Biological and Water Quality Study of Tenmile Creek and the Ottawa River, 2011

Fulton and Lucas Counties, Ohio

Ohio EPA Technical Report EAS/ 2014-06-06

Division of Surface Water
January 27, 2015

Biological and Water Quality Study of Tenmile Creek and the Ottawa River, 2011

Fulton and Lucas Counties, Ohio

Ohio EPA Technical Report /EAS 2014-06-06

January 27, 2015

Prepared by

State of Ohio Environmental Protection Agency
Division of Surface Water
Lazarus Government Center
50 West Town Street, Suite 700
Mail to:
P.O. Box 1049, Columbus, Ohio 43216-1049

Northwest District Office
347 North Dunbridge Road
Bowling Green, Ohio 43402

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

John R. Kasich
Governor, State of Ohio

Craig W. Butler
Director, Ohio Environmental Protection Agency

CONTENTS

A companion document with supplemental information and data appendix tables is available.

Cover illustration: Tenmile Creek at Fulton Lucas County Line Road, RM 15.0.

LIST OF FIGURES

LIST OF TABLES

Summary

Overabundant fine silty clay sediment degrades water quality everywhere in the Tenmile Creek and Ottawa River study area. In compliance with the federal Clean Water Act (CWA), 12 of 33 (36%) sample locations met the fishable goal and 3 of 14 (21%) sites attained the swimmable mark within the 2011 Tenmile Creek and Ottawa River study area. Fair water resource quality was common across the basin (Figures 1-2, Tables 1-2).

Introduction

To determine the beneficial use attainment status of streams relevant to Ohio's Water Quality Standards (WQS), ambient biological, water column chemical, sediment, and bacteriological sampling was conducted in the Tenmile Creek and Ottawa River basins from March to October 2011 (Tables 1-2, Figures 1-2). The study area included Tenmile Creek from its origin above Metamora downstream to its juncture with the Ottawa River in Sylvania (81 mi^2). The study area continued down the Ottawa River to the reach where Lake Erie backwater is encountered near Monroe Street in Toledo (155 mi^2). Sampling was conducted on notable tributaries including Prairie Ditch (17.6 mi^2), North Tenmile Creek (42 mi^2, 1.1 mi^2 within Ohio), and Heldman Ditch (21 mi^2). Sites within the direct Lake Erie tributary subbasins, Halfway Creek (18.6 mi^2 within Ohio) and Detwiler Ditch (6.5 mi^2), were also assessed. Additionally, the survey included the small portion of Bear Creek near Lyons within Ohio (23 mi^2). This River Raisin tributary flows into Michigan. Altogether, 36 (38 including Olander Lake) monitoring locations were encompassed by the 225 mi^2 study area. Some locations were situated specifically to assess performance of National Pollution Discharge Elimination System (NPDES) permitted entities within the study area (Tables 2-3).

Ohio EPA characterizes Assessment Units (AUs) based on USGS 12 digit Hydrologic Unit Codes (HUC 12s) for Integrated Report (IR) purposes. The Tenmile Creek and Ottawa River study area included 11 AUs. To facilitate cross reference, the corresponding HUC number is provided in addition to other site descriptors within tables or other appropriate contexts throughout this document. Otherwise, summary information and assessments will be according to stream names. The aquatic life use attainment status of Bear Creek is followed by similar discussion for Ten Mile Creek and then for the Ottawa River. Tributary streams are likewise presented in a west to east arrangement or according to their successive downstream confluences.

Specific objectives of this evaluation were to:

- monitor and assess aquatic life beneficial use status based on the chemical, physical and biological integrity of the streams within the 2011 Tenmile Creek and Ottawa River study area;

- characterize the consequences of various land uses on water resource quality within the Tenmile Creek and Ottawa River watershed;

- evaluate the potential influence of the Lyons and Metamora wastewater treatment plants (WWTPs) and other small discharges within the Tenmile Creek and Ottawa River watershed;

- evaluate the potential impacts from industrial (Hanson Aggregates) and commercial discharges, spills, nonpoint source pollution (NPS), and habitat alterations (including removal of two Ottawa River low head dams) on the receiving streams;

- identify the relative levels of organic, inorganic, and nutrient parameters in the sediments and surface water,

- determine recreation beneficial use status,

- compare present results with historical conditions, and

- determine the attainment status of the current designated aquatic life and recreation beneficial uses and recommend changes where appropriate.

Table 1. List of sampling locations and sample types for the Tenmile Creek and Ottawa River study area, 2011.

Location	RM	Site #	Sample Types	Rationale / Notes
Bear Creek				
Fulton CR 10	12.98	P11S24	1x Q C_N	Ust. Lyons WWTP
SR 120	11.56	P11S23	2x HD C_N *Ec*	Dst. Lyons WWTP
Fulton CR 7	8.44	301452	2x HD C_N *Ec*	Ohio / Michigan Border
Tenmile Creek				
CR T	18.25	301445	1x Q C_N	
SR 64	16.03	P11S15	1x Q C_N D	Ust. Metamora WWTP
Fulton CR 1	15.00	301446	2x HD C_N D	Dst. Metamora WWTP
Kilburn Road	9.17	P11K65	2x HD C_N D *Ec*	Dst. Agricultural area
Herr Road	**5.94**	**P11S76**	**2x HD C D Cl_A *Ec* S**	**Ust. Hanson Aggregates**
Brint Road	2.97	P11K64	2x HD C O S D	Dst. Hanson Aggregates
Silica Drive	0.47	P11K63	2x HD C *Ec*	Dst. Highland Meadows CC
Ottawa River				
Harroun Road	19.50	301440	2x HD T C O D *Ec* S	Ust. Miakonda impoundment
Sylvania Avenue	16.84	301441	2x HD T *Ec* S	Access via Camp Miakonda
Central Avenue	15.05	P11P35	*Ec* S	Park at Epworth Church
Edgehill Road	14.42	301442	2x HD T C D S	
Talmadge Road	13.16	-	S	
Bancroft Road	12.21	P11S51	2x HD	Ust. historic dam (11/07)
Ust. Secor Dam	11.80	204346	2x HD T S	In former pool
Secor Avenue	11.67	P11K59	2x HD	Dst. historic dam, Ust. UT 319
Stadium Drive	**11.15**	**P11S74**	**2x HD C O D Cl_A *Ec***	**USGS Gage #04177000**
Douglas Avenue	10.86	301443	2x HD S	Dst. UT 319 project
Monroe Street	9.25	301444	2x HD T C D S	Jermain Park from South Cove
Prairie Ditch				
Tupelo Way	1.41	301447	1x Q C_N *Ec*	Secor Metropark
Central Avenue	0.30		1x Q C_N	Ust. Tenmile C confluence
North Tenmile Creek				
Monroe Street	0.12	P11S77	1x Q C D *Ec*	Ohio / Michigan Border
Lake Olander				
Sylvania Avenue		204646	T C	Heath Ditch RM 0.3
Heldman Ditch				
Hill Avenue	2.72	P11S93	1x Q C	Mixed land use
Edgevale Road	0.15	P11S85	1x Q C D	Mixed land use
Zink Ditch				
Dorr Street	0.70		1x Q	Dst. subdivision growth
Hill Ditch				
Carriage Drive	2.57	301450	1x Q	Ust. Botanical impoundment
Reynolds Road	2.11	P11K61	1x Q C	Dst. Botanical impoundment

Location	RM	Site #	Sample Types	Rationale / Notes
Shantee Creek				
Lewis Avenue	3.10	P11S96	1x Q C	Unknown discharge
Stickney Avenue	0.70	P11S60	1x Q C O D S	Dst. Omni Source / E.I. Dupont
Silver Creek				
Lewis Avenue	4.64	P11S79	1x Q C	Dst. General Motors
Futura Drive	1.74	301449	1x Q C *Ec* S	Dst. Shantee Creek
Halfway Creek				
E State Line Road	4.88	301448	1x Q C *Ec* S	Ohio / Michigan Border
Mud Creek				
Suder Avenue	0.42	301451	C	Dst. Hoffman R Landfill
Detwiler Ditch				
Detwiler Park	0.50	P11S84	1x Q C O *Ec* S	Dst. Mud Ck, Dst. Libbey

1x /2x /T: Fish sampling once (1x) or twice (2x), with fish tissue (T) analysis.
Q /HD: Macroinvertebrate qualitative sampling (Q) or quantitative sampling (HD) with Hester-Dendy multiple-plate artificial substrate samplers.
C /C_N /O: Chemistry sampling (C), nutrients (C_N) but no metal parameters, and including organic parameters (O).
Ec: *E. coli* bacteria sampling.
D /Cl_A: Datasonde® deployment site (D), with chlorophyll A analysis (Cl_A). **Sentinel sites are in bold.**
S: Sediment sampling

