0 of 10
Narrative[1]	Non-support	Watch List	Watch List	Watch List	Support	Non-support	Support

1 – Narrative descriptions include; 'Non-support' which indicates the proposed LH use in not supported, 'Watch List' values will be factored into the prioritization process for the lake to receive additional monitoring, and 'Support' which indicates the proposed LH use is supported.

Physical Habitat For Aquatic Life

The assessment of the influence of physical stream features and riparian conditions on ambient biological performance for the Ottawa River basin will proceed in a longitudinal manner (upstream to downstream). The discussion of tributaries will either be treated in the aggregate, or if sufficiently large, tributaries or subbasins will be broken out separately for discussion. For the purposes of continuity, this longitudinal reporting structure will also be applied to the assessment of ambient biological performance throughout this document.

Mean Qualitative Habitat Evaluation Index (QHEI) values from rivers or river segments equal to or greater than 60.0 generally indicate a level of macrohabitat quality sufficient to support an assemblage of aquatic organisms fully consistent with the WWH aquatic life use designation. Reach average values at or greater than 75.0 are generally considered adequate to fully support EWH communities (Rankin 1989 and 1995). Values between 55 and 45 indicate limiting components of physical habitat are present and may exert a negative influence upon ambient biological performance. However, due to the potential for compensatory stream features (e.g., strong ground water influence) or other watershed variables, QHEI scores within this range do not necessarily exclude WWH or even EWH assemblages. Values below 45 indicate a higher probability of habitat derived aquatic life use impairment, but should not be viewed necessarily as a determinant.

An understanding of the unique geological and ecoregional features of the Ottawa River basin assist in the analysis of the habitat quality and its ability to support aquatic communities. The Ottawa River basin is a trans-boundary system, draining two of Ohio's five ecoregions: the ECBP and HELP (Omernik and Gallant 1988). These ecoregions offer vastly contrasting surface land forms and, thus, each exerts considerable influence upon the interplay between human land use, water resource quality, and resulting lotic biology of affiliated waterbodies. At a regional scale, the ECBP is characterized by flat to gently rolling topography, primarily represented by ground moraine, with areas of higher relief defined by dissected end moraine and related glacial features. Soils here are primarily derived from glacial drift and are typically well to moderately well-drained. The combination of naturally adequate drainage and moderate relief associated with most streams and waterways within this region tends to obviate the need for extensive hydrological manipulation to facilitate human land uses. This of course is not universal, as local, subregional or otherwise anomalous conditions may necessitate drainage or other hydrological modification greater than commonly needed or observed throughout the region as a whole.

By comparison, the HELP ecoregion is characterized by a broad and nearly level lake plain, giving way to extensive lacustrine deposits of laminated clays and related still-water deposits in the heart of the region (Pavey et al. 1999). Local relief is very low, with relic beach ridges providing nominal elevation above the plain. Given the low relief and the dominance of clayey soils, stream gradients are typically very low and adjacent uplands are naturally poorly drained. In order to facilitate human habitation, agriculture, and other economic land uses, extensive drainage activities were undertaken within this region as early as the 1850s (ditching, dredging, field tiling, etc.). Over the following 160 years, much of the stream networks draining the HELP have been, to varying degrees, directly channelized or otherwise hydrologically modified so as to efficiently receive and convey surface and subsurface drainage. The scale, pervasive nature, and maintenance of these drainage improvements, coupled with the prevalence of clayey soils and low stream power – the latter a function of gradient and discharge – have rendered many of the associated waterways permanently debilitated in terms of riverine macrohabitat and associated ambient biological potential.

The relationship between existing stream conditions and the adjacent landscape throughout the Ottawa River basin are best explained and comprehended as a nexus between land use (urban/industrial, suburban, or rural/agricultural) and physiography (till plains, lake plain, or post glacial lacustrine/palustrine). In many important ways the degree and extent of hydromodification and its antecedents are among the most important variables supporting the appraisal of macrohabitat quality and its direct influence upon ambient biological potential. Although the generalized ecoregional characteristics, described above, are present and operative within the study area, significant and consequential discontinuities were evident.

Owing to the transitional nature of the study area, non-trivial portions of the watershed draining the ECBP contain an unusually high proportion of lacustrine features (Pavey et al. 1999). Chief among these is a nearly 17,000 acre deposit of lake plain clayey till and laminated lacustrine clays located in the uppermost reaches of the Hog Creek subbasin in northwestern Hardin County. Albeit smaller in area and effects, similar or related discontinuous lacustrine deposits are also found throughout the study area on both the Ottawa River mainstem and selected tributaries. Specific waters so affected include: a six to seven mile segment of the Ottawa River (RMs 25.8-19.2), between the villages of Elida and Gomer, upper Sugar Creek, and upper Plum Creek. The practical consequence of this is that like streams within the HELP ecoregion, these lacustrine-like ECBP streams (and associated catchments) required extensive drainage modification to bring them under cultivation, and in many instances require on-going drainage maintenance. The result of this is that in form, function, and biological potential these streams are highly similar to those common to the HELP.

Although largely unrelated to the study area’s physiography, an entirely different set of hydromodification also affects macrohabitat on the Ottawa River mainstem through the greater Lima area. These include about seven miles of historic channel modification and a suite of five low-head dams, impounding, almost continuously, three river miles in the heart of Lima. Early efforts at improving drainage (channelization) through Lima were undertaken between the late 1800s and early 1900s. Between 1931 and 1936, in an attempt to alleviate chronic septic conditions that continued to plague the river, the Ottawa River was dredged, several dams were installed and sewage treatment works were built. In the early 1950s, two additional dams were installed and the city’s sewage works was upgraded. Outside of Lima, there are three additional low-head dams upstream, between Thayer Rd. and Roush Rd., and a single dam located several miles downstream at Allentown.

Ottawa River Mainstem

Originating in the ECBP, at the confluence of Hog and Little Hog creeks in eastern Allen County, the Ottawa flows in a general south-westerly direction for approximately 16 miles though a narrow glacial valley, bounded to the north and south by the Fort Wayne and Wabash end moraines, respectively (Trautman 1981). Just west of the city of Lima, the river abruptly veers north, breaching the Fort Wayne moraine, and then traverses an additional 14 river miles of ground and lake plain moraine before entering the HELP ecoregion proper, near the village of Rimer. The lower 17 miles are contained entirely within the HELP ecoregion, where the Ottawa River flows through low relief lake plain and related lacustrine deposits before joining the Auglaize River in Putnam county, northwest of the village of Kalida.

As part of the 2010 fish sampling effort, the quality of near and in-steam macrohabitats of the Ottawa River mainstem were evaluated at 25 sampling locations, assessing approximately 47 river miles between RM 46.1 (Thayer Rd.) and RM 1.0 (CR 19, downstream Kalida). QHEI values ranged between 46.5 and 81.0, with a mean score of 66.1 ($\pm$8.302 SD). A matrix of QHEI macrohabitat features, by station, and the longitudinal performance of the QHEI for the Ottawa River are presented in Table 17 and Figure 62.

As measured by the QHEI, the quality of near and in-stream macrohabitat throughout most of the Ottawa River appeared capable of supporting diverse, functionally organized, and well-structured assemblages of aquatic organisms, consistent with its respective ecoregional ECBP and HELP benchmarks. Most sites contained a complement of positive channel, substrate, and riparian features, minimally compatible with the river's WWH aquatic life use designation. However, conditions were not uniform, as the Ottawa River mainstem consists of a patchwork of high to moderate quality free-flowing reaches, found largely within the rural portions of the ECBP, and lower quality channel modified and/or impounded segments within the HELP, and the urban and suburban environs of greater Lima.

Evidenced by a low ratio of modified/warmwater macrohabitat attributes (well under 1.0) and QHEI scores ranging between 70.0 and 81.0, the river appeared in a relatively natural or unmodified state upstream from Lima at both the Thayer Rd. and Fetter Rd. stations (RMs 46.1and 44.3). Substrates here consisted largely of a mix of coarse glacial outwash and native limestone. The channel configuration was diverse, displaying adequate sinuosity, developed riffle and run complexes and associated mixed current velocities. Max pool depths were adequate, but under structured and riparian uplands were wooded. The most significant limiting aspect of physical habitat was siltation and attendant substrate embeddedness which was found locally to be quite severe.

Macrohabitat quality and resulting QHEI scores fell sharply as the Ottawa River entered the greater Lima area. Macrohabitat attribute ratios (modified vs. warmwater attributes) rose to 1.5 and 3.3, at the Metzger Rd. and Roush Rd. stations (RMs 43.4 and 42.5), respectively. Values well above 1.0 are indicative of a predominance of modified features, reflective in this instance of historic channel modification, impoundment, and to a lesser extent sedimentation. Conditions were improved at the Sugar St. station (RM 41.3), where channel form and function were either unmodified or naturally recovered from historic modification. The habitat attributes ratio here fell to well below 1.0. An additional and important factor not directly measured by the QHEI was the diminution of stream discharge beginning downstream from the Metzger Rd. municipal water in-take structure. No stream flow was observed immediately below the dam during both the July and August fish sampling events, and stream discharge farther downstream was minimal or anemic for approximately two miles. Flow regime was locally improved at this point, (RM 41.3, Sugar St.) where surface flow to the Ottawa River appeared augmented, incidentally, by surplus quarry wash water.

Table 17. QHEI attributes report for the Ottawa River waterhed.

Key QHEI Components

04-200-000 **Ottawa River**

Year: 2010

			WWH Attributes											MWH Attributes: High Influence						MWH Attributes: Moderate Influence														
River Mile	QHEI	Gradient (ft/mi)	Not Channelized or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low/Normal Embeddedness	Max Depth>40cm	Low/Normal Riffle Embeddedness	WWH Attributes	Channelized/No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth <40cm	High-influence Modified Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1 or 2 Cover Types	Intermittent/Poor Pools	No Fast Current	High/Moderate Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	M.I. Modified Attributes	MWH H.I.+1/WWH+1 Ratio	MWH M.I./WWH Ratio
46.0	81.0	7.81	X	X		X	X	X	X		X	X	8				X		1		X								X			2	0.22	0.33
44.3	70.0	7.94	X	X		X		X	X		X	X	7				X		1		X			X	X		X		X			5	0.25	0.75
43.4	59.5	4.46		X						X		X	3				X	X	2	X				X	X			X				4	1.00	1.25
42.5	61.3	0.10									X	X	2	X			X		2	X	X			X	X			X	X			6	1.00	2.33
41.3	71.3	3.62	X	X		X	X		X	X	X	X	8				X		1		X								X			2	0.22	0.33
40.1	69.5	3.13		X				X	X		X		4				X		1	X	X			X	X				X	X		6	0.60	1.40
39.7	71.5	3.13		X		X	X	X	X		X	X	7				X		1	X	X			X	X				X			5	0.38	0.75
38.6	46.5	0.10						X			X		2	X	X	X			3		X			X	X			X	X		X	6	1.33	2.33
37.9	74.0	5.56		X					X		X	X	4				X		1	X	X			X	X				X			5	0.60	1.20
37.4	71.8	5.56		X		X	X	X			X	X	6				X		1	X	X			X	X			X	X	X		7	0.43	1.29
37.0	70.3	7.81		X				X			X		3						0	X	X			X	X			X	X	X		7	0.50	2.25
36.1	77.3	3.47	X	X		X	X	X	X	X	X	X	9						0	X	X				X							3	0.20	0.40
34.5	69.3	3.03		X				X	X		X	X	5				X		1	X	X			X	X				X			5	0.50	1.17
31.1	59.8	5.26		X				X			X		3						0	X	X			X	X			X	X		X	7	0.50	2.25
29.3	69.5	6.25		X		X		X			X	X	5				X		1	X	X			X	X			X	X	X		7	0.50	1.33
28.9	78.0	6.25		X		X	X	X	X		X		6						0	X	X								X	X		4	0.29	0.86
25.8	63.5	2.22		X				X			X	X	4				X		1	X	X			X	X			X	X	X		7	0.60	1.80
24.1	68.3	2.22		X		X		X	X	X	X	X	7						0	X	X			X	X							4	0.25	0.63
22.1	54.3	4.59		X							X		2				X		1	X	X			X	X		X	X	X	X		8	1.00	3.33
18.8	66.0	4.76						X		X	X	X	4				X		1	X	X			X	X			X	X			6	0.60	1.60
15.9	68.8	5.26						X	X	X	X	X	5				X		1	X				X	X							3	0.50	0.83
12.7	59.5	1.00					X	X		X	X	X	5				X		1	X	X	X		X	X			X	X			7	0.50	1.33
8.2	55.5	1.53		X				X			X		3						0	X	X			X	X			X	X		X	7	0.50	2.25
3.7	59.5	2.21		X							X	X	3				X		1	X	X			X	X			X	X	X		7	0.75	2.25
1.2	56.0	1.68		X				X			X		3		X		X		2	X	X			X	X			X	X	X		7	1.00	2.25

04-200-002 **Zurmehly Creek**

Year: 2010

River Mile	QHEI	Gradient (ft/mi)	Not Channelized or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low/Normal Embeddedness	Max Depth>40cm	Low/Normal Riffle Embeddedness	WWH Attributes	Channelized/No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth <40cm	High-influence Modified Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1 or 2 Cover Types	Intermittent/Poor Pools	No Fast Current	High/Moderate Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	M.I. Modified Attributes	MWH H.I.+1/WWH+1 Ratio	MWH M.I./WWH Ratio
0.1	65.0	27.78	X	X		X	X	X		X			6					X	1									X	X		X	3	0.29	0.57

Report Date: 4/17/2013

Table 17. QHEI attributes for the Ottawa River watershed, 2010-2011.

QHEI Attributes: Ottawa River Basin (Lima) 2010 TMDL

Key QHEI Components

			WWH Attributes											MWH Attributes – *High Influence*						*Moderate Influence*														
River Mile	QHEI	Gradient (ft/mi)	Not Channelized or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low/Normal Embeddedness	Max Depth>40cm	Low/Normal Riffle Embeddedness	WWH Attributes	Channelized/No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth <40cm	High-influence Modified Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1 or 2 Cover Types	Intermittent/Poor Pools	No Fast Current	High/Moderate Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	M.I. Modified Attributes	MWH H.I.+1/WWH+1 Ratio	MWH M.I./WWH Ratio
04-200-005			**Trib. to Ottawa River (RM 0.70)**																															
Year:		**2010**																																
0.3	64.5	6.25		X			X	X		X	X	X	6						0	X	X			X			X	X	X		X	7	0.29	1.14
04-200-006			**Beaver Run**																															
Year:		**2010**																																
0.5	42.3	7.81		X									1	X			X	X	3	X	X			X	X			X	X		X	7	2.00	4.00
04-201-000			**Plum Creek**																															
Year:		**2010**																																
14.9	39.5	4.27						X					1	X	X	X	X	X	5	X	X			X	X			X	X	X	X	8	3.00	5.00
12.9	60.5	6.02	X	X						X		X	4				X	X	2	X	X			X	X			X	X			6	0.80	1.40
12.1	37.5	6.85										X	1	X		X	X	X	4		X			X	X			X	X		X	6	2.50	4.00
8.1	40.0	2.24											0	X			X	X	3	X	X			X	X			X	X	X		7	4.00	9.00
4.6	29.8	1.86											0	X	X		X	X	4		X			X	X			X	X	X		6	5.00	7.00
0.2	51.3	2.89						X			X	X	3				X		1	X	X			X	X		X	X	X	X		8	0.75	2.50
04-201-001			**Trib. to Plum Creek (RM 7.30)**																															
Year:		**2010**																																
0.4	35.3	3.29						X			X		2		X		X		2	X	X			X	X		X	X	X		X	8	1.33	3.00
04-202-000			**Sycamore Creek**																															
Year:		**2010**																																
0.6	39.0	4.20								X		X	2	X		X	X	X	4	X	X		X	X	X			X	X	X	X	9	1.67	3.67
04-203-000			**Sugar Creek**																															
Year:		**2010**																																
26.0	44.3	16.13											0	X			X	X	3	X	X			X	X			X	X		X	7	4.00	8.00
23.9	51.0	6.17											0				X	X	2	X	X			X	X			X	X	X		7	4.00	9.00
20.0	46.0	3.62					X	X			X		3		X		X		2	X	X		X	X				X	X	X	X	8	1.00	2.25
18.2	65.5	10.41		X				X			X		3						0	X	X			X	X			X	X	X	X	8	0.50	2.50
13.4	52.3	3.62		X							X		2	X			X		2	X	X			X	X		X	X	X	X		8	1.00	3.33
8.8	56.0	3.60		X							X		2				X		1	X	X			X	X		X	X	X	X		8	1.00	3.00
3.5	45.8	2.65						X			X		2		X				1	X	X			X	X			X	X		X	7	1.00	2.67
0.6	60.9	3.82	X	X			X				X		4				X		1	X	X			X	X			X	X	X		7	0.60	1.80

Report Date: 4/17/2013

Table 17. QHEI attributes report for the Ottawa River waterhed.

QHEI Attributes: Ottawa River Basin (Lima) 2010 TMDL

Key QHEI Components

WWH Attributes / MWH Attributes (*High Influence*, *Moderate Influence*)

River Mile	QHEI	Gradient (ft/mi)	Not Channelized or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low/Normal Embeddedness	Max Depth>40cm	Low/Normal Riffle Embeddedness	WWH Attributes	Channelized/No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth <40cm	High-influence Modified Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1 or 2 Cover Types	Intermittent/Poor Pools	No Fast Current	High/Moderate Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	M.I. Modified Attributes	MWH H.I.+1/WWH+1 Ratio	MWH M.I./WWH Ratio
04-204-000			**Rattlesnake Creek**																															
Year:		**2010**																																
1.7	43.8	4.90		X							X		2				X		1	X	X		X	X	X		X	X	X	X	X	10	1.00	4.00
04-207-000			**Leatherwood Ditch**																															
Year:		**2010**																																
0.5	30.5	9.43								X			1		X		X	X	3	X			X	X	X	X	X	X			X	8	2.50	4.50
04-208-000			**Pike Run**																															
Year:		**2010**																																
8.3	50.3	6.85		X				X			X		3	X			X		2	X	X			X	X		X	X	X		X	8	0.75	2.50
7.6	58.3	8.33		X				X			X		3	X			X		2	X	X			X	X		X	X	X	X		8	0.75	2.50
4.6	38.3	4.63										X	1	X			X	X	3	X	X			X	X			X	X	X		7	2.00	4.50
0.8	52.0	5.68		X							X		2				X		1	X	X			X	X		X	X	X	X		8	1.00	3.33
04-209-000			**Honey Run**																															
Year:		**2010**																																
3.6	40.8	2.82						X			X		2	X	X				2	X	X			X	X		X	X	X	X		8	1.00	3.00
0.9	46.5	5.95					X	X			X		3		X				1	X	X			X			X	X	X		X	7	0.75	2.00
04-210-000			**Dug Run**																															
Year:		**2010**																																
0.2	54.0	6.25					X						1				X	X	2	X				X	X			X	X	X		6	2.00	4.00
04-213-000			**Little Ottawa River**																															
Year:		**2010**																																
5.5	57.0	5.55		X			X	X			X		4						0	X	X			X	X		X	X	X		X	8	0.40	2.00
4.5	67.0	6.85	X	X				X		X	X	X	6						0		X			X	X			X		X	X	6	0.14	1.00
1.1	69.3	11.63	X	X		X	X	X		X	X	X	8						0		X		X					X	X	X	X	6	0.11	0.78
0.1	66.8	8.33	X	X		X	X	X			X		6						0		X			X			X	X	X	X	X	7	0.14	1.29
04-214-000			**Lost Creek**																															
Year:		**2010**																																
3.6	33.0	6.94									X		1	X	X		X		3	X	X			X	X		X	X	X		X	8	2.00	4.50
1.7	40.0	8.47									X		1	X	X	X	X		4		X			X	X		X	X	X		X	7	2.50	4.50
0.3	72.0	22.73	X	X		X	X	X			X	X	7						0		X			X			X	X	X			5	0.13	0.88

Report Date: 4/17/2013

Table 17. QHEI attributes report for the Ottawa River waterhed.

QHEI Attributes: Ottawa River Basin (Lima) 2010 TMDL

Key QHEI Components

River Mile	QHEI	Gradient (ft/mi)	WWH Attributes: Not Channelized or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low/Normal Embeddedness	Max Depth>40cm	Low/Normal Riffle Embeddedness	WWH Attributes	MWH Attributes – High Influence: Channelized/No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth <40cm	High-influence Modified Attributes	MWH Attributes – Moderate Influence: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1 or 2 Cover Types	Intermittent/Poor Pools	No Fast Current	High/Moderate Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	M.I. Modified Attributes	MWH H.I.+1/WWH+1 Ratio	MWH M.I./WWH Ratio
04-214-001			**Trib. to Lost Creek (RM 1.15)**																															
Year:		**2010**																																
0.6	43.0	4.27									X		1				X		1	X	X			X	X		X	X	X	X	X	9	1.50	5.50
04-216-000			**Hog Creek**																															
Year:		**2010**																																
13.4	20.0	2.42											0	X	X	X	X	X	5		X			X				X	X		X	5	6.00	6.00
3.8	63.5	2.73		X		X		X	X		X		5						0	X	X			X	X				X	X		6	0.33	1.33
0.3	69.5	6.76	X	X				X			X	X	5				X		1	X	X			X	X			X	X			6	0.50	1.17
Year:		**2011**																																
10.8	24.0	1.42									X		1	X	X	X	X		4		X			X	X		X	X	X		X	7	2.50	4.00
8.7	45.0	1.42		X							X		2	X			X		2		X			X	X	X	X	X	X	X		8	1.00	3.00
6.7	55.3	1.14		X							X		2	X			X		2	X	X			X	X		X	X	X	X		8	1.00	3.00
04-216-001			**Trib. to Hog Creek (RM 13.71)**																															
Year:		**2010**																																
0.5	20.0	1.89											0	X	X	X	X	X	5		X			X				X	X		X	5	6.00	6.00
04-217-000			**Grass Creek**																															
Year:		**2010**																																
3.1	39.8	5.95		X							X		2		X		X		2	X	X			X	X		X	X	X	X	X	9	1.33	3.33
1.2	51.0	6.10		X							X		2	X			X		2	X	X			X	X		X	X	X	X	X	9	1.00	3.33
04-218-000			**No. 28 Ditch**																															
Year:		**2010**																																
0.4	18.0	1.62									X		1	X	X	X	X		4		X			X		X	X	X	X		X	7	2.50	4.00
04-219-000			**Fitzhugh Ditch**																															
Year:		**2010**																																
0.4	23.0	1.62											0	X	X	X	X	X	5		X			X				X	X		X	5	6.00	6.00
04-220-000			**Lord Ditch**																															
Year:		**2010**																																
0.2	36.0	3.76		X				X					2	X		X	X	X	4		X			X				X	X		X	5	1.67	2.33

Report Date: 4/17/2013

Table 17. QHEI attributes report for the Ottawa River waterhed.

QHEI Attributes: **Ottawa River Basin (Lima) 2010 TMDL**

Key QHEI Components

			WWH Attributes											MWH Attributes: High Influence						MWH Attributes: Moderate Influence														
River Mile	QHEI	Gradient (ft/mi)	Not Channelized or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low/Normal Embeddedness	Max Depth>40cm	Low/Normal Riffle Embeddedness	WWH Attributes	Channelized/No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth <40cm	High-influence Modified Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1 or 2 Cover Types	Intermittent/Poor Pools	No Fast Current	High/Moderate Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	M.I. Modified Attributes	MWH H.I.+1/WWH+1 Ratio	MWH M.I./WWH Ratio
04-221-000			**Little Hog Creek**																															
Year:		**2010**																																
3.6	50.5	5.81	X					X			X		3						0		X		X	X	X		X	X	X	X	X	9	0.25	2.75
0.6	55.5	15.63	X	X				X		X			4					X	1		X			X	X			X			X	5	0.40	1.20
0.2	60.5	9.71	X	X			X				X	X	5				X		1		X			X	X		X	X	X	X	X	8	0.33	1.50
04-221-001			**Trib. to L. Hog Creek (RM 0.47)**																															
Year:		**2010**																																
0.3	51.5	12.20	X	X			X			X			4				X	X	2					X	X		X	X			X	5	0.60	1.20
04-222-000			**Mud Run**																															
Year:		**2010**																																
0.6	39.3	10.87	X					X			X		3		X	X			2		X		X	X			X	X	X		X	7	0.75	2.00

Report Date: 4/17/2013

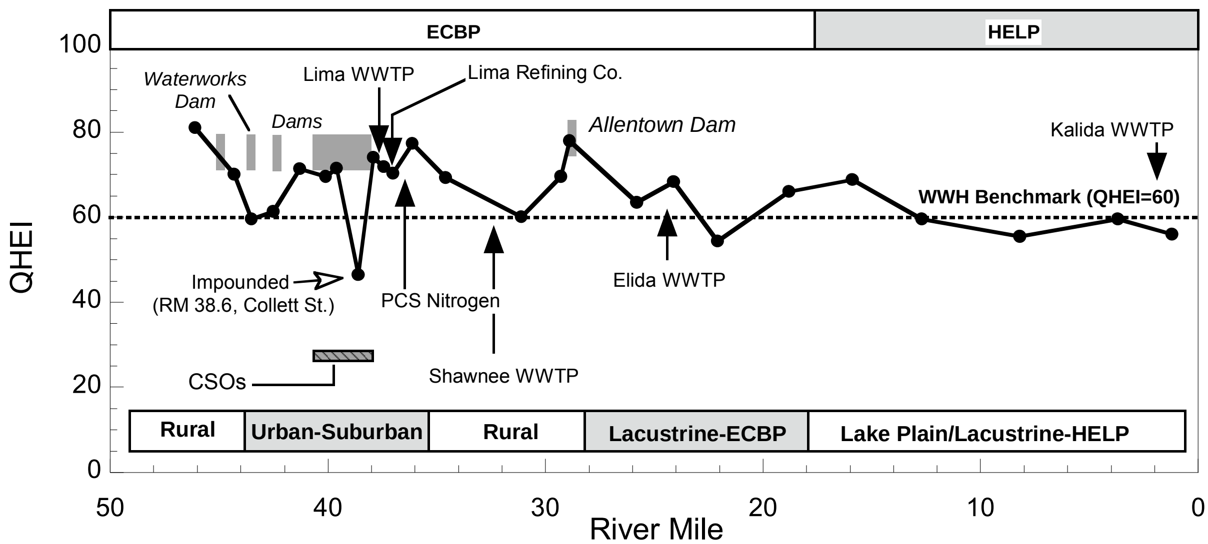

Figure 62. Longitudinal performance of the QHEI for the Ottawa River mainstem, 2010. The horizontal dashed line indicates typical WWH benchmark. The horizontal rectangles atop the figure demark the ECBP and HELP ecoregions. Generalized land use and physiographic characteristics affecting the Ottawa River are indicated above and along the horizontal axis.

Progressing downstream into the heart of urban/industrial environs of Lima, the Ottawa River enters the first of a series of five dam pools contained within an approximately three mile river reach. Longitudinally, these include, Lovers Lane, Elm St., Central Ave., Baxter and Erie R&R/Collet St. pools. Although all are in remarkably close proximity to one another, only the lower two formed a continuous impoundment, in that the spillway of the Central Ave. dam was inundated by the upper limits of the Erie R&R/Collet St. dam pool. Immediately downstream from both the Lovers Lane and Elm St. dams, there persisted small river reaches, ranging between 100-150 meters in length, of high quality, complex free-flowing habitat that yielded QHEI scores within the good-very good range (QHEI of 69.5 and 71.5, respectively). This literal oasis stood in stark contrast to the physical homogeneity of this largely impounded segment. Unlike previous sampling efforts on the Ottawa River (Ohio EPA 1992 and 1998), direct evaluation of the dam pools themselves was limited to one station, RM 38.6, in the Collet St. /Erie R&R pool. Predictably, this site was found habitat limited (QHEI 46.5, macrohabitat attribute ratio of 3.0). Based upon considerable experience garnered by Ohio EPA over the past thirty years regarding general ambient biological performance within and around run-of-the-river impoundments, the deleterious effects upon macrohabitat quality of these relatively small reservoirs are largely limited to the inundated river channel itself. As areas so affected are structurally incapable of fully supporting WWH assemblages (both fish and macroinvertebrate), scarce field resources were not allocated in 2010 to sample and directly evaluate dam pools within the study area. The purpose behind the Erie R&R/Collet St. dam pool sampling in 2010 was for trends assessment purposes relative to CSO abatement activities undertaken since the last intensive survey in 1996.

Leaving the urban center of Lima, the Ottawa River was again free flowing and continued so for approximately ten river miles, between RM 38.6 (downstream Collet St./Erie R&R dam) and RM 28.9 (Allentown dam pool). Eight sampling sites were evaluated in this segment, yielding QHEI values that ranged between 78.0 and 59.8, with the average of 71.3. Both the range and mean indicated WWH potential throughout and this despite ample evidence of past channel modification at nearly all stations. In most instances the Ottawa River had re-established a modest meander and associated habitat complexity (riffle/runs, functional sinuosity, depth heterogeneity, etc.) within confines of a largely artificial active channel, and in many ways was comparable to the unmodified reaches well upstream from Lima. An important explanatory variable regarding macrohabitat quality downstream from Lima is the significant increase in, or perhaps better described as restoration of, stream discharge from the Lima WWTP. Like many rivers serving major municipalities, the reach of the Ottawa River between Lima's primary water works' in-take structure at Metzger Rd. and its WWTP's final discharge, is flow starved. However, after serving various and sundry domestic and industrial uses, diverted water is eventually returned to the Ottawa in the form of treated effluent, and thereby provides strong base flow. This coupled with adequate gradient, yielded an associated improvement in stream power necessary for recovery and maintenance of macrohabitat quality. The combined and ameliorative effects of stream gradient and flow regime are clearly evident on the last impounded segment on the Ottawa River at Allentown (RM 28.9). Despite the ponding effects of the Allentown dam, macrohabitat quality as measured by the QHEI is among the best observed in 2010 (QHEI=78.0). Due to locally high gradient, the Allentown dam actually impounds a small segment of the Ottawa River, no larger than 200 meters. The remainder of the sampling zone (an additional 150 meters) was free-flowing and consisted of a series of riffle-run-pool complexes.

Before entering the lake plain proper (HELP ecoregion), the Ottawa River courses through approximately nine miles of lacustrine deposits contained in the ECBP, the effects of which have been described previously. Evaluated at four sampling stations between RMs 25.8 and 18.8, stream gradient dropped precipitously in comparison to adjacent stations upstream. Similarly, both QHEI scores and macrohabitat attribute ratios reflected the change in topography and associated steam characteristics, declining and increasing, respectively. Despite reduced stream power and diminished macrohabitat quality, most QHEI values remained within the WWH range.

The lower 17 miles of the Ottawa River, evaluated at five stations between RMs 15.9 and 1.2, are contained within the HELP ecoregion. As anticipated, gradients were further reduced through this segment and were typically half of that observed within the free-flowing reaches within the ECBP, increasing the level of sedimentation and diminishing channel form and function through the loss of stream power. These effects were manifested in reduced QHEI scores and increased macrohabitat attribute ratios. Although aggregate macrohabitat quality of the Ottawa River through this segment departed sharply from the typical ECBP stations, minimal complexity was conserved or recovered, and this was reflected in a subreach average QHEI score of 59.9. Despite the presence of strong limiting factors, significant departure from the prescribed WWH QHEI expectations was not indicated by the QHEI.

Ottawa River Tributaries

Hog Creek and Little Hog Creek Subwatersheds

As the Ottawa River mainstem is formed at the confluence of Hog and Littler Hog creeks, these primary tributaries and associated drainages shall be evaluated collectively. The Hog Creek subbasin consists of six named and unnamed streams: Hog Creek (mainstem), unnamed Hog Creek tributary (RM 13.7), Lord Ditch, Fitzhugh Ditch, No. 28 Ditch and Grass Creek. The Little Hog Creek watershed includes three primary waterbodies: Little Hog Creek (mainstem), Mud Run and an unnamed tributary joining Little Hog Creek at RM 0.47.

Seventeen monitoring stations were allocated among these waters, evaluating approximately 28 linear stream miles of the Hog and Little Hog catchments. Aggregated QHEI values from this subbasin ranged from 69.5 to 18.0, with a mean score of 42.4 (±16.84 SD). A matrix of QHEI macrohabitat features, by stations, aggregate QHEI performance of the subbasin, and the longitudinal performance of the QHEI for Hog and Little Hog creeks are presented in Table 17 and Figures 63 - 65.

Hog Creek

Hog Creek arises from a network of tributaries draining a 17,000 acre deposit of lake plain clayey till and laminated lacustrine clays in northwestern Hardin County, immediately east and northeast of the village of Ada. This area was once a vast wetland complex known regionally as the Hog Creek marsh. In order to bring this land under cultivation and to otherwise facilitate human habitation, extensive drainage improvements have been made. The entire drainage network (all tributaries) of Hog Creek have been subjected to extensive channelization and other forms of hydromodification with many streams appearing wholly artificial, being cut into the landscape through human activity to drain the associated marshlands. These modifications were not limited to tributaries, as Hog Creek itself is modified to varying degrees up to the Allen/Hardin county line. Furthermore, the modified areas described above are presently petitioned ditches, and as provided by Ohio law, are maintained for agricultural drainage. Thus, these and other waters so classified will and must serve as outlets and drainage conveyances well into the foreseeable future.

As measured by the QHEI, over 80% of the stations indicated a level of macrohabitat quality below the WWH benchmark. Waters coursing through and draining the former Hog Creek marsh itself were found profoundly limited or otherwise physically degraded, yielding QHEI scores ranging between 36.0 (Lord Ditch) and 18.0 (No. 28 Ditch), with an average of 23.5. Gradients were low and modified attribute ratios were very high, the latter ranging between 3.3 and 10, with three stations containing nothing but modified attributes (i.e., no positive habitat attributes). It must be noted that these waterbodies contained the most degraded macrohabitat observed throughout the study area, surpassing even the low values common to the highly modified HELP ecoregion. Conditions were modestly improved on peripheral waters including Grass Creek and the Hog Creek mainstem upstream from the county line, but the streams were still obviously habitat limited. The lower four miles of Hog Creek, evaluated at RMs 3.8 and 0.3, were found to contain a compliment of positive stream features consistent with WWH faunas (QHEIs of 63.5 and 69.5, respectively).

Given the high degree and pervasive nature of hydromodification, coupled with sanctioned drainage maintenance activities on upper Hog Creek and all associated tributaries, the capacity of these waters to consistently support and maintain an assemblage of fish and benthic macroinvertebrates fully consistent with the applicable WWH biocriteria is very likely precluded. Both the existing low potential and permanent maintenance schedule are fully recognized in the Ohio Water Quality Standards, as these waters are presently designated MWH. The results from this investigation affirm the MWH aquatic life use for upper Hog Creek (headwaters to the Allen/Hardin county line), and all associated tributaries. Given the lack or absence of recent direct hydromodification on the lower four miles of the Hog Creek mainstem, and macrohabitat quality in the good range, the WWH use designation is recommended to be retained for the reach between the Allen/Hardin county line to the mouth.

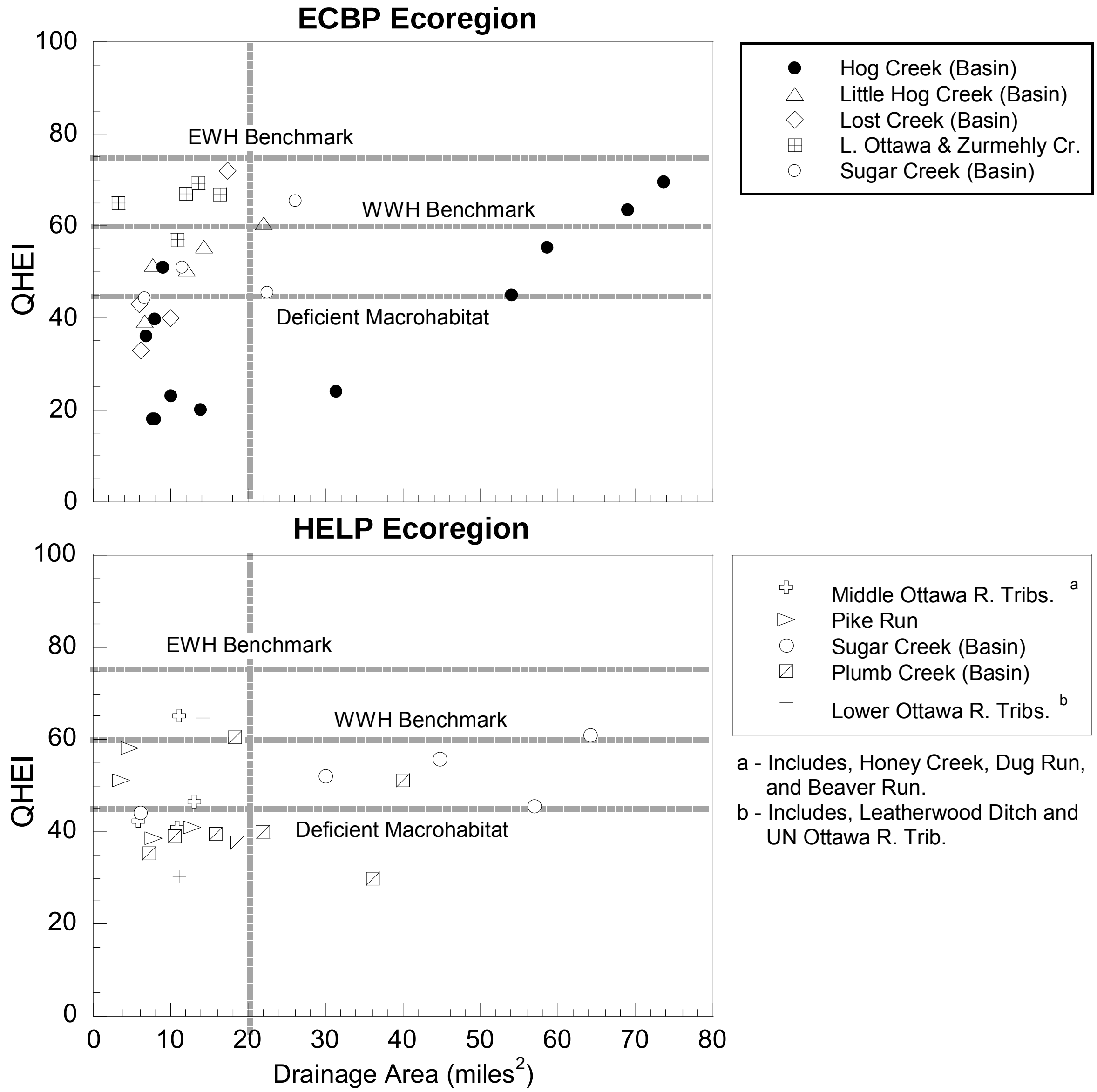

Figure 63. Distributions of QHEI score for all Ottawa River tributaries by stream size (drainage area) and ecoregion, ECBP and HELP. Vertical dashed line represents the threshold between headwaters (≤20mi^2) and wading (>20mi^2) sites. From top to bottom, horizontal dashed lines indicate typical WWH benchmark and threshold at or below which macrohabitat is likely to be limiting. Note extremely low performance for much of the Hog Creek basin. These low score correspond to the streams presently draining the former site of Hog Creek Marsh (lacustrine/palustrine landform).

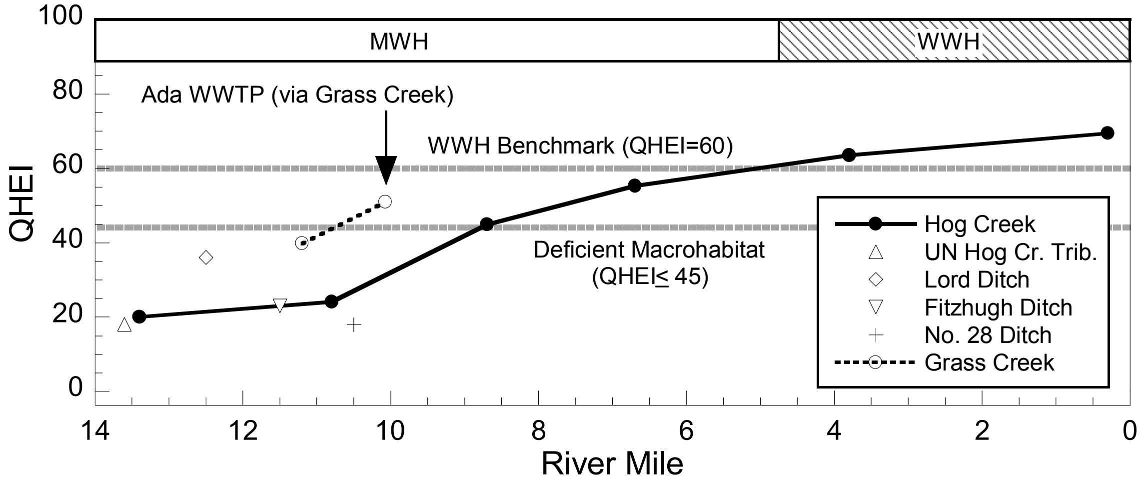

Figure 64. Longitudinal performance of the QHEI, Hog Creek (mainstem), and tributaries 2010-11. From top to bottom: Horizontal rectangle atop the figure demarcates existing MWH and WWH aquatic life uses for mainstem of Hog Creek. Horizontal dashed lines indicate typical WWH benchmark and threshold at or below which macrohabitat is likely to be limiting. Note: the entire Hog Creek subbasin is contained within the ECBP ecoregion.

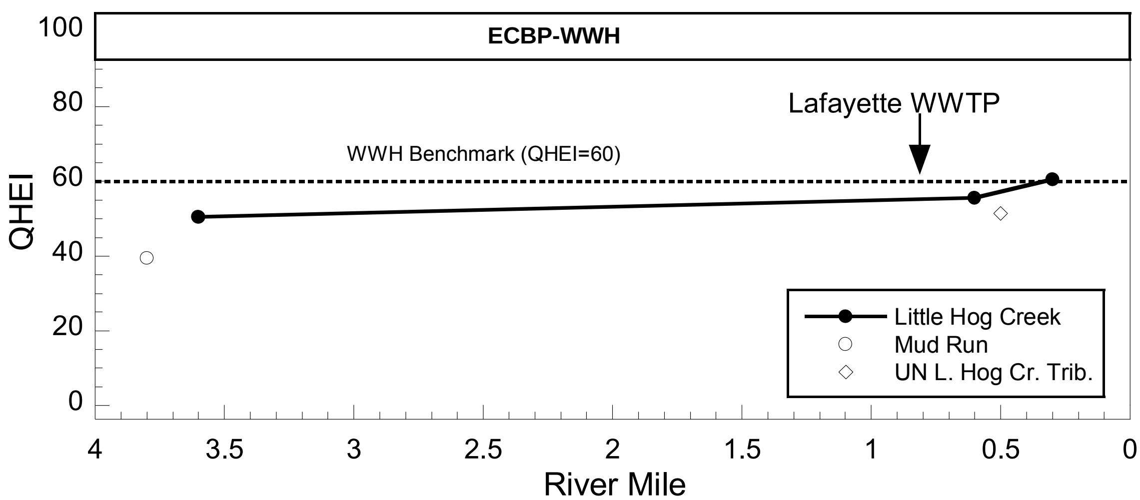

Figure 65. Longitudinal performance of the QHEI, Little Hog Creek (mainstem) and tributaries, 2010. The horizontal dashed line indicates typical WWH benchmark. A horizontal rectangle atop the figure demarks the ecoregion and existing aquatic life use for the Little Hog Creek subbasin.

Little Hog Creek

Like Hog Creek, the Little Hog Creek subbasin is contained entirely within the ECBP. However, unlike Hog Creek, Little Hog and its associated tributaries are not directly affected or influenced by anomalous lacustrine/palustrine physiography. Rather, the stream network drains ground moraine and to a lesser extent the northern slopes of the Wabash end moraine. In the aggregate, macrohabitat quality was in the fair range, as indicated by a subbasin average QHEI score of 51.4. As stated previously, aggregate QHEI values between 55 and 45 indicate that limiting components of physical habitat are present and may exert a negative influence upon ambient biological performance. However, due to the potential for compensatory stream features (e.g., strong ground water influence) or other watershed variables, QHEI scores within this range do not necessarily exclude WWH. Stream gradients were moderate and fairly typical of the ECBP, but modified attributes dominated most sites; this despite the fact that no evidence of previous channel modification was observed within the Little Hog watershed. The primary factor behind subpar performance of the QHEI appeared to be diminished surface flow, as most stations were found intermittent or interstitial, and reduced to residual pools by late summer. The absence of continuous discharge can negatively affect the QHEI through the loss of important categories of lotic habitat. However, headwater faunas are adapted to intermittent/interstitial conditions provided the residual pools are fed by or make contact with groundwater, and, in this way, are thermally stable and kept from turning septic.