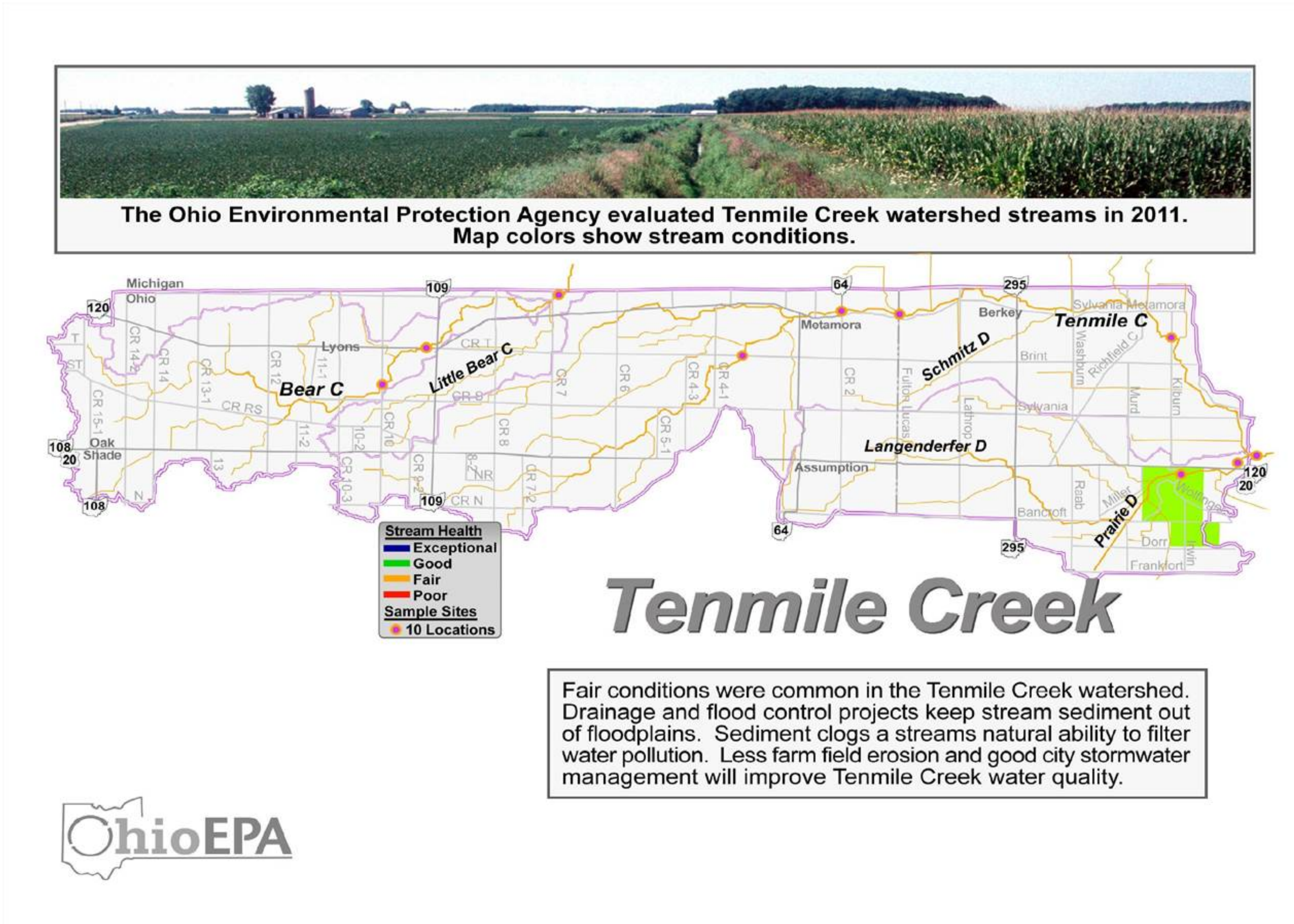


Figure 1. Sampling locations and narrative stream conditions in the Tenmile Creek basin, 2011.

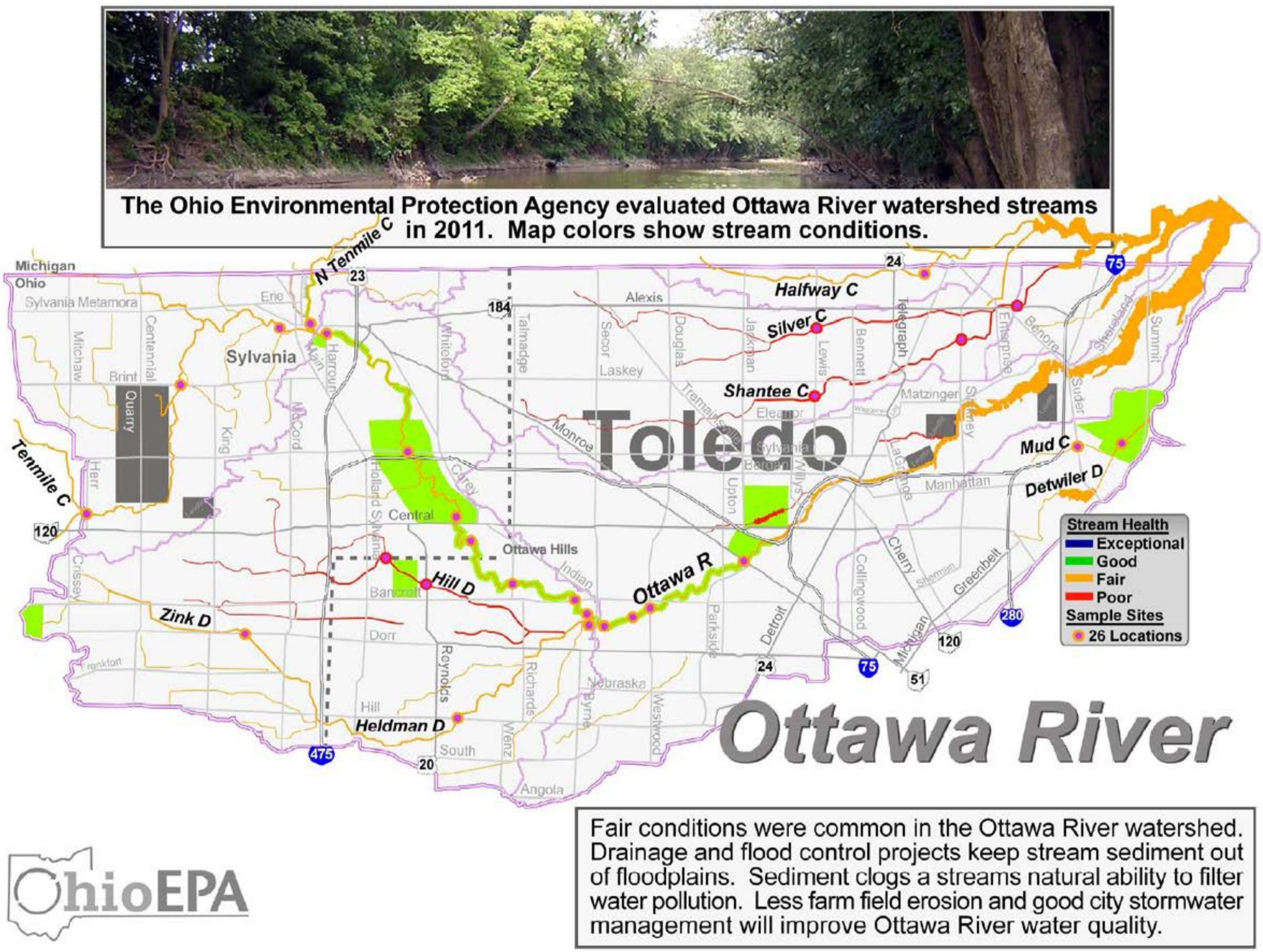


Figure 2. Sampling locations and narrative stream conditions in the Ottawa River basin, 2011.

Table 2. Attainment status of the existing or recommended aquatic life uses for the Tenmile Creek and Ottawa River basins, 2011. See Ohio WQS Table 24-11 (http://epa.ohio.gov/dsw/rules/3745_1.aspx) for beneficial use designations. Symbology and ecoregional biocriteria follow.

RM (Drain. area mi^2)	IBI/ MIwb[a]	ICI[b]	Status	QHEI	Cause	Source	Location
Bear Creek Warmwater Habitat Existing							
Headwaters Bear Creek 04100002-03-01							
12.9 (18.7)[H]	32	Good	Full	37.0			Fulton CR 10
11.6 (20.3)[W]	28/ 8.7	Good	Full	39.0			SR 120
Little Bear Creek-Bear Creek 04100002-03-04							
8.4 (22.9)[W]	26*/ 7.8	38	NON	31.5	Sedimentation/siltation	Channelization	Fulton CR 7
Tenmile Creek Warmwater Habitat Existing							
Headwaters Tenmile Creek 04100001-03-04							
18.3 (9.5)[H]	30	MG[ns]	Full	37.3			CR T
16.0 (22.5)[W]	33/ 8.1	Good	Full	41.5			SR 64
15.0 (25.9)[W]	26*/ 7.4	Good	NON	32.5	Sedimentation/siltation	Channelization	Fulton CR 1
9.2 (43.0)[W]	31[ns]/ 6.7*	Good	Partial	49.0	Sedimentation/siltation	Channelization	Kilburn Road
Tenmile Creek 04100001-03-06							
5.9 (64.5)[W]	34/ 7.0[ns]	18*	Partial	52.5	Sedimentation/siltation	Channelization	Herr Road
2.9 (70.0)[W]	37/ 6.1*	26*	NON	51.0	Sedimentation/siltation	Channelization	Brint Road
0.5 (81.0)[W]	39/ 7.4	38	Full	77.0			Silica Drive
Ottawa River Warmwater Habitat Existing							
Heldman Ditch-Ottawa River 04100001-03-07							
19.5 (124.6)[W]	37/ 6.3*	34	Partial	78.0	Sedimentation/siltation	Urban runoff/storm sewers	Harroun Road
16.9 (127.6)[W]	28[ns]/ 7.5	30[ns]	Full	68.5			Sylvania Avenue
14.4 (131.6)[W]	34/ 5.6*	28*	NON	59.3	Sedimentation/siltation	Urban runoff/storm sewers	Edgehill Road
12.2 (133.0)[W]	30[ns]/ 8.3	30[ns]	Full	67.0			Bancroft Road
11.8 (133.0)[W]	29[ns]/ 7.0[ns]	36	Full	59.3			Ust. Secor Dam
Sibley Creek-Ottawa River 04100001-03-08							
11.6 (154.0)[W]	27*/ 4.3*	22*	NON	63.0	Sedimentation/siltation	Urban runoff/storm sewers	Secor Avenue