Although by no means optimal, and in many ways naturally limited, macrohabitats through most of the Little Hog Creek catchment appeared capable of supporting a minimal warmwater assemblage of aquatic organisms. Coupled with the paucity of evidence of direct channel modification throughout the Little Hog Creek catchment, the WWH use appeared appropriate for Little Hog and its named and unnamed tributaries.

Greater Lima Tributaries
Three small direct Ottawa River tributaries, Lost Creek, Zurmehly Creek and the Little Ottawa River, drain the greater Lima metropolitan area. Although portions of Sugar Creek and Pike Run also function similarly, these streams join the Ottawa River well downstream from Lima and thus are treated separately within this report. Nine stations were deployed among these subbasins, evaluating 16 linear stream miles. All of these waterbodies are contained within the ECBP ecoregion. Aggregated QHEI values from these waterbodies ranged between 72.0 and 33.0, with a mean score of 57.0 ($\pm$14.56 SD). A matrix of QHEI macrohabitat features, by stations, aggregated QHEI performance of the subbasins, and the longitudinal performance of the QHEI for selected waters are presented in Table 17 and Figures 63, 66 and 67.

To varying degrees nearly all of these waters labor under numerous and deleterious effects of a well-drained, urban and suburban landscape that typifies all or most of their respective watersheds. Chief among these effects is a flashy or compressed flow regime, where during periods of wet weather, surface run-off is rapidly delivered to associated streams, resulting in peek flows that are simultaneously greater, but of a shorter duration, than one would expect of a rural or otherwise unmodified counterpart. A hardened watershed, and resulting artificial flow regime, not only disrupts the native fluvial processes responsible for channel formation and maintenance, but also significantly diminishes the surrounding landscape's ability to attenuate precipitation. Instead of being held in the matrix of soil and vegetation and gradually released over time and thus augmenting surface discharge, surplus water is rapidly carried off the landscape and conveyed to associated streams. Over the course of a given year, these factors, combined, can result in a feast or famine hydroperiod (*i.e.*, pulsed and exaggerated peak flow and diminished base flow during dryer months, the latter giving way at times to intermittency or desiccation within the headwaters). Given their position within a populated landscape, these waters are also typically channel modified so as to efficiently receive and convey water to their larger receiving stream during periods of high flow. Many are deeply incised, deliberately recessed and isolated from their floodplain, so as to render flood prone areas habitable. Lastly, waters draining developed areas are also subjected to various and sundry sources of diffuse pollution or contaminated run-off [storm water, home septic systems (failing or otherwise), SSOs, etc.].

Lost Creek

Three of the four sites allocated to appraise the macrohabitat quality of Lost Creek and its principal tributary yielded OHEI scores within the poor range. These include the uppermost stations on the mainstem at RMs 3.6 (Mumaugh Rd.) and 1.7 (Fenway Dr.), and the tributary joining Lost Creek approximately a mile from its mouth at RM 0.6 (Pevee Rd.). All of these sites appeared to have been channel modified to varying degrees in the past. Substrates were typically fine grained, composed largely a mix of sand and silt, the latter reaching in places to a depth of 6-12 inches, and channel redevelopment was limited, resulting in relatively homogeneous and incised form. Modified conditions identified here are very likely to persist into the foreseeable future as waters so described are presently managed as drainage conveyance (Allen County Engineer's Office, pers. com.).

Only the lowest station on Lost Creek, RM 0.3 (Reservoir Rd.), was found to contain a suite of macrohabitat features consistent with WWH aquatic communities. Conditions here, however, were not optimal as the lower reach contained ample evidence of the effects of upstream drainage practices. Specifically, this lower reach appeared to struggle with processing and conveying an excessive sand bedload from the hydrologically modified upper reaches. The bedload is likely transported and deposited during and immediately following pulsed high flow events of the type described above. Under typical summer base flow conditions, Lost Creek appears to lack the stream power to properly sort, convey or otherwise efficiently process this material. Much of the existing deposits are resuspended with the next high flow event, as new deposits from the uplands simply replace the old. Although the constant shifting and unstable nature of this material may serve to limit the function and productivity of some important macrohabitat features, the bedload in and of itself did not appear sufficient to impair lower Lost Creek, as overall habitat complexity appeared minimally compatible with WWH faunas.

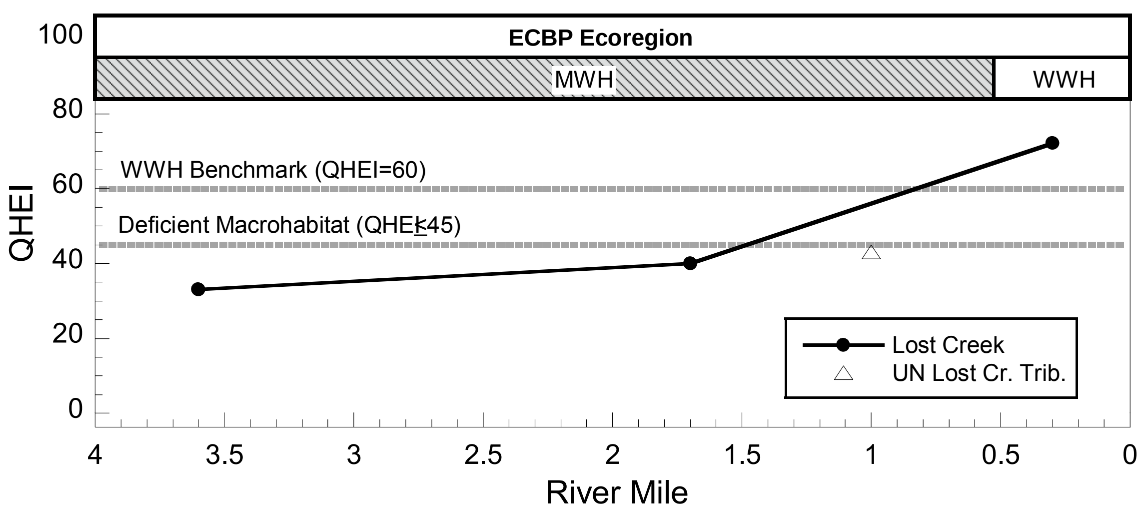

Figure 66. Longitudinal performance of the QHEI, Lost Creek (mainstem) and tributary, 2010. From top to bottom, horizontal dashed lines indicate typical WWH benchmark and threshold at or below which macrohabitat is likely to be limiting. Horizontal rectangles atop the figure demarcate ecoregion and existing and recommended MWH and WWH aquatic life uses.

Given the degree to which upper Lost Creek and its associated tributary are channel modified, the likely persistence of said modification, and their position within a developed and well-drained landscape, aquatic life use impairment related to deficient macrohabitat appeared likely. Therefore, ambient biological potential of these waters is perhaps best or more accurately accounted for by the designation of the MWH aquatic life use designation. Owing to the lack or absence of direct channel modification, macrohabitat quality, as measured by the QHEI, was found to be within the good range through approximately the lower one mile of Lost Creek, and as such the retention of the WWH use best reflects ambient biological potential.

Little Ottawa River and Zurmehly Creek

In contrast to Lost Creek, the vast majority of the Little Ottawa River and all of Zurmehly Creek appeared physically intact; these streams were either never directly channelized or have over time recovered from past modification. QHEI scores from these waterbodies ranged between 69.3 and 57.0. Most stations were found to contain a compliment of positive channel, substrate and riparian features, consistent with WWH aquatic faunas. They did bear evidence consistent with flashy hydrology associated with urban-suburban areas, and like other small waters draining the greater Lima area, also appeared subject to attendant diffuse pollution sources. Only the uppermost site on the Little Ottawa River (RM 5.5, Old Dixies Hwy.) scored below 60.0 (QHEI=57.0), a result of the combined effects of desiccation and channel maintenance. The headwaters of the Little Ottawa River, at and upstream from RM 5.5, are in fact formally maintained as a drainageway (Allen County Engineer's office, pers com.). Although not profoundly degraded at this time, evidenced by a QHEI value in the high fair range, the evaluation of this station was performed at the lower limits or terminus of the drainageway, and thus, the full effect of the initial channel incision and related maintenance activities were not necessarily captured by the QHEI. Alternatively, perhaps considerable recovery or natural physical channel restoration has occurred since the last direct modification.

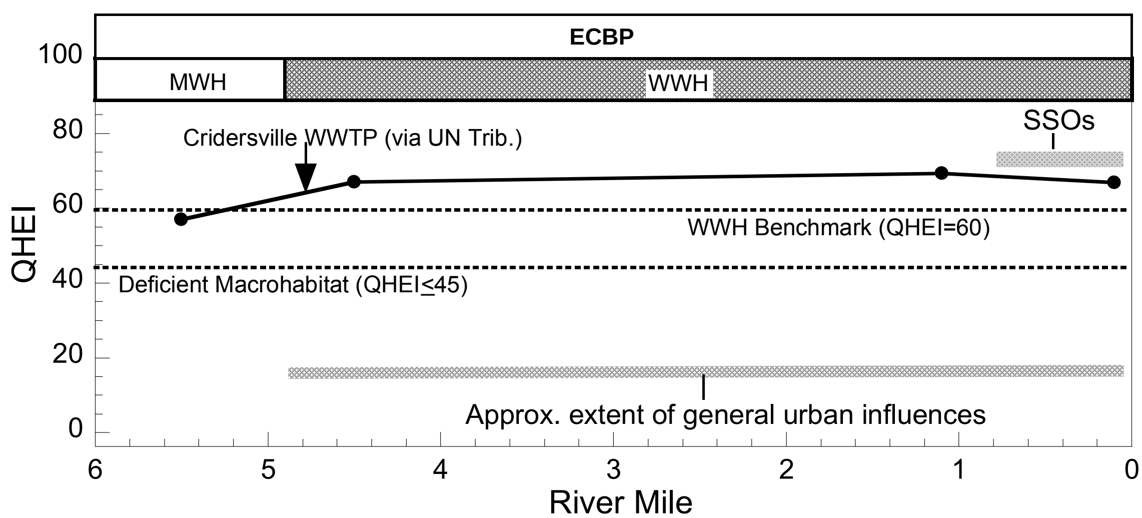

Figure 67. Longitudinal performance of the QHEI, Little Ottawa River, 2010. From top to bottom, horizontal dashed lines indicate typical WWH benchmark and threshold at or below which macrohabitat is likely to be limiting. Horizontal rectangles atop the figure demarcate ecoregion and existing and recommended MWH and WWH aquatic life uses.

Despite coursing through and draining a hardened watershed, macrohabitat complexity consistent with WWH aquatic communities appeared conserved through much of the Little Ottawa River and all of Zurmehly Creek. Aquatic life use impairment attributed to subpar macrohabitat did not appear likely at most sites. However, given the upper Little Ottawa's status as a maintained drainageway, future channel modifications and other activities related to drainage improvement are a near certainty, and would have the effect of resetting or undoing much, if not all, of the natural recovery observed to date. This in turn would very likely result in limiting the physical capacity of the upper Little Ottawa River to consistently support an aquatic community consistent with the WWH use. Therefore, the ambient biological potential of the affected stream segment is better represented by an MWH use designation.

Middle Ottawa River Tributaries

Five direct Ottawa River tributaries, Honey Creek, Dug Run, Beaver Run, Pike Run and Leatherwood Ditch, constitute the middle Ottawa tributaries. Although this aggregation is somewhat arbitrary, these water do in fact share several important characteristics. All said waterbodies are located within the HELP ecoregion, almost all exclusively drain rural portions of the watershed, and owing to the natural poor drainage that typifies the HELP, all of these waters, excepting lower Dug Run, appeared to have been channel modified or otherwise physically manipulated to improve or support local and regional drainage goals.

Nine stations were deployed among these tributaries, evaluating 18 linear stream miles. Aggregated QHEI values from these waterbodies ranged between 58.0 and 30.5, with a mean score of 44.8 ($\pm$5.508 SD). A matrix of QHEI macrohabitat features, by stations, aggregate QHEI performance of the subbasins, and the longitudinal performance of the QHEI for selected waters are presented in Table 17 and Figures 63 and 68.

Taken together, QHEI values as low as 30, and with an average of 46.0, strongly suggest that significant habitat limitations exist throughout these tributaries. All contained ample evidence of past channelization, the degree and extent varying by station or subbasin. Streams so affected were typically trapezoidal in cross section, deeply incised, and monotonous in form. Dominant substrates were typically fines (sand and to a lesser extent pea gravel) with coarser material, if present, often embedded by or with a mix of clayey silts and sand.

Habitat deficits and limitations described above are very common within the HELP, and, thus, benchmarks of performance and the resulting biocriteria for this region are significantly lower than any other portion of the state (Ohio EPA 1987). As such, QHEI scores that would predict habitat related impairment, or otherwise exclude WWH aquatic life use potential outside of the HELP, may within this region, in fact, be compatible with the regional calibrated (i.e., significantly lower) biocriteria. The practical consequence of this is that substandard macrohabitat quality, commonly observed within the middle Ottawa tributaries and narratively described as fair to poor, may support a simple assemblage of fish and macrobenthos minimally consistent with the WWH biocriteria unique to the HELP ecoregion.

Upper Honey Creek and Pike Run

Upper Honey Creek and Pike Run are formally identified as drainage outlets, and as provided for under Ohio law, are maintained as such. In recognition of both the degree to which these waters have been physically modified and maintenance of said drainage on-going, the MWH is affirmed for the entire length of Pike Run and is recommended for upper Honey Creek.

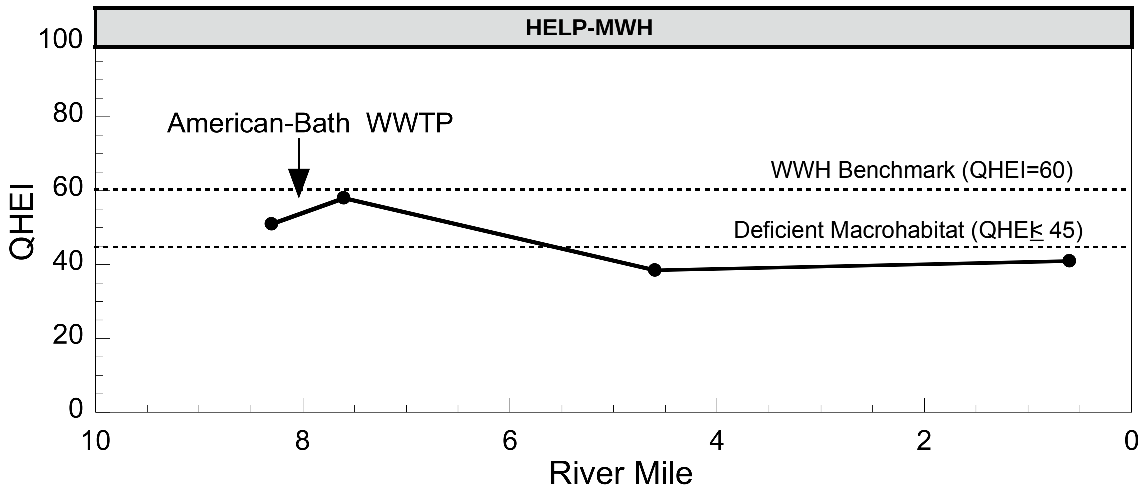

Figure 68. Longitudinal performance of the QHEI for Pike Run, 2010. From top to bottom, horizontal dashed lines indicate typical WWH benchmark and threshold at or below which macrohabitat is likely to be limiting. A horizontal rectangle atop the figure demarcates ecoregion and the existing MWH aquatic life use.

Lower Honey Creek, Beaver Run, and Leatherwood Creek

As measured by the QHEI, and supplemented by direct field observations, deficient macrohabitat attributable to channelization and related drainage maintenance activities were also identified on lower Honey Creek, Beaver Run and Leatherwood Creek. However, given the lack of formal status as a petitioned or otherwise maintained drainageways and diminished predictive power of the QHEI for small streams within the HELP, expectations for WWH biological communities were not unwarranted, despite the paucity of intact stream habitat.

Doug Run

Although obviously hydromodified in the past, considerable physical recovery of channel form and function was evident on Doug Run. Through the action of active lateral erosion and corresponding deposition, a modest meander was observed, with attendant, albeit modest, depth heterogeneity. As noted throughout the middle Ottawa tributaries, dominant substrate was also sand; however, the debilitating effects of embeddedness attributable to clayey silts were minimal. Furthermore, the natural summer base flow appeared stronger than other middle tributaries, and the thermal regime was modestly cooler. These latter observations suggest that Doug Run benefits from modest ground water augmentation, which in headwater settings can mitigate deficient macrohabitat quality. Taken together, the channel, substrate and hydrologic features described above, yielded a QHEI score of 54.0. Although by no means optimal, Doug Run stands in sharp contrast to most other middle Ottawa tributaries, and as such appeared capable of supporting a community of aquatic organisms minimally consistent with the WWH aquatic life use designation.

Lower Ottawa Tributaries

Three streams constitute the lower Ottawa tributaries: Sugar Creek, Plum Creek, and an unnamed tributary joining the mainstem at RM 0.7, just south of Kalida. Said waterbodies are contained within portions of both the ECBP and HELP ecoregions, and all drain primarily rural or otherwise agricultural areas. Owing to the natural poor drainage that typifies the HELP and selected portions of the ECBP, lower Ottawa River tributaries appeared to have been channel modified or otherwise physically manipulated to improve or support local and subregional drainage.

Eighteen monitoring stations were deployed among these streams and their tributaries, evaluating 47 linear stream miles. Aggregated QHEI values from these waterbodies ranged between 65.5 and 29.8, with a mean score of 47.93 (±10.472 SD). A matrix of QHEI macrohabitat features, by stations, aggregate QHEI performance of the subbasins, and the longitudinal performance of the QHEI for selected waters are presented in Table 17 and Figures 63, 69, and 70.

Sugar Creek

Draining approximately 65 square miles, Sugar Creek is second only to Hog Creek in size among Ottawa River tributaries. Sugar Creek is a trans-boundary stream, in that significant portions of its watershed are contained in both the ECBP and HELP ecoregions. Arising near the boundaries of Allen, Hardin and Hancock counties, Sugar Creek flows in a west to south-westerly direction along the northern margin of the Fort Wayne end moraine for approximately eight miles. Like the Ottawa River mainstem, it then abruptly veers northwest, leaving the end moraine, to course through and drain a mix of ground moraine and isolated lacustrine deposits for an additional four miles. The stream reach described thus far is contained within the ECBP. Near the Allen/Putnam county line, Sugar Creek pierces the relic beach ridges that define the southern boundary of the broad and level HELP ecoregion, continuing north for an additional 17 miles before joining the Ottawa River just southeast of Kalida. Sugar Creek receives one significant tributary, Rattlesnake Creek, from the west, near the Allen/Putnam county line. Although arising within the ECBP, the majority of Rattlesnake Creek's catchment is contained wholly within the HELP.

Between RM 26.0 (Napoleon Rd.) and RM 0.6 (CR Q), eight monitoring stations were allocated to evaluate the quality of near and instream macrohabitat on Sugar Creek. QHEI values ranged between 65.5 and 44.3, with a stream average of 52.6. Owing to poor natural drainage throughout much of the catchment, all monitoring stations on Sugar Creek contained ample evidence of direct channel modification or the effects of related hydromodification, the degree and extent varying longitudinally.

The upper eight miles, evaluated at three sites, appeared the most deficient, yielding QHEI scores within the poor range, with very highly modified (high and moderate influence) habitat ratios (Table 17). Specifically, these deficits included deep channel incision, monotonous channel development, dominance of fine or hardpan substrates, a high degree of siltation, and a paucity of instream cover. It is therefore not surprising or otherwise unexpected that this reach coincides with the segment of Sugar Creek currently designated as a petitioned ditch, and thus maintained as a drainageway. As such, this segment is likely permanently debilitated respecting its ability to support a WWH aquatic community. Thus the ambient biological potential is better described by the recommended MWH use designation.

Although decidedly subpar, aggregate channel and substrate features on the remainder of Sugar Creek did not appear profoundly degraded, and in fact were generally much improved within increasing distance downstream. Nearly all remaining stations yielded QHEI scores at or near the WWH benchmark, as considerable recovery from the initial channel incision had occurred. Through the complimentary processes of erosion and deposition, most sites on lower Sugar Creek have reestablished a meander, with associated depth heterogeneity, and at times included modest riffle-run complexes. Substrate coarseness and diversity increased longitudinally with the gradual addition of gravel and cobble to the existing finer material. Given that much of Sugar Creek is contained within the HELP, the level of macrohabitat complexity, although not optimal, appeared adequate to support an assemblage of fish and benthic macroinvertebrates consistent with this region's WWH biocriteria.

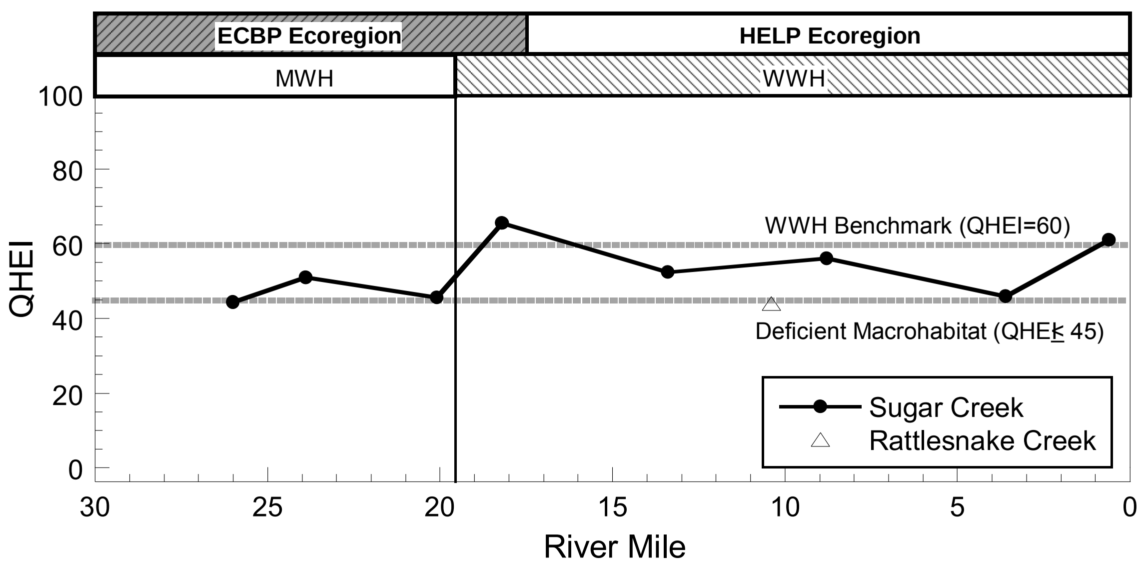

Figure 69. Longitudinal performance of the QHEI for Sugar Creek and its principal tributary, Rattlesnake Creek, 2010. The horizontal rectangles atop the figure delimit both the ECBP and HELP ecoregions, and existing MWH and WWH aquatic life uses. Horizontal dashed lines indicate typical WWH benchmark and threshold at or below which macrohabitat is likely to be limiting.

Rattlesnake Creek

A single station was surveyed in Rattlesnake Creek at RM 1.7 (Hofferbert Rd.). The stream was found deeply incised, with limited sinuosity, fine substrates, and moderate to heavy siltation. As measured by the QHEI, overall macrohabitat quality was characterized as poor (QHEI=43.8). Like upper Sugar Creek, much of Rattlesnake Creek is designated as a petitioned ditch and maintained as an agricultural drainageway, and, thus, is a candidate for the MWH aquatic life use designation.

Plum Creek

Plum Creek is also among the Ottawa River's largest tributaries. Arising from a complex of headwater streams draining sizable former swamp-wetland (lacustrine deposits) in northern Allen County, Plum Creek, with modest variation, flows in a generally northwesterly direction through level plains of Putnam County, until joining the Ottawa River at the village of Kalida. The entire length of Plum Creek, and the tributary network evaluated as part of this survey, is contained within the HELP ecoregion.

Eight monitoring stations were established within the Plum Creek watershed, six on the mainstem, between RMs 14.9 (TR 11-R) and 0.2 (SR 114), and two allocated between Plum Creek's two principal tributaries: Sycamore Creek (headwaters) and a significant, yet unnamed, tributary joining the mainstem at RM 7.3. Taken together these sites accounted for the appraisal of 17 linear stream miles. Aggregated QHEI values from these waterbodies ranged between 60.5 and 29.8, with a mean score of 41.93 (± 9.604 SD). An average QHEI score below 45 is well within the poor range, and suggests a higher probability of WWH use impairment derived from deficient or otherwise inadequate macrohabitat. Although a few stations, specifically RMs 12.9 (TR 11) and 0.2 (SR 114), did yield scores within the fair to good range, the central tendency of Plum Creek and its associated tributaries reflects habitat limited conditions.

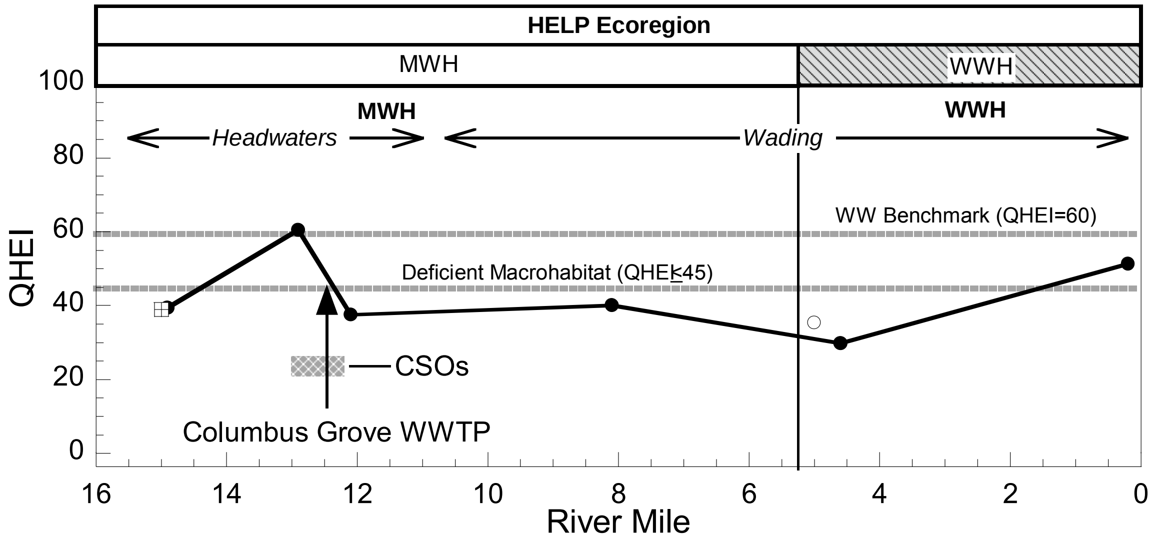

Figure 70. Longitudinal performance of the QHEI for Plum Creek and its principal tributaries, 2010. From top to bottom: Horizontal rectangles atop the figure identify and delimit ecoregion, existing and recommended MWH and WWH aquatic life uses, and stream size. Horizontal dashed lines indicate typical WWH benchmark and threshold at or below which macrohabitat is likely to be limiting.

As was commonly observed throughout the Ottawa River basin, the antecedent to nearly all habitat limited waters throughout the Plum Creek watershed is direct channelization and related hydromodification to facilitate drainage. The effects of these activities appeared especially acute here, as most sites were deeply entrenched, substrates were typically a mix of fines and hardpan, and channel development was monotonous. Modified habitat ratios were high to extremely high (6-7), with four of the six mainstem sites having ≤1 positive WWH habitat attributes (Table 17).

The approximate upper ten miles of Plum Creek are presently designated as open ditch, and thus maintained as an agricultural conveyance. The tributary network that coalesce to form Plum Creek (including Sycamore Creek) is likewise designated, thus resulting in a large and significant portion of the catchment's wetted stream channels being either wholly artificial or maintained in an artificial configuration so as to meet local and regional drainage needs. As repeatedly articulated through this report, ambient biological potential of surface waters so managed is best reconciled to Ohio's Water Quality Standards through the designation of the MWH aquatic life use.

Although subjected to similar hydrologic modification, with commensurate macrohabitat deficits, the lower five miles of Plum Creek and its unnamed tributary (joining Plum Creek at RM 7.0), are not formally maintained as open ditches, and thus retain the existing WWH designation. With QHEI scores as low as 29.8 found among these waters, use impairment related to poor stream habitat would be a near certainty outside of the HELP. However, as Ohio's biocriteria are regionally calibrated, the background of pervasive hydromodification and associated diminished biological potential of waterbodies within the HELP are fully accounted for. As such, QHEI scores within the poor range do not necessarily preclude WWH performance as gauged against the HELP biocriteria.

Biological Assessment of the Fish Community

Ottawa River Mainstem

A total of 34,113 fish comprising 50 species and four hybrids was collected from the Ottawa River between July and September, 2010. The survey effort included 48 sampling events, at 25 stations, evaluating 47 miles of the mainstem between RM 46.1 (Thayer Rd.) and RM 1.2 (CR 12).

Based on aggregated catch statistics, numerically predominant species (number/km) were bluntnose minnow (33.7%), greenside darter/longear sunfish (~7.0%), white sucker/redfin shiner (~5.0%), and Central stoneroller/spotfin shiner/bluegill sunfish (~4%). In terms of relative biomass (kg/km), dominant species were common carp (25.3%), white sucker (17.6%), golden redhorse (8.5%), smallmouth bass (6.2%), and rock bass/channel catfish (5.2%). Over a quarter of the community, measured in terms of numerical abundance and biomass, was concentrated in two highly tolerant and ecological generalist species, bluntnose minnow and common carp, respectively. Furthermore, nearly 47% of all fish and fully 51% of total fish biomass collected from the mainstem were pollution tolerant taxa.

Fish species classified as rare, threatened, endangered, or otherwise recognized for special conservation status by the Ohio DNR included only the Greater redhorse. Six individuals of this state threatened species were collected at five stations through the lower 30 miles of the Ottawa, between RMs 29.3 (Copus Rd.) and 1.2 (CR 19). Other intolerant, rare, declining or otherwise ecologically significant species included mimic shiner and stonecat.

Community indices and accompanying narrative evaluations for the Ottawa River ranged between good-very good (IBI=45 and MIwb=9.8) and fair (IBI=29.0and MIwb=7.3), with a mainstem average characterized as marginally good-good (IBI=36.9 and MIwb=8.46). Summarized index scores and community statistics by station are presented in Table 18. Longitudinal performance of the IBI, MIwb, and other relevant indicators are presented in Figures 71, 72, and 73. Raw index scores, metrics, fish species and abundance data by sampling station are located in Appendices E and F.

Of the 50.7 linear stream miles assessed, 38.4 miles (75.7%) were found to support an assemblage of fish at least minimally consistent with WWH biocriteria. In general terms, corresponding stations contained a typical association of expected species, with some sensitive taxa present and a low to moderate incidence of serious disease. The remaining 12.3 (24.3%) miles failed to support WWH assemblages. However, the magnitude of the departure or degree of impact was not great, as community performance below the fair range (i.e., narratively poor to very poor) was not observed. Impacted areas were not contiguous or affected by a single or single suite of stressors, rather, multiple and at times overlapping causes and sources appeared operative. Performance of the primary fish community indexes (MIwb and IBI) did not share universal agreement regarding the condition of the fish assemblage of the Ottawa River. The MIwb, principally a structural measure, was found in near complete agreement with the associated WWH criteria, with significant departures indicated for only a 5.9 mile contiguous reach immediately downstream from Lima. The performance of the IBI, a more thorough community measure, corresponded to the MIwb through this reach, delimiting additional substandard areas at both the upper and lower margins of this segment. The IBI also described two additional impacted stream reaches within and upstream from Lima, spatially independent from the impacted segment where both indexes concurred.

Table 18. Fish community indices, descriptive statistics, and biological narratives for the Ottawa River study area, 2010.

River Mile	Drain. Area	Total Species	Mean Species	Rel. Weight[a]	Rel. Number	QHEI	IBI	MIwb	Narratives
Ottawa River (04-200)									
				ECBP WWH					
46.1[W]	99.0	22	20.0	31.7	2163.8	81.0	37[ns]	8.7	Marginal/Good
44.3[W]	102.0	24	22.5	38.7	2548.5	70.0	39[ns]	9.4	Marginal/Exceptional
43.4[W]	103.0	24	21.5	9.2	2142.8	59.5	35*	8.6	Fair/Good
42.5[B]	122.0	25	23.5	189.5	3684.0	61.3	32*	8.9	Fair/Good
41.3[W]	125.0	23	21.0	21.2	1602.8	71.3	44	9.1	Good/Very Good
40.1[W]	126.0	24	20.0	29.2	1916.3	69.5	35*	8.7	Fair/Good
39.6[W]	127.0	24	22.0	19.6	1680.8	71.5	37[ns]	9.3	Marginal/Very Good
38.6[B]	128.0	20	18.5	129.9	731.0	46.5	39[ns]	8.0[ns]	Marginal/Marginal
37.9[W]	129.0	31	26.0	27.2	1478.3	74.0	35*	9.3	Fair/Very Good
37.4[W]	130.0	24	21.5	25.8	1770.8	71.8	34*	9.0	Fair/Very Good
37.0[W]	131.0	18	16.5	8.8	593.3	70.3	31*	7.7*	Fair
36.1[W]	131.0	17	15.5	6.2	598.5	77.3	31*	7.7*	Fair
34.6[W]	151.0	21	18.0	11.6	589.5	69.3	29*	7.3*	Fair
31.1[B]	155.0	26	21.0	83.5	719.0	60.0	31*	8.3	Fair/Marginal
29.3[W]	156.0	23	19.5	35.0	486.8	69.5	33*	8.3	Fair/Good
28.9[B]	160.0	26	22.5	117.3	1058.9	78.0	32*	9.1	Fair/Very Good
25.8[W]	166.0	24	20.5	10.3	549.8	63.5	42	8.2[ns]	Good/Marginal
24.1[W]	168.0	26	22.0	38.2	835.5	68.3	38[ns]	9.2	Marginal/Very Good
22.1[W]	194.0	24	19.0	12.0	391.5	54.3	43	8.2[ns]	Good/Marginal
18.8[W]	216.0	28	24.0	50.8	636.8	66.0	41	9.4	Good/Exceptional
				HELP WWH					
15.9[W]	217.0	30	25.5	28.9	688.5	68.8	45	9.4	Good/Exceptional
12.7[W]	231.0	29	23.5	12.9	563.3	59.5	43	8.7	Good
8.1[B]	239.0	23	23.0	55.7	858.0	55.5	38	9.5	Marginal/Very Good
3.6[W]	308.0	33	26.5	42.8	858.0	59.5	35	8.9	Marginal/Very Good
0.9[B]	351.0	26	26.0	512.0	512.0	56.0	44	9.8	V. Good/Exceptional
Hog Creek (04-216)									
				ECBP MWH					
13.4[H]	13.9	15	15.0	-	1256.0	20.0	40	NA	Good
10.7[W]	31.4	10	10.0	2.2	264.0	24.0	32	6.2	Fair
8.7[W]	54.0	19	19.0	57.3	895.5	45.0	36	8.1	Marginal
6.6[W]	58.6	18	18.0	41.8	1312.5	55.3	30	7.9	Fair/Marginal
				ECBP WWH					
3.8[W]	69.0	14	14.0	13.7	5044.5	63.5	24	5.7	Poor
0.3[W]	73.7	26	23.0	64.5	1381.5	69.5	39	8.5	Marginal/Good
UT to Hog at RM 13.7 (04-216)									
				ECBP MWH					

River Mile	Drain. Area	Total Species	Mean Species	Rel. Weight[a]	Rel. Number	QHEI	IBI	MIwb	Narratives
0.5[H]	8.0	17	17.0	-	656.0	20.0	36	NA	Marginal
Lord Ditch (04-220)									
					ECBP MWH				
1.2[H]	6.9	8	8.0	-	200.0	36.0	32	NA	Fair
Fitzhugh Ditch (04-219)									
					ECBP MWH				
0.4[H]	10.1	13	13.0	-	343.5	23.0	32	NA	Fair
No.28 Ditch (04-218)									
					ECBP MWH				
0.3[H]	7.7	7	7.0	-	282.0	18.0	36	NA	Marginal
Grass Creek (04-217)									
					ECBP MWH				
3.4[H]	8.0	16	16.0	-	1725.0	39.8	30	NA	Fair
1.2[H]	9.5	16	16.0	-	1117.5	51.0	30	NA	Fair
Little Hog Creek (04-221)									
					ECBP WWH				
3.6[H]	12.1	17	17.0	-	791.8	50.5	30	NA	Fair
0.6[H]	14.3	17	17.0	18.1	3475.8	55.5	38	NA	Marginal
0.2[W]	22.0	25	23.0	29.0	5193.0	60.5	37	8.7	Marginal/Good
Mud Run (04-222)									
					ECBP WWH				
0.6[H]	6.7	18	18.0	-	2092.0	39.3	36	NA	Marginal
UT to Little Hog Cr. at RM 0.47 (04-294)									
					ECBP WWH				
0.3[H]	7.7	14	14.0	-	384.0	51.5	40	NA	Good
Lost Creek (04-214)									
					ECBP MWH				
3.6[H]	6.2	11	11.0	-	1614.0	33.0	32	NA	Fair
1.7[H]	10.0	13	13.0	-	642.0	40.0	30	NA	Fair
					ECBP WWH				
0.3[H]	17.4	20	20.0	15.6	1605.0	72.0	36[ns]	NA	Marginal
UT to Lost Cr. At RM 1.15 (04-249)									
					ECBP MWH				
0.6[H]	6.0	10	10.0	8.9	1148.0	43.0	28	NA	Fair
Zurmehly Creek (04-200)									
					ECBP WWH				
0.1[H]	3.3	11	11.0	9.1	966.3	65.0	30*	NA	Fair
Little Ottawa River (04-213)									
					ECBP MWH				
5.5[H]	10.9	16	14.0	-	890.0	57.0	26	NA	Poor
					ECBP WWH				
4.5[H]	12.0	15	15.0	-	1572.0	67.0	28*	NA	Fair
1.1[H]	13.6	17	17.0	-	2140.50	69.3	26*	NA	Poor
0.1[H]	16.4	14	14.0	-	534.0	66.8	22*	NA	Poor

River Mile	Drain. Area	Total Species	Mean Species	Rel. Weight[a]	Rel. Number	QHEI	IBI	MIwb	Narratives
Honey Creek (04-209)									
HELP MWH									
3.6[H]	10.9	14	14.0	7.5	1652.0	40.8	26	NA	Fair
HELP WWH									
0.9[H]	13.0	18	18.0	29.1	1230.0	46.5	32	NA	Marginal
Dug Run (04-210)									
HELP WWH									
0.2[H]	11.0	17	17.0	8.4	933.0	54.0	40	NA	Good
Beaver Run (04-293)									
HELP WWH									
0.5[H]	5.7	15	15.0	13.59	1408.0	42.5	30	NA	Marginal
Pike Run (04-208)									
HELP MWH									
8.3[H]	3.5	9	9.0	18.0	2542.0	50.3	24	NA	Fair
7.6[H]	4.6	8	8.0	10.2	750.0	58.3	20	NA	Poor
4.6[H]	7.7	12	12.0	11.0	1876.0	38.3	26	NA	Fair
0.8[H]	12.8	17	17.0	12.3	1250.0	52.0	30	NA	Marginal
Leatherwood Ditch (04-207)									
HELP WWH									
0.5[H]	12.7	11	11.0	-	322.0	30.5	36	NA	Marginal
Sugar Creek (04-203)									
ECBP MWH									
26.0[H]	6.7	13	13.0	5.0	1204.0	44.3	24	NA	Poor
23.9[H]	11.5	12	12.0	12.6	1550.0	51.0	26	NA	Poor
20.1[W]	22.5	12	12.0	38.8	292.5	45.5	26	NA	Fair/Poor
ECBP WWH									
18.2[W]	26.1	23	23.0	23.4	1056.0	65.5	40	8.1[ns]	Good/Marginal
HELP WWH									
13.4[W]	30.0	27	27.0	25.8	1825.5	52.3	38[ns]	8.1[ns]	Good
8.8[W]	44.7	23	23.0	54.1	777.0	56.0	40	7.1[ns]	Good/Fair
3.6[W]	57.0	28	25.5	19.6	1193.3	45.8	41	8.8	Good
0.6[W]	64.3	32	28.5	15.1	1698.8	60.9	39	8.9	Good/Very Good
Rattlesnake Creek (04-204)									
HELP MWH									
1.7[H]	6.1	11	11.0	6.6	2562.0	44.0	28	NA	Fair
Plum Creek (04-201)									
HELP MWH									
14.9[H]	15.8	17	17.0	11.4	2164.0	39.5	<u>26</u>[ns]	NA	Fair
12.9[H]	18.2	5	5.0	0.16	31.5	60.5	<u>16</u>*	NA	Poor
12.1[H]	18.7	3	3.0	0.02	4.5	37.5	<u>12</u>*	NA	Poor
8.1[W]	22.0	18	17.5	11.3	4629.8	40.0	29	8.4	Fair/Good
***Plum Creek (04-201)* (cont.)**									
HELP WWH									
4.6[W]	36.0	24	22.0	11.8	5663.0	29.8	30[ns]	8.8	Fair/Good

River Mile	Drain. Area	Total Species	Mean Species	Rel. Weight[a]	Rel. Number	QHEI	IBI	MIwb	Narratives
0.2[W]	39.9	35	28.5	7.9	3021.0	51.3	29[ns]	7.7[ns]	Fair/Marginal
UT to Plum Creek at RM 7.3 (04-229)									
HELP WWH									
0.4[H]	7.3	21	21.0	13.9	1332.0	35.3	34	NA	Marginal
Sycamore Creek (04-202)									
HELP MWH									
0.8[H]	10.6	16	16.0	11.4	3326.0	39.0	28	NA	Marginal
UT to Ottawa River at RM (04-290)									
HELP WWH									
0.4[H]	14.1	24	24.0	4.8	886.5	64.5	36	NA	Marginal

a - Relative abundance and relative weight estimates standardized to 0.3 km for wading sites and 1.0 km for boat sites, respectively.
H - Headwaters: sites draining areas ≤ 20mi^2.
W - Wadeable streams: sites draining areas > 20mi^2.
B - Boat sites: large or deep waters, necessitating the use of boat sampling methods.
ns - Non-significant departure from the bio criteria (≤4 IBI units or ≤0.5 MIwb units).
* - Significant departure from the biocriteria (>4 IBI units or >0.5 MIwb units).

Ecoregional Criteria (OAC 3745-1-07, Table 7-15)

Index-Site Type	WWH	EWH	MWH[b]
Eastern Corn Belt Plain Ecoregion (ECBP)			
IBI- Headwater/Wading	40	50	24
MIwb-Wading	8.3	9.4	6.2
IBI-Boat	42	48	24
MIwb-Boat	8.5	9.6	5.8
Huron Erie Lake Plain Ecoregion (HELP)			
IBI- Headwater	28	50	20
IBI-Wading	32	50	22
MIwb-Wading	7.2	9.4	5.6
IBI-Boat	34	48	20
MIwb-Boat	8.6	9.6	5.7

b - Modified Warmwater Habitat (MWH) for channel modified or impounded areas

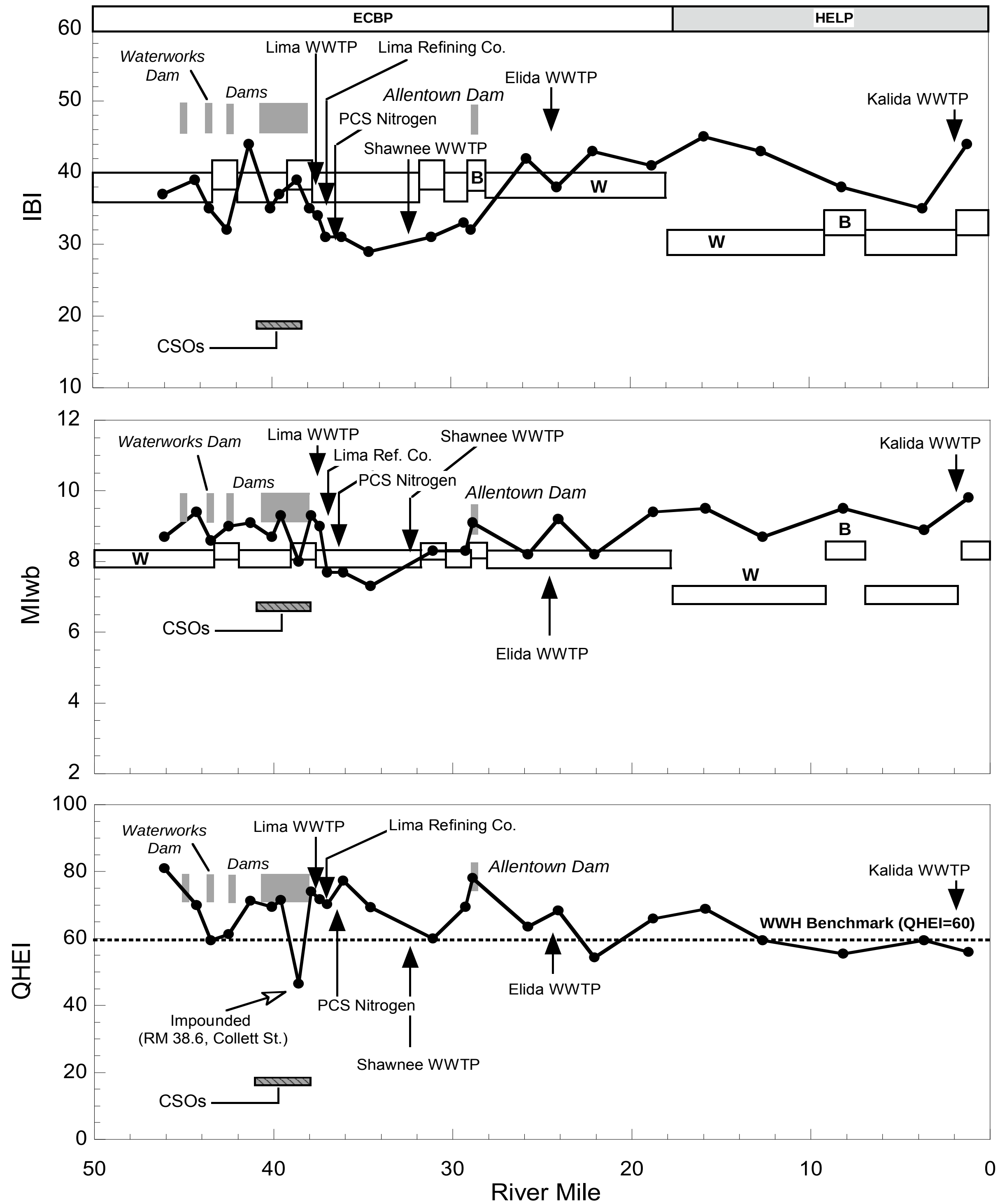

Figure 71. Longitudinal performance of the IBI, MIwb, and the QHEI, Ottawa River (mainstem), 2010. Horizontal rectangles B and W represent the existing WWH biocriteria and areas of non-significant departure for boat and wading methodologies, respectively. Arrows identify significant direct points of discharge for NPDES permitted entities. Horizontal rectangles atop the figure demark the ecoregions through which the Ottawa River flows: ECBP and HELP (Omernik and Gallant 1988).

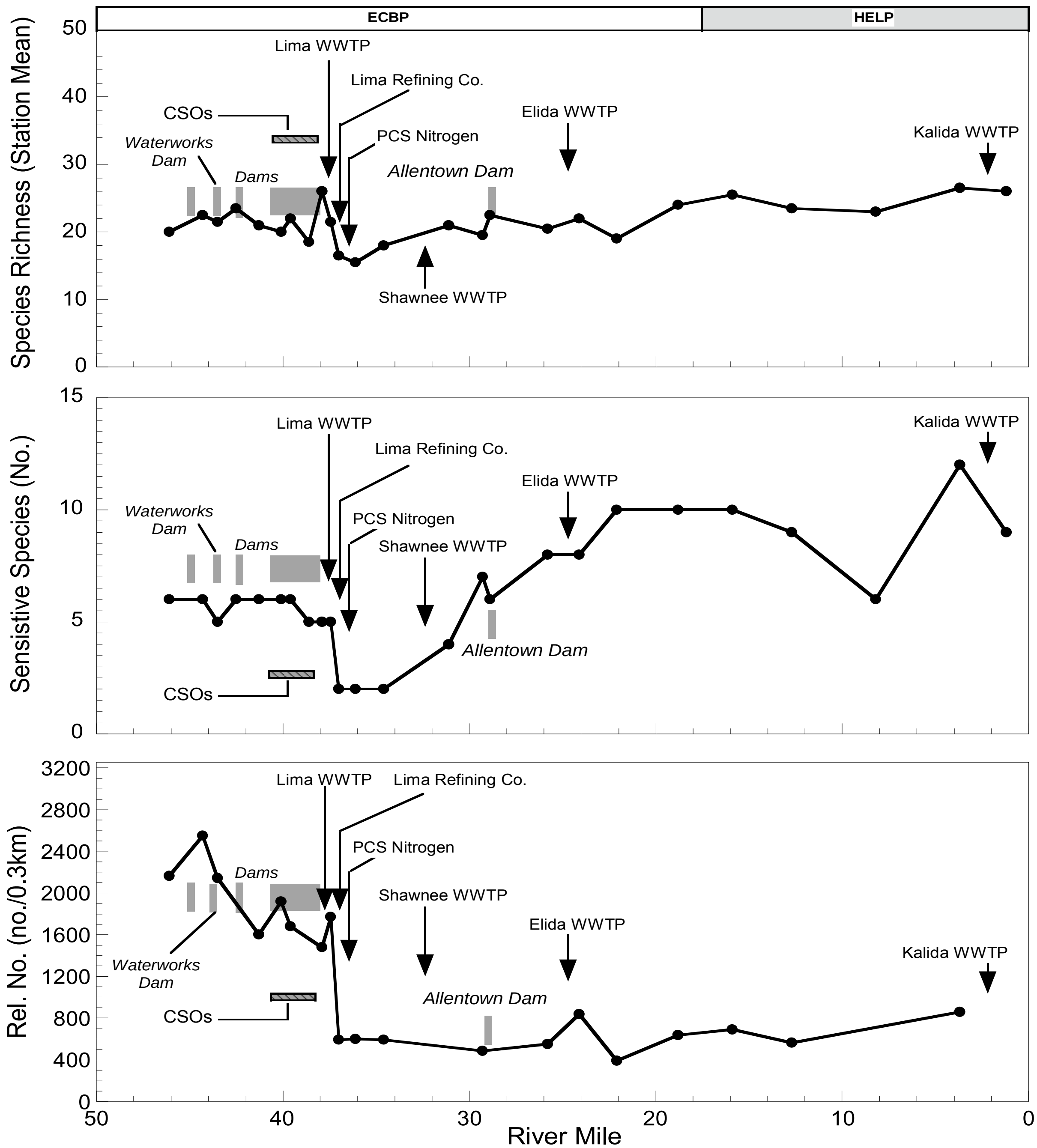

Figure 72. Longitudinal performance of key fish community indicators for the Ottawa River (mainstem), 2010. Arrows identify significant direct points of discharge for NPDES permitted entities. Horizontal rectangles atop the figure demark the ecoregions through which the Ottawa River flows: ECBP and HELP (Omernik and Gallant 1988). Relative abundance (bottom figure) includes results from wading sites only. Note: As relative abundance estimates are unique to each method, boat sample results were excluded from the bottom figure, so as to ensure comparability between and among sites. Similar biases are not present for estimates of taxa richness and thus all data are displayed on the upper two figures (Ohio EPA 1987).

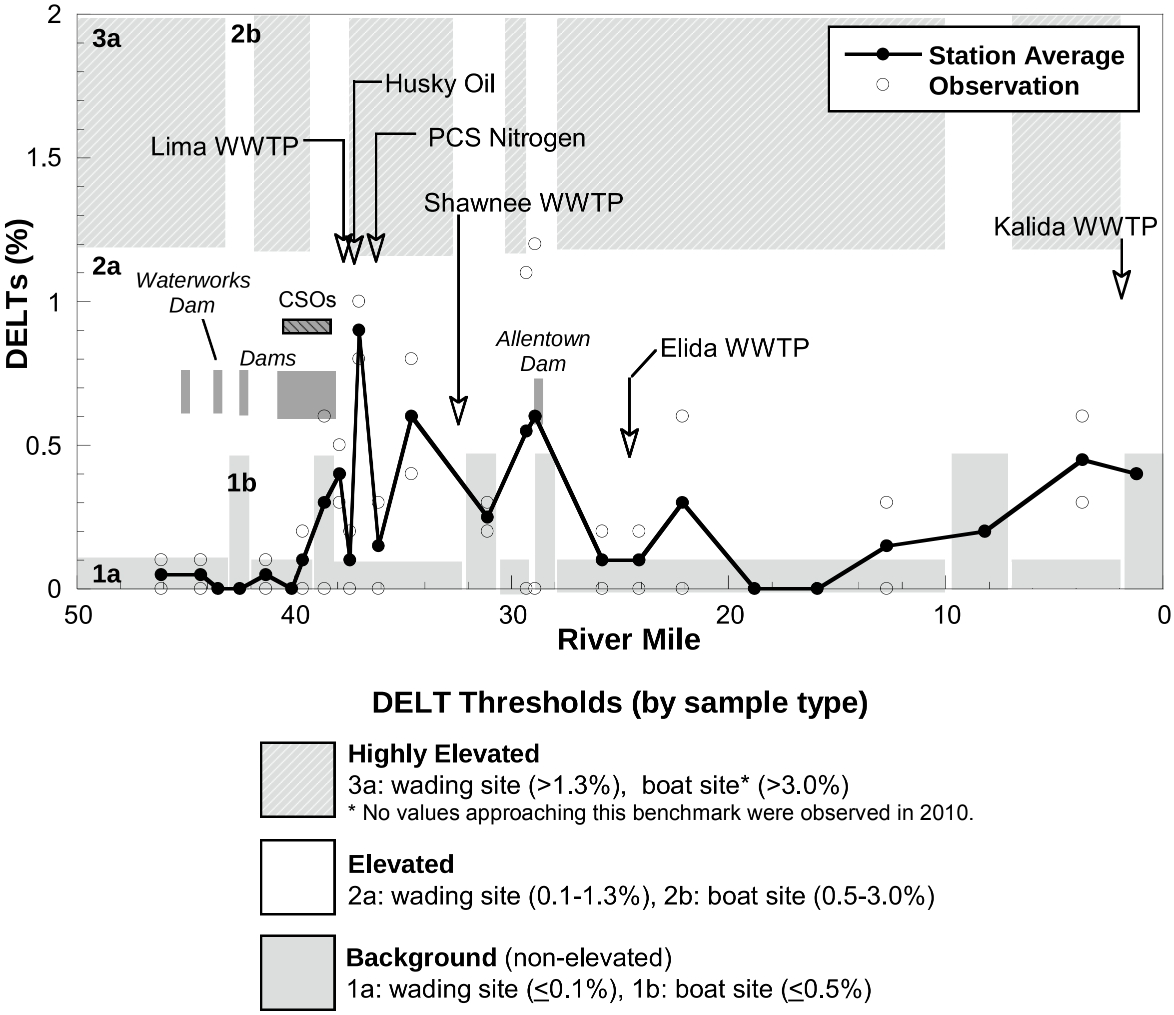

Figure 73. Longitudinal frequency of DELT anomalies for the Ottawa River (mainstem), 2010. Shaded and unshaded areas (1a-3a and 1b-2b) describe the DELT thresholds by sampler type (wading or boat).

As the effects of pollution abatement efforts are realized or otherwise manifest in aquatic communities, the MIwb is often the leading indicator of recovery on formerly degraded larger waterbodies. Often lagging behind the MIwb by a full reporting cycle (5-10 years), the IBI is typically the last biological index employed by Ohio EPA to achieve its respective biocriterion. This pattern of recovery or index succession has been observed by Ohio EPA for most of Ohio's large waterways over the past 20 years, as they transitioned from a degraded or otherwise impacted state to fully recovered status (e.g., Cuyahoga River, middle Great Miami River, Hocking River, Scioto River, Licking River). The strong performance of the MIwb and the absence of poor or very poor IBI scores on the Ottawa River in 2010 indicate that pollution abatement efforts to date have yielded meaningful improvements, leaving little doubt that the Ottawa River has entered a phase of strong environmental recovery.

Given the varied performance of these indexes and associated impact types, performance of the fish assemblage relative to various and sundry stressors is best described longitudinally (upstream downstream) as opposed to the general and aggregated descriptions provided above.

Evaluated at two sampling stations (RMs 46.1, Thayer Rd. and 44.3, Fetter Rd.), the upper 2.5 miles of the mainstem were found to support an assemblage of fish consistent with the WWH biocriteria. Progressing downstream, the first indication of aquatic life use impairment was identified immediately downstream from Lima's primary water in-take structure, the Metzger Dam at RM 43.5. Similar conditions were identified at the next downstream station (RM 43.4, Roush Rd.), which contained an additional, albeit small and seldom used, secondary water in-take structure. Taken together, these sites accounted for 2.1 contiguous impacted river miles. Among other factors, this decline was correspondent with an apparent diminution of stream discharge, as no flow was observed over or immediately below the Metzger dam, during both the July and August fish sampling events, and anemic or otherwise anomalously low flow was observed further downstream. The deleterious effects of diminished discharge (less dilutional flow and reduced current velocities) were compounded by a decline in macrohabitat quality related to historic channel modification, impoundment, and to a lesser extent sedimentation. It must be noted that the magnitude of the WWH departure observed through this reach was not great, as only the IBI failed to meet the prescribed biocriteria, missing by only a few points due to a modest shift in one or more of the index's proportional metrics. These conditions were abated at the next monitoring station at RM 41.2 (Sugar St.), where community performance again fully comported the WWH criteria. This site is located within an active quarry and benefits from incidental flow augmentation from wash water pond(s). The flow regime was locally improved as was overall macrohabitat quality. The positive response of the fish community to improved conditions was manifest in proportional metrics, including a reduction in environmentally tolerant, ecological generalists, and an increase in specialist breeding and feeding guilds.

Progressing downstream into the heart of the urban environs of Lima, the Ottawa River enters the first of a series of five dam pools contained within an approximately three mile river reach. Longitudinally, these include, Lovers Lane, Elm St., Central Ave., Baxter and Erie R&R/Collet St. pools. All dams are in remarkably close proximity to one another, with some near enough so as to form a continuous impoundment, with the spillway of one inundated by the adjacent and downstream dam pool of another. Alternatively, there persisted two small river reaches, ranging between 100-150 m in length of reasonably complex and free flowing habitat immediately downstream from the Lovers Lane and Elm St. dams. Five major CSOs are also located on this reach: Lovers Lane CSO (immediately downstream Lovers Lane dam), Central and McDonalds CSOs (both located within the Baxter Dam pool), and Heindel and Collet CSOs (both located within the Lima R&R/Collet St. pool). Based upon previous investigations by Ohio EPA, these relief points in Lima's collection system have served as significant sources of pollutant loads and have directly contributed to aquatic life use impairment (Ohio EPA 1992 and 1998). Four monitoring stations evaluated this segment, located between RM 40.1(immediately downstream Lovers Lane Dam/CSO) and RM 37.9 (downstream Erie R&R dam/upstream Lima WWTP).

Results from these sites yielded a mix of full and partial attainment, with the upper and lower sites (RMs 40.1 and 37.9) failing to support WWH communities and the intervening stations at RM 39.6 (downstream Elm St. dam) and RM 38.6 (within the Erie R&R/Collet St. dam pool), both found to just meet the WWH criteria. To varying degrees the entire segment appeared affected by the combined influences of CSOs and SSOs, habitat deficits (impoundment and others) and attendant nutrient enrichment — relief points in the collection system (SSO/CSOs) serving as sources of nutrients and the various hydromodification creating optimal conditions for runaway productivity. As observed upstream, impacted sites were not profoundly degraded, rather, departure from the WWH criteria was driven by the IBI alone, a result of modest shifts in the community toward ecological generalists at both RMs 40.1 and 37.9, and elevated incidence of disease, as reflected in portions of DELTs at the lowest site at RM 37.9 only.

Upon exiting Lima, the Ottawa River receives treated effluent from three major NPDES permitted entities over the distance of about one river mile: Lima WWTP, Lima Refining Co., and PCS Nitrogen. Any limitations or other water quality issues related to diminished stream flow are abruptly abated downstream from the Lima WWTP, as the discharge of the Ottawa River is significantly augmented by this 18.5 MGD facility. Non-mixing zone, near field effects or influences from these facilities were evaluated at three monitoring stations, each positioned well downstream from the facilities' primary discharges, at RMs 37.4 (downstream from Lima WWTP), 37.0 (downstream from Lima Refining Co.) and 36.1 (downstream from PCS Nitrogen). All three sites failed to support WWH fish communities; however, the structure, functional organization, and species richness did not vary equally, suggesting differential stress at and among the sites. Community performance downstream from the Lima WWTP was in many ways very similar to that observed immediately upstream from the WWTP, in that WWH departure was indicated by the IBI alone, the index falling short of the WWH criteria by only two units (IBI=34). The community also showed a similar shift towards ecological generalists, with the addition of a decline in overall taxa richness, including the loss of darter species. However, it is important to reiterate that the MIwb, a structural measure, remained comparable to all upstream stations on the Ottawa River, comporting fully with the WWH biocriteria at RM 37.4. The condition of the fish assemblage downstream from the Lima Refining Co. at RM 37.0 was markedly diminished by comparison, as the IBI lost an additional 2 points (station average reduced to IBI=31) and MIwb fell well below the WWH standard (station average reduced to MIwb=7.7). Specific community attributes responsible for this decline included a precipitous reduction in relative abundance, number of environmentally sensitive species, and to a lesser degree overall taxa richness. Furthermore, the incidence of DELT anomalies rose sharply, reaching a station average of 0.9% and overall structural evenness (distribution of numbers and biomass among the various species) declined. Similar conditions were found downstream from PCS Nitrogen, at RM 36.1, and at the next downstream station at RM 34.6 (adj. Westfield Dr./at Shawnee CC).

As measured by the MIwb, longitudinal restoration of basic community structure was evident by RM 31.1 (Elm St./downstream Shawnee WWTP). Although the IBI remained below the WWH criterion here (station average IBI=31), the MIwb easily met its associated criterion. Similar conditions persisted for approximately five miles downstream, namely, subpar IBI and the MIwb at or greater than WWH standard. Near the lower limits of this segment, at the village of Allentown, the Ottawa River enters its last impoundment. Strictly defined in terms of the locale conditions, this impoundment did not appear to have a negatively affected fish community performance or overall macrohabitat quality, as measured at RM 28.9 (SR 81). Due to locally high gradient, the Allentown dam actually impounds only a very small segment of the Ottawa River, the dam pool appearing no larger than 200m in length and was nowhere found exceedingly deep. The remainder of the sampling zone (an additional 150m upstream) was free flowing, and consisted of a repeating series of well-developed riffle-run-pool complexes. However, the absence of disenable local or site specific effects associated with the Allentown dam pool does not exclude the possibility of broader spatial and temporal constraints, as the dam itself very likely serves as a significant barrier to up-river fish passage. By preventing unfettered upstream passage of native fish from recovered or presently unimpacted reaches downstream from the dam, the recovery of this and other impaired upstream segments may have been delayed or otherwise protracted.

The remaining lower 25.8 miles of the Ottawa River are free flowing and were found to support fish assemblages consistent with the WWH biocriteria. The incidence of DELT anomalies through this segment was locally elevated and the frequency (number of stations exhibiting DELTs) greater than expected. However, station averages remained below levels described as highly elevated, and while present at most sites, the percentage of affected fish were typically at or below background levels (Ohio EPA 1987). Although not without effects, point source wasteloads delivered directly to the lower Ottawa River from minor WWTPs (villages of Elida, and Kalida), appeared safely assimilated, as indicated by structure, functional organization, and taxa richness of the fish community.

Ottawa River Tributaries

Hog Creek and Little Hog Creek

A total of 20,835 fish comprising 30 species and three hybrids was collected from the Hog and little Hog basins, between July and September, 2010. The survey effort included 19 sampling events at 17 stations, evaluating 28 cumulative stream miles. The Hog Creek subbasin consists of six named and unnamed streams: Hog Creek (mainstem), unnamed Hog Creek tributary (RM 13.7), Lord Ditch, Fitzhugh Ditch, No. 28 Ditch and Grass Creek. The Little Hog Creek watershed includes three primary waterbodies: Little Hog Creek (mainstem), Mud Run and an unnamed tributary (joining Little Hog Creek at RM 0.47).

Based on aggregated catch statistics, numerically predominant species (number/km) were bluntnose minnow (31.6%), Central stoneroller (22.7%), creek chub (6.9%), white sucker (5.1%), and blackstripe topminnow (4.5%). In terms of relative biomass (kg/km), dominant species were common carp (40.0%), white sucker (12.1%), Central stoneroller (10.3%), creek chub (8.5%), and yellow bullhead (3.9%). Over 50% of all fish and fully 70% of total fish biomass collected from Hog and Little Hog basins were pollution tolerant species. In terms of both relative abundance and biomass, environmental sensitive taxa comprised only nine percent of fish species. The overwhelming dominance of tolerant and ecological generalist fish taxa and the paucity of sensitive forms are indicative of the overall marginal condition of watershed.

No fish species classified as rare, threatened, endangered, or otherwise recognized for special conservation status by the Ohio DNR were observed. Furthermore, intolerant, rare, declining or otherwise ecologically significant species were also found absent from Hog and little Hog Creek.

Among these waters, community indices and accompanying narrative evaluations ranged between good (IBI=40 and MIwb=8.7) and poor-fair (IBI=24 and MIwb=5.7), with an average characterized as fair (IBI=34.12 and MIwb=7.52). Longitudinal performance of the IBI, MIwb, and other relevant indicators are presented in Figures 74-76. Summarized index scores and community statistics by station are presented in Table 18. Raw index scores, metrics, fish species and abundance data by sampling station are located in Appendices E and F.

Hog Creek

Of the 12 monitoring stations dispersed through the Hog Creek watershed, nearly all were found to support fish communities consistent with the existing MWH and WWH aquatic life use designations. Significant departure from the associated biocriteria was limited to only a single station on Hog Creek located at RM 3.8 (Pevee Rd.). This station is situated just downstream from the Allen/Hardin county line, the point at which the MWH use gives way to the WWH use. Hog Creek and its principal tributaries are managed as open ditches upstream from this point, and thus are recognized as modified habitat in Ohio's water quality standards. Downstream from the county line, Hog Creek serves as an unmodified outlet, and thus has retained the WWH designation. Despite being within the WWH segment, the station at RM 3.8, appeared strongly influenced or otherwise effected by the export of nutrients and sediment from the highly artificial conditions that typify the upper half of the Hog Creek basin. In many important ways community performance here was similar or more akin to the MWH segment, and thus biological conditions at RM 3.8 appeared reflective of the transitional nature of this segment.

Little Hog Creek

Lower Little Hog Creek, Mud Run and the unnamed Little Hog Creek tributary were all found to support fish communities fully consistent with the exiting WWH aquatic life use designation. Stations allocated to evaluate the Lafayette WWTP found the wasteload delivered to Little Hog Creek from this facility safely assimilated.

Significant departure from the WWH biocriterion was limited to the uppermost station located on the headwaters of Little Hog Creek, at RM 3.6 (Pevee Rd.). Subpar performance of the IBI was a result of shifts in selected proportional metrics toward environmental tolerant, ecological generalist taxa, including the dominance of pioneering species. Together these community responses suggested stream ephemerality or intermittency as the primary associated cause and source of impairment. Localized septic conditions may have contributed to this, as sewage solids, accompanied by pronounced septic odor, were observed under and immediately downstream from Pevee Rd.

Greater Lima Tributaries

Three small direct Ottawa River tributaries, Lost Creek, Zurmehly Creek and the Little Ottawa River, drain a significant portion of the greater Lima metropolitan area. Nine stations were deployed among these streams, evaluating 16 linear river miles.

Among these waters, community indices and accompanying narrative evaluations ranged between marginally good (IBI=36) and poor (IBI=22), with a station average within the low-fair range (IBI=28.7). Longitudinal performance of the IBI and other relevant indicators for Lost Creek and the Little Ottawa River are presented in Figures 77 and 78. Comparative performance, by drainage area, of the remaining middle Ottawa tributaries are presented in Figure 74. Summarized index scores and community statistics by station are presented in Table 18. Raw index scores, metrics, fish species and abundance data by sampling station are located in Appendices E and F.

Based upon existing and recommended aquatic life use designations, departure from the prescribed biocriteria were indicated at five stations. Specifically, these included the lower 4.5 miles of the WWH designated Little Ottawa River, and the single monitoring site on WWH designated Zurmehly Creek. Environmentally tolerant fish species were overwhelmingly dominant at these sites. Proportional metrics were strongly skewed towards ecological generalists and pioneering taxa. Sensitive species were nearly absent, and specialist breeding and feeding guilds were very poorly represented. The condition of the fish fauna of the lower Little Ottawa River appeared reflective of the combined effects of urban hydrology and diffuse pollution sources attendant to developed areas (e.g., SSOs, storm sewers, nonspecific urban run-off). Treated effluents from a small WWTP on the headwaters, serving the village of Cridersville, served as an important source of additional pollutant loads and contributed to aquatic life use impairment. Grey water, deposits of black (anoxic) solids, sewage fungus, and active SSOs were all observed on the Little Ottawa River. In many important ways, the condition of the fish fauna of Zurmehly Creek was very similar to that of the Little Ottawa River, and appeared to reflect the same structural features of the watershed (urban hydrology and related non-point pollution sources), with the addition of intermittency.

All waters that form the Lost Creek catchment were found to support an assemblage of fish consistent with the existing and recommended, MWH and WWH aquatic life uses. Similarly the MWH designated headwaters of Little Ottawa River (evaluated at RM 5.5, Old S. Dixie Hwy.) supported the request fish community.

No fish species classified as rare, threatened, endangered, or otherwise recognized for special conservation status by the Ohio DNR were observed. Furthermore, intolerant, rare, declining or otherwise ecologically significant species were also found absent from the greater Lima tributaries.

Middle Ottawa River Tributaries

Five streams constitute the middle Ottawa tributaries: Honey Creek, Dug Run, Beaver Run, Pike Run and Leatherwood Ditch. Although this aggregation is somewhat arbitrary, these water do in fact share several important characteristics: all said waterbodies drain an area less than 20mi^2, all are located within the HELP ecoregion, and nearly all exclusively drain rural portions of the watershed and owing to the poor drainage that typifies this ecoregion, most of these waterbodies appeared to have been channel modified or otherwise physically manipulated to improve drainage.

Nine stations were deployed among these tributaries, evaluating 18 linear stream miles. Community indices and accompanying narrative evaluations ranged between good (IBI=40) and poor (IBI=20), with a station average within the low-fair range (IBI=29.1). Longitudinal performance of the IBI and other relevant indicators for Pike Run is presented in Figure 79. Comparative performance, by drainage area, of the remaining middle Ottawa tributaries are presented in Figure 74. Summarized index scores and community statistics by station are presented in Table 18. Raw index scores, metrics, fish species and abundance data by sampling station are located in Appendices E and F.

Based upon the existing and recommended MWH and WWH aquatic life use designations, all monitoring stations in the middle Ottawa River tributaries were found to support fish assemblages consistent with the prescribed biocriteria. Despite the marginal nature of the fish community observed on most of these streams, compliance with the biocriteria reflected the lower expectations of waterbodies contained within the HELP ecoregion and application of the MWH designation. Pike Run was field verified and recommended MWH as part of the 1991 Ottawa River survey (Ohio EPA 1992) and is recognized as such in Ohio's water quality standards. The MWH aquatic life use was recommended for upper Honey Run (affecting RM 3.6, Cremeans Rd.) as a result of the 2010 survey, based upon the combination of existing channel deficiencies and its recognition and management as a drainage conveyance (Allen County Engineer's Office, pers. com.). The remaining streams and stream segments (lower Honey Run, Dug Run, and Beaver Run), retained their existing WWH designation, and thus community performance was gauged against the HELP, WWH biocriteria. Although not without apparent effect, the wasteload from the

American-Bath WWTP appeared safely assimilated as appraised by the fish community performance against the associated MWH biocriteria.

No fish species classified as rare, threatened, endangered, or otherwise recognized for special conservation status by the Ohio DNR were observed. Furthermore, intolerant, rare, declining or otherwise ecologically significant species were also absent from these tributaries.

Lower Ottawa Tributaries

Two primary drainages, Sugar and Plum Creek, and an unnamed stream joining the mainstem at RM 0.7 (south of Kalida) constitute the lower Ottawa River tributaries. Taken together, said waterbodies drain portions of both the ECBP and HELP ecoregions, and all drain primarily rural or otherwise agricultural areas. Owing to the natural poor drainage that typifies the HELP and selected lacustrine portions of the ECBP, lower Ottawa River tributaries have been channel modified or otherwise physically manipulated to improve locale and sub-regional drainage. Eighteen monitoring stations were deployed among these streams and their tributaries, evaluating 47 linear stream miles.

No fish species classified as rare, threatened, endangered, or otherwise recognized for special conservation status by the Ohio DNR were observed. Furthermore, intolerant, rare, declining or otherwise ecologically significant species were also found absent from these tributaries.

Sugar Creek and Rattlesnake Creek

A total of 9,148 fish comprising 38 species and one hybrid were collected from the Sugar Creek catchment, between July and September, 2010. The survey effort included eleven sampling events, at nine stations, evaluating 28 cumulative stream miles. The Sugar Creek subbasin consists of the mainstem and Rattlesnake Creek.

Based on aggregated catch statistics, numerically predominant species (number/km) were bluntnose minnow (22.4%), creek chub (6.7%), redfin shiner (9.5%), white sucker/Central stoneroller (8.8%), and Johnny darter (6.3%). In terms of relative biomass (kg/km), dominant species were common carp (38.0%), white sucker (21.5%), yellow bullhead (9.0%), creek chub (3.5%), and gizzard shad (3.7%). Over 50% of all fish and nearly 80% of total fish biomass collected from the Sugar Creek basin were pollution tolerant species. In terms of both relative abundance and biomass, environmental sensitive taxa comprised only 8.2% and 3.8% of fish species, respectively. The overwhelming dominance of tolerant, ecological generalist fish taxa and the paucity of sensitive forms are indicative of the overall marginal condition of Sugar Creek.

Community indices and accompanying narrative evaluations ranged between good/marginally good (IBI=41 and MIwb=8.9) and fair (IBI=24 and MIwb=7.1), with a basin average characterized as fair/marginally good (IBI=33.56 and MIwb=8.2). Longitudinal performance of the IBI, MIwb, and other relevant indicators are presented in Figure 80. Summarized index scores and community statistics by station are presented in Table 18. Raw index scores, metrics, fish species and abundance data by sampling station are located in Appendices E and F.

Based upon the existing and recommended MWH and WWH aquatic life use designations, all monitoring stations on Sugar Creek and Rattlesnake Creek were found to support fish assemblages consistent with the prescribed biocriteria. Conditions on the upper eight miles of the MWH recommended segment of Sugar Creek and all of Rattlesnake Creek were fairly typical of those observed on most Ottawa River tributaries, namely, marginal or fair biological performance, concurrent with marginal macrohabitat quality, the latter attributable to drainage improvement. Although not optimal, macrohabitat quality improved significantly through the lower 18 miles, with corresponding improvement in the fish community performance. Given the degree of existing hydromodification on both upper Sugar Creek and Rattlesnake Creek and their current status as formal drainage conveyances, the MWH aquatic life use was recommended for these streams and stream segments. The lower 18 miles of Sugar Creek retained the WWH use, and community performance through this reach typically exceeded the prescribed biocriteria.

Plum Creek Basin

A total of 20,657 fish comprising 39 species and three hybrids was collected from the Plum Creek basin, between July and September, 2010. The survey effort included 11 sampling events, at eight stations, evaluating 17 cumulative stream miles. The Plum Creek basin consists of the mainstem, Sycamore Creek and an unnamed Plum Creek tributary.

Based on aggregated catch statistics, numerically predominant species (number/km) were bluntnose minnow (50.1%), sand shiner (8.1%), fathead minnow (6.3%), creek chub (5.6%), and silverjaw minnow (4.0%). In terms of relative biomass (kg/km), dominant species were creek chub (19.9%), bluntnose minnow (19.0%), yellow bullhead (8.7%), longear sunfish (7.9%), and Central stoneroller (5.9%). As observed on nearly every Ottawa River tributary, the vast majority of the fish assemblage (65%) in terms of relative number and biomass were concentrated in tolerant species, with a commensurate paucity of sensitive or otherwise environmentally intolerant taxa.

Community indices and accompanying narrative evaluations ranged between fair (IBI=34 and MIwb=8.7) and poor (IBI=12), with a basin average characterized as poor (IBI=25.5). Longitudinal performance of the IBI, MIwb, and other relevant indicators are presented in Figures 81 and 82. Summarized index scores and community statistics by station are presented in Table 18. Raw index scores, metrics, fish species and abundance data by sampling station are located in Appendices E and F.

Based upon existing and recommended MWH and WWH aquatic life use designations, only two of the eight monitoring stations deployed to evaluate the Plum Creek and tis principal tributaries failed to support fish assemblages minimally consistent with the associated biocriteria. These included the sites bracketing the village of Columbus Grove and it WWTP, at RMs 12.9 (upstream Columbus Grove WWTP, at Wayne St.) and 12.1 (downstream Columbus Grove), and both portrayed a profound impact to Plum Creek. The degradation was nearly complete as this reach was almost void of fish life. Each site was found to contain 21 and 3 fish, respectively, these divided among five species. Compared against adjacent stations, these primary community measures were several orders of magnitude greater that than those observed at RMs 12.9 and 12.1, bringing the full magnitude of the impact in to stark relief. Direct field observations noted septic condition through the effected segment: anoxic (black) sediment, despots of sewage solids, sewage fungus, and a pronounced septic odor. Conditions here appeared as result of highly active CSOs from Columbus Grove's collection system following heavy rains the week prior to the fish sampling event of August 18th, 2010.

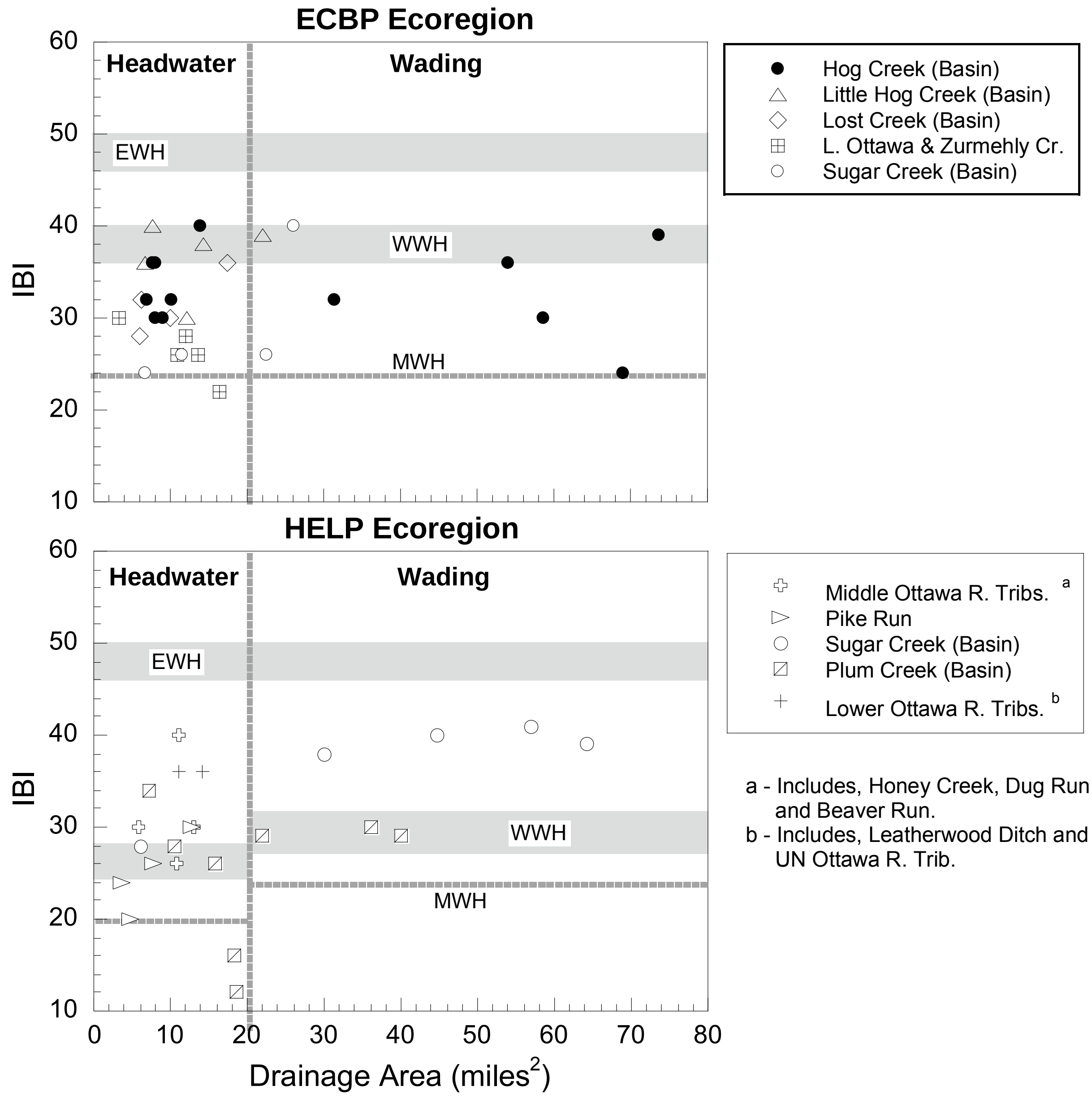

Figure 74. Distributions of IBI score for all Ottawa River tributaries by stream size (drainage area) and ecoregion, ECBP and HELP. The vertical dashed line represents the threshold between headwaters (≤20mi^2) and wading (>20mi^2) sites. From top to bottom, horizontal shaded areas indicate EWH and WWH biocriteria. Dashed horizontal line identifies the MWH biocriteria.

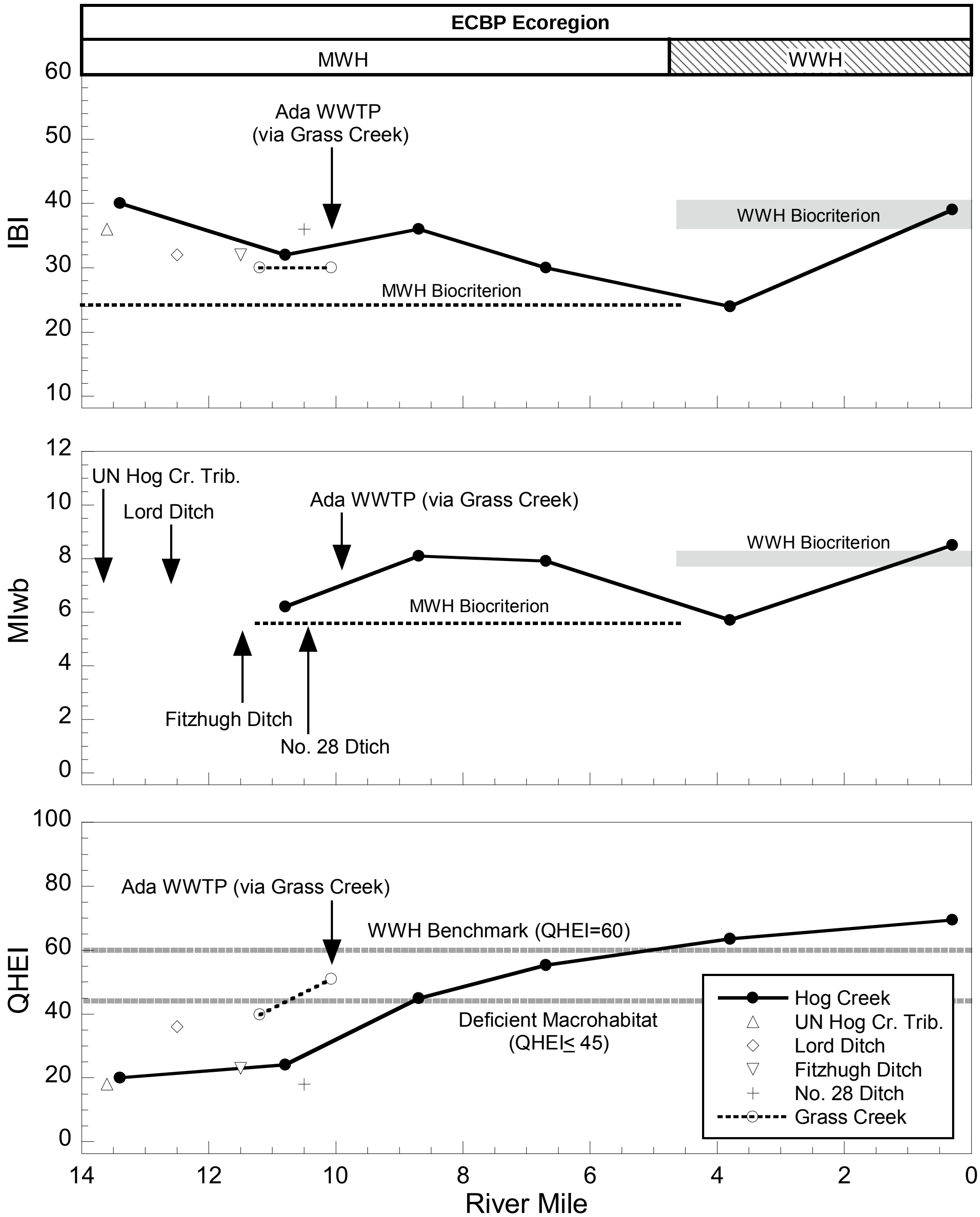

Figure 75. Longitudinal and spatial performance of the IBI, MIwb, and QHEI for Hog Creek (mainstem), and tributaries 2010-11. Rectangles atop the figure demark ecoregion and existing and recommended MWH and WWH aquatic life use designations. For the QHEI, horizontal dashed lines indicate typical WWH benchmark and threshold at or below which macrohabitat is likely to be limiting.

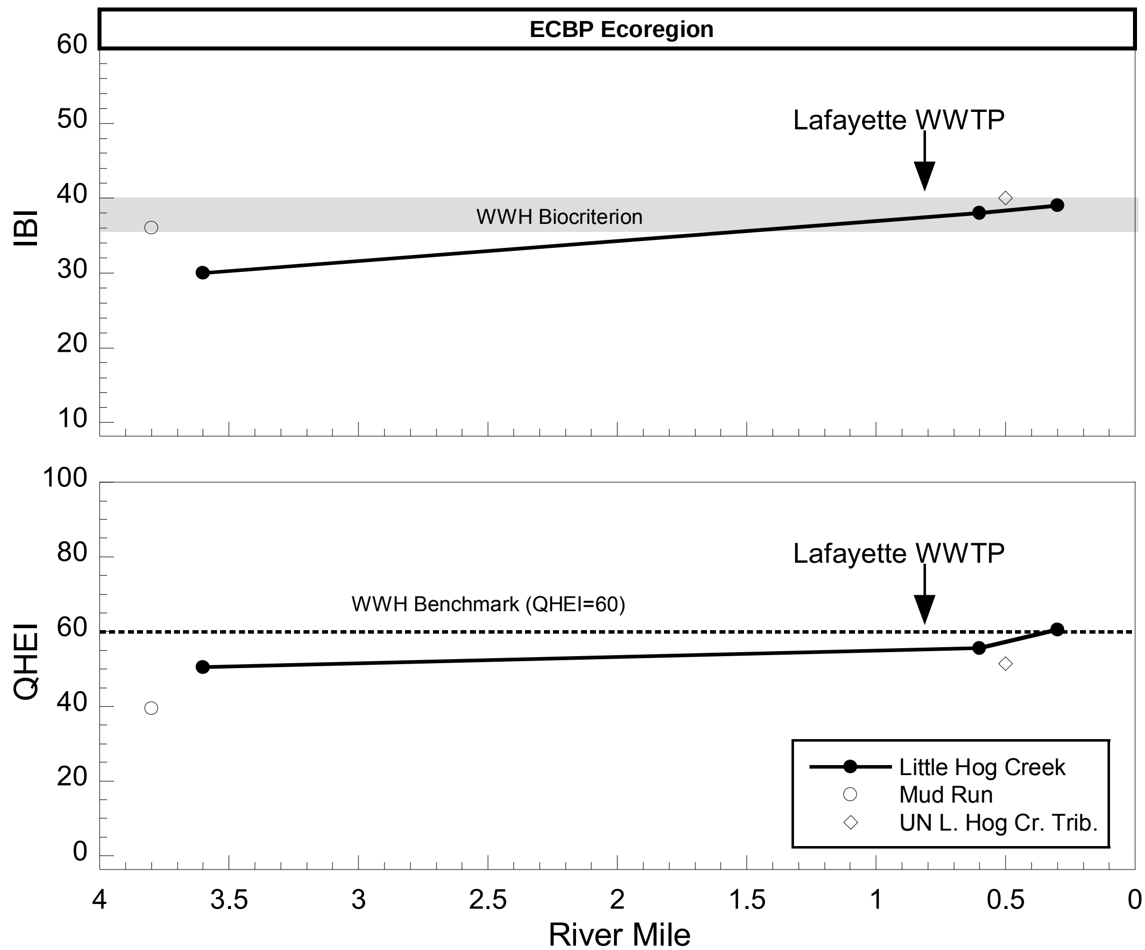

Figure 76. Longitudinal and spatial performance of the IBI and QHEI for Little Hog Creek (mainstem), and tributaries, 2010. The rectangle atop the figure demarks the ecoregion. For the QHEI, horizontal dashed lines indicate typical WWH benchmark.