RM (Drain. area mi^2)	IBI/ MIwb[a]	ICI[b]	Status	QHEI	Cause	Source	Location
11.1 (155.0) [W]	33/ 7.1[ns]	28*	Partial	48.5	Sedimentation/siltation	Urban runoff/storm sewers	Stadium Drive
10.9 (155.0) [W]	30[ns]/ 6.2*	16*	Partial	43.0	Sedimentation/siltation	Urban runoff/storm sewers	Douglas Avenue
9.4 (155.6) [B]	25*/ 8.4[ns]	24*	NON	72.0	Sedimentation/siltation	Urban runoff/storm sewers	Monroe Street
Prairie Ditch *Modified Warmwater Habitat recommended*							
Prairie Ditch 04100001-03-03							
1.4 (16.9) [W]	28	Fair	Full	27.0			Tupelo Way
0.3 (17.3) [W]	28	Fair	Full	19.0			Central Avenue
North Tenmile Creek Warmwater Habitat Existing							
North Tenmile Creek 04100001-03-05							
0.6 (42.1) [W]	28[ns]/7.9	Fair*	Partial	54.0	Low flow alteration	Crop production with subsurface drainage	State border
Heldman Ditch Modified Warmwater Habitat Existing							
Heldman Ditch-Ottawa River 04100001-03-07							
2.7 (8.4) [H]	22	Fair	Full	39.0			Hill Avenue
0.2 (21.0) [W]	32/7.5	Fair	Full	59.0			Edgevale Road
Zink Ditch *Modified Warmwater Habitat recommended*							
0.7 (3.5) [H]	38	L Fair*	Partial	43.5	Sedimentation/siltation	Channelization	Dorr Street
Hill Ditch *Modified Warmwater Habitat recommended*							
2.6 (3.5) [H]	22	Poor*	Partial	64.5	Sedimentation/siltation	Urban runoff/storm sewers	Carriage Drive
2.2 (6.3) [H]	22	L Fair*	Partial	55.0	Sedimentation/siltation	Urban runoff/storm sewers	Reynolds Road
Shantee Creek Limited Resource Water Existing							
Shantee Creek 04100001-03-01							
3.1 (7.7) [H]	12*	VP*	NON	29.0	Sedimentation/siltation	Urban runoff/storm sewers	Lewis Avenue
Modified Warmwater Habitat Existing							
0.7 (9.1) [H]	24	L Fair*	Partial	35.0	Priority organics (PCB/ PAH in sediments)	Sediment resuspension (contaminated sediment), Urban runoff/storm sewers	Stickney Avenue
Silver Creek Limited Resource Water Existing							
4.4 (4.6) [W]	16*	Poor	NON	43.0	Sedimentation/siltation	Urban runoff/storm sewers	Lewis Avenue

RM (Drain. area mi²)	IBI/ MIwb[a]	ICI[b]	Status	QHEI	Cause	Source	Location
Modified Warmwater Habitat Existing							
1.7 (5.7) [B]	22/ 7.0	VP*	NON	41.0	Sedimentation/siltation, Priority organics (PAH in sediments)	Sediment resuspension (contaminated sediment), Urban runoff/storm sewers,	Futura Drive
Halfway Creek Warmwater Habitat Existing							
Halfway Creek 04100001-03-02							
4.8 (22.1)[W]	36/8.0	Fair*	Partial	50.0	Sedimentation/siltation, Priority organics (PAH in sediments)	Sediment Resuspension (Contaminated Sediment), Urban Runoff/Storm Sewers	State Line Road
Detwiler Ditch *Modified Warmwater Habitat recommended*							
Detwiler Ditch-Frontal Lake Erie 04100001-03-09							
0.5 (6.2)[B]	31[ns]/ 7.2	Poor*	Partial	35.0	Priority organics (PCB in sediments), Sedimentation/siltation	Sediment resuspension (contaminated sediment), Urban runoff/storm sewers	Detwiler Park

* Significant departure from ecoregion biocriterion; poor and very poor results are underlined.
ns Nonsignificant departure from biocriterion (≤4 IBI or ICI units; ≤0.5 MIwb units).
a The MIwb (Modified Index of well-being) is not applicable to headwater sites (<20mi²).
B Boat criteria *only* apply to the Ottawa River at Monroe St. (RM 9.4), Silver Creek at Futura Dr. (RM 1.7) and Detwiler Ditch at Detwiler Park (RM 0.5).
H Headwater site.
W Wading site.
b Narrative evaluation used in lieu of ICI (Good; MG=Marginally Good; Fair; L Fair=Low Fair; Poor; VP=Very Poor).

Ecoregional Biological Criteria: Huron-Erie Lake Plains			
Index – Site Type	**WWH**	**MWH - Channelized**	**LRW**
IBI –Headwater	28	20	18
IBI – Wading	32	22	18
IBI – Boat	34	20	16
MIwb – Wading	≥7.9	≥5.6	4.5
MIwb – Boat	≥8.6	≥5.7	5.0
ICI	34	22	8

Study Area Description

The study area is wholly contained within the Huron/Erie Lake Plains (HELP) ecoregion (Omernick 1987). Many reviews generally note three land use patterns within the study area (USACE 2009, Maumee RAP 2006, Maumee RAP 2013). Agriculture prevails in the western third of the area on Lake Plain glacial till deposits overlying Devonian bedrock. Rural and suburban development exists in the central third largely occupying the Sand Plains of the Oak Openings on top of a Devonian or Silurian base. The eastern third is an urban area on Lake Plain lacustrine fine sand, silt, and clay deposits over Silurian bedrock. Area bedrock is dense, offering little ground water storage or contribution to surface flows (Schiefer 2002). Soils throughout the basin are poorly drained. The severely wet soils are generally unsuitable for basement building foundations, septic leach fields or manure application without artificial drainage (Stone et. al. 1980, Stone and Michael 1984).

The 27.4 mile long Tenmile Creek begins west from St. Rt. 109 and south from U.S. Rt. 20 in Fulton County (Figure 1). With an origin elevation of 755', the stream falls an average of 4.9'/mi to an elevation of 620' at Sylvania. The confluence of Tenmile Creek with North Tenmile Creek in Sylvania forms the Ottawa River. Ohio EPA identifies this juncture to be 19.75 miles upstream from the Ottawa River's Lake Erie mouth (Figure 2). The 19.75 mile long Ottawa River maintains a similar grade (4.7'/mi) over its 9.6 mile course in Lucas County to reach Lake Erie's level.

The entire routes of Tenmile Creek and the Ottawa River have been altered to facilitate agricultural drainage and alleviate flooding repeatedly over time. Organized efforts to enhance drainage began in the 1850s following statewide legislation (Reighard 1920) and continue today (Earley 2014). Tenmile Creek and the Ottawa River are channelized and maintained throughout their lengths, and have little tree cover throughout the riparian areas. The tributary streams are maintained in a similar fashion as Tenmile Creek and the Ottawa River. Artificial drainage was well established throughout the study area prior to systematic stream flow measurements beginning in the 1920s (Schiefer 2002).

Beginning in 2002, storm water management and associated solutions for drainage issues have focused on green infrastructure. By referendum, the Toledo Waterways Initiative began in 2002 (http://www.toledowaterwaysinitiative.com/). Increased sewer user fees support the 18 year project to eliminate combined sewer overflows (CSOs) and improve WWTP processes. The project provides the local matching money for the green storm water enhancements and funds many other stalled drainage proposals. In 2013, major flow blockages were removed from Halfway and Silver creeks, Shantee Creek was dredged, and Hill Ditch erosion was controlled (Toledo 2013). Similarly, the Lucas County Storm Water Utility, created in 2011, is an assessment based on impervious surface. Specific information is available at http://oh-lucascounty.civicplus.com/index.aspx?NID=1304. The money is used to correct storm runoff concerns and to address long standing drainage issues. Of $453,040 awarded for storm water utility construction projects in 2012, $39,700 was spent to characterize Tenmile Creek Herr Rd. flooding and $4,795 was paid to remove a Silver Creek log jam (Lucas County Engineer 2012, http://www.co.lucas.oh.us/documents/91/2012%20-%202013%20Forecast%20and%20Awarded%20Storm%20Water%20Utility%20Projec_2.PDF). In April 2014, the city of Toledo was awarded $200,000 through the Great Lakes Restoration Initiative for green infrastructure in the Silver Creek watershed. With a local match, the money will be used to install bioswales and rain gardens to capture and slow storm water flows (Messina 2014).

NPDES

Ohio EPA has issued 25 facility specific NPDES permits authorizing the discharge of substances compliant with WQS in the study area (Table 3). These minor discharges (<1 million gallons per day, MGD) include a confined animal feeding operation (CAFO), two municipal wastewater lagoons, four package waste treatment plants, ten industrial storm water outfalls and a combined sewer overflow (CSO). Facilities provide Discharge Monitoring Reports (DMR) characterizing the amount and frequency of their releases. DMR data is useful for compliance and trend assessment. Specific individual permit information is available at: http://epa.ohio.gov/dsw/permits/npdes_info.aspx.

General NPDES permits allow entities with common conditions to release substances likely to have minimal environmental consequence (e.g. small sanitary discharges, non-contact cooling water, construction site runoff, etc.: http://epa.ohio.gov/dsw/permits/gpfact.aspx). Municipal separate storm sewer systems (MS4) are required to conform to either an individual or a general NPDES permit. Sylvania, Ottawa Hills, and Lucas County are generally permitted as small MS4 entities. General permit information is available at: http://epa.ohio.gov/dsw/permits/gplist.aspx. Toledo is individually permitted as a large MS4 discharge: http://epa.ohio.gov/dsw/storm/index.aspx. These communities are encouraged to implement best management practices (BMPs) to promote better water quality.

Maumee Rap

In addition to the objectives identified in the Introduction section above, the 2011 Tenmile Creek and Ottawa River study was also intended to supplement the ongoing efforts of the Maumee Remedial Action Plan (RAP). The Tenmile Creek and Ottawa River study area is within the Maumee RAP's Area of Concern (AOC). The Maumee RAP is the lead organization for all Toledo area stream restoration activities. The RAP successes may be reviewed at the sponsoring Partners for Clean Streams, Inc. website: http://www.partnersforcleanstreams.org/.

Ohio EPA had a formative role in RAP creation and has maintained a commitment to its environmental improvement process through funding and collaborative personnel involvement. Within the Ottawa River portion of the Maumee RAP's AOC, Ohio EPA has conducted nine water quality assessments providing RAP support data. Results of these inquiries are available at Ohio EPA's report website: http://www.epa.state.oh.us/dsw/document_index/psdindx.aspx.

The 1991 Ohio EPA report *Fish Tissue, Bottom Sediment, Surface Water, Ottawa River / Tenmile Creek* based on 1986, 1988, and 1990 sampling efforts provided foundation for issuance of a primary contact and fish consumption advisory for the Ottawa River by the Ohio Department of

Health. This advisory, applicable to 19 miles of the 19.75 mile long Ottawa River, cautioned against any wading, swimming or fishing. Ohio State University researchers, Leroy Hushak and Mary Bielen completed a 1999 report, *Valuing the Ottawa River: the Economic Values and Impacts of Recreational Boating* to gain better understanding of public perceptions and interests in dredging and pertinent environmental issues (http://www.partnersforcleanstreams.org/ValuingtheOttawaRiverFinalReport.pdf). While their report confirmed local support for improving recreational opportunities, it also clarified significant economic losses had occurred subsequent to the advisory posting.

The lower reach of the Ottawa River was severely contaminated with polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and metals (lead). The RAP produced reports summarizing where these sediments persisted and prioritized specific reaches for remediation. Sibley Creek joins the Ottawa River (RM 5.59) after flowing through an industrial area adjacent to the Dura Avenue landfill. Having previously evaluated the stream in 1996, Ohio EPA confirmed acutely toxic conditions were still present in 2002 (Ohio EPA 2003). During the 2002 sampling, beneath a surface layer of silt and muck, the bottom urban grit substrates released an oily sheen and creosote odors when disturbed. A two year long lower Ottawa River sediment dredging project removed nearly 10,000 yd^3 of sediments from Sibley Creek.

Additionally, several other landfills along the lower Ottawa River have been remediated in the last fifteen years. These sites were formerly known to leach toxins into the Ottawa River. Thus, with proper closure of these facilities and the removal of contaminated sediment, it is hoped that the environmental improvements observed in other areas will be expedited in the lower Ottawa River.

Table 3. Discharge locations (RM), design flows (MGD), and types of NPDES permitted entities in the Tenmile Creek and Ottawa River study area, 2011.

Facility (Ohio EPA Permit #)	Discharge to	RM	MGD	Type
Bear Creek				
Headwaters Bear Creek 04100002-03-01				
Chesterfield Dairy (2IK00027-601)	Tributary (3.55)	15.11		storm water detention pond
BW Supply Co. (2PR00229-001)		13.83	0.005	package plant
Lyons WWTP (2PA00009-001)		12.50	0.065	controlled discharge lagoon
Tenmile Creek				
Headwaters Tenmile Creek 04100001-03-04				
Evergreen High School (2PT00033-001)		22.43	0.024	package plant
Metamora WWTP (2PB00065-001)		15.70	0.2	controlled discharge lagoon
Tenmile Creek 04100001-03-06				
Hanson Aggregates (2IJ00096-001)	Tributary (0.2)	5.33	8.9	sedimentation pond
Hanson Aggregates (2IJ00039-002)	Tributary (0.2)	3.80	2.34	sedimentation pond
Ottawa River				
Sibley Creek-Ottawa River 04100001-03-08				
BP Products (2IG00010-001)	Fleig D (2.0)	11.14		oil/ water separator
Toledo WWTP (2PF00000-067)		9.23		CSO
Langenderfer Ditch				
Prairie Ditch 04100001-03-03				
Holy Trinity Church (2PR00246-001)		2.84	0.0075	package plant
Silver Creek				
Shantee Creek 04100001-03-01				
Remediation Liability Mgmt. Co. (2IN00200-009,008)		5.36		ground water
Remediation Liability Mgmt. Co. (2IN00200-004,005)		5.25		storm water
General Motors Corp. (2IC00026-001,002)		5.14		oil/ water separator
General Motors Corp. (2IC00026-006)		5.01	1.8	storm water
Remediation Liability Mgmt. Co. (2IN00200-007)		5.00		storm water/ ground water
General Motors Corp. (2IC00026-003)		4.64		storm water
All Ohio Ready Mix (2IN00236-001)	Shantee C (0.7)	1.71		sedimentation pond
Lucas Co. Landfill (2IN00142-001)		1.70		sedimentation pond
Lucas Co. Landfill (2IN00142-004)		0.90		sedimentation pond
Halfway Creek				
Halfway Creek 04100001-03-02				
Grimes, Inc. (2PR00218-001)		4.80	0.003	package plant
Lucas Co. Landfill (2IN00142-002,003)	Tributary (0.44)	3.29		sedimentation ponds
Detwiler Ditch				
Detwiler Ditch-Frontal Lake Erie 04100001-03-09				
Libbey Inc. (2IN00075-001,003)	Ditch #1139 (headwater of Detwiler Ditch)		0.068	non-contact cooling water
Libbey Inc. (2IN00075-007,011,012)	Ditch #1139 (headwater of Detwiler Ditch)			storm water/ ground water
Hoffman Road Landfill (2IN00117-004,005)	Mud Creek	0.72	0.073	sedimentation ponds
West Paxton Landfill (2IN00126-001)	Mud Creek	0.72		sedimentation pond

Aquatic Life Use Attainment Status

Bear Creek

In Ohio, Bear Creek is a small ditch (25 mi^2). It flows into Michigan where it joins the River Raisin via Black Creek. Full WWH aquatic life use attainment was recorded at two upstream Bear Creek locations (RMs 12.9 and 11.6) in 2011 (IBI$\bar{x}$=30, MIwb=8.7, ICI$\bar{x}$=Good). Sampling results from these sites bracketing the Lyons WWTP discharge did not indicate any facility influence.

Fair fish community performance downstream at Fulton County Road 7 (RM 8.4) resulted in WWH non-attainment (IBI=26, MIwb=7.8, ICI=38). Poor stream habitat conditions were typical throughout Bear Creek (QHEI$\bar{x}$=35.8, n=3). Silty sand bars served as surrogate riffles at the most downstream site. Here, easily redistributed fine sediment was conducive to high turbidity. The smothering effect of sediment trapped within the Bear Creek channel limited better biological performance.

Tenmile Creek

Tenmile Creek (81 mi^2) joins North Tenmile Creek (42 mi^2) in Sylvania. This confluence forms the Ottawa River. Ohio EPA determined full WWH aquatic life use attainment occurred at three of seven Tenmile Creek sites. Two sites in partial WWH attainment had marginally better biological scores compared to two other sample locations where poor evaluations resulted in non-attainment. In 2011, the overall Tenmile Creek aquatic community performance was fair (IBI$\bar{x}$=33, MIwb$\bar{x}$=7.1, ICI$\bar{x}$=32, n=7).

Maintained as a headwater ditch, Tenmile Creek's poor habitat conditions generally improved in a downstream direction with increased drainage area. Riparian trees in Lucas County contributed to fair habitat quality. In Sylvania near the mouth, very good habitat was created by clean, well washed dolomite bedrock substrates (QHEI=77.0). The very good habitat here resulted in the highest IBI score (IBI=39) on the mainstem, though the majority of Tenmile Creek exhibited only fair habitat quality (QHEI$\bar{x}$=48.7, n=7).

The Tenmile Creek aquatic community was predominated by macroinvertebrates and fish that tolerate pollution and the limiting aspects of silty substrates. This assemblage was resistant to extremes in dissolved oxygen (D.O.) availability, nutrient pulses, water temperature, and flow. Indications of nutrient enrichment downstream from the Metamora WWTP were essentially masked by the resilient biological performance.

Ottawa River

In 2011, full attainment of the WWH aquatic life use designation was observed at three of nine Ottawa River sampling locations. Partial attainment was documented at three sites. Poor fish index scores triggered non-attainment at three sites. Overall, Ottawa River aquatic community performance was fair (IBI$\bar{x}$=30, MIwb$\bar{x}$=6.7, ICI$\bar{x}$=28, n=9).

Dams removed at Camp Miakonda in 2003 and at Secor Road in 2007 facilitated the upstream movement of several fish species not present in prior Ohio EPA Ottawa River surveys. Two redhorse species and a darter, all considered moderately sensitive to water pollution, were among the 2011 collections. Northern pike were also more abundant. Despite these advances and generally good habitat (QHEI$\bar{x}$=62.1, n=9), the modestly rich Ottawa River fish community lacked species intolerant of pollution and included disproportionally few that need clean well sorted substrates. Absence of these lithophils was indicative that substrates were extensively embedded by fine silts and clay.