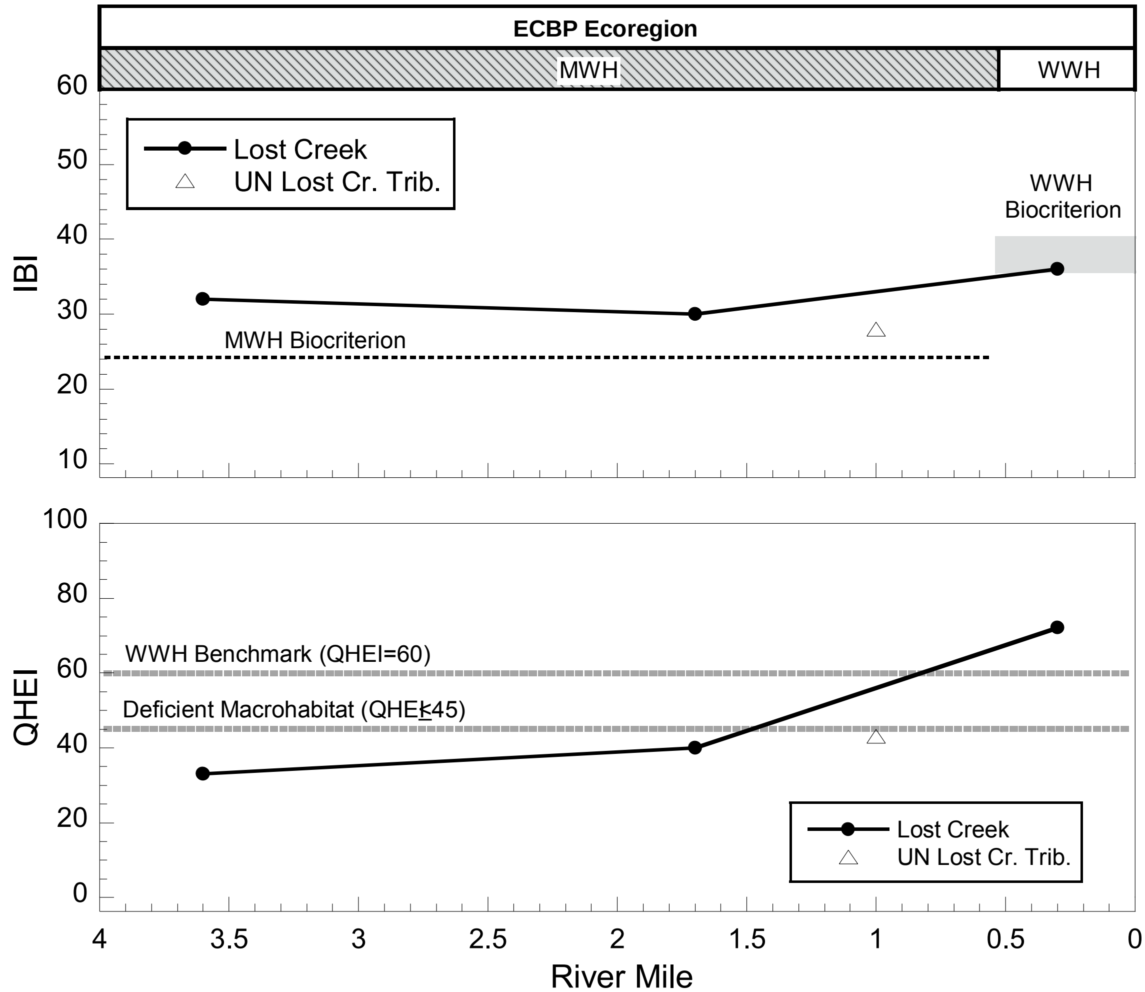

Figure 77. Longitudinal and spatial performance of the IBI and QHEI for Lost Creek and its tributary 2010. Rectangles atop the figure demark ecoregion and existing and recommended MWH and WWH aquatic life use designations. For the QHEI, horizontal dashed lines indicate typical WWH benchmark and threshold at or below which macrohabitat is likely to be limiting.

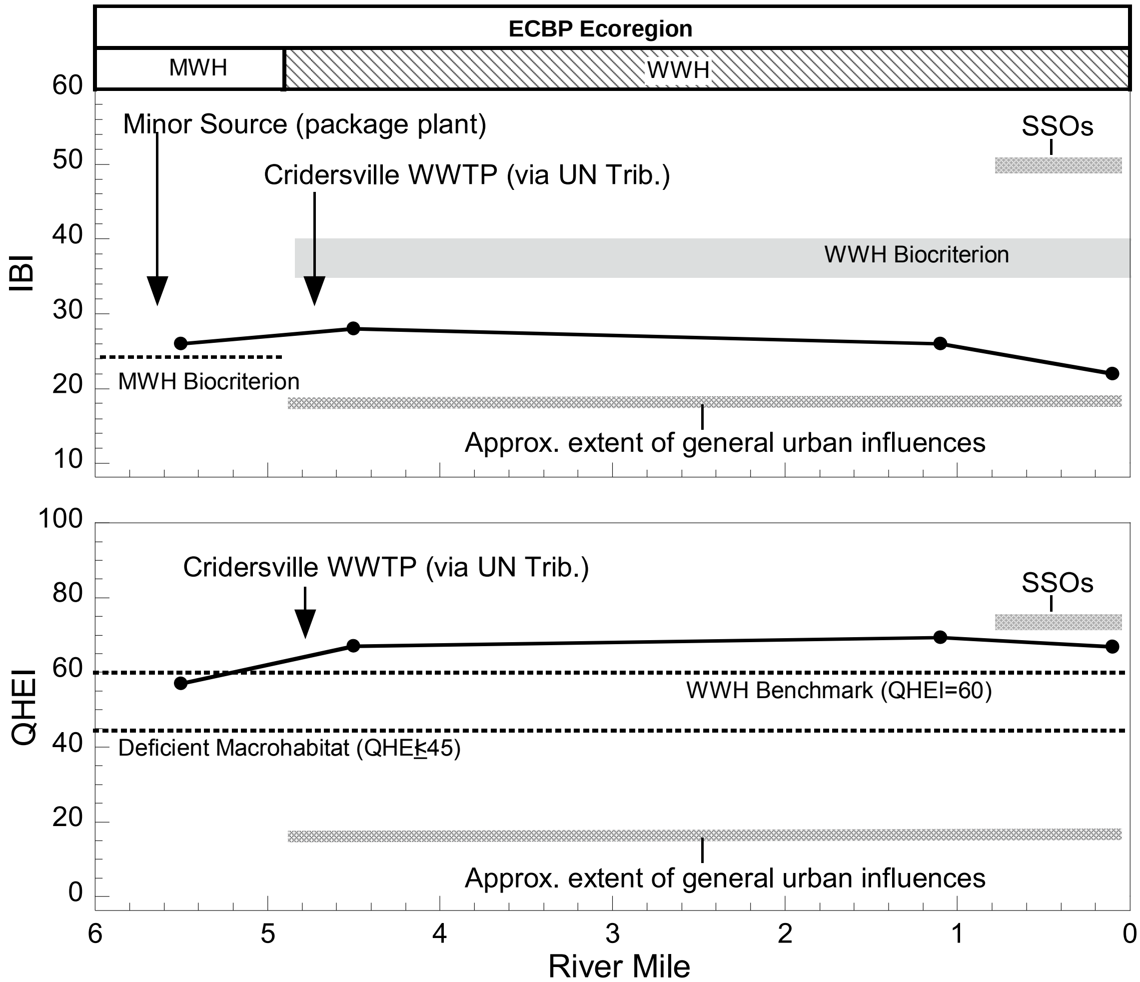

Figure 78. Longitudinal and spatial performance of the IBI and QHEI for the Little Ottawa River, 2010. Rectangles atop the figure demark ecoregion and existing and recommended MWH and WWH aquatic life use designations. For the QHEI, horizontal dashed lines indicate typical WWH benchmark and threshold at or below which macrohabitat is likely to be limiting.

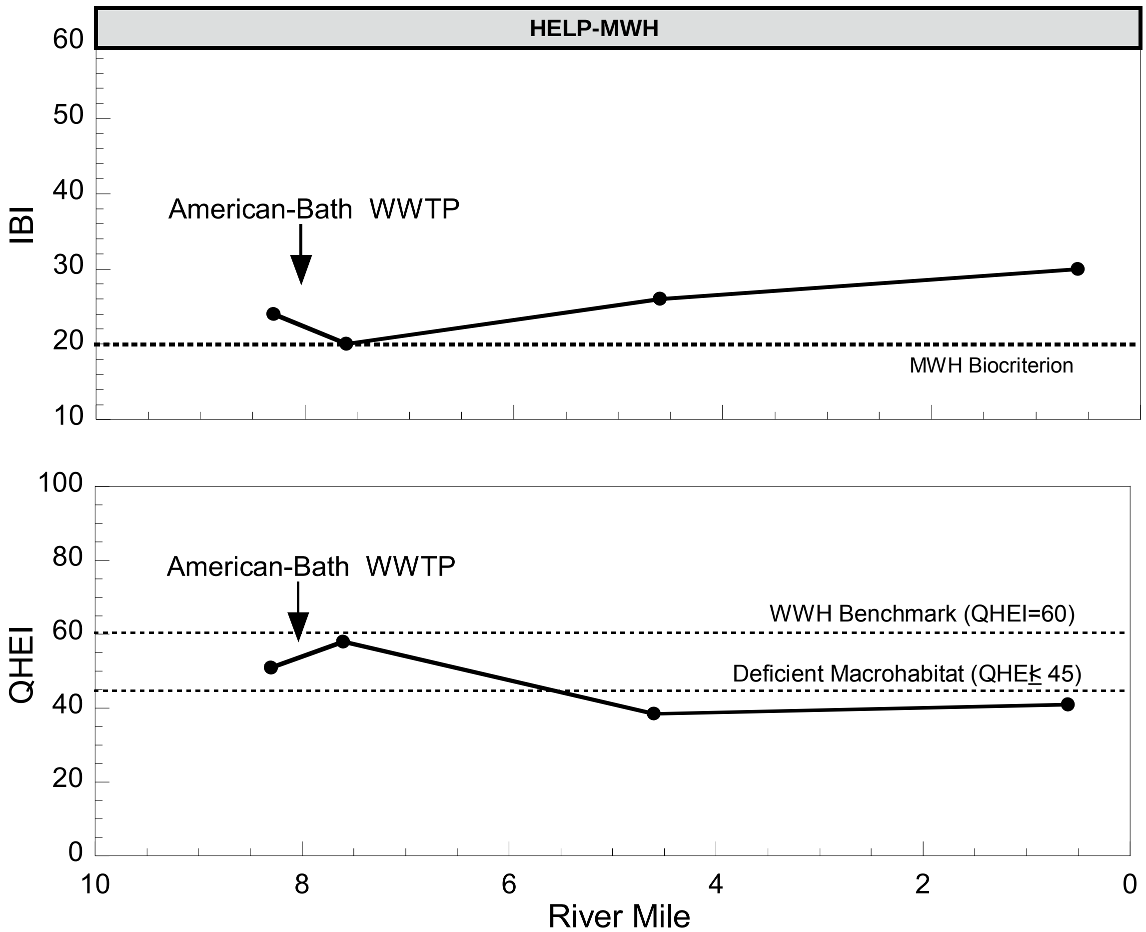

Figure 79. Longitudinal and spatial performance of the IBI and QHEI for Pike Run, 2010. Rectangles atop the figure demark ecoregion and existing MWH aquatic life use designation. For the QHEI, horizontal dashed lines indicate typical WWH benchmark and threshold at or below which macrohabitat is likely to be limiting.

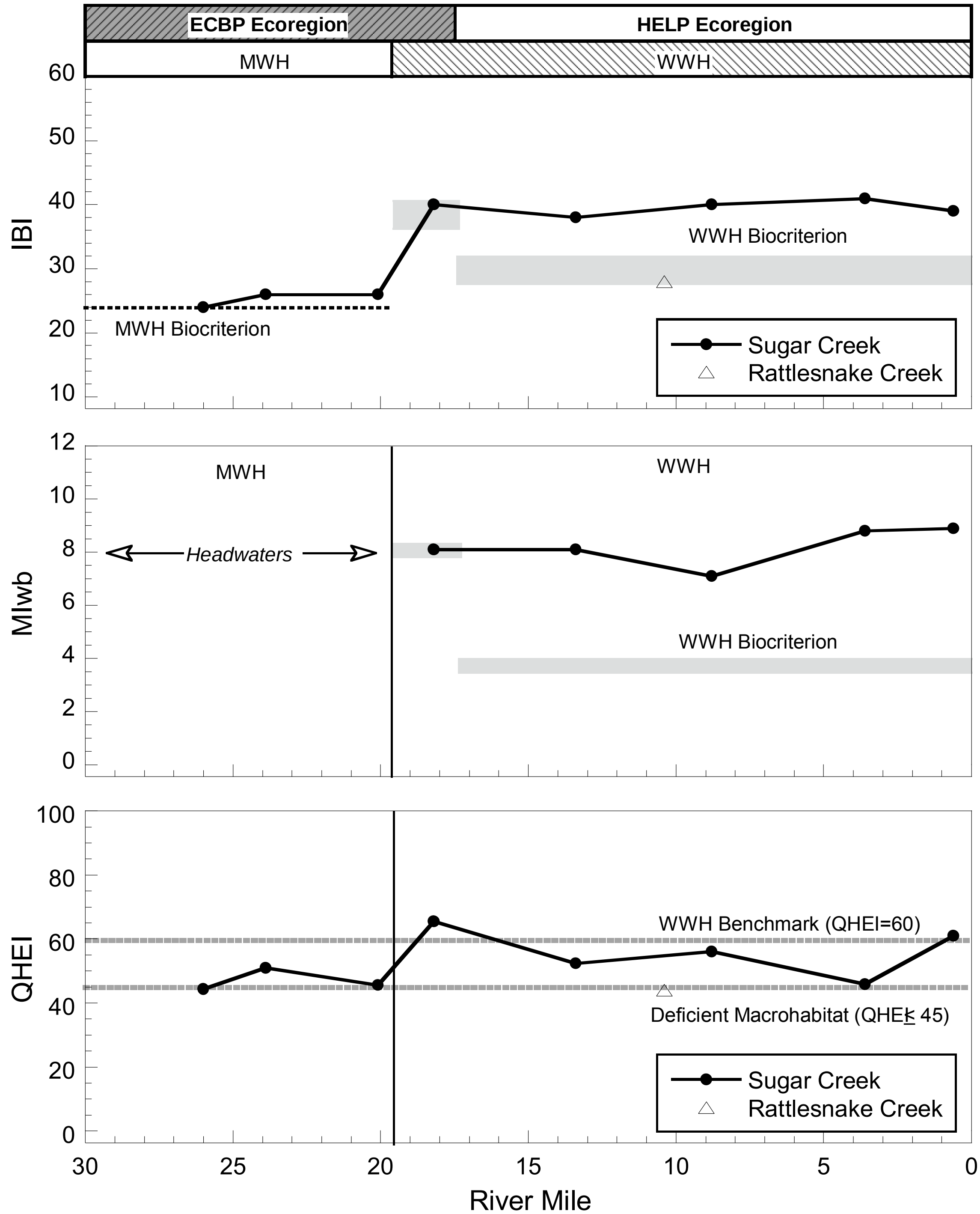

Figure 80. Longitudinal and spatial performance of the IBI, MIwb, and QHEI for Sugar Creek and Rattlesnake Creek, 2010-11. Rectangles atop the figure demark ecoregion and existing and recommended MWH and WWH aquatic life use designations. For the QHEI, horizontal dashed lines indicate typical WWH benchmark and threshold at or below which macrohabitat is likely to be limiting.

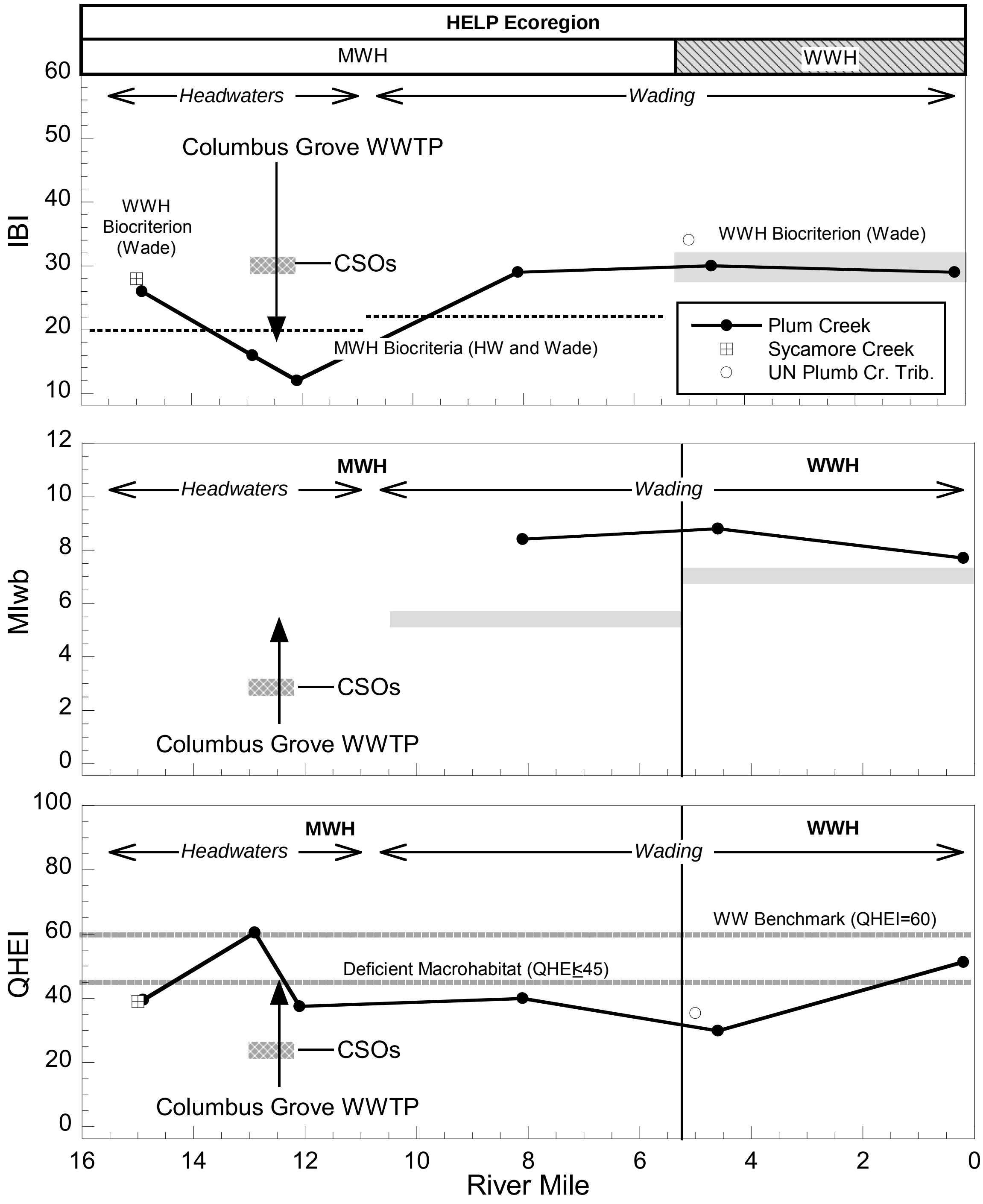

Figure 81. Longitudinal and spatial performance of the IBI, MIwb, and QHEI for Plum Creek and tributaries, 2010. Rectangles atop the figure demark ecoregion and existing and recommended MWH and WWH aquatic life use designations. For the QHEI, horizontal dashed lines indicate typical WWH benchmark and threshold at or below which macrohabitat is likely to be limiting. Horizontal arrowed lines identify stream size, headwaters (≤20mi^2) and wading (>20mi^2).

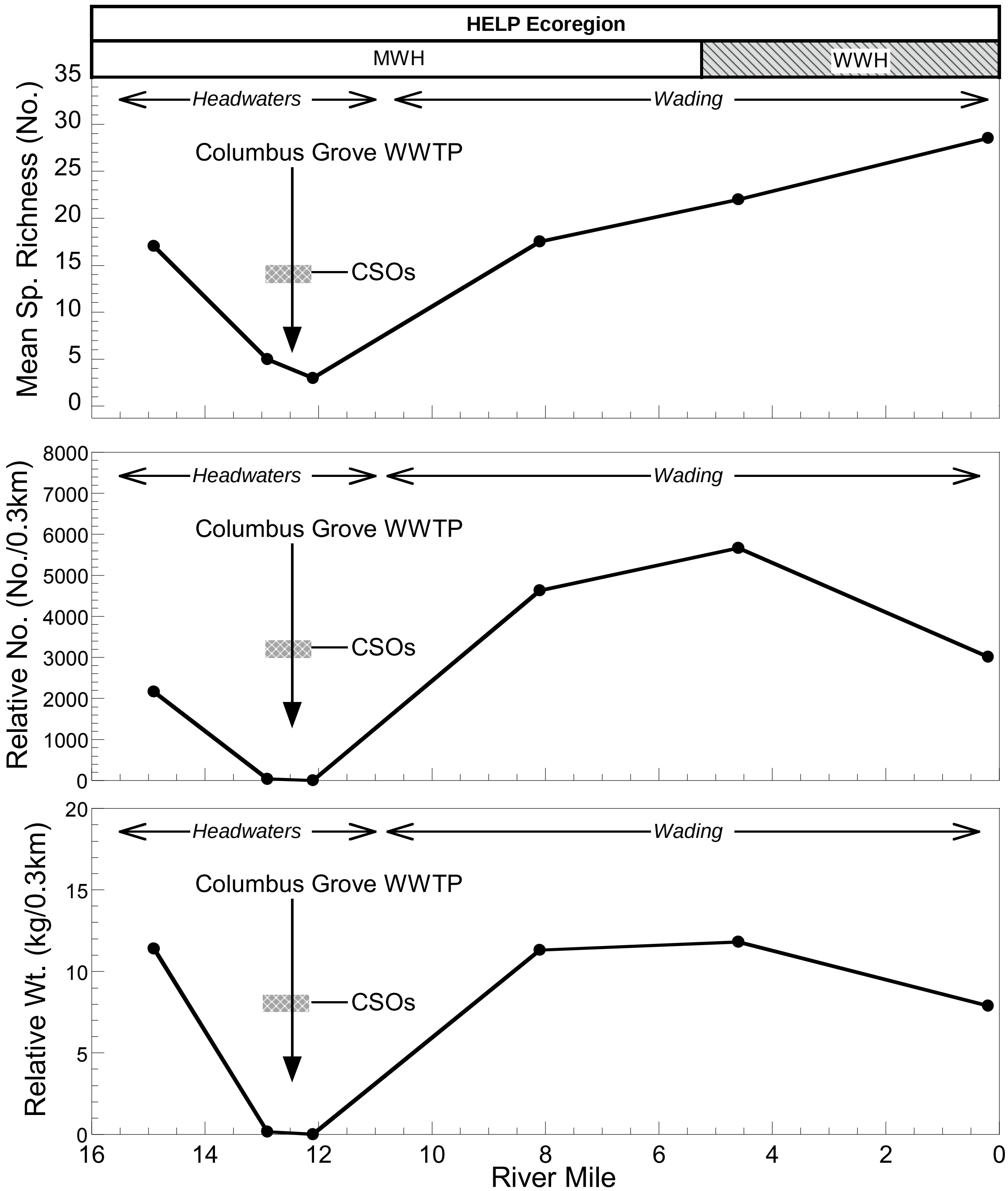

Figure 82. Longitudinal performance of selected community metrics, Plum Creek, 2010. Horizontal rectangles atop the figure identify and delimit ecoregion, existing and recommended MWH and WWH aquatic life uses. Stream class (headwaters and wading) are indicated by horizontal arrows. Vertical arrows indicate the point of discharge for the Columbus Grove WWTP.

Fish Community Trends Assessment

Ottawa River Mainstem

For over 120 years, the Ottawa River has been identified as being severely polluted by a mix of municipal and industrial wastes. Early written accounts of the degraded condition of the river include Lesson (1885), Ohio Board of Health (1900), and Dittoe (1914). Observations in these early reports typically described the Ottawa River at Lima as being: "…rendered very objectionable.", or "…very foul and dirty and gives off a horrible stench." In addition to these anecdotal observations, some of these early investigators attempted to objectively describe pollutant levels, and found the Ottawa River bore heavy loads of ammonia, dissolved solids, petroleum and related wastes, and putrescible material. The period between the 1950s and 1960s saw pollution problems on the Ottawa River the subject of numerous and varied studies by public, private and academic investigators, and included but were not limited to, Ohio Department of Health (1953 and 1966), Ludzack et al. (1957), Patrick et al. (1957, 1960, and 1965), Ohio DNR (1966), Stucky and Wentz (1969). During the 1960s, the Ottawa River was found so severely polluted that it was at times nearly devoid of fish life for its entire length downstream from Lima. The impacted area commonly included a significant portion of the Auglaize River, extending from its confluence with the Ottawa River, downstream to the mouth of Flatrock Creek, near the Paulding-Defiance County line (Allison and Clark 1966). During periods of peak pollution, the impacts described above were expanded to portions of the Auglaize and Maumee Rivers (US Department of the Interior 1966).

Following basic pollution abatement efforts, environmental conditions on the Ottawa River gradually improved through the 1970s, but still remained well-below CWA goals. More recent investigations (1980s through present) are far too numerous, varied, and wide ranging to summarize or otherwise relate here. Although a review of these and other related studies may prove useful and informative, the practical issues regarding the condition of the fish community of the Ottawa River viewed within the context of contemporary state and federal regulatory frameworks is best and most efficiently described by the results of the numerous biosurveys conducted by Ohio EPA. In comparison to the sundry investigations of the past, the overwhelming advantages of these data for the assessment of gross trends are compelling and numerous, and include: continuity of method and effort through time, thorough-going nature of said field investigations, temporal breadth, and objective and regionally calibrated benchmarks by which biosurvey results can be gauged directly against CWA goals.

The fish fauna of the Ottawa River has been regularly surveyed and assessed by Ohio EPA since 1979. Systematic surveys of the mainstem, evaluating the river's entire length, were under taken for the field years: 1985, 1987, 1989, 1996, and 2010. Field sampling before and through the intervening years was limited in scope, and included smaller or otherwise more discrete segments of the mainstem, often focusing on the historically impacted steam reach within and downstream from Lima. These narrower activities typically supported specific water quality management goals or activities (e.g. NPDES compliance, litigation, stream regionalization, use attainability analysis, and reference site monitoring).

The findings and conclusions drawn from previous state sponsored intensive water quality surveys consistently found the Ottawa River, within and downstream from Lima, profoundly degraded by multiple, varied, and interactive municipal, industrial, legacy and diffuse pollution sources, and was consistently ranked among the state's most polluted inland waters (Ohio EPA 1979, 1990, 1992 and 1998). Given this distinction, these data, among others, served as pollution case studies and were employed in the development of biological response signatures, a diagnostic matrix of aquatic community characteristics and other related water quality indicators, that together describe nine generalized surface water impact types (Yoder and Rankin 1995; Yoder and DeShon 2003). Based upon this approach, much of the aquatic life use impairment identified on the Ottawa River was attributed to complex toxic effects – defined as impacts derived from the complex combination and interactions of major municipal WWTP and industrial point sources that together comprise a significant fraction of summer base flow of the receiving stream. This has resulted in serious instream chemical water quality impairments involving toxics, recurrent whole effluent toxicity, fish kills, and severe sediment contamination involving toxics. These condition are often compounded by CSOs and/or related effects associated with highly urbanized areas.

In order to facilitate a succinct summary of survey results between field years, analysis of trends will take two forms: 1) aggregated annual trends, examining cumulative performance of selected measures and biological indexes from comparable field years through time, and 2) comparative longitudinal trends, relative to the principal associated stressors, through time.

Aggregate Community Performance

In terms of spatial coverage, the mainstem survey of 2010 was comparable to previous efforts for the field years: 1985, 1987, 1989, and 1996. Given the robustness and contiguous nature of these efforts, the overarching trends of the mainstem are best described by these data. Cumulative community performance, summarized by box and whisker plots, of the IBI and MIwb for each of the field years identified above are presented in Figure 83. These data unambiguously portray recent improvement in the performance of the fish assemblage of the Ottawa River. Between 1985 and 1996, the overwhelming majority of stations in each field year failed to support WWH fish communities. Through this eleven year period, the central tendency of each year's results remained within a range narratively described as poor to fair. Although incomplete, the 2010 survey found considerable evidence of recovery, with over half of the monitoring stations supporting WWH fish communities. Although readily apparent from even a cursory examination of the ordinations, non-parametric statistical treatments (Wilcoxon-Mann-Whitney Rank Sum Test) indicated a strong and significant statistical difference between community measures (IBI and MIwb) between 1985 and 2010 (p values <0.0001). In addition, results from the other previous years' data (1987, 1989 and 1996) were also statistically distinct from 2010 results (p values ≤ 0.0004). Similar data treatments failed to yield significant differences between and among the IBI scores from the field years preceding 2010 (p values 1.0-0.199), indicating a surprising stability in effects of the major pollution sources (active or legacy or both) as reflected in this index. Analysis of the MIwb yielded similar results, with some exceptions resulting from a subtle and incremental positive trend through the period of record. However, taken together, the aggregated IBI and MIwb scores in 2010 clearly yielded the highest scores, largest portion of sites meeting the WWH criteria, and the lowest variance between and among sites observed thus far on the Ottawa River mainstem.

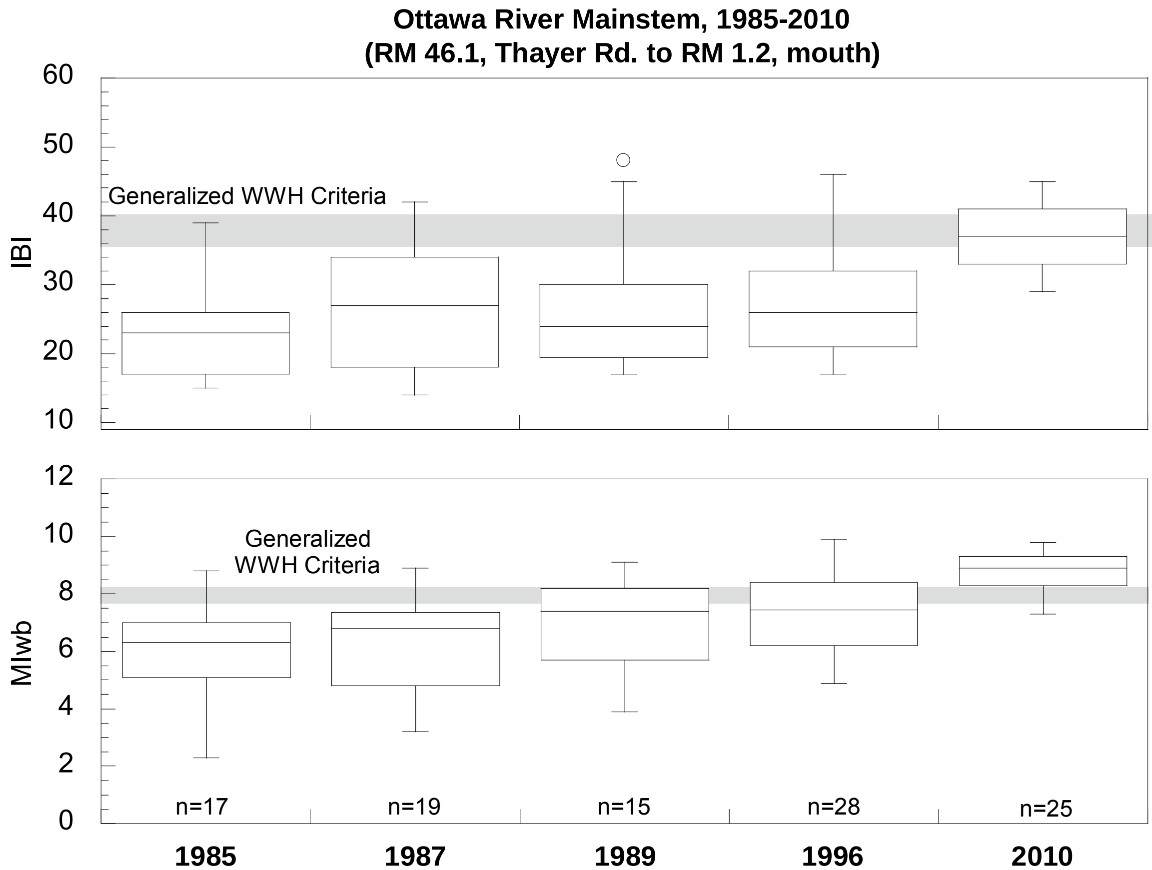

Figure 83. Cumulative performance of the IBI and MIwb, Ottawa River: 1985-2010. As these data are derived from monitoring stations contained in both the HELP and ECBP ecoregions, and were generated with a mix of wading and boat sampling gear, a generalized criteria or benchmark is indicated by shaded areas.

An important measure of fish health, the incidence of DELT anomalies, was also aggregated by field year and subjected to similar statistical treatment (Figure 84). The broad categories of gross external anomalies that comprise the DELT metric can have a number of direct, indirect and interrelated causes: toxic chemicals (including heavy metals), viral and bacterial agents, a variety of parasitic infections, and poor or marginal water quality (e.g., low dissolved oxygen or high temperature). The metric was designed to function as a coarse, yet meaningful, measure of fish health and in practice has been found a reliable indicator of community level, chronic, sublethal stress (Ohio EPA 1987).

Between 1985 and 1996, the incidence of DELT anomalies on the Ottawa River remained highly elevated and consistently ranked among the highest in the state. Through this eleven year period and over the course of four mainstem fish surveys, median station DELTs ranged between 4.4% and 12%, with station averages as high as 50%, and values greater than 10% (extremely elevated) regularly observed downstream from Lima. During this time, both the persistence and magnitude of the incidence of diseased fish was noteworthy. A precipitous decline in the incidence of DELT anomalies was documented in 2010, with station averages ranging between 0.0% and 0.9%, with a median of 0.15%. Although the incidence of DELTs remained within the elevated range at many sites, the frequency and magnitude of the incidence of gross external anomalies was significantly reduced in comparison with historical results.

Current selenium loads downstream from the Lima Husky Refinery resulted in summer average instream concentrations at or below the current ambient criterion. The 2010 instream Se concentrations were significantly different in 2010 compared to 1996, as ambient selenium concentrations in 1996 were markedly and consistently higher throughout the entire 37 river miles of the Ottawa River downstream from the refinery (p value < 0.0001) (Table 9, Figures 58, 59 and 61). Non-violation excursions were limited to only two individual sampling events in 2010 from two separate monitoring stations in close proximity to the refinery. The small number of Se exceedances in 2010 was statistically different from the large number of Se exceedances during the 1996 survey (*p value < 0.0001* using Kolmogorov-Smirnov Two Sample Test in SYSTAT) (Table 9).

The percent fish deformities at the 1996 and 2010 fish survey sites were apportioned out of the overall DELT totals (possibly directly attributed to selenium inputs) and compared with the 1996 and 2010 selenium exceedances. Deformities that can be associated with excess selenium included skeletal malformations of the head, mouth, gill cover, and various portions of the spine (Lemly, 2002). Other fish deformities caused by toxic selenium concentrations include distended pericardia and abdominal cavities, distorted caudle peduncles, edema (accumulation of body fluid), cloudy eye lens or cornea (cataracts), and popeye (Lemly 1993, 2002). Using Analysis of Variance (ANOVA) in SYSTAT, the differences in percent deformities between the survey years of 1996 and 2010 were statistically significant at $p < 0.0062$. The 1996 percent deformities linked to the 1996 selenium exceedances was statistically different from the much lower 2010 deformities and Se exceedance totals at $p= 0.073$, which affirmed the obvious visual differences shown in Figure 18.

The abrupt departure from the historical DELT anomalies trend observed on the Ottawa River in 2010 is not without precedence in Ohio. The incidence of gross external anomalies has been reduced throughout many formerly impacted waters of the state over the past 20 years, following various pollution abatement activities, the process or rate of recovery being either punctuated or gradual as indicated in Figure 84**.**

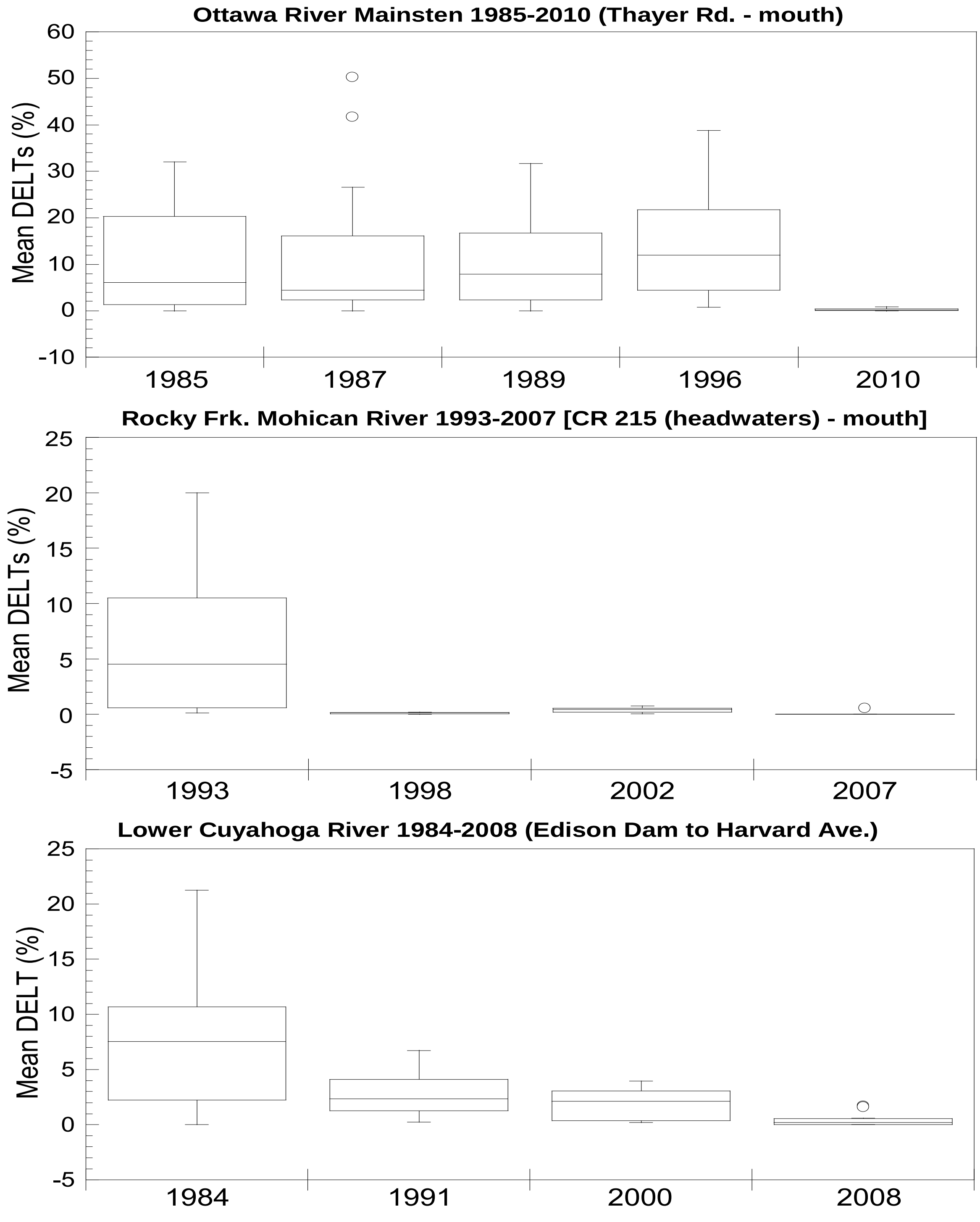

Figure 84. Cumulative incidence of DELT anomalies through time for three Ohio Rivers: Ottawa River (upper), Rocky Fork Mohican River (middle), and middle-lower Cuyahoga River (lower). Both Rocky Fork Mohican and Cuyahoga River results are provided for comparative purposes. Either abrupt or gradual, all portray a significant decline in the incidence of gross external anomalies following pollution abatement activities.

Longitudinal Trends
To clearly display the spatial and temporal performance of the relevant fish community indexes and biometrics, longitudinal trends of the Ottawa River mainstem were derived from three of the five field years' data sets employed for the aggregate assessment detailed above: 1987, 1996, and 2010. The great advantage of longitudinal ordination is that important spatial relationships within the study area are conserved, allowing relational variables and other relevant features (e.g., permitted entities, use designations, ecoregions, stream size, sampling method, associated biocriteria, and impoundments) to be displayed concurrently with biological measures. The resulting spatial accuracy yields figures that are simultaneously information dense, yet easily comprehended. Longitudinal ordinations of the IBI, MIwb, and other relevant community metrics for the Ottawa River, through time, are presented in Figures 85 and 86.

As described previously by the aggregated data, longitudinal performance of fish community biometrics portrayed a trend of significant recovery in 2010. However, unlike the aggregated results, these data also clearly delineate impacted areas (and corresponding areas of recovery through time), relative to major pollution sources, stressors or limiting factors on the Ottawa River. Prior to 2010, historical surveys portrayed significant and unambiguous depressions in community performance (indexes and other biometrics) both through and downstream from Lima, with a secondary depression evident well downstream from Lima, beginning in the vicinity of Elida and extending down to Kalida. Persistent locale departures from the associated biocriteria and diminutions of other biometrics were also documented immediately upstream from Lima as well.

Over this period of time (1987-1996), community indexes and related measures portrayed a mix of incremental improvement or relative stability. Specifically, the IBI in 1996 paralleled or tightly tracked 1987 results for the upper 33 miles of the mainstem, reflecting the persistent effects of, 1) impoundment, water withdrawals, and rural/suburban NPSs upstream from Lima, 2) the combination of impoundment, CSOs and urban NPSs through Lima, 3) cumulative effects of the wasteloads and legacy pollutants from the Lima WWTP, Lima Refining Co. and PCS nitrogen, and 4) the secondary impact associated with Elida (Ohio EPA 1998). Deviations from the 1987 results in 1996 were limited to the lower 13 miles, where the IBI improved with increasing distance downstream, marking the first evidence of recovery on the lower Ottawa River by Ohio EPA. Like the IBI, the MIwb paralleled the 1987 results upstream and through Lima. However, both the magnitude and breadth of the departure from the MIwb WWH biocriteria downstream from Lima contracted significantly in 1996, and was found in complete agreement with the associated WWH criteria from the Allentown dam to the mouth (approximately 29 river miles) at that time.

By 2010, 38.4 miles (75.7%) of the 50.7 linear stream miles of the mainstem were found to support an assemblage of fish at least minimally consistent with WWH biocriteria. The remaining 12.3 (24.3%) miles failed to support WWH assemblages; however, the magnitude of the departure or degree of impact was not great, as community performance below the fair range (i.e., narratively poor to very poor) was not observed. Furthermore, selected biometric community measures based upon station averages (species richness, number of sensitive taxa, incidence of DELTs), showed similar, significant improvement. Compared against historical results, common stations among these efforts in nearly every instance supported richer communities, a greater number of environmentally sensitive taxa, and a significant reduction in the frequency of diseased fish in 2010.