The presence of contaminated sediments especially in proximity to Central Avenue (RM 15.05), where PAH concentrations were above likely threshold values, was another influence on aquatic community performance. The Ottawa River macroinvertebrate community declined in the channelized reach lacking riffles through the University of Toledo campus. The simplified poor habitat created by the 1957 river re-routing was conducive to facultative organisms tolerant of excess detritus. Habitat improvements were completed here in 2013 and should be evaluated in future surveys.

Prairie Ditch

The recommended Modified Warmwater Habitat (MWH) aquatic life use was attained at two sampling locations (IBI$\bar{x}$=28, ICI$\bar{x}$=Fair). A limited array of pollution tolerant aquatic species were typical of the very poor habitat conditions (QHEI$\bar{x}$=23, n=2).

North Tenmile Creek

Partial WWH aquatic life use attainment at one sample site was attributed to interstitial flow (IBI=28, ICI=Fair). Although habitat quality was fair (QHEI=54), limited flow conditions precluded better aquatic community scores. The location was considered “dry” on three of five planned water chemistry sample dates in 2011.

Heldman, Zink and Hill Ditches

Full MWH aquatic life use attainment was recorded at two Heldman Ditch sites (IBI$\bar{x}$=27, ICI$\bar{x}$ =Fair). Partial attainment of the recommended MWH aquatic life use was observed at a single Zink Ditch location (IBI=38, ICI=Low Fair) and at both Hill Ditch sites (IBI$\bar{x}$=22, ICI$\bar{x}$=Poor/Low Fair). Aquatic assemblages were consistent with the fair habitat conditions present at all sample sites (QHEI$\bar{x}$=52.2, n=5). The Zink Ditch fish community was unique for the highest IBI score in the 2011 study. This assemblage appeared to benefit from construction of a “two stage” channel.

Shantee and Silver Creeks

Non-attainment of the Limited Resource Water (LRW) aquatic life use designation at individual upstream sites on both Shantee Creek (IBI=12, ICI=Very Poor) and Silver Creek (IBI=16, ICI=Poor) was influenced by ammonia toxicity and degraded sediments. Downstream, partial and non-attainment, respectively, of the MWH use at single sites on both streams (Shantee Creek IBI=24, ICI=Low Fair, Silver Creek IBI=22, MIwb=7.0, ICI=Very Poor) was also due to sediment contamination. Generally poor habitat conditions (QHEI$\bar{x}$=37.0, n=4) were of sufficient quality to support the designated MWH and LRW aquatic life uses. Marginal flow was maintained and a limited amount of cover included pools for overwinter refuge.

Halfway Creek

The recommended MWH aquatic life use was partially attained at one sample site (IBI=36, ICI=Fair). Wetland qualities influenced a fair habitat assessment (QHEI=50). The effects of limited cover and little riffle presence were further aggravated by sediment contamination.

Detwiler Ditch

A marginally good to fair fish community (IBI=34, MIwb=7.2) and a poor macroinvertebrate assemblage (ICI=Poor) typified this degraded pond-like environment (QHEI=35.0). Partial attainment of the recommended MWH aquatic life use was associated with contaminated sediments.

Recreational Use Attainment Status

The Ohio Department of Health (ODH) and the Toledo-Lucas County Health Department rescinded "no contact" advisories for the Ottawa River upstream from I-475 in 2011 and downstream in 2012. Swimming and other water recreation in the Ottawa River was deemed unsafe by ODH in 1991 due to the legacy of industrial pollution in the lower portion of the watershed. Completion of a $47 million Ottawa River sediment dredging project in 2010 following numerous multimillion dollar cleanup projects at other contaminated sites may be credited for the environmental improvements leading to the direct contact advisory retraction.

Ohio's water recreational use period occurs annually from May 1 to October 31. To protect the health of participants, waters are designated based on the likely type of recreational use, e.g. swimming, boating, or wading, etc. Primary Contact Recreation (PCR) Class B streams are anticipated to support wading or other water recreation where the likelihood of full-body contact is limited or infrequent. All 2011 Tenmile Creek and Ottawa River study area streams are designated for PCR Class B recreational use (OAC 3745-1-07 (B)(4)(b), page 8: http://www.epa.ohio.gov/portals/35/rules/01-07.pdf). Table 7-13 (OAC 3745-1-07, page 24) stipulates the number of *Escherichia coliform* colony forming units per 100 ml of water (*E. coli* cfu/100ml) which serve as criteria for recreational use attainment status.

Present in large numbers in the excrement and intestinal tracts of humans and other warm-blooded animals, *E. coli* comprise more than 90% of the fecal coliform bacteria in mammalian feces (Dufour, 1977). Ear, nose, and throat infections, stomach upsets, skin rashes, and diarrhea have been associated with recreation in surface water with high *E. coli* concentrations. Young children, the elderly, and those with depressed immune systems are most susceptible to these maladies. Streams designated for PCR Class B recreational use should not exceed geometric mean concentrations of *E. coli* above 161 cfu/100 ml based on multiple samples nor should ten percent of the samples exceed 523 cfu/100 ml within any thirty day period.

Recreational use assessment encompassed 83 bacteria samples collected from 14 sites on eight Tenmile Creek and Ottawa River study area streams between May 10 and September 14, 2011 (Table 4, Appendix Table 11). Full attainment of the PCR Class B recreational use geometric mean criterion was recorded at three sites on three different study area streams. Unique flow conditions accounted for the limited bacteria presence at these locations. Little or no discernable flow at the upstream Bear Creek site (RM 12.9) and in Detwiler Ditch RM 0.5 was contrasted by an apparent flow increase at the Ottawa River Central Avenue (RM 15.05) site. *E. coli* are presumed to perish within a few days after elimination from an animal host. Where bacteria in flowing water may have originated miles away within an assumed time frame, *E. coli* in still water suggests an immediate source.

Surrounded by agricultural crop land with few livestock farms and sparse residential density, low bacteria counts in the headwaters of Bear Creek were characteristic of unmoving water and little animal presence. Detwiler Ditch bisects a public golf course before entering Lake Erie. Water in the former wetland area of Detwiler Ditch is at lake level. Excess water is pumped from the under drained greens to keep conditions playable. Several wetlands including an Ohio Department of Transportation (ODOT) mitigation unit exist upstream from the golf course (http://www.dot.state.oh.us/Divisions/Planning/Environment/Ecological_Resources_Permits/MitigationInventory/Pages/Lucas_Detwiler.aspx). With the City of Toledo's Bay View WWTP in close proximity, the nearby residential area has good sanitary sewer coverage. The limited bacteria presence in Detwiler Ditch can be attributed to an ample amount of water in the channel and nearby wetlands with proportionally few bacteria sources.

The only site on the Ottawa River which met the Recreation Use standard was located at Central Avenue (RM 15.05). The Ottawa River flows through a forested area and Toledo Metropark before reaching Central Avenue. The lower intensity land use may have contributed to the decline in potential pathogens at Central Avenue.

The highest geometric mean *E. coli* concentration (704 cfu/100ml) recorded during the 2011 study occurred at Silver Creek RM 1.7 (Futura Drive). This site is downstream from a small unsewered neighborhood on Dearden Place and Birdsall Road. The Toledo Metropolitan Area Council of Governments (TMACOG) anticipates this "critical sewage area" will have sanitary sewers installed in 2015 (TMACOG 2013).

High bacteria concentrations were documented broadly across the entire 2011 study area. For instance, high bacteria values were routine at the Stadium Drive (RM 11.15) sampling location on the University of Toledo (UT) campus. Since 2006, UT has been striving to incorporate the Ottawa River more directly in school affairs. Therefore, more effort is warranted to reduce potential pathogen exposure to ensure everyone can safely recreate in the Ottawa River.

Table 4. Attainment status of the existing PCR-B recreational use for Tenmile Creek and Ottawa River study area streams, May 10-September 14, 2011. All values are expressed as *E. coli* colony forming units per 100 ml of water (cfu/100ml). **Bold** values exceed the pertinent criterion noted below.

Stream/ Location	RM	n	Geometric Mean	Maximum	Status
Bear Creek					
Headwaters Bear Creek 04100002-03-01					
SR 120	11.56	5	81	400	Full
Little Bear Creek-Bear Creek 04100002-03-04					
Fulton CR 7	8.44	5	**450**	**1400**	NON
Tenmile Creek					
Headwaters Tenmile Creek 04100001-03-04					
Kilburn Road	9.17	5	**416**	**1100**	NON
Tenmile Creek 04100001-03-06					
Herr Road	5.94	11	**606**	**2700**	NON
Silica Drive	0.47	5	**316**	**2800**	NON
Ottawa River					
Heldman Ditch-Ottawa River 04100001-03-07					
Harroun Road	19.50	5	**325**	**4400**	NON
Sylvania Avenue	16.84	5	**315**	**2000**	NON
Central Avenue	15.05	5	112	590	Full
Sibley Creek-Ottawa River 04100001-03-08					
Stadium Drive	11.15	12	**682**	**6000**	NON
Prairie Ditch					
Prairie Ditch 04100001-03-03					
Tupelo Way	1.41	5	**190**	510	NON
North Tenmile Creek					
North Tenmile Creek 04100001-03-05					
Monroe Street	0.12	5	**168**	**1700**	NON
Halfway Creek					
Halfway Creek 04100001-03-02					
East Stateline Road	4.88	5	**287**	**1800**	NON
Silver Creek					
Shantee Creek 04100001-03-01					
Futura Drive	1.74	5	**704**	**5200**	NON
Detwiler Ditch					
Detwiler Ditch-Frontal Lake Erie 04100001-03-09					
Detwiler Park	0.50	5	158	1600	Full

PCR Criteria	geo$\bar{x}$	max.
Class B	<161	≤523

Fish Consumption and Non-drinking water Human Health Use Assessment

Ohio's Fish Consumption Advisory Program (FCA) was reorganized in 1993 as a cooperative effort amongst the Departments of Health and Natural Resources, and the Ohio EPA (Ohio EPA 2008a). This multi-agency approach has produced a broad consistent fish tissue contaminant database from all of the State's waters. Concurrently, the Great Lakes Governors Association, US EPA, and Ohio's FCA have improved data evaluation and risk communication. The Ohio FCA website provides further information:
http://www.epa.state.oh.us/dsw/fishadvisory/index.aspx.

Fish tissue samples from five sites comprised of 34 fish either singularly or combined was collected from the Ottawa River in 2011. Extensive electrofishing in Lake Olander was attempted but only fish too small to fillet were collected so no tissue assessment was conducted. Table 8 summarizes the concentrations of detected organic compounds present in 16 samples. Results for other routine tissue parameters not presented in the table were consistent with typical values or were less than the method detection limits. These analytes, specific FCA guidance, and contaminant thresholds are discussed in: *State of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program* (2010, http://www.epa.state.oh.us/portals/35/fishadvisory/FishAdvisoryProcedure.pdf).

The ubiquitous presence of mercury has resulted in a statewide recommendation to monitor fish consumption based on location and species specific risk. Broadly, it's prudent to eat most fish about 52 times annually (once a week). While yellow perch, crappie and sunfish may be consumed more often, the mercury contamination in other species could exceed the amount most people would normally metabolize and eliminate. In places where the amount of species specific mercury contamination is excessive, advisories are issued to limit consumption accordingly. Thus, a monthly advisory suggests certain fish from a particular waterbody should be eaten less frequently than the weekly recommendation would suggest.

Northern pike and flathead catfish that are 23 inches or more in length and steelhead trout caught in any Lake Erie tributary or in Lake Erie should be limited to monthly consumption. These larger predatory fish tend to accumulate PCBs in higher concentrations compared to other species. In 2011, three Ottawa River northern pike (approximately 16", 26", and 20") collected at Harroun and Edghill roads (RMs 19.5 and 14.4, respectively) had PCB concentrations below method detection. Four pike (approximately 20", 20", 16", and 15") assessed from Secor Avenue (RM 11.6) and Monroe Street (RM 9.4) had PCB accumulations consistent with the monthly consumption recommendation.

Common carp from the Ottawa River were determined to have higher PCB concentrations than appropriate for weekly meals. Limiting consumption of common carp caught between Sylvania and the University of Toledo to about 12 times annually is recommended. Carp downstream from the University exhibited elevated amounts of PCB contamination and should not be eaten. Similarly, a do not eat advisory exists for all Ottawa River fish obtained downstream from Auburn Avenue due to PCB presence. Figure 3 (created by Matthew Horvat and reproduced herein from the TMACOG website [http://www.tmacog.org/enviro_maps.htm]) illustrates current Tenmile Creek and Ottawa River fish consumption advisories.

Table 5. Organic compounds (mg/kg) in fish tissue samples collected from the Ottawa River, 2011. Values preceded by a less than sign (<) indicate results were below the method detection limit. Comparative values below Total PCBs are Ohio adopted recommendations. **Bold** values exceed the unrestricted consumption risk trigger, ***bold italicized*** values exceed the weekly consumption risk trigger. **Yellow** and ***red*** highlighted mean values support respective consumption advisories. Sample types are: SFF=skin off fillet, SFFC= skin off fillet composite.

Ottawa River			
Species n/type	RM	Location	Total PCBs (mg/kg) **0.050/ *0.220***
White Sucker			
1/SFF	19.5	Harroun Rd.	<0.050
Common Carp			
3/SFFC	16.8	Sylvania Ave.	***0.266***
3/SFFC	14.4	Edgehill Rd.	**0.100**
1/SFF	11.8	Secor Ave.	***0.807***
3/SFFC	9.3	Monroe St.	***1.985***
1/SFF	9.3	Monroe St.	***2.065***
		Mean value	***1.045***
Brown Bullhead			
2/SFFC	11.8	Secor Ave.	<0.050
Yellow Perch			
1/SFF	11.8	Secor Ave.	<0.050
5/SFFC	9.3	Monroe St.	**0.068**
		Mean value	**0.059**
Northern Pike			
1/SFF	19.5	Harroun Rd.	<0.050
1/SFF	14.4	Edgehill Rd.	<0.050
1/SFF	14.4	Edgehill Rd.	<0.050
2/SFFC	11.8	Secor Ave.	**0.129**
2/SFFC	9.3	Monroe St.	***0.218***
		Mean value	***0.099***
White Bass			
5/SFFC	9.3	Monroe St.	***0.248***
Largemouth Bass			
2/SFFC	19.5	Harroun Rd.	<0.050

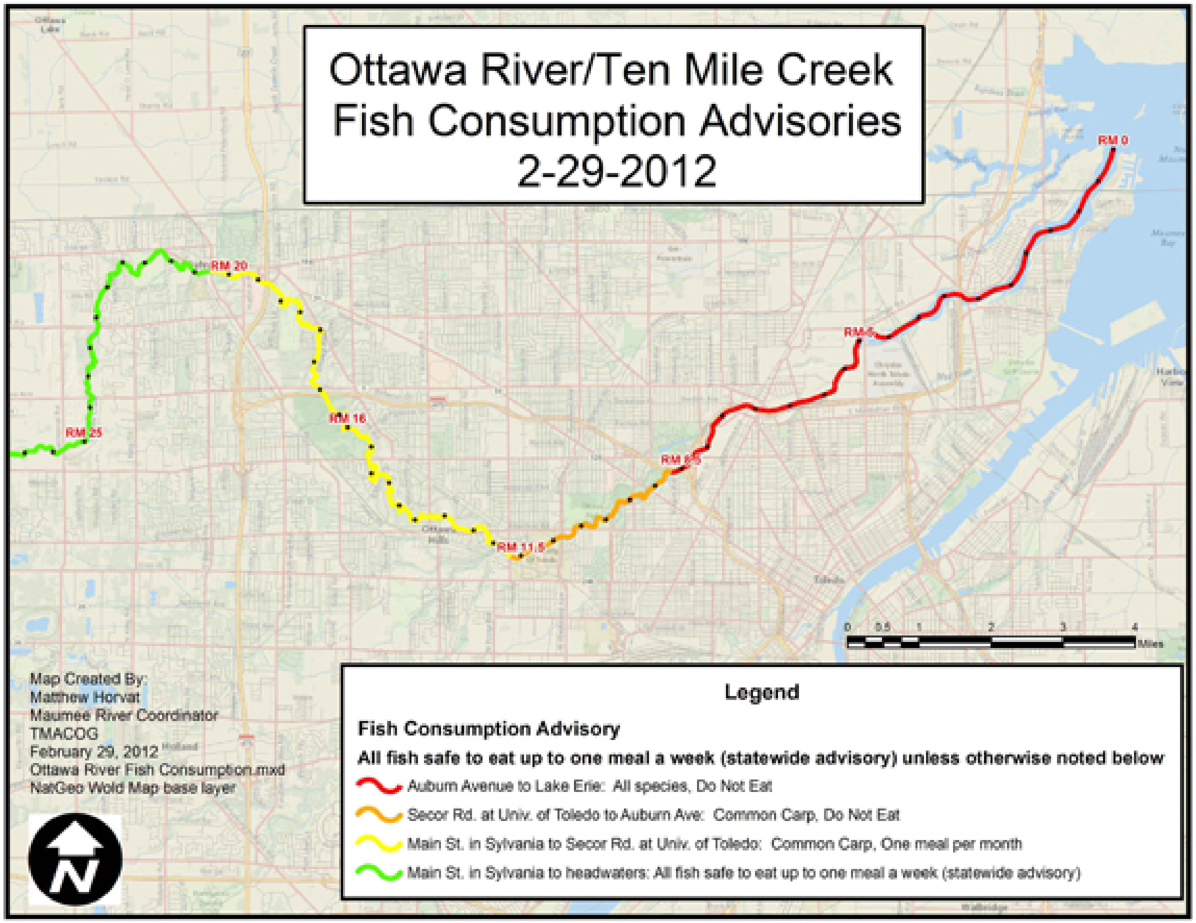


Figure 3. Location of fish consumption advisories subsequent to the 2011 Tenmile Creek and Ottawa River biological and water quality study. The illustration was created by Matthew Horvat, Maumee River Coordinator. It is reproduced here from the Toledo Metropolitan Area Council of Governments, TMACOG, website (http://www.tmacog.org/enviro_maps.htm).

In addition to consumption advisories, fish tissue data supports assessment of the non-drinking water human health use. "Section E: Evaluating Beneficial Use: Human Health (Fish Contaminants)" of the 2012 Ohio EPA *Integrated Report* (http://epa.ohio.gov/portals/35/tmdl/2012IntReport/IR12SectionEfinal.pdf) explains the rationale used to characterize this attainment status. Table 9 of the *Integrated Report* includes the calculation procedure that determined two study area assessment units were impaired due to PCB contamination (Ohio EPA 2012a). PCBs have been illegal to manufacture in the U.S. since 1979 and worldwide since 2001. The persistence of these carcinogens in the environment challenges contemporary source location. The frequent detection of PCBs in study area fish tissue reflects the regions industrial heritage and calls for vigilance in the proper disposal of these toxins.

Table 6. Non-drinking water human health use attainment status for the Heldman Ditch-Ottawa River and Sibley Creek-Ottawa River assessment units, 2011. ***Red bold*** highlighted values violate the criterion and signify impairment of the use.