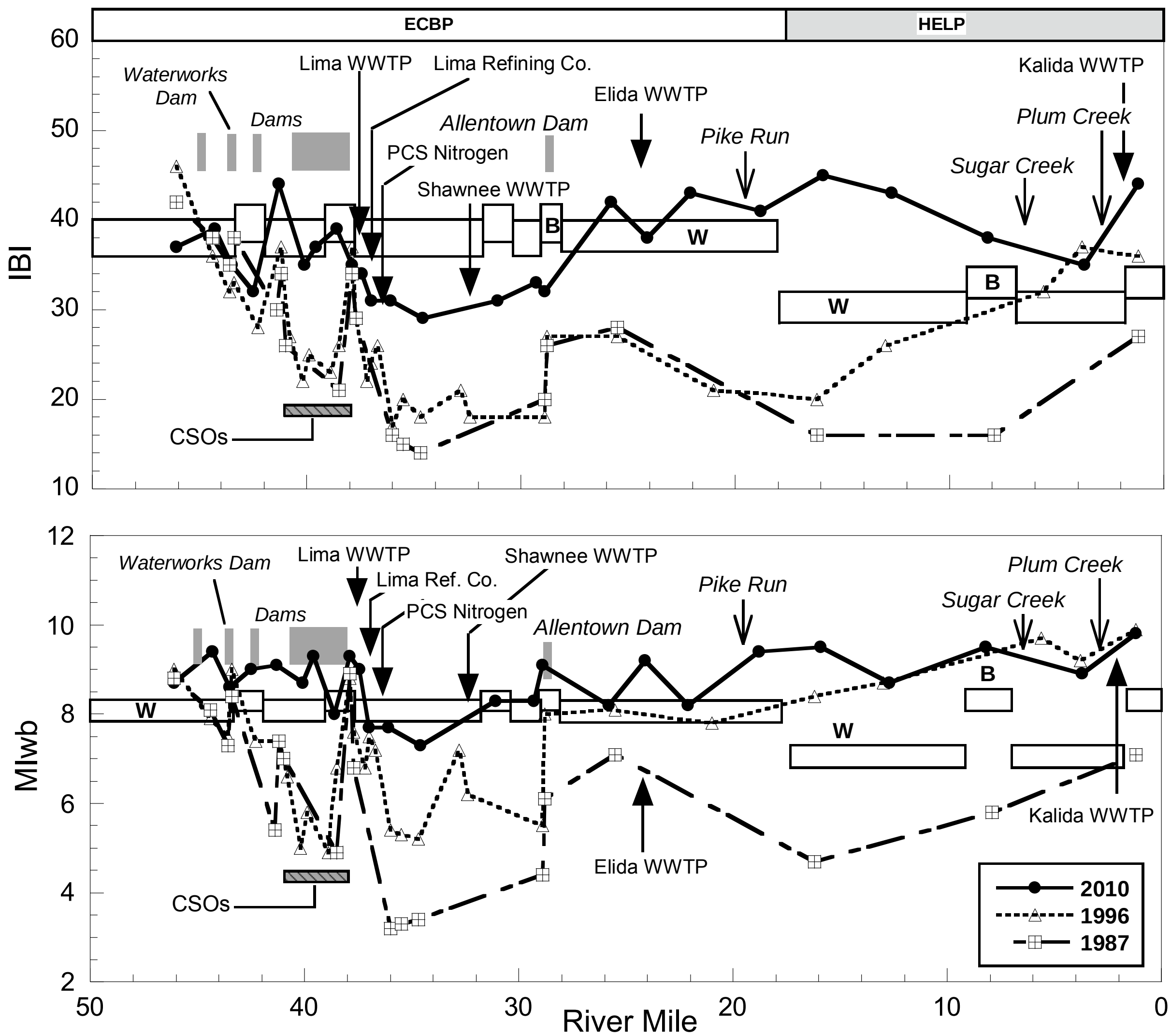

Figure 85. Longitudinal performance of the IBI and MIwb of selected field years, Ottawa River: 1987-2010. Horizontal rectangles represent the associated biocriteria and area of nonsignificant departure for the ECBP and HELP ecoregions and sample type ("W" wading and "B" boat). Note the extent and magnitude of WWH departure documented within and downstream from Lima prior to 2010.

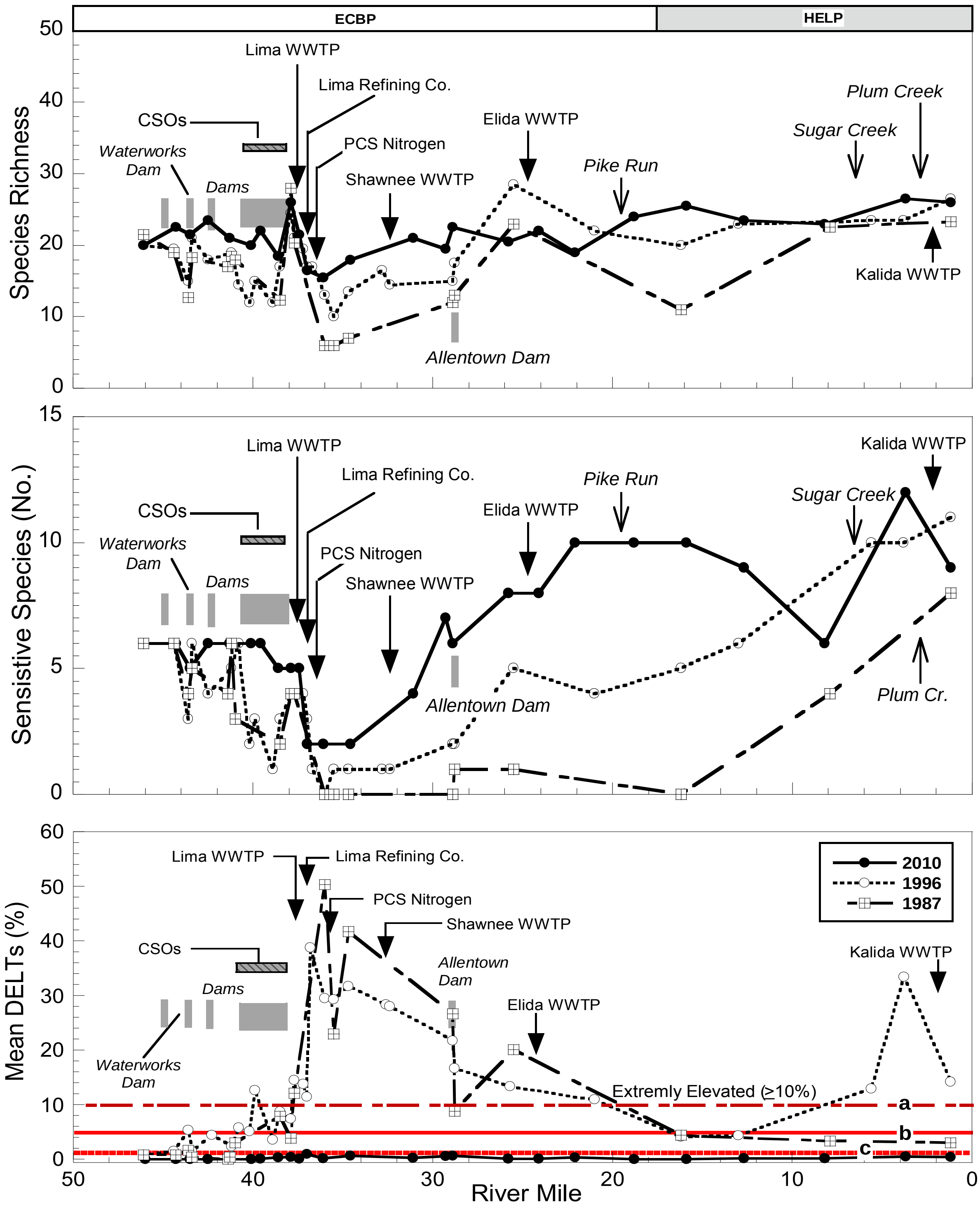

Figure 86. Longitudinal performance of selected fish community biometrics, Ottawa River: 1987-2010. Horizontal red lines "a", "b", and "c" superimposed atop DELT ordination (bottom figure) identify thresholds for *extremely elevated* (>10%, all sample types), *highly elevated* (>3.0%, boat type) and highly elevated (>0.1%, wading type), respectively. Note the accrual of fish species, including environmentally sensitive taxa, within and downstream from Lima and a simultaneous and significant decline in the incidence of DELT anomalies.

The areas showing the greatest improvements included two contiguous segments through and downstream from Lima. The first of these historically degraded reaches coursed through the heart of Lima, between approximately RM 40.5 (Lovers Lane Dam pool) and RM 37.9 (immediately downstream the Erie RR dam) and contained several major CSOs and numerous impoundments. The second segment receives treated effluent from three major facilities: Lima WWTP, Lima Refining Co., and PCS Nitrogen. Historically, this segment has consistently been found significantly impacted by the combined influence of the aforementioned entities, with contributory effects of sewer bypasses and impoundments upstream, rendering the associated causes of impairment complex in nature and the effects of which were evident, at a minimum, downstream to Allentown.

Through Lima, the effects of CSOs, as manifest in the fish assemblage, were significantly reduced as two of the four stations through this reach now support WWH communities. For the two remaining stations, the IBI alone fell short of the WWH criterion, but remained in the high fair range. As stated previously, the MIwb consistently met or exceeded the WWH criteria through this segment. Downstream from Lima, similarly striking improvements were documented in 2010 on the river reach affected by the three aforementioned major public and private NPDES facilities. Although not fully recovered, significant improvements were noted in all community measures. Index scores previously in the poor to very range, were advanced into the fair range. By 2010, the affected reach accrued additional species, including environmentally sensitive taxa. Of equal import, is the significant reduction in both the frequency and incidence of diseased fish as indicated by the observed DELTs. In addition to these improvements, historical impairments immediately upstream and well downstream from Lima were largely abated by 2010.

In comparison to all historical results, the 2010 findings provide clear and unambiguous evidence of improved environmental conditions on the Ottawa River, as reflected in the structure, functional organization, and health of the resident fish assemblages. These positive changes followed the implementation (partial or complete) of pollution abatement actions recommended as part of the findings from the 1996 biosurvey (Ohio EPA 1998).

Ottawa River Tributaries

Regarding the environmental conditions of the principal tributaries that comprise the Ottawa River catchment, the 2010 survey represents the most thorough effort to date, in that all waters of consequence were surveyed and assessed in this single field year. Although much historical data does exist for these waters, previous sampling efforts were not necessarily concurrent or otherwise coordinated with past basin-wide efforts. As a result, the multiple and varied historical data collected by Ohio EPA were employed for the purposes of trends assessment, and included results from 1984 to 1997 in Hog Creek, Lost Creek, Little Ottawa River, Zurmehly Creek, Pike Run, Sugar Creek, and Plum Creek.

Hog Creek: 1991-2010

Available historical fish community data on Hog Creek was limited to a small, two station effort as part of the 1991 Ottawa River survey (Ohio EPA 1992). At that time, community performance appeared controlled by macrohabitat quality. At stations common in the 2010 sampling effort, conditions appeared universally advanced (Figure 87). These improvements very likely reflect improved macrohabitat quality achieved through natural fluvial processes. Despite the modified nature of this system, particularly for the upper reach draining Hardin County, subtle, but consequential physical recovery has likely occurred within the confines of Hog Creek's artificial channel over the past 19 years. As observed on many other rural streams statewide, Hog Creek has also very likely benefited from modern tillage practices that have reduced overland erosion and thus the delivery of fine sediment to surface waters.

Little Hog Creek: 1991-2010

A single station on lower Little Hog Creek was evaluated as part of both the 1991 and 2010 surveys. Compared with the 2010 results, the environmental conditions on Little Hog Creek appeared stable, as WWH communities were conserved through time.

Lost Creek: 1988-2010

Twenty-two years separates Ohio EPA sampling efforts on Lost Creek. At stations common to both 1988 and 2010 surveys, the condition of the fish assemblage was improved, including WWH attainment on the lower reach (Figure 88). Recovery of the IBI to WWH near the mouth was a result of increased species richness, and improved functional organization, namely reduced proportion of ecological generalists, with a proportional increase in specialized feeding guilds. These changes likely reflected improved macrohabitat achieved through natural fluvial processes.

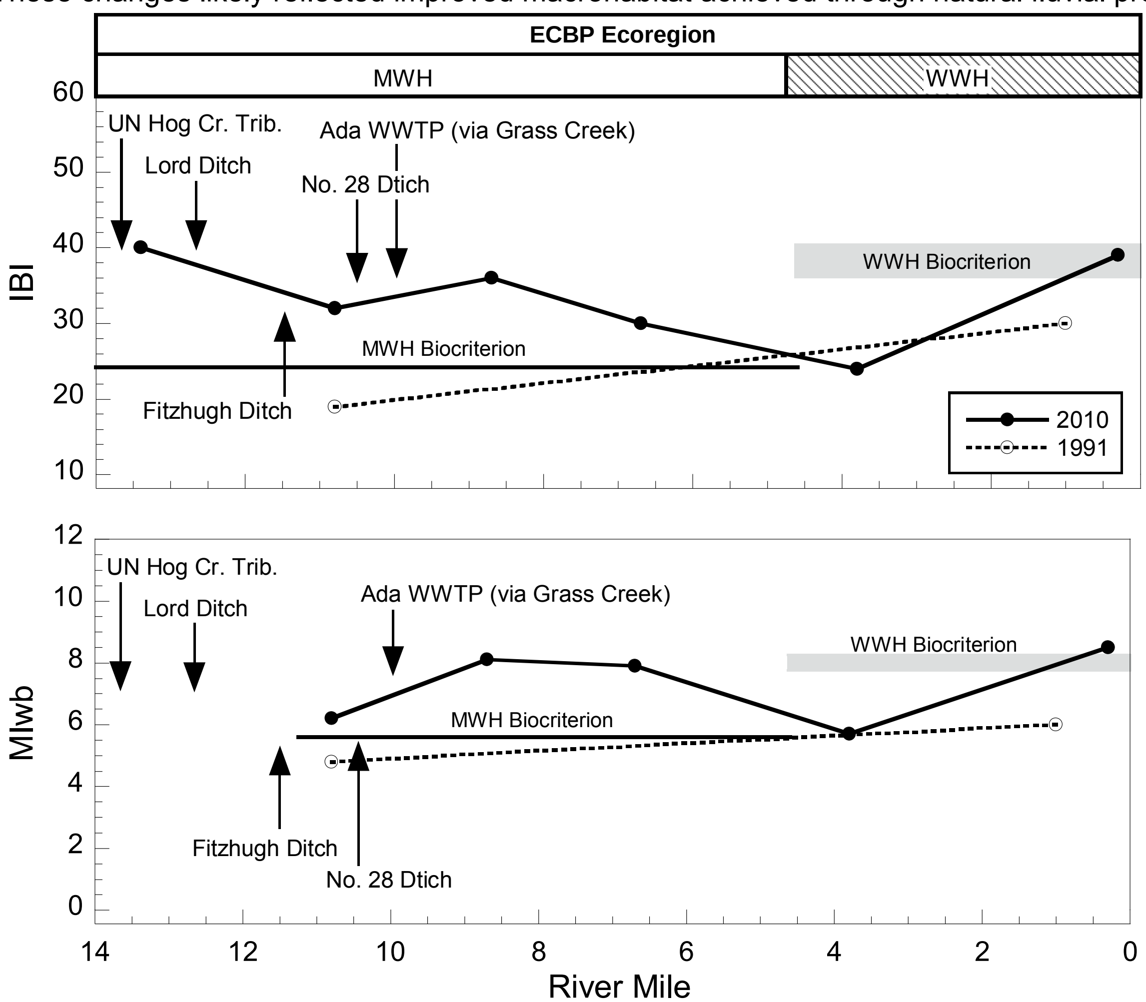

Figure 117. Longitudinal performance of the IBI and MIwb, Hog Creek: 1991 and 2010.

Little Ottawa River and Zurmehly Creek: 1996-2010

Single stations on the lower Little Ottawa River and Zurmehly Creek were evaluated as part of the 1996 Ottawa River survey (Ohio EPA 1998). As reflected by the fish community in both 1996 and 2010, the environmental conditions on these tributaries appeared stable, in that the fish community continues to labor under the effects of SSOs and the sundry effects attendant to an urban or otherwise developed catchment (diffuse pollutant sources, flashy hydroperiod, etc.).

Pike Run: 1992-2010

The fish community of Pike Run was previously sampled in both the 1991 and 1996 surveys of the Ottawa River basin (Ohio EPA 1992 and 1998). The 2010 results portray a trend of significant recovery in comparison with previous survey results (Figure 89). Nearly every community biometric was improved, including both the frequency and magnitude of diseased fish, which reached levels characterized as highly elevated in 1996. Presently, all sites were found to support an assemblage of fish fully consistent with Pike Run's existing MWH aquatic life use designation. These improvements were directly attributable to the American-Bath WWTP, installed in 1996. As observed elsewhere, natural macrohabitat improvement may have contributed to aquatic life use recovery on Pike Run, but given the nature of the impact, this appeared to be a secondary or tertiary factor associated with the noted improvement.

Sugar Creek: 1984-2010

Monitoring efforts on Sugar Creek through the mid-1980s found much of the stream impaired relative to existing and recommended aquatic life uses as nearly every station failed to support communities consistent with the prescribed biocriteria. These data portrayed a significant impact or depression in community performance downstream from the Ford Motor Co. (Lima Engine Plant) via a small unnamed tributary that joins Sugar Creek at approximately RM 18.0. At and downstream from that point, severe petroleum contamination was observed, accompanied by persistent deposits of an unidentified flocculent. Longitudinal response of community measures to this included a sharp rise in the incidence of DELT anomalies and depressed species richness. Field observations at that time also noted several minor septic discharges well up and downstream from "Ford" tributary and diffuse sources of urban-industrial pollution through the lower 1.2 miles (e.g., scrapyard and automotive finisher). By 2010, nearly every biometric improved, including a significant reduction in the incidence of DELTs, increased species richness and the accrual of environmentally sensitive taxa through the reach formerly affected by Ford Motor Co. Presently, all sites support communities fully consistent with the existing and recommended aquatic life use designations. In addition to pollution abatement, both the recovery of macrohabitat through natural fluvial processes, sediment reduction achieved through modern tillage practices and the diminution of urban-industrial NPS likely contributed to overall improved ambient biological performance documented in 2010.

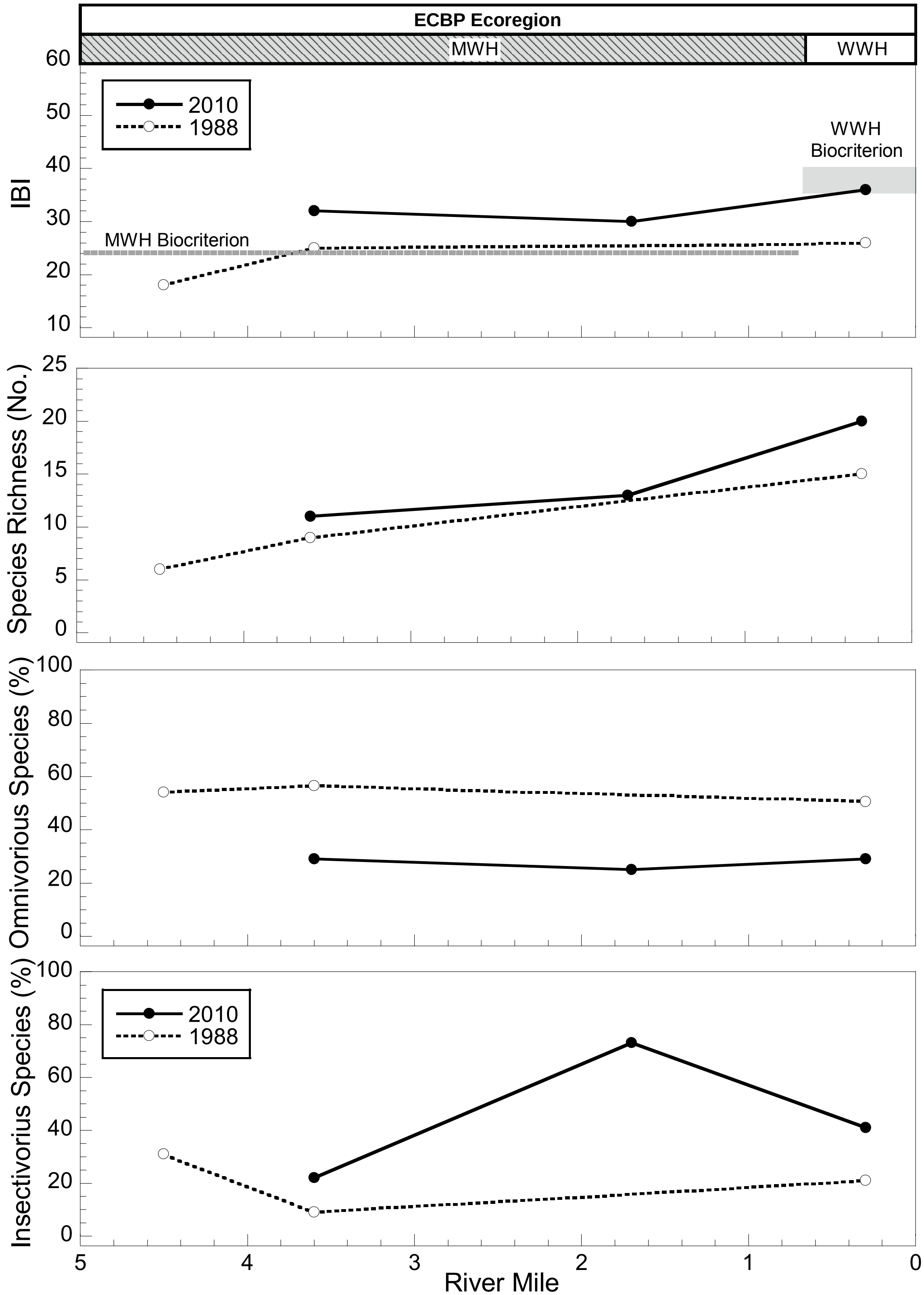

Figure 88. Longitudinal IBI performance and selected community metrics, by station, Lost Creek: 1988 and 2010.

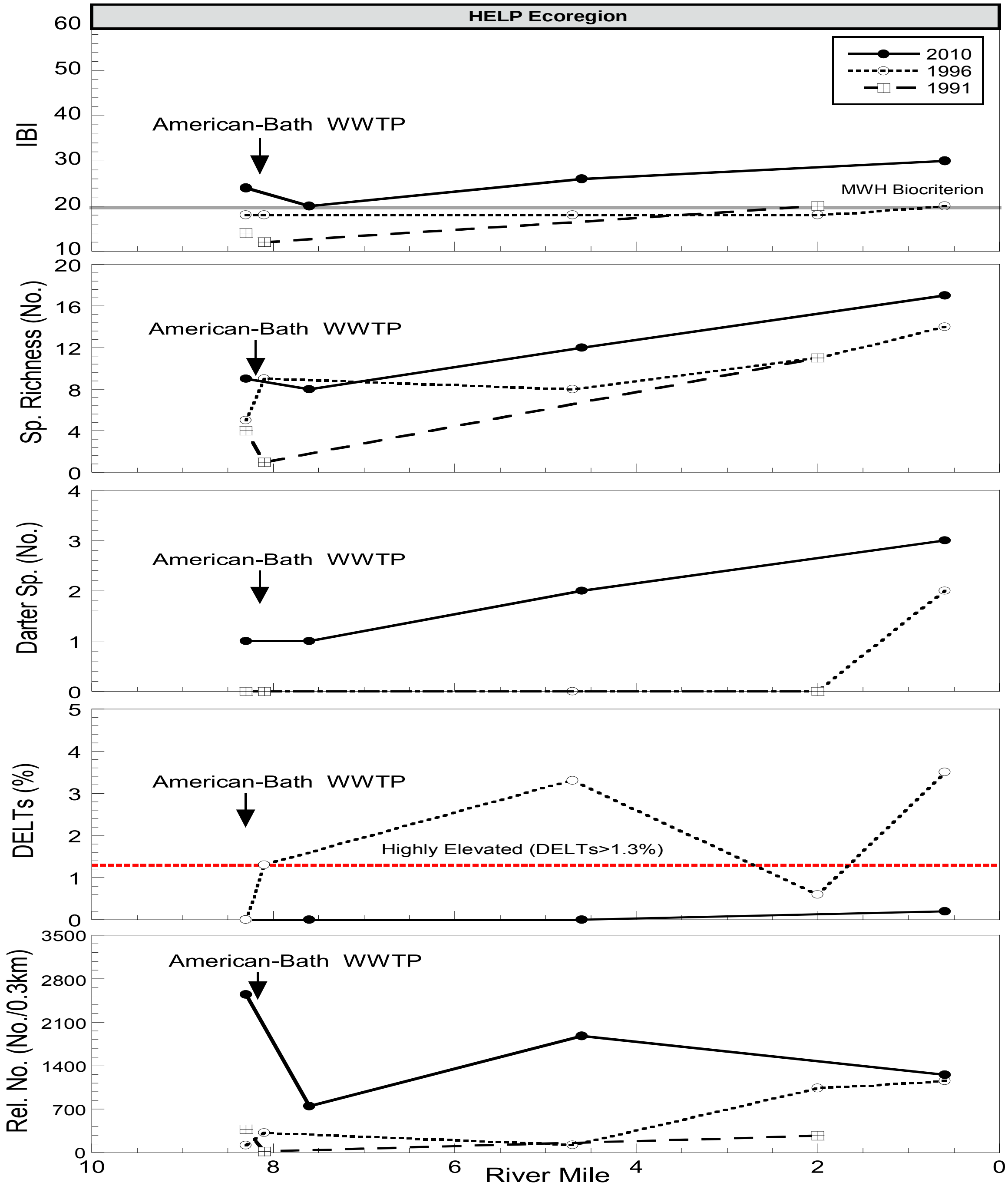

Figure 89. Longitudinal performance of the IBI and selected community metrics, Pike Run: 1991-2010. Note consistent improvement among all measures since 1996.

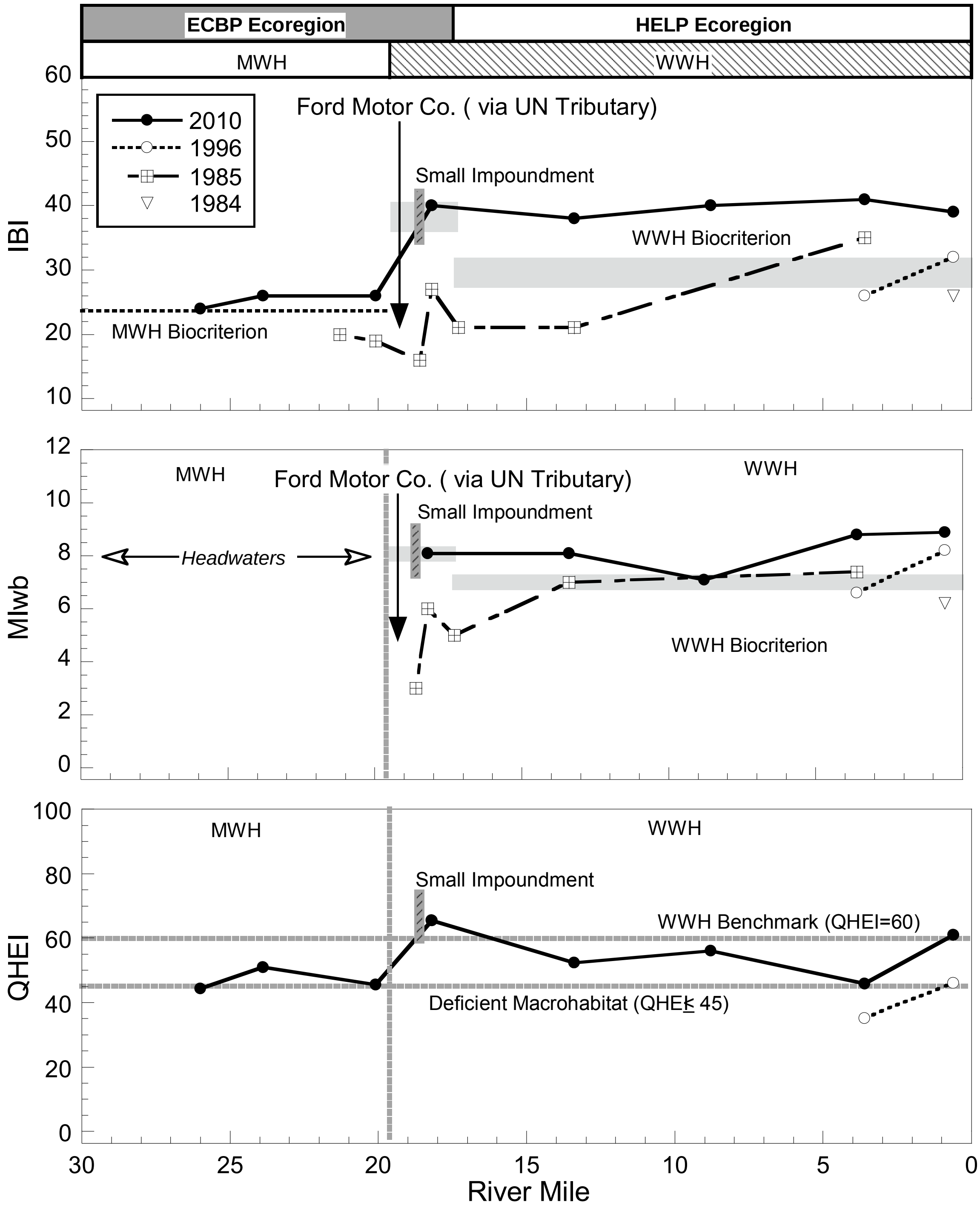

Figure 90. Longitudinal performance of the IBI and MIwb for Sugar Creek, 1984-2010. Historical QHEI scores available for 1996 only. Note both impact abatement downstream from Ford Motor Co. Lima Engine Plant (via unnamed tributary) and improved macrohabitat quality through the lower two miles likely contributed to the biological performance improvement.

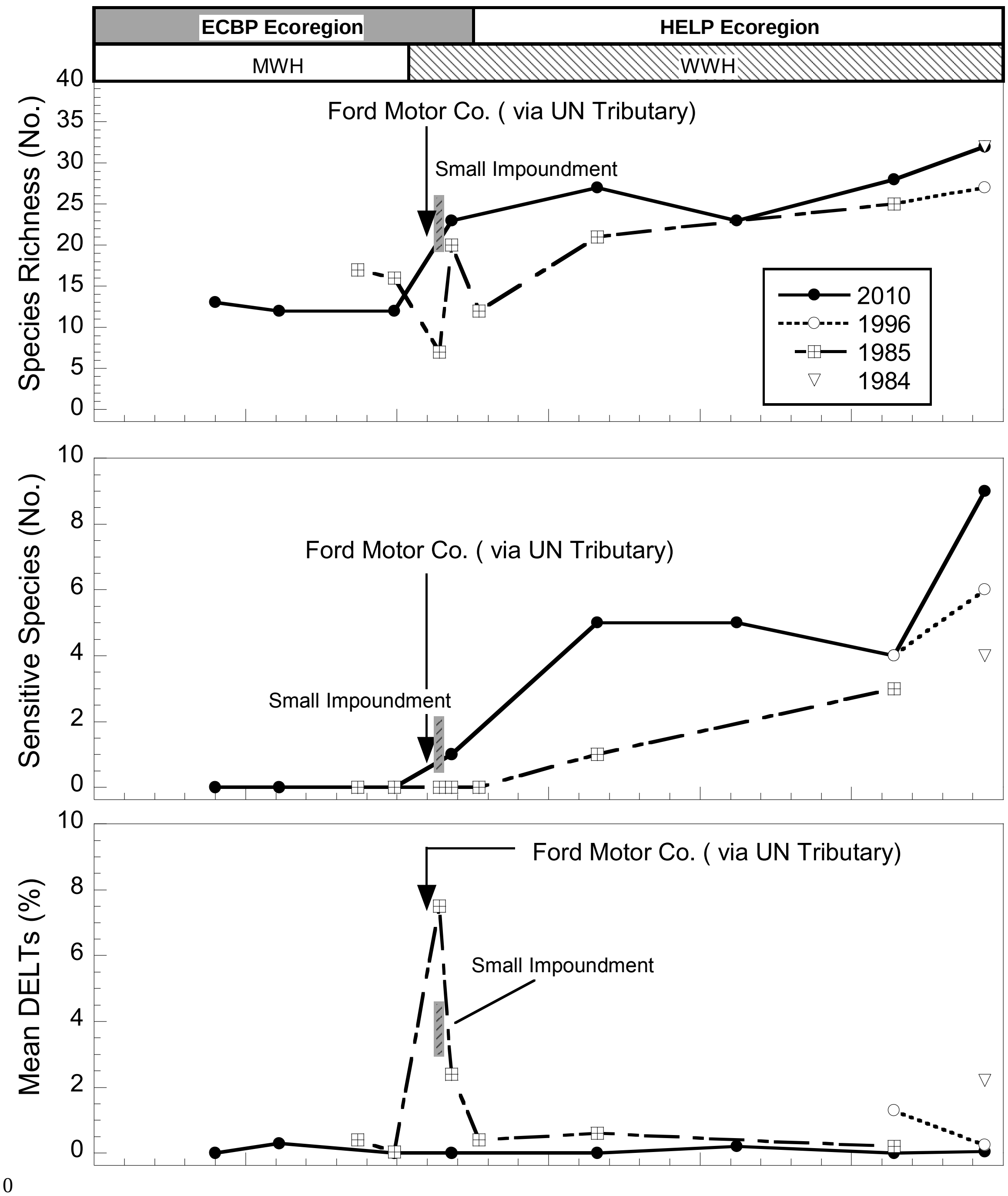

Figure 91. Longitudinal performance of selected community metrics, Sugar Creek: 1984-2010. Note impact abatement downstream from Ford Motor Co. Lima Engine Plant (via unnamed tributary).

Plum Creek: 1996-2010

First surveyed by Ohio EPA in 1996, Plum Creek represents the only waterbody showing significant declines in comparison with the 2010 results (Figures 92 and 93). However, negative deviation from previous results was not universal, in that both positive and negative trends were observed. Worsening conditions were documented on Plum Creek in 2010 at Columbus Grove. Although the WWTP was upgraded in 2000, and additional upgrades are on-going, CSO by-passes rendered Plum Creek septic and nearly devoid of fish at the sites immediately up and downstream from Columbus Grove's point of final discharge. However, far-field effects documented in 1996 appear abated, as the lower eight miles of Plum Creek recovered to WWH levels in 2010. The general benefits of modest natural improvement to macrohabitat and reduced sedimentation may have contributed to the recovery documented on the lower eight miles.

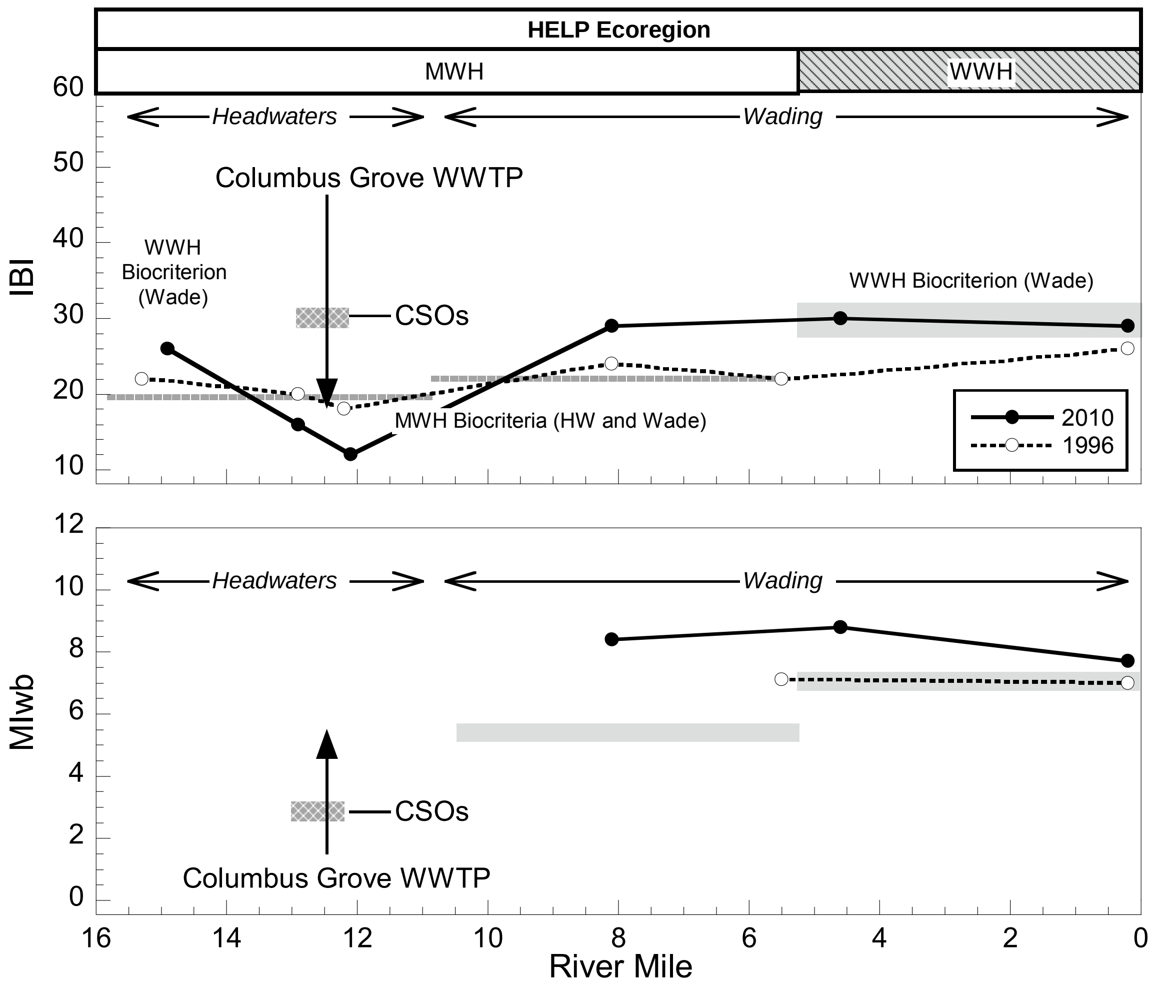

Figure 92. Longitudinal performance of the IBI and MIwb for Plum Creek, 1996 and 2010. Note improvements through the lower eight miles, but local degradation through the village of Columbus Grove.

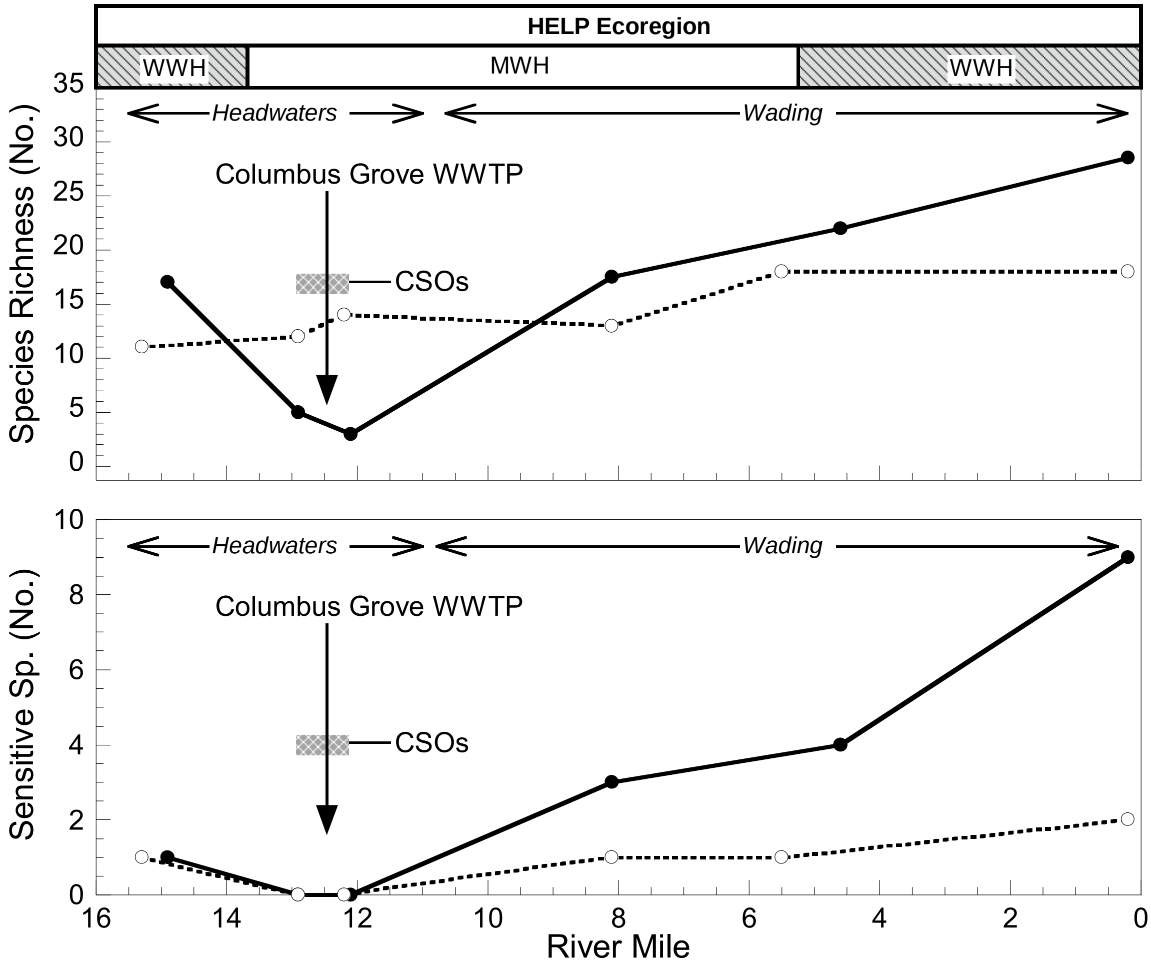

Figure 93. Longitudinal performance of Plum Creek, 1996 and 2010. Note improvements through the lower eight miles, but local degradation through the village of Columbus Grove.

Biological Assessment of the Macroinvertebrate Community

Macroinvertebrate communities were assessed at 80 sampling locations in the Ottawa River watershed in 2010. Qualitative samples from the natural substrates were collected from all sampling locations. Quantitative, artificial substrate samplers were scheduled for deployment at approximately 40 sites (>20mi^2 and/or regional reference locations). Most samplers were recovered with sufficient current and water depth. Where quantitative data was lacking or quantitative macroinvertebrate colonizers were lost or lacked flow, narrative assessments based on the qualitative collections were substituted. A summary of the macroinvertebrate data are presented in Table 19, while ICI metric scores and raw data are presented in Appendices G and H. Sampling locations were evaluated using either WWH or MWH biocriterion for each ALU designation.

Ottawa River watershed sites achieved the applicable WWH or MWH macroinvertebrate biocriterion at 67 of 80 sites (84%) evaluated in 2010. Eight sites were not achieving the WWH biocriterion and five additional sites were not meeting the MWH biocriterion, representing a total of 16% of the Ottawa River watershed sites.

Ottawa River Mainstem Summary

From the confluence of Hog and Little Hog Creek, the whole Ottawa River mainstem was assessed (RM 50.7 to the mouth) at 26 sites in the 2010 survey. Twenty sites were located in the ECBP, and the six most downstream (northern) survey sites (RMs 16.0 to 0.8) were located in the HELP ecoregion. Twenty-one of 26 Ottawa River mainstem survey sample sites (81%) attained the designated WWH aquatic life use performance criterion. During this survey, the Ottawa River reach upstream from Lima and the lower 28.8 river miles of the Ottawa River mainstem met the WWH macroinvertebrate ecoregional biological performance criteria. The 21 Invertebrate Community Index (ICI) scores attaining WWH from the 2010 survey ranged from 36 (good) to 50 (exceptional) (Figure 94, Table 19). In order to fully comprehend the current conditions of the Ottawa River macroinvertebrate community and its associated reflection of past and present influences, a longitudinal discussion of the mainstem and a trends section follows this summary.

The macroinvertebrate community upstream of Lima, from Thayer Road (RM 46.0) to downstream of the Elm St. dam (RM 39.6) may narratively be described as good to excellent. Within Lima, five contiguous stations within a four mile reach did not meet the macroinvertebrate WWH biocriterion (Figure 94, Table 19). The stream reach was from the Collett St./Erie RR dam pool (RM 38.65) to downstream PCS Nitrogen (RM 36.1) and included the three dam pools and associated CSO inputs (Figure 94, Table 19). CSO inputs and low DO events contributed to decreased diversity and more tolerant community structure while nutrient enrichment, high ammonia inputs, excess algae, and chronic toxicity from historic residual instream sources and current dischargers contributed to low fair and fair community performance within this reach. Downstream from these combined additive sources, some assimilation and natural treatment allowed for the macroinvertebrate community to recover and meet WWH biocriteria expectations at Westfield Drive (RM 34.55). However, diverse EPT and sensitive taxa totals did not completely recover to ambient conditions until downstream from Allentown dam (RM 28.8) with a stronger community performance noted at Piquad Rd. (RM 25.8). Incomplete community recovery was due to nutrient enrichment with wide DO fluctuation swings from continued lingering upstream discharger effects; elicit SSO inputs, storm sewer inputs and Shawnee #2 WWTP inputs.

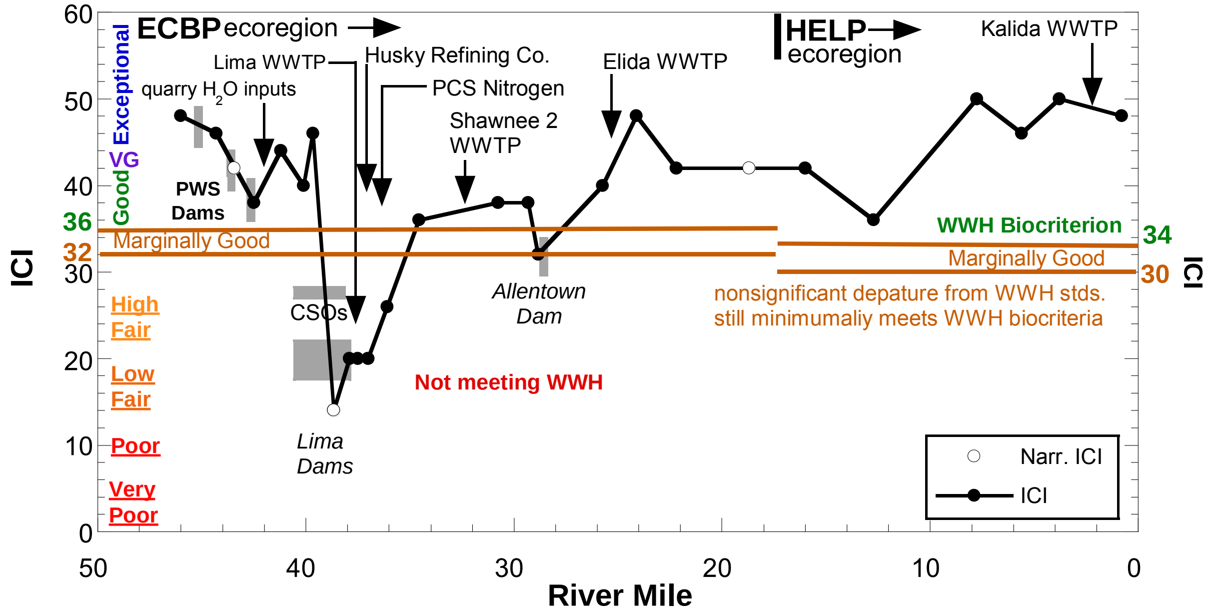

Figure 94. Macroinvertebrate ICI Scores for the Ottawa River mainstem for the 2010 survey.

Table 19. A summary of macroinvertebrate collection information, field observations, and narrative evaluations from the Ottawa River mainstem in 2010. Designated WWH reaches are green and ICI scores and narrative evaluations are color coded by quality: **Exceptional** (**blue**), **Very Good** (**purple**), **Good** (**green**), **Marginally Good** (**brown**), **Fair** (**orange**), and **Poor** to **Very Poor** (**red**).

River	RM	Drain. Area	Ql./Total Taxa	Ql./Total EPT	Sens. Taxa Qual./Total	Density (# / ft.^{2})	ICI	Narr. Eval.	Predominant Populations (Tolerance Ratings[2])
Ottawa River[RR] (ECBP)[1]	46.0	99.0	58 / 72	15 / 17	15 / 17	High / 2169	48	E	Fingernet caddisflies (*Chimarra*)(MI), Tanytarsini midges (F), midges (F,MI), Net-spinning caddisflies (hydropsychids) (F,MI), baetid mayflies (F,MI)
Ottawa River	44.3	102	62 / 79	17 / 18	13 / 15	Mod.-High/ 1385	46	E	Midges (F,MI), hydropsychids (F,MI), baetid mayflies (F,MI), *Chimarra* (MI)
Ottawa River	43.45	103	55 / -	16 / -	14 / -	Mod.-High	--	VG	*Chimarra* (MI), hydropsychids (F,MI), *Rheotanytarsus* midges (F), baetid mayflies (F,MI)
Ottawa River	42.5	122	60 / 66	16 / 17	10 / 11	High / 3095	38	G	*Polypedilum* & *Rheotanytarsus* midges (F), hydropsychid caddisflies (F,MI)
Ottawa River	41.2	125	51 / 59	15 / 16	13 / 13	High / 1972	44	VG	Baetid mayflies (F,MI), *Rheotanytarsus* & *Polypedilum* midges (F), bryozoan colonies (F)
Ottawa River	40.1	126	43 / 60	11 / 13	8 / 11	Mod.-High/ 1706	40	G	*Rheotanytarsus* & other midges (F,MI,MT), baetid mayflies (F,MI), snail-cased caddisflies (*Helicopsyche*) (MI), micro caddisflies (Hydroptilids) (F)
Ottawa River	39.67	127	44 / 55	15 / 16	9 / 11	Mod. / 970	46	E	Hydropsychid caddisflies (F), baetid mayflies (F,MI), *Polypedilum* & *Rheotanytarsus* midges (F), riffle beetles (F), Helicopsyche (MI), heptageneid mayflies (F,MI)
Ottawa River	38.65	128	17 / 30	1 / 1	1 / 2	High-Low / 2689	6 X2,8	Low F*	Chironomid *Glyptotendipes* & *Dicrotendipes* midges (F,MT,T), Oligochaete worms (T), flatworms (F)
Ottawa River	37.9	129	49 / 52	7 / 7	7 / 7	Mod.-High/ 2526	20*	F*	Midges *Glyptotendipes*, *Hayesomyia*, *Dicrotendipes*, & *Cricotopus* (F,MT,T), flatworms (F), Oligochaete worms (T), and hydropsychid caddisflies (F,MI)
Ottawa River	37.5	130	42 / 55	9 / 9	4 / 6	Mod.-High / 1713	20*	F*	Midges (F,MT,T), Oligochaete worms (T), flatworms (F), hydropsychid caddisflies (F,MI)
Ottawa River	37.0	131	38 / 52	7 / 7	4 / 5	Mod. /1289	20*	F*	Midges (F,MT,T), flatworms (F), Oligochaete worms (T)
Ottawa River	36.1	131	41 / 46	9 / 9	4 / 4	Mod.-High/ 1935	26*	F*	Hydropsychid caddisflies (F,MI), midges (F,MI,MT,T)
Ottawa River	34.55	151	29 / 52	10 / 10	3 / 3	Mod.-High/ 2324	36	G	Hydropsychid caddisflies (F,MI), hydroptilid caddisflies (F), baetid mayflies (F), midges (F,MI,MT,T), Asian clams (F)
Ottawa River	30.75	155	33 / 46	8 / 10	3 / 6	Mod.- Low / 698	38	G	Baetid mayflies (F,MI), *Stenacron* sp. mayfly (F), hydropsychid caddisflies (F,MI), tanytarsini & other midges (MI,F), minnow mayflies (F,MI,MT,T), Asian clams (F)
Ottawa River	29.3	156	40 / 51	10 / 12	5 / 6	Mod.-High / 801	38	G	Baetid mayflies (F,MI), *Polypedilum* midges (F,MT), *Stenacron* sp. mayfly (F)
Ottawa River	28.85	160	23 / 47	3 / 5	1 / 3	Low / 356	32^{ns} X2,15	MG^{ns}	*Stenacron* sp. mayflies (F), tanytarsini & other midges (F,MI), elmid beetle larvae (F), scuds (F), *Argia* sp. (F) &

River	RM	Drain. Area	Ql./Total Taxa	Ql./Total EPT	Sens. Taxa Qual./Total	Density (# / ft.^{2})	ICI	Narr. Eval.	Predominant Populations (Tolerance Ratings[2])
									other damselflies (T)
Ottawa River	25.75	166	52 / 66	15 / 19	16 / 19	Mod. / 642	40	G	Saddlecased caddisflies (*Protoptila* sp.) (I), *Polypedilum* spp. & other midges (F,MI,MT,T), hydropsychid caddisflies (F,MI), baetid mayflies (F,MI), riffle beetles (F)
Ottawa River	24.11	168	50 / 64	13 / 17	11 / 15	Mod. / 632	48	E	Baetid mayflies (F), hydropsychid caddisflies (F,MI)
Ottawa River	22.2	194	59 / 70	19 / 21	16 / 21	Mod.-High / 993	42	VG	Baetid mayflies (F), *Polypedilum* spp. & other midges (F,MI,MT,T), *Protoptila* sp.(I), hydropsychids (MI,F)
Ottawa River (ECBP)[1]	18.7	216	52 / -	16 / -	14 / 14	Mod.-High	--	VG	Midges (F,MI,MT), baetid mayflies (F), hydropsychid caddisflies (F,MI)
Ottawa River (HELP)[1]	16.0	217	52 / 62	17 / 20	15 / 16	Mod.-High / 1241	42	VG	Hydropsychid caddisflies (MI,F), baetid mayflies (F,MI), *Polypedilum* spp. & other midges (F,MI,MT,T)
Ottawa River	12.7	231	50 / 61	18 / 20	21 / 21	Mod. / 954	36	G	Hydropsychid caddisflies (F,MI), *Protoptila* sp.(I), Asian clam (F), baetid mayflies & *Tricorythodes* sp. (F,MI) *Polypedilum* spp. & other midges (F,MI,T), flatworms (F)
Ottawa River	7.75	239	35 / 60	15 / 21	12 / 21	Mod.- Low / 448	50	E	Moth larvae (*Petrophila* sp.) (MI), baetid mayflies (F,MI), *Protoptila* sp.(I)
Ottawa River	5.6	305	53 / 69	15 / 19	16 / 20	Mod. / 868	46	E	*Petrophila* sp. (MI), baetid mayflies (F,MI), *Protoptila* sp.(I), minnow mayflies (*Isonychia* sp.) (MI), hydropsychid caddisflies (F,MI)
Ottawa River	3.8	307	37 / 52	20 / 22	18 / 23	Mod.-High / 903	50	E	*Petrophila* sp. (MI), baetid mayflies (F,MI), *Protoptila* sp.(I), hydropsychid caddisflies (F,MI), *Tricorythodes* sp. (MI)
Ottawa River[RR] (HELP)[1]	0.8	351	41 / 55	17 / 19	16 / 20	Mod. / 875	48	E	*Protoptila* sp.(I), baetid mayflies (F,MI), *Isonychia* sp. (MI), *Petrophila* sp. (MI)

RR	Regional reference site for ecoregion
X2	Dam pool sample
X8	Non – detectable current
X15	Flow > 0 fps < 0.3 fps (can invalidated quantitative Sample)
ns	Nonsignificant departure from ecoregional biocriterion (± 4 pts.)
1	Beginning site ( ) and end site ( ) sampled in each ecoregion.
2	Tolerance ratings are as follows; tolerant (T), moderately tolerant (MT), moderately intolerant (MI), intolerant (I) and facultative (F)
*	Not in attainment of Aquatic Life Use (ALU) biocriterion or narrative assessment performance expectations

From a longitudinal perspective, the macroinvertebrate community of the Ottawa River mainstem reflects the current and historical water quality influences over time. The macroinvertebrate community sample collected at Thayer Rd. (RM 46.0), a regional reference site, yielded an exceptional ICI score of 48 with 17 sensitive and total Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa (Table 19). However, nutrient enriched conditions existed instream (2169/ft.^{2} – macroinvertebrate relative density) and were associated from largely NPS upstream agricultural inputs (Hog Creek/Little Hog Creek). Sufficient instream flow allowed sufficient natural instream treatment (physical and biotic assimilation with sequestration) that a diverse quality benthic community could be sustained. Flow and continuity of lotic conditions in the upper Ottawa River was a dominant factor that influenced the benthic community diversity and quality downstream into Lima (Figure 95).

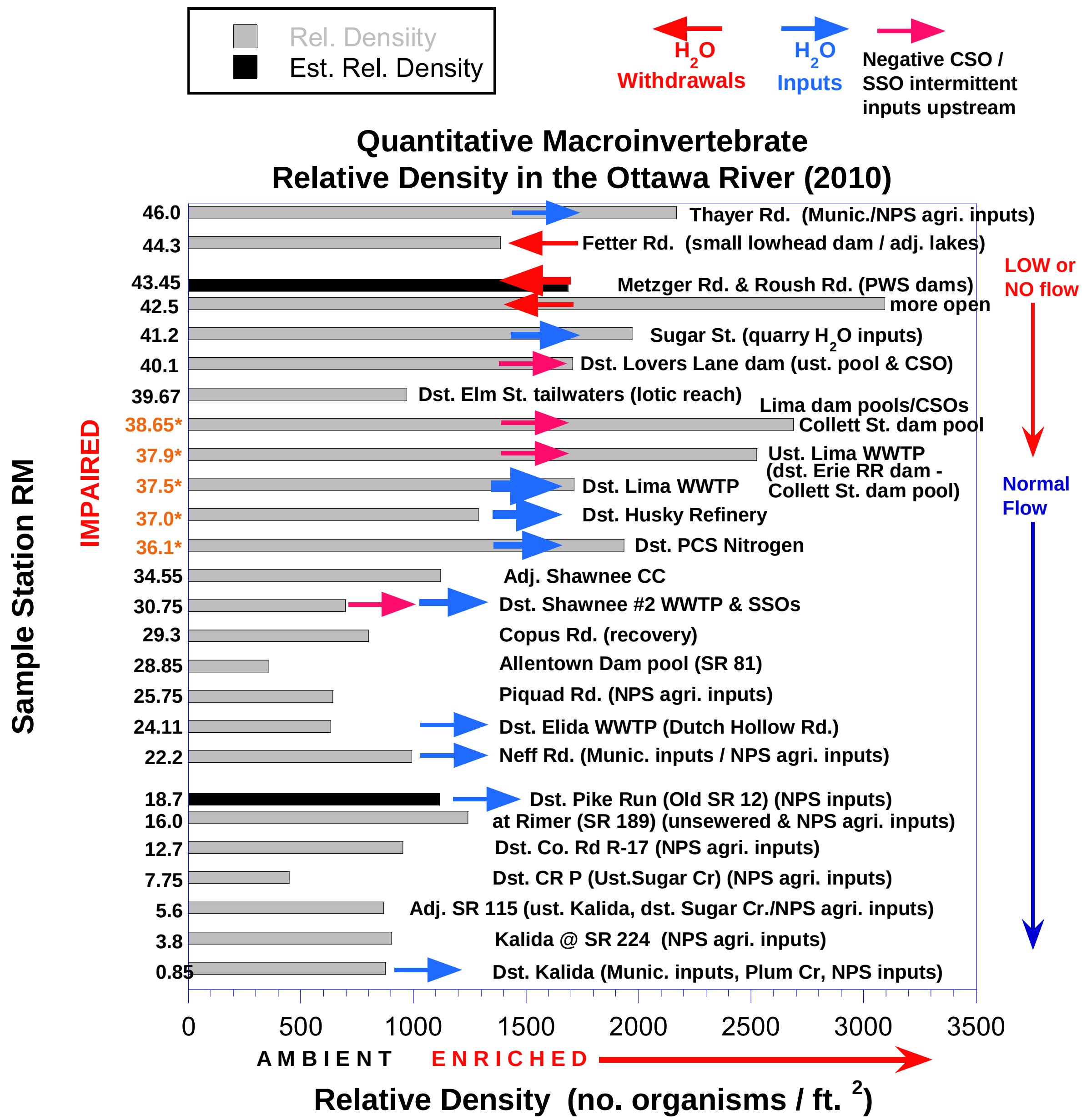

Figure 95. Macroinvertebrate community relative densities for the Ottawa River mainstem, 2010.

Exceptional to very good benthic quality communities were present and continued downstream from Thayer Road to below the Metzger Rd. dam (RM 43.45), but the flow regime changed drastically during late spring/summer conditions (Figure 20). Earlier stream volume flow decreases due to scheduled spring PDWS withdrawals, and decreasing summer upstream flows allowed less surface flow and recharge. Increased lentic conditions in the PDWS impoundments combined with open pooled conditions and higher water temperatures caused increased algal production in the nutrient enriched waters.

The influence of the nutrient enriched waters was apparent at the next downstream site at Roush Rd. (RM 42.5) which had the highest macroinvertebrate relative density (3095/ $ft.^2$) and a lower ICI of 38 (good). The gradual decrease in macroinvertebrate diversity and quality from Thayer Rd. (ICI of 48) to Roush Rd (ICI=38) was marked by less mayfly diversity and abundance and an increases in dipteran abundance (filterers) with less diversity. Decreased scores aligned with increased lentic conditions, less volume flow, higher stream temperatures, and more open canopy conditions. The upper reach sites at Fetter Rd. (RM 44.3) and Metzger Rd. (RM 43.45) were more shaded, so benthic relative densities were less than the Thayer Rd. community (Figure 94, Table 19). In general, the overall diversity of sensitive taxa collected upstream from Lima in the Ottawa River was slightly lower but comparable to downstream high quality sites (Figures 96 and 97). However, the total percent of sensitive taxa in the quantitative sampled populations was much lower due to nutrient enriched conditions with periodic flow limitations (Figure 98).

With the instream flow at critical levels, cooler quarry water inputs upstream from Sugar St. (RM 41.2) replenished stream volume which supported lotic instream conditions. The Sugar St. benthic community, mostly upstream from the urban Lima influences, was correspondingly documented as very good quality (ICI= 44) (Figure 94).

Not far downstream from Sugar Street, the first of five lowhead dams and five major CSOs negatively influenced water quality on the Ottawa River in Lima. The next downstream site, a flowing lotic reach, was below the Lovers Lane dam downstream from the Lovers Lane CSO (RM 40.1). The next downstream site (RM 39.67) was sampled in a lotic reach with good habitat below the Elm Street dam and upstream from the Central Ave. dam pool with no other additional CSO inputs (Figure 94). These two sites scored ICIs of 40 and 46, respectively, with similar EPT and sensitive taxa as upstream sites (Figures 94, 96, and Table 19). Benthic community relative density decreased to more ambient levels at the Elm Street reach, possibly due to past stormwater improvements with CSOs and SSOs in the eastern (upstream) portion of downtown Lima (Figure 95).

Through the next four miles, water quality conditions declined as CSOs in the urban reach of Lima contributed high solids and CBOD during rain events that persistently depleted dissolved oxygen. The five sites from Collett St./Erie RR dam pool (RM 38.65) to downstream PCS Nitrogen (RM 36.1) did not attain the macroinvertebrate WWH biocriterion. The lentic impounded sample site at Collett Street (RM 38.65) in the Erie RR dam pool was downstream from two impoundments and four CSOs. The benthic community was of low fair quality, and the tolerant organisms comprised 26.7% of the macroinvertebrate population (Figure 99). Tolerant midges (organic-tolerant *Glyptotendipes* (*G.*) sp. and toxic-tolerant *Dicrotendipes simpsoni*) and organic-tolerant oligochaete worms and flatworms dominated the macroinvertebrate community amidst pooled conditions that were nutrient enriched and supplemented with urban storm waste inputs. Corresponding wide diel DO swings, elevated pHs, and low mean and minimum DO violations from excess algal production caused the lowest number of EPT (1), sensitive(2), and total taxa (30) to be collected at the Collett St./Erie RR dam pool (RM 38.65) site (Tables 6 and9, Figure 53). Low ICI scores (low fair), low EPT taxa totals (1), and high percentages of tolerant taxa are toxic impact response signature (TIRS) measures that characterize macroinvertebrate communities exposed to toxic substances (Yoder and Rankin, 1995b). Comparisons of 2010 data against TISR measures through the more urbanized and industrial portion of Lima are presented in Table 20.

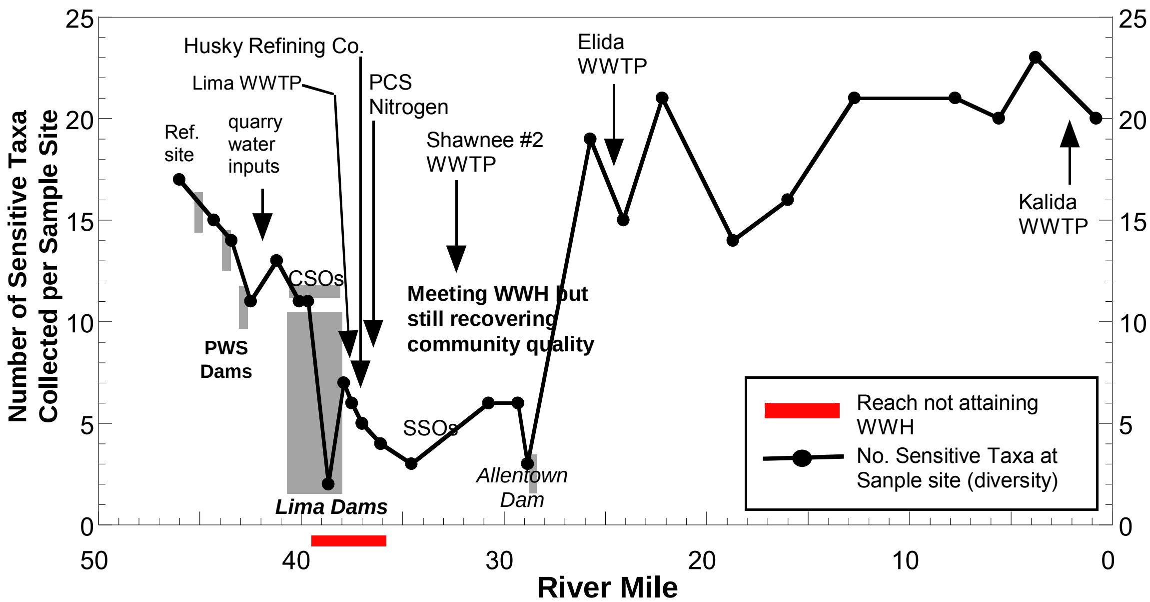

Figure 96. Number of sensitive taxa (diversity) collected at each Ottawa River mainstem site in 2010.

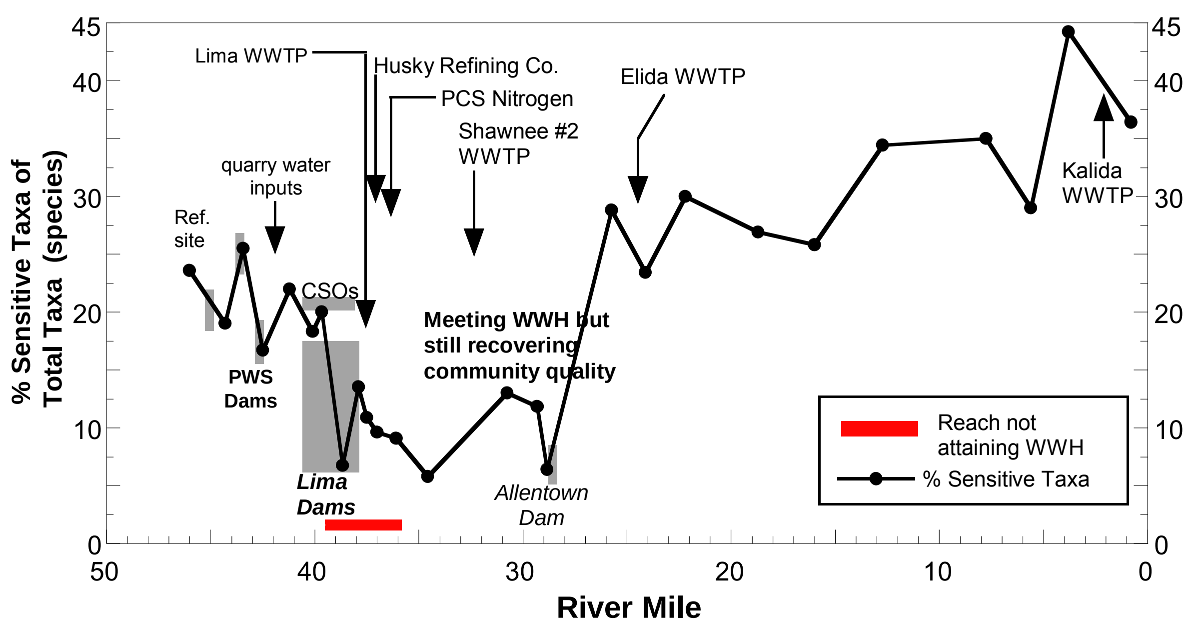

Figure 97. Percent sensitive taxa of distinct taxa (diversity) collected at each Ottawa River mainstem site in 2010.

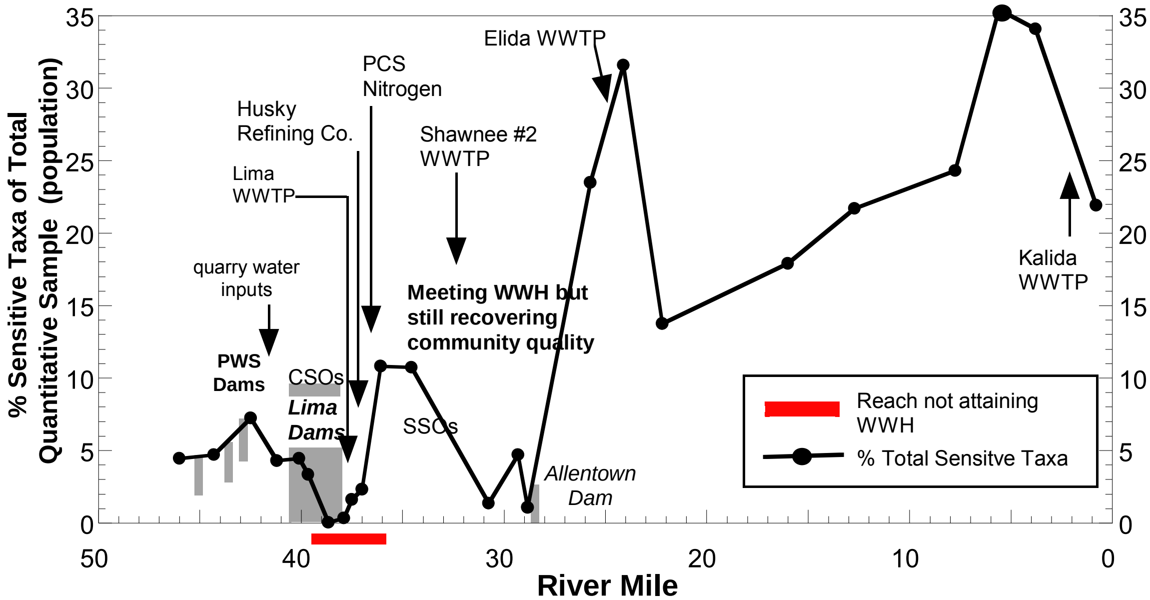

Figure 98. Percent sensitive taxa of quantitatively sampled macroinvertebrate populations collected at each Ottawa River mainstem site in 2010.

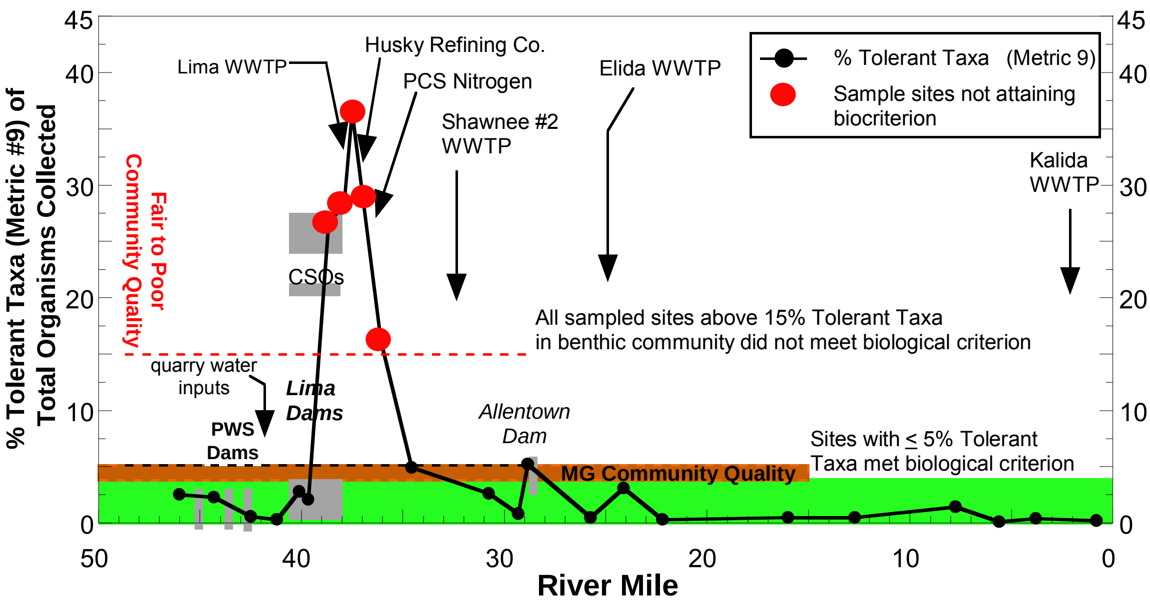

Figure 99. Percent tolerant taxa (ICI Metric #9) of quantitatively sampled macroinvertebrate populations collected at each Ottawa River mainstem site in 2010.

Table 20. Comparison of criteria used to determine the extent of a toxic impact response signature (TIRS) exhibited by the macroinvertebrate assemblage in the urban and industrial reaches of the Ottawa River through Lima, (RMs 40.1 to 34.6), 2010.

Impact Response Signature Groups	Criteria	**40.1**	**39.67**	**38.65**	**37.9**	**37.5**	**37.0**	**36.1**	**34.55**
Invertebrate Community Index (ICI)	≤ 18	40	46	**(LF)**	**20**	**20**	**20**	**26**	36
Qualitative EPT Taxa	≤ 4	11	15	**1**	7	9	7	9	10
Percent *Cricotopus* sp.	≥ 5 %	0.02	1.77	0	3.44	**17.1**	4.2	**11.7**	2.48
Percent Toxic-Tolerant Taxa[a]	≥ 35 %	1.36	2.12	17.93	5.91	24.7	19.5	13.1	2.23
Percent Organic/Nutrient/DO Tolerant Taxa[b]	≥ 35 %	21.8	4.16	**71.6**	**78.7**	**45.7**	33.5	3.8	2.44

a - Toxic-tolerant taxa include tolerant (T/MT) *Cricotopus* midges (from Ohio EPA Macroinvertebrate Taxa List), *Dicrotendipes simpsoni* (T), *Glyptotendipes (G.) barbipes* (VT), *Polypedilum (P.) illinoense* (T), and *Nanocladius (N.) distinctus* (MT).

b - Organic-tolerant taxa include Oligochaeta (T), *Glyptotendipes (G.) sp*. (MT), tolerant *Chironomus* spp. (from Ohio EPA Macroinvertebrate Taxa List) (primarily *Chironomus (C.) decorus gr*. and *Chironomus (C.) riparius gr*. (T)), *Dicrotendipes lucifer* (MT), *Dicrotendipes neomodestus* (F), *Polypedilum (Tripodura) scalaenum gr.* (F), Turbellaria, *Physella* sp. (T), and *Simulium* sp. (F).

Downstream from the Collett St./Erie RR dam pool and upstream from the Lima WWTP (RM 37.9), the benthic community diversity improved to 52 total taxa with 7 total EPT and sensitive taxa. The ICI of 20 indicated a slight improvement to fair water quality conditions, though the benthic community was dominated by tolerant midges (*Glyptotendipes* (*G*.) sp. and *Cricotopus bicinctus*) and oligochaete worms. Mayflies were very scarce and comprised only 0.8% of the macroinvertebrate fauna. Nutrient enriched conditions persisted downstream from the dam pool with a large DO swing range (> 7 mg/l), high pHs, and high COD values of 23 and 152 mg/l.

In addition to the nutrient enriched conditions, black organic sediments released an oily petroleum odor when disturbed while sampling the macroinvertebrate community at this locale (RM 37.9) (Figure 100). Just upstream from the L5 landfill, the Lima WWTP and directly across from a portion of the Husky Refinery facility, the RM 37.9 site had the highest amount of total sediment PAHs on the Ottawa River mainstem. Regardless of whether or not the presence of the PAHs and the black, oily sediments are a historic legacy or chronic contamination from these sources, they are a likely route of exposure of organic compounds to the macroinvertebrate community (Table 12, Figure 100). *Cricotopus bicinctus*, noted in Simpson and Bode (1980) to be tolerant of metals and crude oil, increased in numbers to five percent of the identified midge sample population, while *Glyptotendipes* (*G*.) sp., tolerant of sewage waste, low DO, and nutrient enrichment, comprised 73% of the midge community. The only other midge to have a higher population in the benthic community was the species, *Hayesomyia senata*, that was predatory on the oligochaete worms and other small midges present (12%). The 78.7% organic/nutrient/DO tolerant taxa from TIRS measures were similar to the 1996 totals of 80.7% (Table 20).

Downstream from the Lima WWTP (RM 37.5), the Ottawa River had 10 to 100 times more flow than upstream of the 001 effluent outfall thereby eliminating the low flow, starved condition (Figure 95). The qualitative EPT taxa increased slightly to 9 with no heptageneid mayflies (total mayflies still <1%) and an ICI=20, consistent with the upstream site at RM 37.9 (Figure 94, Table 19). Nutrient enrichment persisted with algae present on substrates despite the dilution, as upstream urban stormwater inputs and WWTP inputs combined for total phosphorus inputs as high as 0.288 mg/l recorded downstream from the WWTP. The macroinvertebrate community reflected the nutrient enriched conditions with only two percent sensitive taxa in the sampled benthic community and domination by organic/nutrient/DO tolerant taxa (45.7%) that typified a community exhibiting TIRS (Figure 98, Tables 19 and 20). *Glyptotendipes (G.)* sp., the organic/nutrient/DO tolerant midge that was predominant upstream (50%) decreased to 14% of the sampled community in the more lotic conditions present at RM 37.5. The midge species, *Hayesomyia*/*Thienmannimyia* sp., predatory on oligochaete worms and other small chironomid midge flies, comprised a significant population in the macroinvertebrate community similar to upstream (9%).

Figure 100. Oily substance suspended from sediment as colonizers were being deployed in riffle substrates at the Ottawa River RM 37.9, 2010.

Since 1996, the city of Lima has attempted to address several issues associated with the multiple CSOs and SSOs. A portion of the work designed to address the negative impact of the CSOs and SSOs involved rerouting flow to the WWTP that previously was discharged through either CSOs or SSOs. While eliminating the discharge at its original location, the increased nutrient and possible toxic inputs associated with the rerouted flow to the WWTP has negatively influenced water quality downstream of the WWTP (Figure 95). With the increased stormwater inputs, there has been an average of >6 tertiary bypasses per month with possible incomplete nitrification. There was an ammonia exceedance of 5.41 mg/l in July 2010 downstream from the Lima WWTP 001 discharge which likely impacted the macroinvertebrate community. The quality decrease to an ICI of 20 in 2010 from an ICI of 42 in 1996 was indicative of the increased load and pressure from periodic stormwater inputs to the treatment system. The 2010 quantitative sample contained 37% tolerant organisms, the highest of any mainstem sample site (Figure 99). Toxic tolerant midges comprised approximately 25% of the sampled community: *Cricotops (C.) bicinctus* (17%), *Nanocladius distinctus* (2%), and *Polypedilum (P.) illinoense* (6%) and these midges collectively can tolerate high pHs, toxic inputs, metals, sewage, crude oil, increased chlorides, and high BODs (Simpson and Bode, 1980). In addition, predatory midges of the genus *Nanocladius* were found attached to algae and are known to feed on chironomid midges.

Downstream from the Lima Husky Refinery (RM 37.0), the macroinvertebrate community was similar to the adjacent upstream site (RM 37.5) with midges, flatworms, and oligochaete worms predominant (Table 19). There were slightly less EPT and total taxa, though the percent sensitive taxa ($\leq$ 2.5%) and the ICI of 20 were equal to the preceding two upstream sites (upstream and downstream from the Lima WWTP, RMs 37.9 and 37.5, respectively) (Figures 94 and 98). The mayflies collected in the quantitative sample totaled only 0.3% - the lowest among all lotic sample sites. The total tolerant taxa (metric # 9) from the quantitative sample decreased slightly from ~37% downstream from the Lima WWTP (RM 37.5) to 29% at this locale (RM 37.0) (Figure 99). Continued enriched conditions were still evident, as large floating algal mats were clumped in slow current and open areas. In addition, ammonia, selenium, and temperature exceedances were noted and the relative density of macroinvertebrates decreased to 1,289 organisms/ft.^{2} (Table 19). Sediment metals (including mercury) (>TEC) and PAHs (> PEC) were present at concentrations that likely affected benthic community quality (Table 12, Appendix B). The percent toxic-tolerant and organic/nutrient tolerant taxa were slightly lower than upstream (24.7% to 19.5% and 45.7% to 33.5%, respectively), but these percentages still corresponded to a lesser or intermittent acute or sublethal chronic TIRS (Table 20). The toxic-tolerant midges *Nanocladius distinctus* and *Cricotopus (C.) bicinctus*, tolerant of organic pollution, high chlorides, crude oil, sewage, and high pHs, composed 77% of the toxic-tolerant taxa collected (Table 20).

Downstream from PCS Nitrogen (RM 36.1), increased nutrient inputs produced large, long algal strands commensurate with a large increase in facultative filtering organisms; predominantly midges and hydropsychid caddisflies. Macroinvertebrate relative density consequently increased to 1,935 organisms/ft.^{2} and organic/nutrient/DO tolerant taxa (*Glyptotendipes (G.) sp*., *Polypedilum illinoense*, Turbellaria, and *Simulium sp*.) dramatically decreased to 3.8% from 33.5% upstream, as these taxa were replaced by mostly facultative filtering midges and the net-spinning detritivore caddisfly, *Cheumatopsyche sp*. (Table 20). Total P (0.31 mg/l) was the highest concentration of all mainstem sites, as PCS was documented to input 41% of the phosphorus loadings (Figure 36, Figure 95). Excessive primary production from the nutrient enriched conditions was documented by highly elevated daytime DO concentrations (~ 17 ppm) and a DO range exceedance of 10.97 which can negatively affect aquatic communities (Table 13). The ammonia-N load from PCS Nitrogen to the Ottawa River was documented to be 90%, and there were concentrations of NH_3 (0.12-1.79 mg/l) and nitrites (0.08-0.363 mg/l) present in every chemical grab sample at RM 36.3 (downstream PCS Nitrogen) and at Shawnee Rd. (RM 35.44) which alludes to the possibility of chronic sublethal stress/toxicity (Figures 35, 45, 46, and 95).

In addition, ammonia and selenium exceedances were documented downstream PCS Nitrogen (RM 36.3) to Shawnee Rd. (RM 35.44) and sediment metals with PAHs were present at concentrations that likely affected benthic community quality (Table 12). While toxic-tolerant taxa decreased from 19.5% at RM 37.0 to 13.1% downstream from PCS Nitrogen (RM 36.1), the toxic-tolerant midge, *Cricotopus (C.) bicinctus*, indicative of a TIRS from toxic wastes, metals, crude oil, high pHs, and elevated chlorides, comprised 11.7% of the collected macroinvertebrate community (Table 20). The increase in ICI to 26 combined with a QCTV value of 37.5 indicated modest water quality improvement (Figure 94). However, only four of the 46 individual taxon collected were sensitive (<10%) and two of the four (MI caddisfly *Ceratopsyche morosa gr*. and midge *Thienemanniella similis*) combined to increase the total percentage of sensitive taxa in the quantitative sample to >10% from 2.5% upstream (Figure 96). In contrast, the total number of taxa collected at RM 36.1 (downstream from PCS Nitrogen) decreased to the lowest number collected on the Ottawa River mainstem (46), and there were still no sensitive mayflies with the percent mayfly totaling only 1.1% of the community.

Further downstream, the Ottawa River macroinvertebrate community met the WWH biocriterion with an ICI of 36 adjacent Shawnee Country Club (RM 34.55) despite the lowest number of sensitive taxa on the Ottawa River (3 of 52 – 5.8%) (Table 19 and Figure 96). The percent sensitive taxa in the quantitative sample were similar (11%) to upstream sites, and relative density increased to 2324 organisms/ft.^{2} (Figure 98). Nutrient inputs from upstream (and possibly the golf course) combined with the shallow, open riffle/run habitat had hydropsychids and Baetis spp. mayflies as the dominant taxa, totaling 58% of the quantitative data (Table 19, Figure 95). Total % mayflies increased to 22% from 1.1% upstream, though almost all were facultative (Figure 98, Table 19). The largest change in the macroinvertebrate community, due to distance and assimilation downstream from the three dischargers, was the drastic decrease of tolerant organisms within the community structure. Percent tolerant organisms decreased from >16% downstream from PCS Nitrogen (RM 36.1) to < 5% at RM 34.55 with no TIRS (Figure 99, Table 20). The QCTV, increased to 39.2 – a value indicative of a macroinvertebrate community attaining WWH due to less tolerant organisms. Despite meeting WWH biocriterion, the macroinvertebrate community diversity had not recovered. The sensitive taxa upstream from Lima still were not present (including *Petrophila* moth larva, *Chimarra* spp. caddisflies, or *Isonychia* sp. and *Macaffertium* spp. mayflies). The unbalanced community structure pointed toward intermittent or chronic toxicity pulses with lingering effects from the large dischargers and CSOs upstream and urban stormwater inputs, including SSO inputs from Shawnee # 2 sewer collection lines and SSO inputs from the Little Ottawa River and possibly stormwater runoff from Zurmehly Creek (Table 6).

The next two downstream sites, Elm Street (RM 30.75) and Copus Rd. (RM 29.3), each met the WWH performance criteria (ICI = 38) but the macroinvertebrate communities still had not recovered diverse community quality due to large local SSO inputs from lines to Shawnee #2 WWTP and urban stormwater runoff (Figure 95). The Shawnee #2 SSO overflows ranged in frequency and volume from nine events totaling 470,000 gallons up to 328 events of over 141.8 million gallons reported between 2006 and September 2010. Additionally, treated wastewater from Shawnee #2001 combined with the large nutrient and raw sewage inputs caused the largest recorded diel DO swings on the Ottawa River mainstem. Continuous data recorders documented a high DO reading of 20.68 mg/l with the largest diel DO range exceedance of 16.98 mg/l (Table 13, Figure 49). These extremes caused a violation of the Outside Mixing Zone Minimum DO criteria of 4.0 mg/l with a documented low DO concentration of 3.71 mg/l (Table 13).

Ten to twelve EPT taxa were collected at the Elm St. and Copus Rd. sites (Table 19). The predominant organisms were filtering midges and primarily facultative mayflies including *Baetis* spp. and the heptageneid *Stenacron* sp. which totaled 42% at Elm St. (RM 30.75) and 62% at Copus Rd. (RM 29.3), respectively (Table 19). Caddisflies comprised 11% and 13%, respectively, at RMs 30.75 and 29.3 and while tolerant taxa totals had decreased (2.6% and < 1%, respectively), flatworms were still a substantial portion of the community comprising 13% of the community at Elm St. (RM 30.75) and 5% of the community at Copus Rd. (Figure 99). In addition, only six sensitive taxa were collected at each sample site, and the % sensitive taxa from the quantitative samples totaled only 1.4% and 4.7% at RM 30.75 and 29.3, respectively (Figures 96 and 98). The largest proportion of the sensitive taxa totals were hydropsychid caddisflies (*Ceratopsyche morosa* gr.) with some *Corynoneura* spp. and/or *Thienemanniella similis* midges (Table 19).

Similar water quality and biological performance continued downstream to the reach in Allentown dam pool (RM 28.85). Only three sensitive taxa were collected as expected (lentic conditions), but enough heptageneid mayflies, tanytarsini midges, and a few hydropsychid caddisflies were present on the colonizers in this slow-moving pooled reach to have met the WWH biocriterion with a marginally good ICI score of 32 (Table 19, Figures 94 and 96). Some low-level residual accumulation of urban sediment deposition (cadmium, copper, and zinc) had accumulated at > TEC with mercury above the SRV which could have possible effects on the benthic community (Table 12). The continued presence of *Chironomus (C.) decorus gr*. and *Glyptotendipes (G.)* sp. midges at a combined quantitative community total of 4% indicated a slight continued effect from occasional urban sewage waste inputs (Table 20). In addition, percent tolerant taxa quantitative totals increased to 5% with the sensitive taxa totals at 1% (Figures 98 and 99).

Downstream from the Allentown dam pool, at Piquad Rd. (RM 25.75), the Ottawa River flowed through more rural areas. The drainage area was now almost half its final total (166 mi.^{2}) and the ICI improved to 40 (good) with a more complete and balanced community. The percent sensitive taxa increased to 23.56% and the saddlecased caddisfly, *Protoptila* sp. which is pollution intolerant, was predominant with *Polypedilum flavum* midges, hydropsychid caddisflies, and *Baetis* spp. mayflies also present (Table 19).

From Piquad Rd. (RM 25.75) to downstream Kalida (RM 0.8), the macroinvertebrate community had recovered to a higher quality community structure, as the total number of EPT taxa, sensitive taxa, and percent sensitive taxa increased to expected ambient levels (Table 19, Figures 98 and 99). Not including two sites closely downstream from WWTPs, total EPT and number of sensitive taxa averaged >20 with ~ 33% sensitive taxa in quantitative samples with a high of 44% near Kalida (RM 3.8). All sites met WWH biocriteria with a range of 36 to 50 and benefited from the good riparian corridors present throughout this reach (Figure 94, Table 19).

Downstream from the Elida WWTP (RM 24.11) *Baetis intercalaris*, a facultative lotic mayfly, and *Ceratopsyche morosa* gr. (a filtering caddisfly) replaced the intolerant *Protoptila* sp. caddisfly as predominant, and there were a few less EPT and sensitive taxa (17 and 15, respectively) present (Table 19, Figure 96). The percent tolerant taxa did increase to 3.1%, the highest of any site downstream from the Allentown dam pool (RM 28.8), though the percent sensitive taxa stayed high at 31.6%, as *Ceratopsyche morosa* gr. caddisflies still singly comprised 28% of the quantitative sample (Figure 99). Thus, the ICI improved to a 48 (very good).