Species n/type	RM	Trophic Level Location	Total PCBs (mg/kg) (criterion = 0.054)
Heldman Ditch-Ottawa River Assessment Unit			
White Sucker		**3**	
1/SFF	19.5	Harroun Rd.	<0.050
Common Carp		**3**	
3/SFFC	16.8	Sylvania Ave.	0.266
3/SFFC	14.4	Edgehill Rd.	0.100
1/SFF	11.8	Secor Ave.	0.807
		Geometric mean	0.278
Brown Bullhead		**3**	
2/SFFC	11.8	Secor Ave.	<0.050
Yellow Perch		**3**	
1/SFF	11.8	Secor Ave.	<0.050
Northern Pike		**4**	
1/SFF	19.5	Harroun Rd.	<0.050
1/SFF	14.4	Edgehill Rd.	<0.050
1/SFF	14.4	Edgehill Rd.	<0.050
2/SFFC	11.8	Secor Ave.	0.129
		Geometric mean	0.063
Largemouth Bass		**4**	
2/SFFC	19.5	Harroun Rd.	<0.050
Mean 3 value (11.8)		0.107	1.26
Mean 4 value (5.7)		0.057	3.25
		Sum	4.51
		Divided by /17.5	***0.258***
Sibley Creek-Ottawa River Assessment Unit			
Common Carp		**3**	
3/SFFC	9.3	Monroe St.	1.985
1/SFF	9.3	Monroe St.	2.065
		Geometric mean	2.025
Yellow Perch		**3**	
5/SFFC	9.3	Monroe St.	0.068
Northern Pike		**4**	
2/SFFC	9.3	Monroe St.	0.218
White Bass		**4**	
5/SFFC	9.3	Monroe St.	0.248
Mean 3 value (11.8)		1.046	12.346
Mean 4 value (5.7)		0.233	1.328
		Sum	13.674
		Divided by /17.5	***0.781***

Recommendations

Beneficial uses for water resources are fundamental to Ohio's Water Quality Standards (WQS). Table 24-11 of the Ohio WQS specifies waters within the Maumee River watershed, including the Tenmile Creek and Ottawa River study area, and their ascribed uses (http://epa.ohio.gov/dsw/rules/3745_1.aspx). Attainment status of those uses and recommended changes are discussed within this document (Tables 2 and 7).

The Ottawa River, Tenmile Creek, and North Tenmile Creek are designated and were previously confirmed for the WWH aquatic life use (http://epa.ohio.gov/dsw/rules/3745_1.aspx). Aquatic community sampling within those three streams confirmed the appropriateness of the WWH aquatic life use for all three streams. Bear Creek, Halfway Creek, and Prairie Ditch were anticipated to be WWH streams in an original 1978 beneficial use assignment for all Ohio named streams. This 2011 study confirmed the WWH aquatic life use for Bear and Halfway creeks but recommends MWH for Prairie Ditch. Shantee Creek upstream from Detroit Avenue (RM 2.8) and Silver Creek upstream from Maybee Road (RM 2.8) are designated and were previously confirmed for the LRW aquatic life use. Prior assessments supported MWH designations downstream from those landmarks.

Bear Creek was presumed to be a WWH stream in 1978 when all named streams in Ohio were administratively assigned uses to facilitate subsequent needs. In 2011, attainment of the WWH criteria confirmed this aquatic life use designation was appropriate. Prairie Ditch was also designated for WWH aquatic life use in 1978. The MWH use was established after 1978 recognizing many Ohio streams maintained for drainage needs might not support WWH aquatic communities, but these waterways should at least sustain a pollution tolerant biological assemblage. In 2011, fair aquatic community performance and very poor QHEI scores at two Prairie Ditch locations supported the recommendation of the MWH use designation for Prairie Ditch ($IBI\bar{x}$=28, $ICI\bar{x}$=Fair, $QHEI\bar{x}$=23.0, n=2).

Halfway Creek harbored marginally good fish and fair macroinvertebrate assemblages at one location exhibiting fair habitat in 2011 (IBI=36, ICI=Fair, QHEI=50.0). Stream sediments at this site were contaminated by PAHs in excess of the Probable Effect Concentration (PAH=28.2 mg/kg, PEC=22.8 mg/kg, MacDonald *et.al*. 2000). Recognizing the impaired macroinvertebrate performance was likely due to substrate toxicity, achievement of the WWH aquatic life use criterion by the fish community confirmed the original 1978 designation.

Ohio WQS presently represent Heldman Ditch to be a tributary to Hill Ditch. However, Hill Ditch is actually a tributary to Heldman Ditch. The Ohio WQS should be revised accordingly. Heldman Ditch was previously confirmed for the MWH aquatic life use while Hill Ditch was previously confirmed for the LRW aquatic life use. In 2011, generally fair aquatic community performance and QHEI scores sustained the MWH use designation for Heldman Ditch ($IBI\bar{x}$=27, $ICI\bar{x}$=Fair, $QHEI\bar{x}$=49.0, n=2). Similar biological and habitat scores in Hill Ditch were sufficient to recommend the MWH use designation for this tributary, too ($IBI\bar{x}$=22, $ICI\bar{x}$=L Fair, $QHEI\bar{x}$=59.8, n=2).

Zink Ditch joins Heldman Ditch at RM 5.96. At the time of this report, Zink Ditch is not among the Ohio WQS listed water bodies. Marginally good fish and low fair macroinvertebrate index scores at Dorr Street (RM 0.7) with poor habitat were conducive to recommend the MWH use designation for Zink Ditch.

Prior assessments confirmed the LRW aquatic life use for Shantee Creek upstream from Detroit Ave. (RM 2.8) and for Silver Creek upstream from Maybee Road (RM 2.8). Downstream, both water bodies were previously confirmed for MWH use designations. These uses were regarded to be appropriate pursuant to aquatic community and habitat evaluations in 2011. In addition to sediment contamination present in both streams, acutely toxic concentrations of ammonia were detected in Shantee Creek upstream from Lewis Avenue during June and July, 2011. The source of this pollution merits discovery and elimination.

Detwiler Ditch is currently undesignated in the Ohio WQS. Detwiler Ditch sediments, like those in Shantee, Silver and Halfway creeks, were contaminated in amounts exceeding the associated PEC. These sediments and the ponded conditions of Detwiler Ditch fostered a poor macroinvertebrate assemblage. The marginally good to fair fish community was comprised of species better adapted to the modified lentic environment (IBI=34, MIwb=7.2, QHEI=35.0). Considering that the sub-par macroinvertebrate community was limited by sediment quality while the fish assemblage was fair to marginally good and that stream habitat conditions were adequate, the MWH aquatic life use is recommended for Detwiler Ditch.

A significant effort was made in the past 15 years to remove contaminated sediments from the lower reach of the Ottawa River. This accomplishment would be enhanced through removal of contaminated sediments from the above named tributaries. Action to correct the sediment related water quality impairment identified in this Tenmile Creek and Ottawa River study is recommended.

All Ohio lakes, including Lake Olander, are designated with the EWH aquatic life use. The proposed Lake Habitat aquatic life use is intended to supplant the existing EWH criteria in a future revision of the Ohio WQS. Lake Olander is also designated for PCR Class A recreational use. Both uses are appropriate and should be continued for Lake Olander.

All study area streams are designated for PCR Class B recreational use and are listed as potential agricultural or industrial water supply sources. These uses are appropriate and should be retained.

Table 7. Use designations for water bodies in the Ten Mile Creek and Ottawa River portion of the Maumee River drainage basin. Designations based on the 1978 and 1985 water quality standards appear as asterisks (*). Designations based on Ohio EPA biological field assessments appear as a plus sign (+) and a delta (Δ) indicates a new recommendation based on the findings of this report. Plus sign and asterisk designations shaded in gray are to be replaced by the new recommendations (Δ). Designations based on the 1978 and 1985 standards for which the results of a biological and habitat assessment are now available are displayed to the left of existing markers.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Raisin creek		*							*	*		*		
Bear creek		*/+							*/+	*/+		*/+		
Little Bear creek		*							*	*		*		
Detwilter ditch				Δ					Δ	Δ		Δ		
Halfway creek		*/+							*/+	*/+		*/+		
Shantee creek - headwaters to Detroit ave. (RM 2.8)							+		+	+		+		Small drainageway maintenance
- Detroit ave. to the mouth				+					+	+		+		HELP ecoregion - channel modification
Eisenbraum ditch							+		+	+			+	Small drainageway maintenance
Tifft ditch							+		+	+			+	Small drainageway maintenance
Silver creek - headwaters to upstream Maybee rd. (RM 2.9)							+		+	+		+		Small drainageway maintenance
- RM 2.9 to the mouth				+					+	+		+		HELP ecoregion - channel modification
Ketcham ditch (Silver creek RM 4.34)							+		+	+			+	Small drainageway maintenance
Ottawa river		+							*/+	*/+		+		
Sibley creek							+		+	+		+		Small drainageway maintenance

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Flieg ditch (Ottawa river RM 9.66)							+		+	+			+	Small drainageway maintenance
Williams ditch (Flieg ditch RM 1.0)							+		+	+			+	Small drainageway maintenance
Hill ditch (Ottawa river RM 11.81)				Δ			+		+	+			+	Small drainageway maintenance
Heldman ditch (Hill ditch RM 0.47)				+					+	+			+	HELP ecoregion - channel modification
Zink ditch (Heldman ditch RM 5.96)				Δ					Δ	Δ			Δ	
Haefner ditch (Hill ditch RM 0.96)							+		+	+			+	Small drainageway maintenance
Tenmile creek		+							*/+	*/+		*/+		
North branch		+							*/+	*/+		*/+		
Ottawa lake outlet		*							*	*		*		
Clampitt drain		*							*	*		*		
Big Ravine drain		*							*	*		*		
Saxton drain		*							*	*		*		
Bischoff drain		*							*	*		*		
Prairie ditch		*		Δ					*/+	*/+		*		
Unnamed tributary (Tenmile creek RM 16.92) - at RM 1.25								o						PWS intake - Metamora

Results

Chemical Water Quality and Sediment Chemistry

Aquatic life and recreational use results were found to portray generally fair water quality conditions in the Tenmile Creek and Ottawa River study area (Tables 2 and 4). Consistent with this characterization, watershed wide fair stream habitat offered limited buffering from water pollution. The pervasive efforts to facilitate better drainage have concurrently degraded stream assimilative capacity. Artificially deepened streams were prevented from displacing bedload sediments onto attendant floodplains and thereby the stream had potentially degraded pollution assimilative capacity. In this low gradient system, trapped fine sediments have diminished the ability of stream riffles to aerate and filter while water contaminants are flushed downstream. In addition, the open sunlit pools stimulated by the combination of sunlight and abundant nutrients harbored thriving algal communities.