Slight nutrient enriched conditions were present at four sites from Neff Rd. (RM 22.2) to downstream Rimer (RM 12.7). Relative densities were 993, ~1120, 1241, and 954 organisms/ft.^{2}, at RMs 22.2, 18.7, 16, and 12.7, respectively (Figure 95). Predominant riffle organisms were primarily facultative filtering midges (*Polypedilum flavum*), facultative *Baetis intercalaris* mayflies, filtering hydropsychid caddisflies, and/or *Protoptila* sp. with flatworms and *Petrophila* sp. very common. The three upstream sites within this reach received ICIs of 42 (very good) (Figure 94). Downstream Rimer (RM 12.7), the sandy runs were filled with aquatic macrophytes, and *Protoptila* sp. caddisflies were predominant. However, flatworms comprised 45% of the quantitative sample, and the ICI subsequently scored only 36 (good) (Table 19, Figure 94).

Sample sites through the lowest eight miles had exceptional ICI scores that ranged from 46 to 50 (Figure 94). Good, stable, riffle/run habitat with consistent riparian corridors supported the exceptional macroinvertebrate community in the lower reaches as evidenced by predominant organisms including *Petrophila* moth larvae, *Protoptila* sp. caddisflies, baetid, and *Isonychia* sp. mayflies with hydropsychid caddsiflies and Tricorythodes sp. mayflies (Table 19).

Ottawa River Mainstem Trends

Gradual improvements have occurred in the Ottawa River macroinvertebrate community through the years as seen by comparative ICI graphs plotted between 1985 -2010 (Figure 101). Comparing the last two surveys, more sites met WWH criterion in 2010 and ICI scores improved at eight sites (Figure 101). Lower ICI scores were found at four locations with the most significant decrease associated with projects intended to improve water quality. The rerouting of CSO and SSO flows to the WWTP significantly improved the water quality downstream of Lovers Lane dam, as the ICI score improved from an ICI of 20 in 1996 to and ICI of 40 in 2010. The upstream Lima WWTP site (RM 37.9) was still affected by Lima CSOs and SSOs combined with sediment organics (Figure 100, Table 21). Sediment organic contamination was likely historic, but further investigation might be warranted to insure that oil present in the substrates is not from a new or renewed source (Figure 100). The CSO and SSO work in Lima to reduce overflow severity by diverting more stormwater to the Lima WWTP has placed more pressure on the WWTP with increased internal bypasses and possibly more nutrient and toxic inputs. Downstream from the Lima WWTP (RM 37.55), the ICI decreased 22 points from 42 in 1996 to 20 in 2010 (Figure 101, Table 21).

Slight ICI improvements occurred downstream from PCS Nitrogen (RM 36.1) to high fair quality conditions (Table 21). PCS Nitrogen ammonia total loadings were similar (~50 to 55 kg/day) between 1996 and 2010, though the total percent loadings increased to 90% in 2010 from 73.4% in 1996 (Figures 27, 34 and 35, Ohio EPA, 1998). Addressing the stormwater runoff problems within the PCS facility since 1996 has likely reduced the amount and number of high ammonia-N spikes downstream from PCS outfalls. Similar phosphorus loadings (~30% in 1996 to 41% in 2010) (~10 kg/day) did enrich the stream but did not cause documented low DO violations (Figures 27, 34-36, Table 13).

Downstream from Elm Street (RM 30.75), the decrease in amount and duration of SSOs from sanitary sewer lines and at the Shawnee #2 WWTP plant resulted in improved macroinvertebrate community performance with the ICI increasing from a 28 in 1996 to a 38 in 2010 (Figure 101, Table 21). Downstream from the Elida WWTP (RM 24.11) a 12 point improvement to an ICI of 48 compared to 36 in 1996 was due to improved treatment at the Elida WWTP. Better instream water quality with increased assimilation upstream from Elida also contributed to improved community quality (Figure 101, Table 21).

The macroinvertebrate community near the unsewered community of Rimer (RM 16.0) showed a decrease in ICI from 48 to 42 in 2010 indicative of decreased water quality from local NPS stormwater inputs, local bridge construction, and possible poor water quality inputs from Pike Run associated with the unsewered community of Gomer.

Improved instream water quality resulted in improved ICI scores beginning upstream Sugar Creek (RM 7.75) to Kalida (RM 3.8) (Table 21). Decreased overall load inputs, greater assimilation and improved sediment quality slightly increased community quality to ICIs of 50 from 46 at these two locations (Table 21, Figure 101). Sensitive and EPT taxa increased from 14% to 33% in 2010, and tolerant taxa (species count and percent tolerant taxa in quantitative sample) decreased an average of 62% compared to 1996 totals (Table 19, Figures 96, 98 and 99).

Macroinvertebrate community TIRS measures were compared from 1985 to 2010 at urban and industrial sites within Lima (Table 22). Declines in the magnitude and severity of toxic impacts have occurred generally through time and TIRSs documented within the Ottawa River at sites through were as follows: 23 in 1985, 17 in 1991, 10 in 1996, and 7 in 2010 (Table 22). Of the seven urban sites with TIRS measures from 2010, three were documented in the Collett St./Erie RR dam pool (RM 38.65) and another immediately downstream with the reach upstream of the Lima WWTP (RM 37.9). The other three TIRS measures were downstream from dischargers; two noted downstream Lima WWTP (RM 37.5) and one downstream PCS Nitrogen (RM 36.1) (Table 22).

Below Husky Refinery (RM 37.0), the macroinvertebrate community was still comprised of 33.5% organic/nutrient/DO tolerant taxa (just under the TIRS criteria of 35%) in 2010 (Table 22). Ammonia discharger loadings from Lima Husky Refinery (5.3% of total to river) combined with a large phosphorus load (45% of total load) from the Lima WWTP upstream allowed for continued enrichment instream (Table 19, Figures 27 and 95).

Organic/nutrient inputs from the CSOs and SSOs in Lima have continued in 2010 at Collett St./Erie RR dam pool (RM 37.9). There were 71.6% and 78.7% organic/nutrient/DO tolerant taxa in 2010 at RMs 38.65 and 37.9, respectively which were similar to 1996 totals (Table 22). The CSO abatement and diversion projects that resulted in improved water quality downstream Elm St. (RM 30.75) increased NPS sewer/stormwater loads to the Lima WWTP. These organic/sewage inputs and the large P loads, increased TIRS for tolerant midges (17.1% *Criciotopus* sp.) and organic/nutrient/DO tolerant taxa (45.7%) downstream from Lima WWTP in contrast to 1996 (Table 22, Figures 24-27).

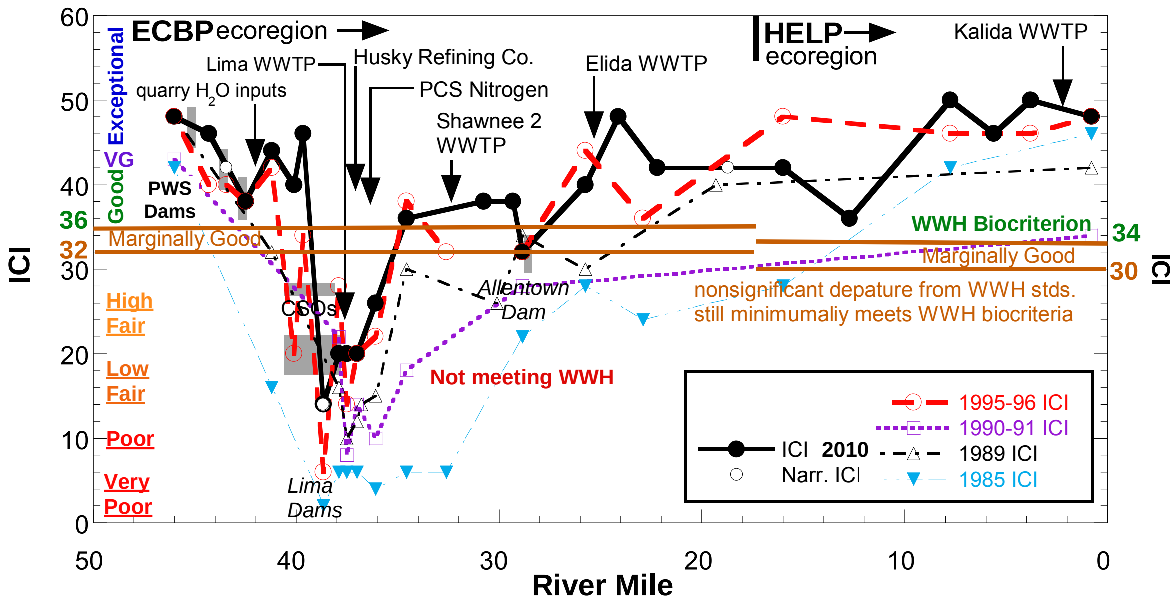

Figure 101. Longitudinal ICI plots for the Ottawa River mainstem in 1985, 1989, 1990-91, 1995-96, and 2010.

Table 21. Comparison of ICI scores and macroinvertebrate community attainment for the Ottawa River mainstem from 1996 and 2010.

RM	2010 ICI	1996 ICI	Change[1] (+ or -)	Change in Attainment	Comments
46.0	**48**[2]	**48**	0	NO	
44.3	**46**	**40**	**+4**	NO	mayfly & caddisfly taxa ↑, qual. EPT ↑and total taxa increases
43.4	**42**	**40**	+2	NO	
41.2	**44**	**42**	+2	NO	
40.1	**40**	**20***	**+20**	**YES- FULL**	CSO and SSO decreases with quarry water augmentation and low flow management
39.67	**46**	**34**[ns]	**+12**	NO	CSO and SSO decreases with quarry water augmentation and low flow management
38.65	**6***	**6***	0	NO	
37.9	**20***	**28***	**-8**	NO	Cont. urban CSO/SSO & oil/organic effects
37.5	**20***	**42**	**-22**	**YES - NON**	Less consistent Lima WWTP performance due to increased stormwater inputs
37.0	**20***	**20***	0	NO	
36.1	**26***	**22***	**+4**	NO	Decrease in nutrient spikes from PCS
34.55	**36**	**38**	-2	NO	
30.75	**38**	**28***	**+10**	**YES- FULL**	Decreases in amount and duration of SSOs
28.85	**32**[ns]	**32**[ns]	0	NO	
25.75	**40**	**44**	**-4**	NO	More dipterans from residual NPS nutrients
24.11 / 22.9	**48**	**36**	**+12**	NO	Improved treatment at Elida WWTP and American #2 WWTP on line now (Dug Run) & better WQ from upstream – now exceptional community quality
16.0	**42**	**48**	**-6**	NO	Rimer NPS inputs (unsewered) and local bridge construction & possible contributions from Pike Run (Gomer (unsewered))
7.75	**50**	**46**	**+4**	NO	Slightly better overall instream water quality
3.8	**50**	**46**	**+4**	NO	Slightly better overall instream water quality and improved sediment quality
0.8	**48**	**48**	0	NO	

[1] Scores with ≥6 points difference is considered a significant change; scores with 4 points difference is considered a slight change and scores with 0-2 points difference are considered similar

[2] **Blue**= Exceptional; **Purple**= Very Good; **Green**= Good; **Brown**= Marginally Good; Yellow = Fair; **Red**=Poor/VP

* **Non attainment** for macroinvertebrate community assessment at that site.

Table 22. Comparison of Criteria Used to Determine the Extent of Impact Response Signatures Exhibited by the Macroinvertebrate Assemblage in the Urban and Industrial Reach of the Ottawa River through Lima, Ohio (RMs 40.1 to 34.6), June to October, 1985 - 2010.

Impact Response Signature Group	ICI				Qual. EPT Taxa				Percent *Cricotopus* sp.				% Toxic- Tolerant Taxa[a]				% Organic/Nutrient/ DO Tolerant Taxa[b]			
Sample Site	1985	1991	1996	2010	1985	1991	1996	2010	1985	1991	1996	2010	1985	1991	1996	2010	1985	1991	1996	2010
Criteria	≤ 18				≤ 4				≥ 5%				≥ 35%				≥ 35%			
RM **40.1** Dst Lovers Lane CSO	**16** RM 41.1	-	20	40	**4** RM 41	-	8	11	3.48 RM 41.1	-	**5.0**	0.02	4.62 RM 41.1	-	5.0	1.36	17.8 RM 41.1	-	**45.0**	21.8
RM **39.6/39.67** Dst. Elm St. (tailwaters)	-	-	34	46	-	-	12	15	-	-	0.86	1.77	-	-	4.3	2.12	-	-	8.70	4.16
RM **38.6/38.65** Collett St. (Erie RR dam pool)	**2 (P)**	-	**6 (P)**	**6 (LF)**	**2**	-	**2**	**1**	0	-	0	0	13.1	-	26.5	17.9	**86.4**	-	**62.1**	**71.6**
RM **37.9** Ust. Lima WWTP / dst. Erie RR dam pool	**6**	**6**	28	20	**4**	6	8	7	0.77	2.23	0.3	3.44	16.9	1.78	5.49	5.91	**75.0**	**94.6**	14.81/ **80.7**[c]	**78.7**
RM **37.4/37.5** Dst. Lima WWTP	**6**	**8**	42	20	**0**	**1**	8	9	1.92	**51.8**	3.29	**17.1**	7.6	**53.9**	3.55	24.7	25.0	30.6	5.18/ 11.5[c]	**45.7**
RM **37.0** Dst. Lima Husky Refinery	**6**	**14**	20	20	**0**	**2**	**4**	7	**17.2**	**34.7**	2.42	4.2	**42.1**	**36.4**	3.24	19.5	12.4	20.3	6.58/ 21.6[c]	**33.5**
RM **36.1** Dst. PCS Nitrogen	**4**	**10**	22	26	**1**	**2**	**4**	9	**17.3**	**41.7**	**10.8**	**11.7**	**35.4**	**49.2**	18.9	13.1	**41.5**	3.62	0.73/ 5.93[c]	3.8
RM **34.5/ 34.55** Adj. Shawnee CC	**6**	**18**	38	36	**1**	**3**	9	10	**16.2**	**5.2**	**5.2**	2.48	**35.3**	11.0	7.43	2.23	31.0	4.79	1.76	2.44
No. of Impact Responses	**7**	**5**	**1**	**1**	**7**	**4**	**3**	**1**	**3**	**4**	**3**	**2**	**3**	**3**	**0**	**0**	**3**	**1**	**3**	**3**

a - Toxic-tolerant taxa include tolerant (T/MT) *Cricotopus* midges (from Ohio EPA Macroinvertebrate Taxa List), *Dicrotendipes simpsoni* (T), *Glyptotendipes (G.) barbipes* (VT), *Polypedilum (P.) illinoense* (T), and *Nanocladius (N.) distinctus* (MT).

b - Organic-tolerant taxa include Oligochaeta (T), *Glyptotendipes (G.) sp*. (MT) (not *G. (G.) barbipes*) , tolerant *Chironomus* spp. (from Ohio EPA Macroinvertebrate Taxa List, primarily *Chironomus (C.) decorus gr*. and *Chironomus (C.) riparius gr*. (T)), *Dicrotendipes lucifer* (MT), *Dicrotendipes neomodestus* (F), and *Polypedilum (Tripodura) scalaenum gr.* (F), Turbellaria, *Physella* sp. (T), and *Simulium* sp. (F).

c - *Hydra* sp. included in % organic/nutrient/DO tolerant taxa

Downstream from PCS Nitrogen (RM 36.1), with 90% of the ammonia discharge load and 41% of the P load, there was a classic nutrient enriched community with high and low DOs (~17 mg/l with range of ~11 mg/l) and elevated relative density (>1900/ft.^{2}) (Table 19, Figures 24-27 and 95). These highly enriched conditions likely caused intermittent chronic impacts from excess nutrients and combined mixed effluent conditions, based upon the large tolerant midge population of *Cricotopus bicinctus* (11.7%) (Table 22).

Comparisons of percent EPT taxa and tanytarsini midges in the composite samples and total EPT and tanytarsini taxa were documented at common sample sites through different surveys. Additionally, percent tolerant taxa totals in the composite samples were also compared through time. These comparisons are discussed below and provide a reflection of water quality based upon the macroinvertebrate community.

During the 1985 survey, CSOs and stormwater overflows in Lima decimated aquatic benthic communities with most samples containing 90% tolerant taxa with low numbers of EPT taxa (Figures 102 and 103). Subsequent discharge inputs from Lima WWTP, Husky Refinery (at that time, Clark Oil), and PCS Nitrogen, no EPT taxa or tanytarsini midge taxa were present and tolerant taxa were predominant.

The 1989 results showed slight incremental progress, as the percent tolerant taxa decreased with further distance from dischargers. Additionally, positive community attributes such as proportions of mayflies and tanytarsini midges increased downstream Husky Refinery, PCS Nitrogen, and in Lima (RMs 37 – 34.5) until a more complete diversified recovery was noted at Allentown (RM 28.8) (Figure 103). Just two years later, in 1991, increased impacts from stormwater sewage and CSOs/SSOs from Lima decreased community diversity and quality (higher totals of tolerant taxa and less EPT diversity) through Lima. There was no documented recovery until downstream from Lima at the mouth site (RM 0.8) in 1991 (Figures 102 and 103).

The 1996 survey results indicated some slight community quality improvements downstream from the urban Lima impoundments compared to 1991 (Figures 102 and 103). An ICI of 6 in 1991 improved to 28 in 1996 downstream Erie RR dam (RM 37.9) despite continued CSO impacts from sewage, excess nutrients, low DOs, metals, and suspended and dissolved solids (Tables 19 and 20, Figure 101). Improvements in Lima WWTP performance allowed for higher EPT and tanytarsini midge totals collected with lower tolerant taxa percentages which culminated in a very good ICI of 42 downstream of the Lima WWTP (RM 37.55) (Figures 101-103, Table 19). Impacts from Husky Refinery and PCS Nitrogen contributed to the poor water quality resulting in impaired communities with partial recovery at Westfield Drive (RM 34.5) (Figure 103). The SSOs from lines to Shawnee #2 WWTP in the western portion of Lima and Allen County decreased quality downstream to Allentown dam pool (RM 28.8) with recovery documented three miles further downstream at Neff Rd. (RM22.2) with continued higher quality benthic communities present downstream to the mouth (Figures 27 and 103).

In 2010, the EPT and tolerant taxa totals still indicated CSO impacts with higher tolerant taxa totals than 1996, as oligochaetes and *Glyptotendipes (G.)* sp. midges dominated the benthic community downstream of the Erie RR dam (Figure 102). The percent EPT totals were similar to 1996 downstream from the CSOs and the community quality downstream from Lima WWTP was much lower in 2010 than in 1996 with an ICI of 20 in contrast to an ICI of 42 in 1996 (Tables 19 and 21, Figures 101 and 103). Eleven times more tolerant taxa (78.1% in 2010 vs.

6.85 in 1996) and 35 times less mayflies (EPT and tanytarsini midge totals only 4% in 2010 vs. 71% in 1996) were the result of flow diversion from CSO/SSO abatements in the city of Lima to the WWTP. In addition, lower summer flows exacerbated the impacts to macroinvertebrate community quality.

Impacts below Husky Refinery were observed strongly in the community quality in 2010 though the ICIs (20 in both 1996 and 2010) were equivalent. In 2010, four to five times less EPT taxa were present and more tolerant taxa were collected with 10 times more TIRS taxa present including: Oligochaeta, *Cricotopus bicinctus*, *Nanocladius distinctus*, *Glyptotendipes (G.)* sp., and *Polypedilum (P.) illinoense* (Figures 102 and 103, Table 22). Effects from ammonia, temperature, and selenium exceedances with periodic higher pulses of nitrogen inputs, elevated TDS and conductivity all combined to limit macroinvertebrate community diversity in 2010 (Table 6, Figures 102 and 103).

In 2010, downstream PCS Nitrogen (RM 36.1) increased nutrient enrichment with less acute toxicity compared with 1996 allowed increases in benthic filterers which decreased tolerant taxa totals (Figure 102). *Polypedilum* midges increased more than tanytarsini midges along with hydropsychids, so the percent EPT and tanytarsini midges decreased slightly (Figure 103). With some increased EPT taxa, it seemed the overall benthic community quality improvements were mixed. Downstream from the dischargers, adjacent Shawnee CC (RM 34.55) similar community diversity (ICIs of 38 in 1996 and 36 in 2010, respectively) was present in 2010 and 1996. A slight improvement in quality occurred in 2010, as the percent tolerant taxa decreased by half to 4.5% (Figure 102).

The magnitude of impact from upstream dischargers and lower number of SSO overflows with decreased overflow volumes over time from Shawnee #2 WWTP since 1996 have improved resulted in improved macroinvertebrate community quality at Copus Rd. (RM 29.3). The EPT and tanytarsini midge quantitative totals in 2010 more than doubled to 77.2% compared to 34.0% in 1996 at Allentown dam pool (RM 28.8) (Figure 103). The impaired reach of the Ottawa River from the impacts within Lima decreased, as recovery improved with less severe near-field impacts upstream. The macroinvertebrate communities sampled from Piquad Rd. (RM 25.75) to the mouth (RM 0.8) all met WWH expectations and the mouth site continued to exhibit an exceptional macroinvertebrate community with an ICI of 48 and EPT and tanytarsini midge taxa totals in the quantitative sample of > 83% in the 2010 survey consistent with the results of the 1996 survey (Figure 103).

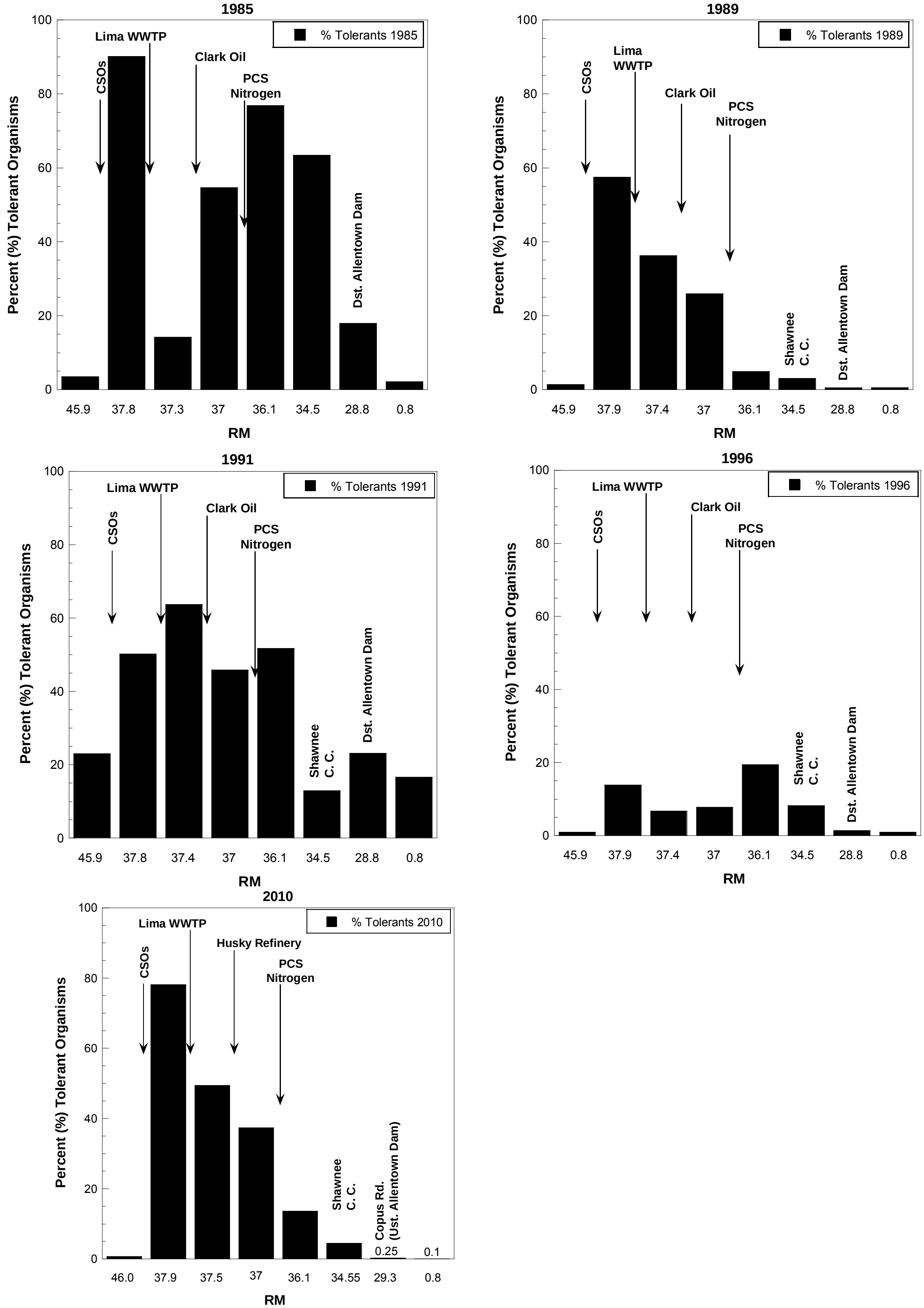

Figure 102. Longitudinal trend of the percent tolerant macroinvertebrates collected from the artificial substrates in the Ottawa River for the years 1985, 1989, 1991, 1996, and 2010.

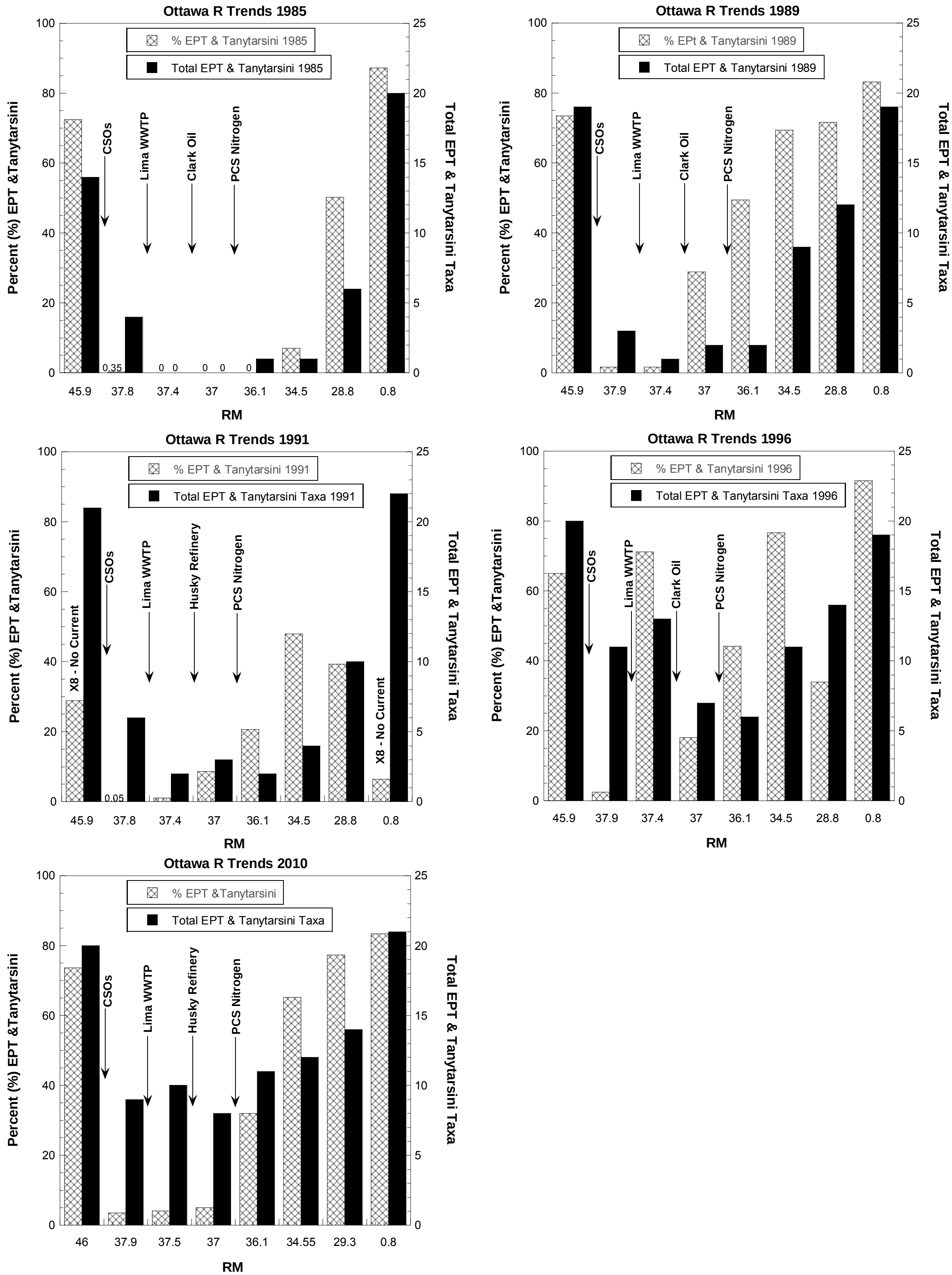

Figure 103. Percent EPT and tanytarsini midges collected on artificial substrates and total number of EPT and tanytarsini midge taxa collected from both artificial and natural substrates for selected sites on the Ottawa River, 1985-2010.

Ottawa River Tributaries

Fifty-four sites on 25 tributaries in the Ottawa River basin were sampled and included sixteen sites in the Hog Creek subbasin in Hardin and Paulding counties (Table 1, Figures 2 and 3). Most subbasin tributaries in Hardin County were under county stream maintenance.

Forty of the 53 tributary sites (75.5%) on 24 streams met their respective existing or recommended biological performance criteria for the macroinvertebrate community. There were 30 ECBP and 24 HELP tributary sites which included 25 WWH and 29 MWH sites sampled within Hardin, Allen, and Putnam Counties (Figures 2 and 3, Tables 1, 23).

Table 23. A summary of macroinvertebrate survey data with totals for attainment and non-attainment of ecoregional biological expectations for the Ottawa River tributaries in 2010.

Ecoregion	Total Sites	WWH	Criterion MET	Criterion NOT MET	MWH	Criterion MET	Criterion NOT MET
ECBP	30	13	6	7	17	14	2
HELP	24	12	12	0	12*	7*	4
Totals	54*	25	18	7	29*	21*	6

*One HELP MWH site not sampled for fish biology and therefore not assessed for meeting biocriterion

The WWH tributary sites within the HELP all met the biological performance criterion (Table 23). Most HELP ecoregion streams in the Ottawa River basin were straightened or entrenched with riparian removal and similar manipulations decades ago (Figure 104). Since that time, in the absence of continued maintenance activities, many have partially recovered with improved stream habitat quality and WWH function. Others, on intermittent county stream maintenance, recovered enough habitat quality to meet the WWH biocriterion (Table 23). However, nutrient enrichment from agricultural crop production in the modified stream reaches was exacerbated by open canopies from channel maintenance activities. Most of the modified streams had minimum DO exceedances, and several MWH streams had nutrient loads that affected downstream WWH performance (e.g., Hog Creek in eastern Allen County and the upper Ottawa River) (Tables 9 and 20). Proactive maintenance options to diminish algal production and enhance fish and stream habitat quality could be utilized to ensure continued attainment of WWH biological performance.

Two of the four MWH sites in the HELP ecoregion that did not meet MWH performance standards, Plum Cr. (RM 8.12) and upper Honey Creek, were similarly due to nutrient enrichment/low DOs from agricultural production associated with tile drainage and magnified by past stream maintenance. Two Plum Creek sites further upstream, also MWH, were overwhelmed by urban impacts within and downstream from Columbus Grove. The Little Ottawa River at RM 5.5 and the unnamed tributary to Lost Creek at RM 1.15 did not attain their associated MWH biocriterion for macroinvertebrates in the ECBP ecoregion due to impacts associated with urban spills, stormwater, and sewage inputs (Tables 1, 23 and 24).

The seven impacted WWH sites within the ECBP ecoregion were divided between rural and urban landuse and associated issues. Little Hog Creek (RM 50.5) and Hog Creek (RM 3.9) both along Pevee Rd. were impacted by agriculture, nutrients, and/or habitat impacts. Mud Run was affected by organic enrichment from malfunctioning HSTSs. Two urban streams, Little Ottawa River and Zurmehly Creek, were impacted by urban runoff, storm sewers and possible toxic spills (Tables 23 and 24).

Table 24. A summary of macroinvertebrate survey data with ICI or narrative evaluations from the sampled Ottawa River tributaries in 2010. The ALU designation is shaded green for WWH reaches and orange for MWH reaches. ICI scores and narrative evaluations are color coded by quality: **Exceptional** (**blue**), **Very Good** (**purple**), **Good** (**green**), **Marginally Good** (**brown**), **Fair** (**orange**), and **Poor** to **Very Poor** (**red**).

River / ALU	RM	Drain. Area	Ql./Tot. Taxa	Ql./Tot. EPT	Sens. Taxa Qual./Total	QCTV[a]	Relative Density (# / ft.^{2})	ICI	Narr. Eval.	Predominant Populations (Tolerance Ratings)
Upper Hog Creek subwatershed (Hardin Co.) **(HUC 040000703 01)**										
Hog Creek	13.42	13.9	34 / -	4 / -	0 / -	31.8	Moderate	--	**High Fair**	Fingernial clams (F), flatworms (F), flatheaded mayfly *Stenacron* sp. (F)
Middle Hog Creek subwatershed (Hardin Co.) **(HUC 040000703 02)**										
Hog Creek	10.77	31.4	28 / 32	5 / 6	1 / 2	34.6	Mod. / 127	**18 X15**	**High Fair**	Corixids (MT), burrowing mayflies (F), flatheaded mayflies (F), squaregill (*Caenis*) mayflies(F), *Dicrotendipes neomodestus* (F)
Lower Hog Creek subwatershed (Hardin Co.) **(HUC 040000703 04)**										
Hog Creek	8.72	54.0	33 / 43	7 / 8	3 / 4	35.7	High / 1289	**32**	**MG**	Net-spinning (hydropsychid) caddisflies (F), midges (F,MI,MT,T)
Hog Creek	6.6	58.6	43 / 52	8 / 10	4 / 4	35.7	High / 2079	**32**	**MG**	Moth larvae (*Petrophila* sp.) (MI), hydropsychid caddisflies (F,MI), *Tanytarsus*, *Dicrotendipes*, & *Polypedilum* midges (F,MT,T), Bryozoa (*Plumatella* sp.)
Lower Hog Creek subwatershed (Allen Co.) **(HUC 040000703 04)**										
Hog Creek	3.9	69.0	47 / 56	12 / 14	10 / 11	40.5	Mod. / 459	**46**	**E**	Hydropsychid caddisflies (F,MI), baetid mayflies (F), midges (F,MI,MT,T)
Hog Creek	0.1	73.7	63 / 62	15 / 16	14 / 15	40.5	High / 1574	**48**	**E**	*Rheotanytarsus* sp. midges F), hydropsychid caddisflies (F,MI), baetid mayflies (F,MI), flatheaded mayflies (F,MI)
Upper Hog Creek subwatershed (Hardin Co.) **(HUC 040000703 01) (cont.)**										
UT to Hog Creek (@ RM 13.71)	0.52	8.0	41 / -	4 / -	1 / -	32.8	Moderate-Low	--	**High Fair**	Chironomid midge (F,,T), flatworms (F), beetles including elmids (MT,F), damselflies (F,T)
Middle Hog Creek subwatershed (Hardin Co.) **(HUC 040000703 02) (cont.)**										
Fitzhugh Ditch	0.4	10.1	31 / -	2 / -	0 / -	29.2	Moderate-Low	--	**High Fair**	Beetles including elmids (F,MT,T), water mites (F), *Caenis* & burrowing mayflies (F), damselflies (F,T), midges (MT,F)
No. 28 Ditch	0.37	7.7	23 / -	3 / -	0 / -	28.9	Moderate-Low	--	**High Fair**	burrowing mayflies (F), water boatmen (MT)
Grass Cr.	2.57	8.8	38 / -	5 / -	0 / -	29.2	Moderate-High	--	**High Fair**	Midges (MT,T,F), dragonflies (MT,F), flatworms (F), *Caenis* mayflies(F)
Grass Cr.	1.2	9.5	41 / -	10 / -	1 / -	34.3	Moderate	--	**MG**	Midges (F,MT,T), hydropsychid & hydroptilid caddisflies (F), baetid & *Caenis* mayflies (F)

River / ALU	RM	Drain. Area	Ql./Tot. Taxa	Ql./Tot. EPT	Sens. Taxa Qual./Total	QCTV[a]	Relative Density (# / ft.^{2})	ICI	Narr. Eval.	Predominant Populations (Tolerance Ratings)
Little Hog Creek subwatershed **(HUC 040000703 03)**										
Little Hog Creek	3.62	12.1	37 / -	7 / -	2 / -	34.3	Moderate	--	**MG[ns]**	Midges (F,MT,T), burrowing mayflies (F), flatheaded mayflies (F)
Little Hog Creek	0.64	14.3	48 / -	12 / -	8 / -	37.1	Moderate	--	**G**	*Rheotanytarsus* midges (F), hydropsychid caddisflies (F), *Caenis* mayflies (F), water pennies (MI), flatworms (F)
Little Hog Creek	0.20	22.0	50 / 64	16 / 17	11 / 12	42.6	High / 1516	**46**	**E**	*Rheotanytarsus* midges (F), hydropsychid caddisflies (F,MI), *Chimarra* (MI), baetid mayflies (F,MI)
Mud Run	0.65	6.7	26 / -	3 / -	1 / -	33.8	Moderate-Low	--	**Low Fair***	Corixids (MT), midges (F,MT,T,MI)
UT to Little Hog Cr. (@ RM 0.47)	0.1	7.9	48 / -	12 / -	8 / -	37.1	Moderate-Low	--	**G**	Midges (F,MT,T), snail-cased caddisflies (*Helicopsyche borealis*) (MI), flatheaded mayflies (F,MI)
Lost Creek subwatershed **(HUC 040000703 05)**										
Lost Creek	3.56	6.2	37 / -	3 / -	0 / -	30.8	Moderate-Low	--	**Fair**	*Sphaerium* sp. fingernail clams (F), *Physella* sp. snails (T), midges (F,MT,T)
Lost Creek	1.7	10.0	21 / -	5 / -	0 / -	37.8	Low	--	**High Fair**	Caenis mayflies (F), midges (F,MT,T), flatheaded mayflies (F), damselflies (T)
UT to Lost Creek (@ RM 1.15)	0.62	6.0	15 / -	1 / -	0 / -	27.3	Low	--	**Very Poor***	Midges (F,MT,T)
Lost Creek subwatershed **(HUC 040000703 05)**										
Lost Creek	0.3	17.4	44 / -	10 / -	7 / -	39.7	Moderate-Low	--	**G**	*Rheotanytarsus* midges (F), hydropsychid caddisflies (F), *Helicopsyche borealis* (MI), *Stenacron* sp. mayflies (F), flatworms (F)
Lima Reservoir – Ottawa River subwatershed **(HUC 040000703 06)**										
Zurmehly Creek	0.03	3.3	27 / -	4 / 4	0 / -	34.9	Moderate-Low	--	**High Fair***	Hydropsychid caddisflies (F), *Stenacron* sp. mayflies (F), midges (F,MT,T)
Little Ottawa River (**MWH** Use Designation) Recommended/Confirmed (≥ RM 4.54) (**(HUC 040000704 01)**										
Little Ottawa R.	5.5	10.9	19 / -	1 / -	0 / -	33.2	Moderate-Low	--	**Low Fair***	*Stenonema femoratum* mayflies (F), crayfish (F), damselflies (F,T)
Little Ottawa River (**WWH** Use Designation) Confirmed (< RM 4.54) (**(HUC 040000704 01)**										
Little Ottawa R.	4.45	12.0	33 / -	5 / -	0 / -	35.7	Moderate	--	**High Fair***	*Rheotanytarsus* & *Polypedilum* midges (F,T)
Little Ottawa R.	1.85	13.6	34 / -	5 / -	3 / -	34.5	Mod.- Low	--	**MG[ns]**	*Caenis* mayflies (F), chironomid midges (F,MI,T), flatheaded mayflies (F)
Little Ottawa R.	0.03	16.4	42 / -	14 / -	9 / -	40.0	Low -Mod.	--	**G**	hydropsychid caddisflies (F), flatheaded mayflies (F,MI), (MI,F), and midges (F,MI,T)
Honey Run subwatershed **(HUC 040000704 03)**										

River / ALU	RM	Drain. Area	Ql./Tot. Taxa	Ql./Tot. EPT	Sens. Taxa Qual./Total	QCTV[a]	Relative Density (# / ft.^{2})	ICI	Narr. Eval.	Predominant Populations (Tolerance Ratings)
Honey Run	3.58	10.9	23 / -	2 / -	0 / -	33.2	Low	--	**Low Fair***	*Sphaerium* sp. fingernail clams (F), midges (F,MT,T)
Honey Run	1.1	13.0	32 / -	10 / -	4 / -	38.2	Moderate	--	**G**	Flatheaded mayflies (F), *Sphaerium* sp. fingernail clams (F)
Dug Run – Ottawa River subwatershed **(HUC 040000704 02)**										
Dug Run	0.19	11.0	34 / -	8 / -	4 / -	40.0	Mod. - High	--	**G**	Tanytarsini & chironomid midges (F,MI,T), baetid mayflies (F)
Beaver Run – Ottawa River subwatershed **(HUC 040000704 06)**										
Beaver Run	0.51	5.7	41 / -	9 / -	3 / -	38.6	Moderate	--	**G**	Hydropsychid caddisflies (F), *Rheotanytarsus* midges (F)
Pike Run – Ottawa River subwatershed **(HUC 040000704 04)**										
Pike Run	8.50	3.4	24 / -	3 / -	1 / -	34.9	Mod. - Low	--	**High Fair**	Flatheaded mayflies (F), midges (F), damselflies (F,T)
Pike Run	7.56	4.6	23 / -	6 / -	0 / -	37.1	High	--	**High Fair**	*Rheotanytarsus* and *Polypedilum* midges (F), baetid mayflies (F), and hydropsychid caddisflies (F)
Pike Run	4.61	7.7	37 / -	9 / -	4 / -	40.5	Mod. - High	--	**G**	Hydropsychid caddisflies (F,MI), baetid mayflies (F,MI), *Rheotanytarsus* & *Polypedilum* midges (F), *Sphaerium* sp. (F)
Pike Run	0.84	12.8	33 / -	4 / -	2 / -	34.9	Mod. - High	--	**High Fair**	Baetid mayflies (F), hydropsychid & hydroptilid caddisflies (F), midges (F,MI,MT,T), *Argia* sp. (F)
Leatherwood Ditch – Ottawa River subwatershed **(HUC 040000704 05)**										
Leatherwood Ditch	0.48	12.7	41 / -	9 / -	5 / -	40.0	Mod. - High	--	**G**	Snail-cased and hydroptilid caddisflies (F,MI), tanytarsini & *Polypedilum* midges (F), hydropsychids (F,MI)
Sugar Creek subwatershed **(HUC 040000705 01)**										
Sugar Creek	26.0	6.7	33 / 33	5 / -	0 / -	36.4	Mod. - Low	--	**High Fair**	Hydropsychid caddisflies (F), midges (F,T), riffle beetles (F)
Sugar Creek	23.85	11.5	34 / 34	6 / -	1 / -	33.2	Mod. - Low	--	**High Fair**	Hydropsychid caddisflies (F), riffle beetles (F), flatheaded mayflies (F)
Sugar Creek	20.05	22.5	50 / -	11 / -	4 / -	36.1	Mod. - Low	--	**G**	Baetid mayflies (MI,F), hydropsychid caddisflies (F), midges (F,MI,MT,T)
Sugar Creek	18.24	26.1	47 / 61	12 / 12	5 / 5	34.9	Mod. – High / 1545	**26 X10**	**MG[ns]**	Midges (F,MI,MT,T), *Caenis* mayflies (F), flatheaded mayflies (F), *Hydra* sp. (F), aquatic worms (T)
Sugar Creek	13.50	30.0	44 / 61	12 / 13	7 / 9	40.0	Mod. – Low / 190	**44**	**VG**	Hydropsychid caddisflies (F,MI), riffle beetles (F), baetid mayflies (F,MI), *Stenacron* sp. (F)
Sugar Creek	8.55	44.7	46 / 55	13 / 14	8 / 8	38.2	Mod. – High / 1368	**40**	**G**	Bryozoa, hydropsychids (F,MI), baetid mayflies (F,MI), *Rheotanytarsus* & *Polypedilum* midges (F)
Sugar Creek[RR]	4.80	55.0	31 / 49	9 / 12	4 / 6	39.7	Mod. – High / 1642	**36**	**G**	Hydropsychid caddisflies (F,MI), baetid mayflies F,(MI), riffle beetles (F), midges (F,MT,T)
Sugar Creek[RR]	0.64	64.3	51 / 72	15 / 18	10 / 14	38.3	Low - Mod.	**36**	**G**	Hydropsychids (F,MI), *Petrophila* sp. (MI), baetid mayflies

River / ALU	RM	Drain. Area	Ql./Tot. Taxa	Ql./Tot. EPT	Sens. Taxa Qual./Total	QCTV[a]	Relative Density (# / ft.^{2})	ICI	Narr. Eval.	Predominant Populations (Tolerance Ratings)
							/ 536			(MI,F), flatheaded mayflies (F)
Rattlesnake Creek	1.74	6.1	30 / -	8 / -	1 / -	40.0	Mod. - High	--	G	Hydropsychids (F,MI), riffle beetles (F), flatheaded mayflies (F,MI)
Plum Creek subwatershed **(HUC 040000705 02)**										
Plum Creek	14.35	15.9	46 / -	9 / -	7 / -	35.9	Mod. - High	--	G	*Sphaerium* sp. fingernail clams (F), hydropsychids (F), midges (F, MI,T)
Plum Creek	12.95	18.2	12 / -	0 / -	0 / -	26.0	Mod. – Low	--	VP*	Midges (T), flatworms (F)
Plum Creek	12.14	18.7	11 / -	1 / -	0 / -	26.0	Low	--	VP*	Flatworms (F)
Plum Creek	8.12	22.0	33 / 42	3 / 3	0 / 0	34.3	Mod. / 892	14*	Low Fair*	Oligochaetes (T), hydropsychids (F), midges (F,MT,T)
Plum Creek	4.62	36.0	44 / 60	12 / 13	5 / 8	40.0	Mod./ 2567	44	VG	Hydropsychids (F,MI), midges (F,MI,MT,T), *Tricorythodes* sp. (MI)
Plum Creek	0.19	39.9	56 / -	9 / -	12 / -	40.0	Mod. - Low	--	G	Hydropsychids (F), midges (F,MI,MT,T), *Stenacron* sp. (F)
Sycamore Creek	0.8	10.6	35 / -	7 / -	1 / -	35.7	High	--	MG	Hydropsychids (F), *Helicopsyche borealis* (MI), *Caenis* sp. mayflies
UT to Sycamore Creek (@ RM 0.85)	0.26	5.6	28 / -	7 / -	2 / -	37.8	Mod. - Low	--	MG	Hydropsychids (F), midges (F,MT,T)
UT to Plum Creek (@ RM 7.30)	0.4	7.3	43 / -	7 / -	3 / -	34.6	Mod. - High	--	MG[ns]	Hydropsychids (F), leptocerid caddisflies (MI), *Berosus* beetles (MT)
Village of Kalida – Ottawa River subwatershed **(HUC 040000705 03)**										
UT to Ottawa River (@ RM 0.70)	0.4	14.1	26 / -	9 / -	4 / -	41.5	Mod. - Low	--	G	Baetid mayflies (MI,F), hydropsychids (F), flatheaded mayflies (F,MI)

Tolerance categories for taxa groups are parenthetically expressed: VT = Very Tolerant, T = Tolerant, MT = Moderately Tolerant, F = Facultative, MI = Moderately Intolerant, and I = Intolerant.

ICI = Invertebrate Community Index

-- Dashed lines indicate sites where quantitative data and ICI were not available due to small drainage area <20mi^2 (excluding reference sites), vandalism, desiccation, or some other disturbance of Hester Dendy artificial substrates (HDs).

EPT = total Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa richness.

Data codes: **X15** = current velocity >0.0 feet per second but < 0.3 fps. **X10** = Reservoir/lake Effect

RR Regional Reference site for ecoregion

ns Nonsignificant departure from ecoregional biocriterion (+ 4 pts.)

* Not in attainment of ALU biocriterion or narrative assessment performance expectations.

Hog Creek

Hog Creek is designated MWH east of the Hardin/Allen county line and typically had deeply entrenched, ditched channels with field drain tiles (Figure 104). Despite high diel respiration from excess nutrient enrichment which caused low DO exceedances, macroinvertebrate sampling at four sites within this reach were all reflective of the MWH use. Qualitative sampling from TR 85 (RM 13.42) and CR 65 (10.77) netted high fair narrative evaluations and met MWH performance criteria. Strong connections to groundwater ameliorated nutrient effects and organic inputs to the point that four to six EPT taxa and two mussel species were present within this upper reach (Tables 9 and 24). Quantitative samples from SR 235 (RM 8.72) and St. Paul Rd. (RM 6.6) exhibited increased aeration from rocky substrates in developed riffle/runs and produced identical ICI scores in the marginally good range (ICI = 32) (Figure 105). The macroinvertebrate community, however, was very enriched with >2,000/ft.^{2} relative density from NPS including tiled agricultural inputs that contributed to excess algae (Table 24). Facultative filterers (*Tanytarsus glabrescens gr*. and *Polypedilum flavum* midges with hydropsychid caddisflies) and a collector midge (*Dicrotendipes neomodestus*), which "thrives in areas containing high levels of nutrients and organic wastes", were the predominant organisms in this enriched reach (Simpson and Bode, 1980). These sites were downstream from Grass Creek, which drains Ada and its WWTP, and had maximum *E. coli* concentrations of >24,000 cfu/ 100 ml. The Hog Creek macroinvertebrate community in western Hardin County was still lacking baetid mayflies and had more heptageneid mayflies given the predominant rocky bottom substrates (Figure 105). Tolerant midges (including *Cricotopus (C). bicinctus*, *C. (C). tremulus gr*., *C. (I). sylvestris gr*., and *Polypedilum illinoense*) that can flourish in high nutrients and organic wastes with elevated pHs and/or high BODs still comprised 7.6% of the quantitative community sample.

Figure 104. Channelized conditions of Hog Creek (RM 13.42) in Hardin County, 2010.

Further downstream, the ICI results for Pevee Rd (RM 3.9) and Swaney Rd. (RM 0.1), within the WWH reach of Hog Creek, were in the exceptional range with scores of 46 and 48, respectively (Table 24). The stream habitat improved toward the mouth with numerous riffle/run /pool complexes and an island with a divided channel that formed two confluence points to Little Hog Creek as it formed the Ottawa River.

Even though all six sites in Hog Creek supported macroinvertebrate assemblages consistent with the designated ALUs, there was a marked difference between the diversity of sensitive taxa collected from the natural substrates within the MWH and WWH stream segments. Zero to four sensitive taxa were recorded in the upper, MWH section in Hardin County versus ten and fourteen taxa at the two WWH sites further downstream within Allen County. Nutrient enriched conditions persisted throughout the length of Hog Creek as the benthic total relative density downstream from Swaney Rd. (RM 0.1) was measured at 1,574 organisms/ft.^{2} (Table 24).

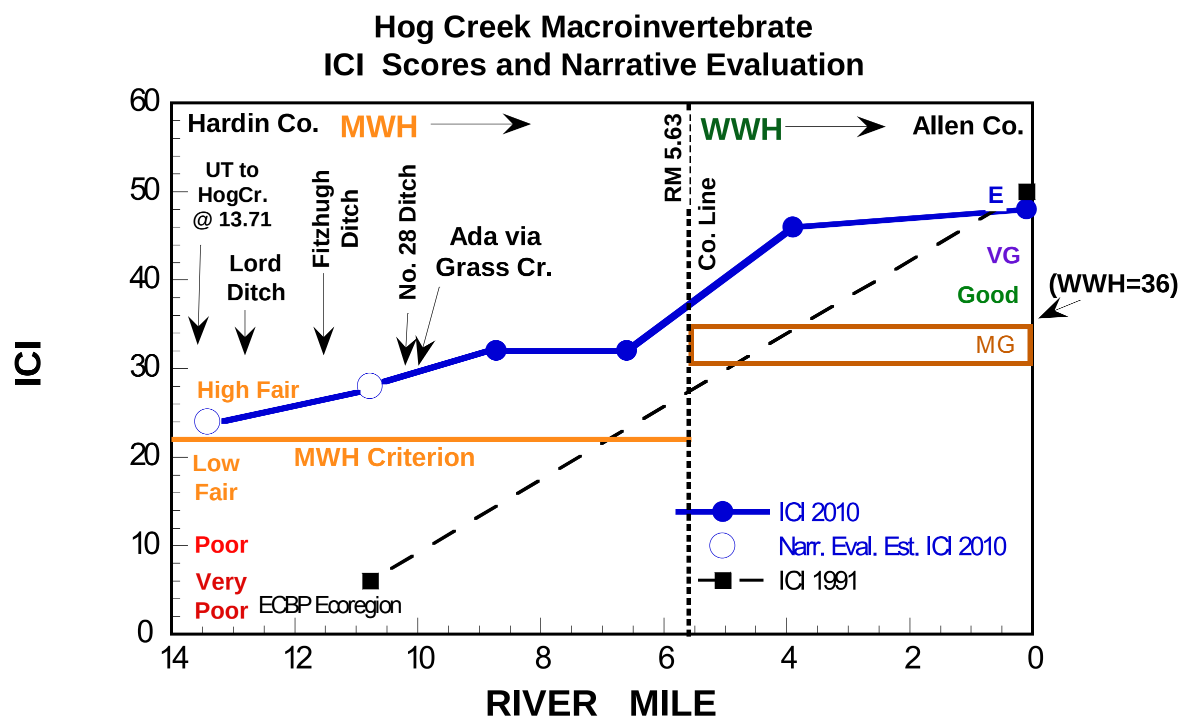

Figure 105. Macroinvertebrate community ICI scores in Hog Creek, 1991 – 2010.

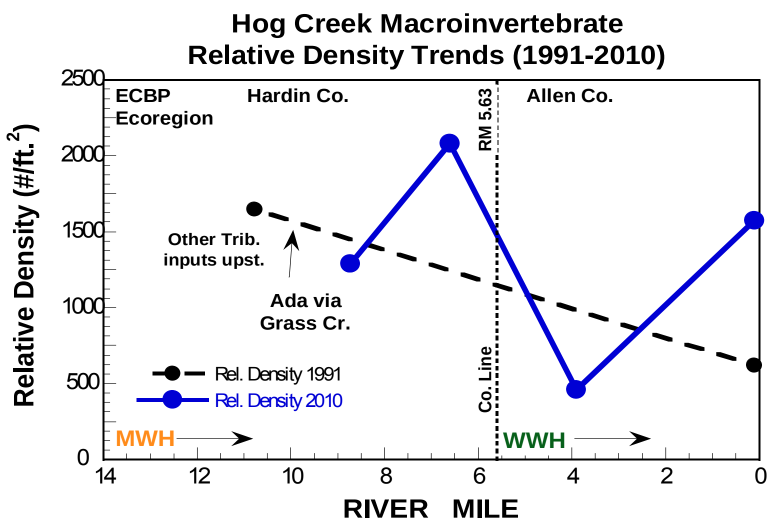

Figure 106. Community relative density trends for Hog Creek, 1991-2010.

Hog Creek Trends: 1991 - 2010

In 2010, the upstream Hog Creek sites within the MWH reach met the MWH biocriterion with high fair narrative evaluations and had double the total EPT taxa collected in contrast to an evaluation of very poor in 1991 at CR 65 (RM 10.8) which had a TISR measure of 70.5% for %organic/nutrient/DO tolerant taxa (Figures 98, 99 and 103). There were still water quality exceedances in Hog Creek and its tributaries and the macroinvertebrate community still indicated highly enriched conditions downstream in Hog Creek which negatively influenced water quality on the Ottawa River mainstem (Figure 106, Table 20).

Four tributaries to Hog Creek sampled in 2010 were recommended for the MWH use. The unnamed tributary to Hog Creek at RM 13.71, Fitzhugh Ditch, and No. 28 Ditch all met or the MWH use with high fair or fair ratings with *Caenis,* burrowing mayflies and midges among the common taxa collected (Table 24). A planned site location on Lord Ditch was not sampled due to a lack of water downstream from the site location in the streambed. These agricultural drainageway tributaries contributed intermittent low DOs and nutrient loads to Hog Creek (Table 6).

Grass Creek

Upstream from the Ada WWTP, Grass Creek at RM 2.57 met the MWH use with a high fair evaluation and five EPT taxa (Table 24). Downstream of Ada and the Ada WWTP, Grass Creek RM 1.2, a slight improvement in the macroinvertebrate community was noted as it exhibited marginally good condition and ten EPT taxa were collected (Table 24). A required plant performance evaluation issued in 2010 will hopefully lead to lower *E. coli* and ammonia load violations which had increased the organic and nutrient load from Grass Creek into Hog Creek downstream (Tables 9 and 10).

Little Hog Creek

Sampling results from Little Hog Creek were consistent with the WWH use and showed macroinvertebrate community condition improvement with increasing drainage area. The macroinvertebrate community at Pevee Rd. (RM 3.62), which had a drainage area of $12mi^2$, was in marginally good condition within a largely lentic pooled reach (Table 24). The stream was intermittent in this location, as dry riffle areas separated the pools. However, the pool sampled exhibited a strong connectivity to groundwater, as its temperature was recorded at 16.0^o C. The remaining sites further downstream had continuous surface flow and the number of EPT and filtering lotic taxa increased accordingly. Downstream from the Lafayette WWTP (RM 0.64), the benthic community did not appear significantly impacted and was narratively evaluated as good quality. Twelve EPT and eight sensitive taxa were collected with filterers *Rheotanytarsus* and hydropsychid caddisflies predominant (Table 24). Diversity increased downstream at SR 81 (RM 0.2), as there were 17 EPT and 12 sensitive taxa collected with the ICI in the exceptional range (ICI = 46). Though the macroinvertebrate community showed signs of enrichment from Lafayette and NPS inputs with a relative density of $1,516/ft.^2$, the high quality community indicated generally high quality water from Little Hog Creek contributed to the formation of the Ottawa River at the confluence with Hog Creek.

Mud Run

Mud Run, west and south of Ada in Hardin County, entered Little Hog Creek after flowing north and east into Allen County. Home sewage treatment systems in the area had a significant impact downstream Bluffton Bentley Road (RM 0.65) which resulted in failure of the macroinvertebrate community to attain WWH expectations. Septic solids had collected in pools and low dissolved oxygen exceedances were documented and were the likely result of the organic material in the stream (Table 6). A limited macroinvertebrate assemblage was collected, predominated by water boatmen (Corixidae) and midges, reflective of a low fair resource condition.

Unnamed Tributary to Little Hog Creek

The UT to Little Hog Creek at RM 1.15 at Bryn Mawr Ave. (RM 0.62), supported a good macroinvertebrate community. Forty-eight taxa were recorded including twelve EPT taxa with spiral-cased caddisflies (*Helicopsyche*) and midges predominant. The biota of the stream likely benefited from the cobble and gravel substrates with limited slit deposition.

Lost Creek

The macroinvertebrate community of Lost Creek improved in a downstream direction from Mumaugh Rd. (RM 3.56) to E. High St. (RM 0.3). Near Mumaugh Rd. (RM 3.56), the fair macroinvertebrate community reflected the MWH conditions of channelized reach which had little or no flow. Fingernail clams (*Sphaerium* sp.), lunged snails (*Physella* sp) and midges predominated and primarily reflected the MWH conditions, though there had been records of spills upstream between RMs 7 and 8.0 (used motor oil in May 2010 and hog manure -2004) (Appendix D). An increased number of *Chironomus (C.) decorus gr*. midges present could be indicative of the presence of some organic waste, though the soft sediments with sluggish and turbid stream reaches also represent their preferred habitat. Downstream near Fenway Drive (RM 1.7), the Lost Creek community was assessed as high fair quality in line with the channelized habitat conditions. There were some urban inputs including SSOs in stormwater and sump pump discharge from residences, however, with facultative mayflies predominant, the benthic community mainly reflected and met MWH biocriterion (Table 9, Appendix C).

Lost Creek at E. High St. (RM 0.30) possessed typical stream habitat features associated with WWH streams than the two sites in the modified reach upstream. Consequently, the macroinvertebrate community was substantially improved and met WWH performance criteria. Forty-four taxa and 10 EPT taxa were recorded including two mussel species: *Anodontoides ferussacianus* (cyllindrical papershell) and *Strophitus undulatus undulatus* (creeper). Seven sensitive taxa were recorded at RM 0.30, while none were collected at RMs 3.56 and 1.70. Eleven tolerant taxa were present at RM 0.3 (25%) and could be related to more rare, sporadic small upstream spills, SSO releases, and other urban stormwater inputs (Appendices C and D).

Lost Creek Trends: 1988 - 2010

In 1988, the channelized portions of Lost Creek received urban and stormwater inputs that negatively influenced water quality, as there were high numbers of tolerant taxa at all sample sites with no sensitive taxa collected (Figure 107). Assessments ranged from poor to high fair in 1988, indicating only partial attainment, and rose to full attainment in 2010 with high fair quality in the MWH upper reach and good quality in the lower WWH reach. With improvements, EPT taxa had doubled at the mouth site from five in 1988 to ten in 2010. Though reduced from the 56% found in 1988, the persistently high number of tolerant taxa (25%) at E. High St. (RM 0.3) was likely still related to more rare, sporadic small upstream spills, SSO releases, and other urban stormwater inputs (Appendices C and D).

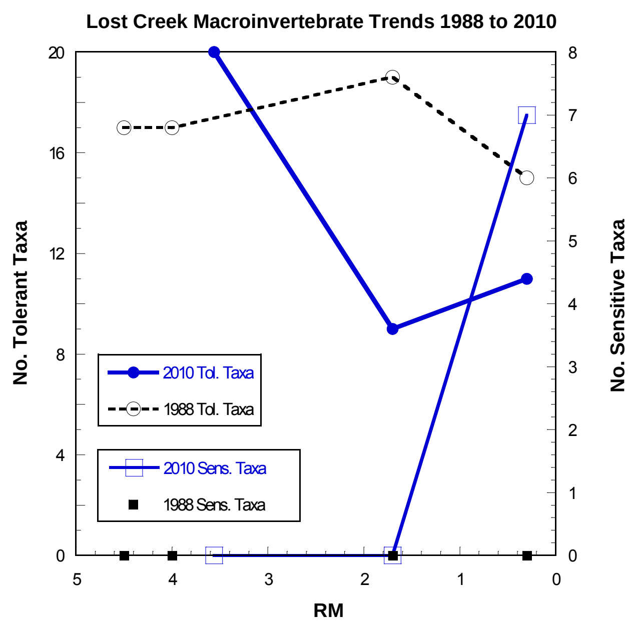

Figure 107. Lost Creek macroinvertebrate trends of tolerant and sensitive taxa, 1988 and 2010.

Unnamed Trib. to Lost Creek at RM 1.15

The UT to Lost Creek at RM 1.15 was channelized and partially contained in a culvert upstream from RM 0.62 at I-71 and SR 309 and drained urban and industrial areas of southeast Lima.

Documented spills and fish kills of fermented corn syrup/ethanol and detergent waste from upstream sources occurred in 2008 (Appendix D). The stream supported a very poor macroinvertebrate community. Just fifteen taxa were collected in low numbers and included only one EPT taxa. This result suggested periodic, toxic, urban runoff likely involving industrial and urban storm sewers, and possibly SSOs from the surrounding watershed which is a mix of residential and light industrial areas (Table 10, Appendices C and D). After sampling was completed, recent stream channelization was later observed through the golf course downstream.

Zurmehly Creek

Zurmehly Creek possessed physical habitat attributes that were consistent with the designated WWH use. However, the macroinvertebrate community predominated by facultative and pollution tolerant taxa. Four EPT taxa were collected but no sensitive taxa were recorded. Overall, the community rated a high fair evaluation which did not meet the WWH biocriterion. Much of the watershed is industrialized and likely is subject to storm event scouring and sedimentation. In May 2010 there was a documented diesel fuel spill in the tributary to Zurmehly Creek at RM 1.19 that leaked 30,000 gallons to a retention pond with an unspecified amount escaping. Other documented spills concerning fuel oil and petroleum products in 2001 indicated intermittent spill incidents occur which could continue to chronically impact and depress the benthic community quality (Appendix D).

Little Ottawa River

The Little Ottawa River was sampled at four locations in 2010 with mixed quality performance (Table 24). Upstream from Old S. Dixie Highway (RM 5.5) the stream was a series of interstitial pools with cooler temperatures. Low fair conditions did not meet the MWH biocriterion, as the macroinvertebrate community was limited by habitat and inputs from a small upstream package plant serving Indian Village MHP and other NPS stormwater runoff. According to one landowner, additional impacts to water quality may have occurred from a small derailment within the recent past and a leaking sewage pipe that was recently fixed.

At Fort Shawnee Rd. (RM 4.5), the benthic community was impacted by urban stormwater runoff. Black septic solids had collected near the stormwater pipe outlet by the bridge. Local on-site home treatment systems, stormwater runoff inputs, and occasionally Cridersville WWTP effluent inputs from a tributary upstream were the likely sources of the negative impact here on the Little Ottawa River. High fair conditions with only five EPT taxa and no sensitive taxa reflected the periodic impacts that caused non-attainment of the WWH biocriterion.

Gradual improvement from past channel maintenance activity was noted in the Little Ottawa River as impacts from past channel maintenance appeared to have ameliorated over time. Macroinvertebrate communities at Zurmehly Rd. (RM 1.85) and upstream Ft. Amanda Rd. (RM 0.03) were marginally good and good, respectively, which met the WWH biocriterion. The site at Zurmehly Road (RM 1.85) was strictly pool habitat which limited the lotic community component. Pollution sensitive and EPT taxa, 9 and 14, respectively, were well represented near the mouth of the Little Ottawa River (RM 0.03) with good quality community performance despite sporadic SSO releases from stormwater discharges upstream (Table 24).

Little Ottawa River Trends: 1996 - 2010

The combination of less stormwater runoff, and fewer SSO and WWTP episodes decreased the volume and frequency of toxic impacts and allowed more stability in the benthic community in the Little Ottawa River near the mouth (RM 0.3) compared to a 1996 sample (Appendices C and D). Sensitive taxa improved from one in 1996 to nine in 2010, and the number of EPT taxa increased from 8 in 1996 to 14 in 2010. Marginally good conditions in 1996 improved to good quality in the 2010 survey and were a reflection of infrastructural improvements.

Honey Run

The Honey Creek macroinvertebrate community at Cremeans Rd (RM 3.58) was severely limited due to agricultural related low DO exceedances and relatively recent channel maintenance. These impacts restricted the development of more favorable taxa diversity with the community quality assessed as low fair and thereby not adequate for minimum MWH expectations. Just two EPT taxa were collected and pollution tolerant taxa predominated among the 23 total taxa recorded (Table 24).

Comparatively, good community structure commensurate with better habitat was recorded at Wapak Rd. (RM 1.1) on Honey Creek. Both riparian and instream habitat attributes were improved though excess sedimentation was noted. Ten EPT taxa were collected and the community was consistent with attainment expectations for a WWH stream in the HELP ecoregion.

Dug Run

Dug Run produced a good assortment of macroinvertebrate taxa owing to the relatively good habitat at Dutch Hollow Rd. (RM 0.19) that included a variety of substrate and flow conditions. Nutrient inputs from the surrounding agricultural activities and American #2 WWTP increased community density and had facultative baetid mayflies and filtering midges (*Polypedilum* spp. and tanytarsini midges) predominant at a moderate to high population density in the riffle/run habitat.

Beaver Run

Forty-one taxa were collected on Beaver Run at Dutch Hollow Rd. (RM 0.51). Overall, the macroinvertebrate community was rated in good condition and met WWH expectations. A wide, thick, wooded riparian corridor decreased NPS runoff inputs and promoted stream health. Subsequently, the number of tolerant taxa was lower with a high QCTV of 41.5 (Table 24). Beaver Run, like many other streams in the HELP ecoregion, had been historically modified to promote drainage and contained a significant amount of glide habitat. Incremental recovery to more natural stream morphology with more riffle/runs and deeper pools was slowly ongoing.

Pike Run

The four sites sampled qualitatively on Pike Run had results consistent with the MWH use. The macroinvertebrate community was rated high fair both upstream (RM 8.50) and downstream (RM 7.56) from the American Bath WWTP despite recent upstream channel maintenance including tree removal. Downstream from the American Bath WWTP (RM 7.56) nutrient enrichment contributed to the increased riffle density of the macroinvertebrate community riffle density from moderate – low density upstream to high at this location. Primarily, facultative midges with baetid mayflies and hydropsychid caddisflies were the predominant organisms (Table 24). Additional improvement in Pike Run was indicated at State Rd. (RM 4.61) where nine EPT taxa were recorded, and moderately intolerant species of hydropsychid caddisfly and baetid mayfly taxa were present. EPT and sensitive taxa totals improved (QCTV=40.5) despite significant sand depositional bedload (Table 24).

Macroinvertebrate community condition in Pike Run declined significantly in Gomer at Lima Gomer Rd. (RM 0.84). Black sludge solids were noted at outlets and high *E. coli* concentrations (max. = 7,700 cfu/ml with mean of 3,144 cfu/ml) were documented as exceedances of the PCR criterion (Table 10). As the result of septic inputs from the unsewered community of Gomer, total EPT and sensitive taxa diversity was reduced by 50% or more (Table 24). There was still four EPT and two sensitive taxa present with facultative baetid mayflies and *Polypedilum flavum* and *Dicrotendipes neomodestus* midges predominant at moderate-high densities (Table 24). A narrative evaluation of high fair quality for the macroinvertebrate community still minimally met the MWH criterion despite these issues.

Pike Run Trends: 1996 - 2010

Pike Run macroinvertebrate community quality improved over time with full attainment in 2010 compared to partial attainment in 1996. The number of EPT taxa improved downstream from American Bath WWTP reflecting the improvements to the plant since 1996 (Figure 108). Similar EPT taxa were collected in the recovery reach downstream from Lima at RM 4.61. In Gomer, sampling in 1996 was slightly more downstream and more EPT taxa were collected. The Lima inputs, NPS agricultural inputs, and Gomer inputs in 1996 caused the number of tolerant taxa (23) to be twice the total in 2010 (11) (Figure 108). The number of tolerant taxa was lower overall in 2010 due to American Bath WWTP improvements and riparian cover improvement (Figure 108). All QCTV values in 2010 were 2.1 to 5.7 points higher than 1996 with a maximum value of 40.5 at State Rd. (RM 4.61) (Table 24).

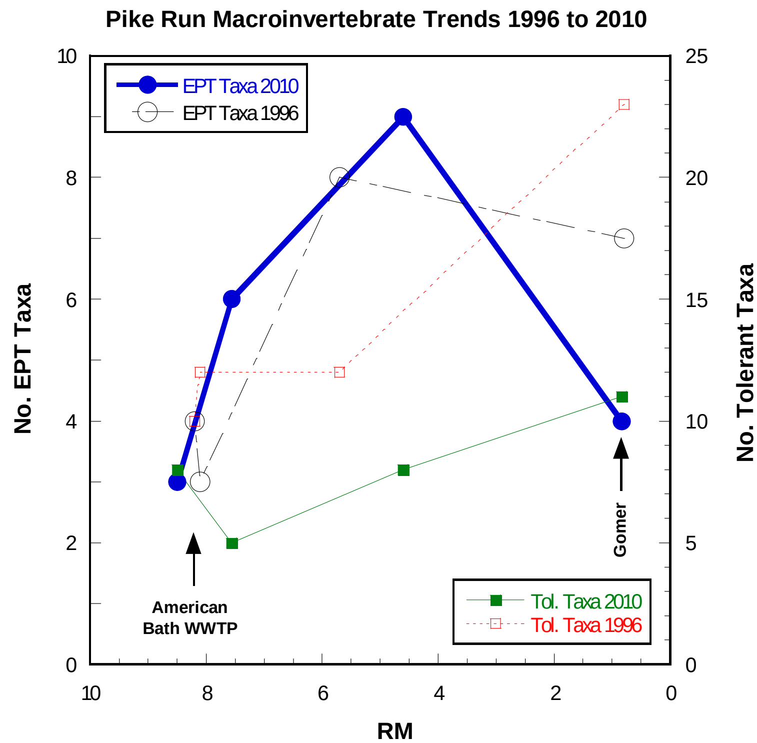

Figure 108. Number of EPT and tolerant taxa in Pike Run, 1996-2010.

Leatherwood Ditch

Leatherwood Ditch was typical of many HELP ecoregion streams in that it had been historically channelized down to the hardpan clay and agricultural nutrients entered the stream via drainage tiles. As a result, filamentous algae were present in areas that lacked a shaded riparian corridor. There was one DO exceedance that indicated nutrient enrichment and occasional low diel DOs may occur at State Rd. (RM 0.48) though it appeared that adequate DO levels were maintained by the presence of 41 macroinvertebrate taxa, including nine EPT taxa. A high

QCTV of 40.0 was recorded for the site and caddisflies (*Helicopsyche borealis* and *Hydroptila* sp.) were the predominant taxa along with facultative midges and hydropsychids in the runs and few riffles. The community relative density was moderately high in response to nutrient inputs but overall, the macroinvertebrate community was in good condition and met the HELP WWH biocriterion (Table 6, 24).

Leatherwood Ditch Trends: 1996 – 2010

In 1996, the macroinvertebrate community in Leatherwood Ditch (RM 1.6) was sampled near CR U and TR 19T. The macroinvertebrate community received an ICI of 34 which met the HELP WWH biocriterion. There were similar total EPT taxa between 1996 and 2010, and cylindrical papershell mussels were present during both surveys. There were, however, 60% less sensitive and 60% more tolerant taxa with a much lower QCTV value in 1996 compared to 2010 (33.3 vs. 40.0, respectively). So there has been some overall community quality improvement over time.

Sugar Creek

Eight sites in the agricultural dominated Sugar Creek watershed were sampled. The upper three sample sites in the ECBP ecoregion were recommended for the MWH aquatic life use designation with QHEIs from 44.3 to 51 and no or minimal WWH attributes reflective of the surrounding agricultural land use (Table 17, Figures 69 and 80). The upper two locations, Napoleon Rd. (RM 26.0) and Thayer Rd. (RM 23.85) supported modest EPT diversity and macroinvertebrate communities in high fair quality condition despite at least one DO exceedance from decaying grass and algae. Macroinvertebrate community recovery from past channelization had occurred at Stewart Rd (RM 20.05) as facultative hydropsychids and baetids were predominant with an increase in EPT taxa to 11 and sensitive taxa present including three margin baetids. The narratively good benthic community benefited from the better riparian corridor with clay and gravels as the main bottom substrates with a small amount of scattered rubble.

The last ECBP site on Sugar Creek was downstream Bluelick Rd. (RM 18.24) and was just downstream from an old small dam that impounded Sugar Creek. Eutrophication in the sand/sediment filled shallow impoundment upstream resulted in only a marginally good macroinvertebrate benthic assemblage downstream from the dam. The relative density increased to >1,500 organisms/ft.^{2} as transplanted lentic taxa, like *Hydra* and *Glyptotendipes* midges, competed for predominance with heptageneid and *Caenis* mayflies. Green suspended algae were noted in the channel downstream from the dam (Figure 109). This dam, if there is no present use such as for water removal or pipe crossing, should be considered for removal to further improve Sugar Creek water quality. Currently, Sugar Creek was shallow, silty and wide and lacked a clearly defined riffle downstream from the impoundment (Figure 109). Downstream in the HELP ecoregion (< RM 17.0) there were four sample sites on Sugar Creek from upstream of Old US 30 (RM 13.5) to CR 16-O (RM 0.64). All four remaining sites supported good to very good macroinvertebrate communities which met the WWH biocriterion.

The most upstream site at Old Lincoln Highway (RM 13.5) received an ICI of 44 and reflected improved macroinvertebrate community quality. Less than five miles downstream from the impoundment, the macroinvertebrate community relative density was low (190/ft.^{2}) and reflected

Figure 109. Sugar Creek near Bluelick Rd. (RM 18.24). The picture on the left depicts the green suspended algae present downstream of the dam while the picture on the right shows the lack of a well-developed riffle downstream of the dam.

the stable corridors with efficient nutrient sequestration and assimilation. Mayflies constituted >75% of the quantitative sample with a low 1.6% tolerant organisms. The facultative and sensitive mayflies (baetids and heptageneids), hydropsychids, and riffle beetles were predominant in the qualitative samples. The QCTV was a 40.0, the highest for all Sugar Creek benthic samples in this reach (RM 13.5) (Table 24).

Four miles downstream, immediately adjacent to Vaughnsville and SR 115 (RM 8.55), the macroinvertebrate ICI score of 40 (good) was slightly lower than upstream community quality. Agricultural NPS inputs from Sugar Creek above, Rattlesnake Creek, and stormwater runoff from unsewered Vaughnsville definitely added excess nutrients and *E. coli* (Table 10). There were two low DO exceedances in Sugar Creek at Vaughnsville (SR 115), likely from excess nutrient enrichment (Table 6). Besides the large masses of water willow present as evidence to the utilization of available instream nutrients, the benthic community relative density increased dramatically from 190 to 1368/ft.^{2} at RM 8.55 (Table 24). Bryozoa, facultative baetids, hydropsychids, and midges (particularly *Polypedilum flavum*) were the predominant organisms, similar to other enriched benthic communities. While there were similar EPT and sensitive taxa compared to the upstream reach, there were also a lower number of total taxa and a lower QCTV (Table 24).

The next downstream site, CR Q (RM 4.8), appeared similar in regards to excess nutrient enrichment issues. However, these issues were magnified by less habitat recovery and stream development due to intact historic levees. Likely, there were still instances of sporadic low diel DO concentrations (Table 6). Less mayfly, EPT, and sensitive taxa were collected, as the ICI score decreased 36 (good). Predominant taxa were similar (except Bryozoa) with an increased relative density of 1642/ft.^{2} at this HELP ecoregion reference site (Table 24).

The Sugar Creek site near the mouth at CR 16-O (RM 0.64), which was also a HELP reference site, received an ICI of 36. The improved riparian corridor facilitated nutrient sequestration and provided increased shading which combined with the loss of distinct levees and some limited but defined habitat development (riffle/run and margins) provided overall improved conditions for the macroinvertebrate community (Figure 110). Despite sporadic diel DO issues, the highest number of EPT, sensitive, and total taxa were collected at this lower Sugar Creek reach (Table 6). Among the sensitive taxa present in the riffle/runs were *Acerpenna* and *Procloeon* spp. mayflies and *Chimarra* caddisflies. In addition, *Protoptila* sp. caddisflies were collected for the first time in Sugar Creek.

Figure 110. Sugar Creek near the mouth at CR 16-O (RM 0.64) (upstream and downstream view)

Sugar Creek Trends: 1984 – 2010

Historic macroinvertebrate sample sites were collected in the lower reaches of Sugar Creek in 1984, 1996, and 1997. At CR Q (RM 4.9), the 1996 sample had more mayfly taxa diversity, mayfly predominance (~50%), sensitive taxa, and less dipteran density (lower relative density) with an ICI score of 48 (exceptional), which dropped 12 points to 36 in 2010. The 2010 benthic community surveyed at RM 4.8 had significantly less total taxa and sensitive taxa collected and was nutrient enriched (high relative density at ~1640 organisms/ft.^{2}) with low DO exceedances (Tables 6, 24).

Sugar Creek macroinvertebrate community samples were collected at RM 0.64/0.70 in 1984, 1997, and 2010. The 2010 community sample at RM 0.70 improved with significantly more EPT taxa, six in 1984 versus 15 in 2010, though the ICI improved by just four points, from a 32 in 1984 to a 36 in 2010. The 1997 sample contained a greater population of mayflies and caddisflies with lower dipteran densities, and the ICI of 44 (very good) scored eight points better than the ICI score of 36 in 2010 (Table 1). The general trend in the macroinvertebrate community in Sugar Creek was continued attainment in spite of continued nutrient enrichment and low diel DOs dampening community quality improvements.

Rattlesnake Creek

Rattlesnake Creek is a historically channelized headwater tributary to Sugar Creek. Partial recovery from past channel maintenance allowed partial increased habitat diversity despite sedimentation. Rocky substrates from armored banks and fragmented shading from a partial wooded riparian corridor increased the EPT taxa total to include the sensitive heptageneid, *Leucrocuta* sp. The macroinvertebrate community, enriched from NPS nutrients, had a high relative density with hydropsychids, heptageneids, and riffle beetles predominant (Tables 6 and 24). Qualitative sampling produced eight EPT taxa and the macroinvertebrate community was reflective of reasonably good water quality which met WWH expectations.

Plum Creek

Plum Creek, a HELP stream on county maintenance in Putnam County, was sampled at six locations from upstream Columbus Grove to the mouth (Table 24). The macroinvertebrate community in Plum Creek was in relatively good condition at TR 11-R (RM 14.35) despite historic maintenance (Table 17). Forty-six taxa were collected and the community was described narratively as good. Water quality, however, declined precipitously within the village of Columbus Grove at Wayne St. (RM 12.95) and downstream from the Columbus Grove WWTP (RM 12.14). Qualitative sampling produced just 12 and 11 taxa at RMs 12.95 and 12.14, respectively and reflected a very poor resource condition. Septic black solids, apparently from CSO discharges, were present at Wayne St. (RM 12.95) upstream from the Columbus Grove WWTP. *E. coli* violations and a toxic ammonia concentration of 7.92 mg/l were documented downstream from Columbus Grove and the CSOs (Tables 9 and 10). A fish kill was reported on 8/3/10 in Columbus Grove. Documented low DO exceedances occurred at RMs 14.92, 12.14, and 0.19 and masses of algae mats downstream from the Columbus Grove WWTP (RM 12.14) were additional evidence of excess nutrient inputs. The macroinvertebrate community was still impaired four more miles downstream at TR O (RM 8.12) with an ICI value of 14. Agricultural nutrient inputs and channelization with large, unstable, sand bedload movement likely contributed to the inhibited recovery at TR O (RM 8.12).

Water quality and benthic community quality were markedly improved at RE M-10 (RM 4.62) despite maintained channel conditions with only occasional macrophytes and rocky substrates present (Table 17, Figure 99). The ICI increased to 44 (very good) and had the most EPT taxa collected on Plum Creek (Figure 111, Table 24). The improved habitat downstream from Kalida near SR 114 (RM 0.19) contributed to the good macroinvertebrate community which included twelve sensitive and nine EPT taxa, and 56 total taxa collected (Tables 17 and 24).

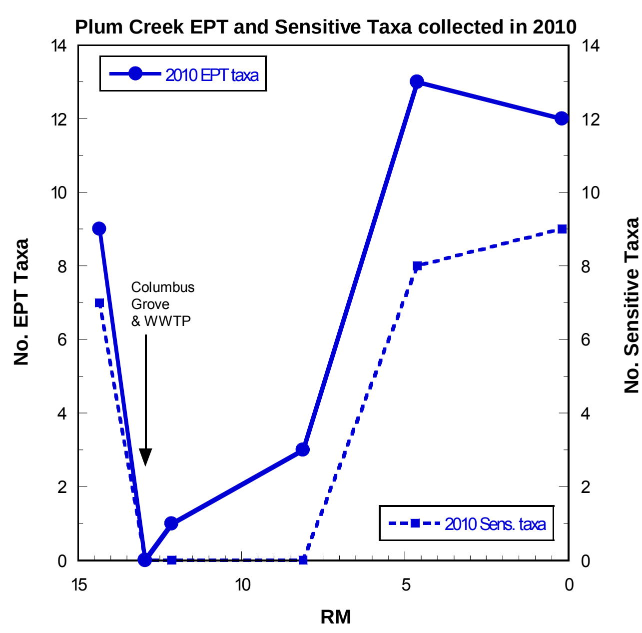

Figure 111. Number of sensitive and EPT taxa collected in Plum Creek, 2010.

Plum Creek Trends: 1996 – 2010

Plum Creek was sampled in 1996 and 2010 at similar locations (Figure 112). Columbus Grove CSOs were issues since before 1996, but the WWTP was operating more efficiently during the 1996 survey (Ohio EPA 1998). Benthic community quality was narratively marginally good in 1996 downstream from Columbus Grove and met the HELP ecoregion WWH biocriterion downstream to the mouth (Figure 112). However, in 2010, recovery from the negative influence of Columbus Grove did not occur until TR M-10 (RM 4.62), several miles further downstream than the recovery noted in 1996. (Figure 112, Appendices A, C and D, Table 6).

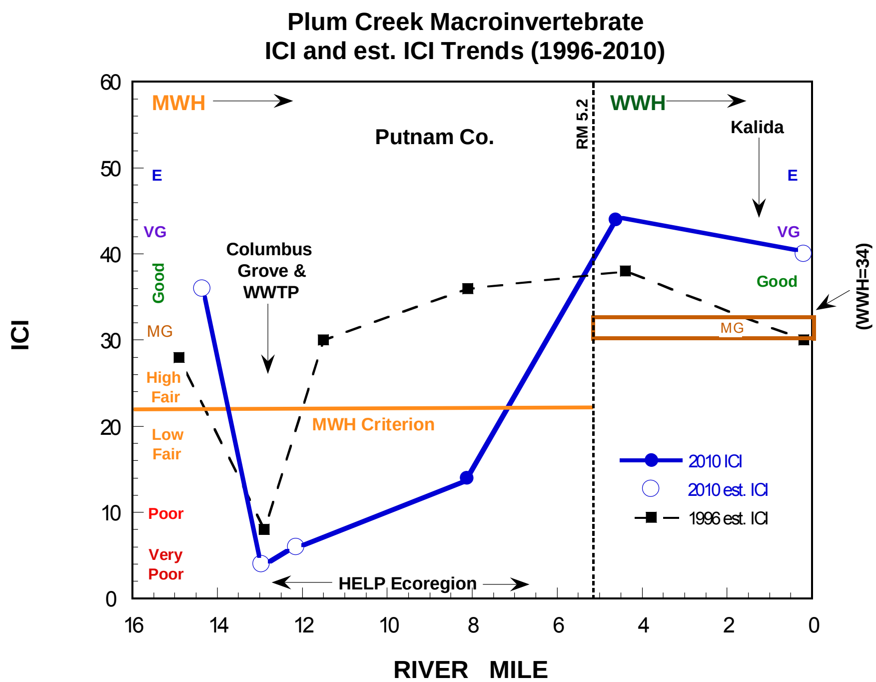

Figure 112. Plum Creek ICI scores over time, 1996 – 2010.

A significant decrease in macroinvertebrate community quality expressed by a loss of sensitive taxa and lower ICI occurred downstream from Kalida (RM 0.20) in 1996 (Figure 112). The source(s) were likely a combination of NPS agriculture inputs and Kalida stormwater runoff. In 1996, the sensitive / tolerant taxa ratio (S/T) was 0.15 (low), and the QCTV of 34.9 indicated decreased quality (Table 24). The benthic community structure in 2010 was similar upstream and downstream from Kalida, as a QCTV of 40.0 was documented at both sites (RMs 4.62 and RM 0.19) and communities were narratively very good (RM 4.62) and good (RM 0.19). Therefore, little discernible effect was evident in Plum Creek from Kalida in 2010 in contrast to 1996 (Figure 112).

Tributary to Plum Creek at RM 7.30

The tributary to Plum Creek at RM 7.30 had been ditched to facilitate drainage and had only partially recovered habitat features (QHEI=35.3). Despite localized sedimentation, sufficient gravel substrates with macrophytes/grass were present to collect seven EPT taxa with hydropsychid and leptocerid caddisflies predominant at higher densities. This HELP WWH stream produced a marginally good macroinvertebrate community that minimally met the WWH biocriterion.

Other Tributaries to Plum Creek

Sycamore Creek (RM 0.8) and the unnamed tributary to Sycamore Creek at RM 0.85 (RM 0.26) were both channelized headwater streams which were a part of the Plum Creek headwaters.

Nearly all habitats were limited throughout the Plum Creek watershed with direct channelization and related hydromodification to facilitate drainage. The effects of these activities appeared especially acute here, as most sites were deeply entrenched with minimal channel development (Table 17). Substrates were typically a mix of gravel, silt, and clay. Both Sycamore Creek subwatershed tributaries were sampled and produced similar macroinvertebrate communities reflective of the surrounding agricultural practices (Table 6). Rocky substrates and macrophytes were present in sufficient amounts for seven EPT taxa to be collected at both sites. Overall, the benthic communities were in marginally good condition and met the MWH biocriterion.

Tributary to Ottawa River at RM 0.7

The unnamed tributary to the Ottawa River at RM 0.70 was typical of many small streams in the watershed in that past channelization had limited habitat diversity and altered the hydrology of the waterway (Figures 92 and 67, Table 17). Over time, some recovery had occurred (QHEI = 64.3), and habitat and water quality were sufficient to support a macroinvertebrate community condition that met WWH expectations despite occasional low DOs (Table 6). Rocky substrates supported diversity while entrenched conditions limited pool depths (Table 17). Most importantly, small riffles continued flowing between pools. These riffles contained sensitive *Isonychia* mayflies and *Petrophila* moth larvae, which are indicative of sustained continuous flow with more rigorous flows previously present. Hydropsychids and baetids were predominant in the riffle with heptageneids predominant in high density in the pools (Table 24). The macroinvertebrate assemblage contained nine EPT and four sensitive taxa (Table 24). Taken as a whole, the macroinvertebrate sample reflected relatively good quality conditions in 2010 and met the HELP ecoregion WWH biocriterion.

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