Normal stream flows were recorded during the survey period at the Ottawa River US Geological Survey gage (http://nwis.waterdata.usgs.gov/nwis/uv?site_no=04177000) adjacent to Stadium Drive (RM 11.15). Most sampling (Figure 4) occurred after some initial high spring flow events (10^{th}%tile=306 cfs, cubic feet per second) and was completed before the sporadic late summer low flows were noted (90^{th}%tile=6.6 cfs). Permitted stream waste loads are developed with reference to natural low flow conditions which statistically occur over seven consecutive days in a ten year period (Q7, 10). The Ottawa River remained above its Q7, 10 flow (1.8 cfs) throughout 2011 and 2012. Low flow conditions (6.6 to 4.0 cfs) were observed during additional sampling conducted from July 31 to August 2, 2012.

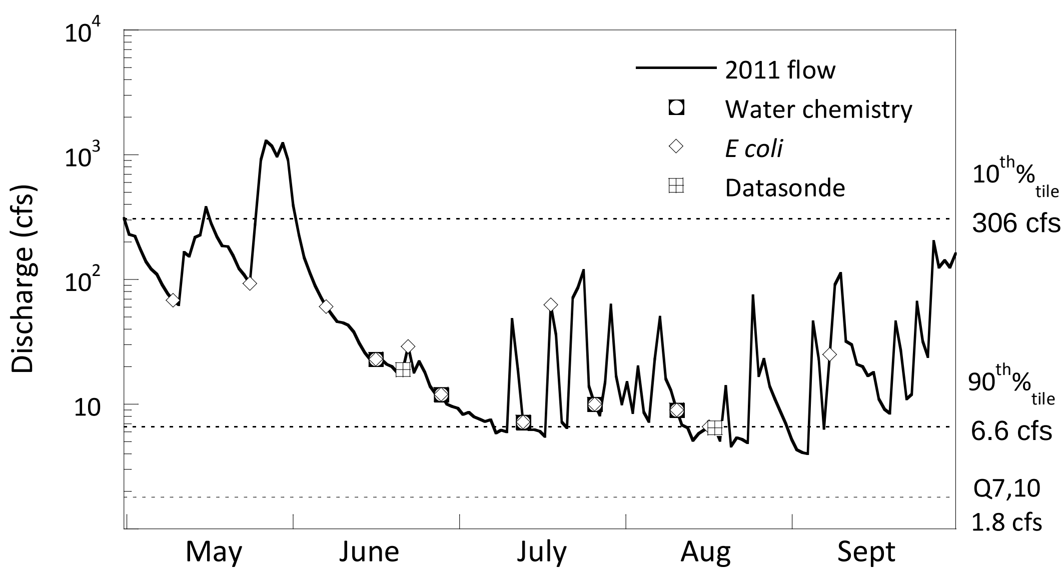


Figure 4. Flow hydrograph for the Ottawa River at Stadium Drive (USGS gage #04177000, RM 11.15) from May through September, 2011. Dates of surface water chemical and bacteria sampling and of Datasonde® continuous monitor deployment are depicted. Discharge and flow duration percentiles are indicated in cubic feet per second (cfs).

Sampling locations were primarily established from bridges in free-flowing stream reaches (Table 1). Five sets of surface water samples were collected at 27 study area locations between June 16 and August 10, 2011. Additional spring 2011 and summer 2012 sampling occurred at two “sentinel” sites (Tenmile Creek at Herr Road, RM 5.94 and Ottawa River at Stadium Drive, RM 11.15), where water chemistry concentrations were paired with flow measurements to facilitate parameter load calculations. All practices adhered to the *Surface Water Field Sampling Manual* (Ohio EPA, 2013).

Field measurements (temperature, pH, conductivity, and dissolved oxygen concentration and percent saturation) were obtained with surface water samples. Dissolved oxygen (D.O.) concentrations deemed likely to stress aquatic communities were documented at nine locations (Table 9). Surface water samples were analyzed for physical properties and inorganic compounds including total dissolved solids (TDS), total suspended solids (TSS), total phosphorus (TP), nitrate-nitrite nitrogen (NOx-N), ammonia nitrogen (NH3-N), and major anions (chloride, sulfate). Dissolved metal concentrations were determined at 18 locations where detection was likely to support identification of probable sources of exposure or determination of causes of stress. Surface water sample results are presented in Appendix Table 7.

Datasonde® continuous monitoring devices were utilized at 14 sites. These instruments logged hourly field measurements over two day periods from June 21 to 23, and August 16 to 19 in 2011, and from July 31 to August 3 in 2012. Low D.O. concentrations were frequently recorded throughout the study area, though only two sites, Tenmile Creek RMs 16.03 and 15.00, had values resulting in violations of the aquatic life use WQS criteria (Table 8). The lower flows in 2012 resulted in more D.O. criteria violations at all four Tenmile Creek sampling locations.

The presence of volatile and semi-volatile organic compounds was assessed in single samples from Tenmile Creek at Brint Road (RM 2.97), Ottawa River at Harroun Road (RM 19.50) and Stadium Drive (RM 11.15), from Shantee Creek at Stickney Avenue (RM 0.7), and from Detwiler Ditch in Detwiler Park (RM 0.5). Bis(2-Ethylhexyl)phthalate (16.3 ug/l) was detected from the Ottawa River at Stadium Drive (RM 11.15). Phthalates, used to manufacture plastic materials, are often detected in urban streams. No influence was attributed to the single detection. Organic compounds were absent in surface water samples from other study area sites (Appendix Table 8).

Between August 30, 2011 and January 11, 2012, stream sediments were conservatively sampled from 13 study area sites focusing on depositional areas of fine grain material (silts and clays). These areas typically trap sediment with contaminant levels above values associated with coarse sands or gravels. Fine grained depositional areas, generally restricted to stream margins, were less abundant than other aggradations of sorted substrates. Ohio EPA’s *Sediment Sampling Guide and Methodologies* (2012b) sets forth pertinent protocols followed in this survey.

Stream sediments were assessed for the presence of metal and organic compounds (Table 12, Appendix Tables 9 and 10). Ohio EPA’s *Guidance on Evaluating Sediment Contaminant Results*

(2010) suggests a course of analysis regarding possible exposure and response risks. Initial comparison with statewide and ecoregional Sediment Reference Values (SRV, Ohio EPA 2008b) for metals and with Threshold Effect Concentrations (TEC) and Probable Effect Concentrations (PEC) for metals and organic constituents (MacDonald *et.al*. 2000) is recommended to interpret results in regard to likely influences. Amounts below the SRV and TEC are considered unlikely to exert harmful effects. Results greater than the PEC are highly correlated with adverse environmental effects due to sediment toxicity.

Silt and other fines were consistently abundant at every sampling location. Interstitial voids among larger substrate materials were usually filled with silt and other fines. The dense compact mixture of tightly fit particles embedding the stream aggregate diminished stream functions. Where these substrates were further impacted by the accumulation of contaminants, aquatic community performance was impaired.

A pattern is apparent in sediment data as Tenmile Creek flows from a rural region to become the Ottawa River in an urban setting. Upstream, sediment metal concentrations were several times less than the associated SRV. Polycyclic aromatic hydrocarbons (PAHs) were limited to one compound (fluoranthene=0.60 mg/kg) measured just above the method detection limit (MDL=0.56 mg/kg). Downstream, sediment metal concentrations were more variable. Although none of the detected metals were present in amounts considered harmful, the irregular results were especially evident in sediment collected upstream from the former Secor dam. Eliminated in November 2007, the backwater reach of the former dam harbored sediment with metal concentrations similar to that of sediment from the rural area. Likewise, only two PAHs were present in relatively small amounts (fluoranthene=0.85, MDL=0.51mg/kg and pyrene=0.64, MDL=0.51mg/kg). Sediments from adjacent reaches contained appreciably more PAH contamination.

In "Assessing Potential Removal of Low-Head Dams in Urban Settings: An Example from the Ottawa River, NW Ohio" (Roberts et al. 2007), collaborators from Bowling Green State University and the University of Toledo determined "the Secor Dam has very low trapping efficiency and has not retained significant quantities of fine-grained sediments." The study predicted dam removal would spur sediment redistribution in consequence of future "channel-forming" type flows. Prior to dam removal, the authors reported sediment contamination similar to the conditions determined in this survey at adjacent sites. The relative difference in 2011 suggests the reach has effectively been washed clean. This result, concurrent with improved biological community performance, can be regarded as positive outcomes of the dam removal and stream restoration project.

The need for additional sediment focused restoration was apparent in sediment data from Shantee, Silver and Halfway creeks and from Detwiler Ditch. Total PAH sample concentrations exceeded the PEC in Shantee, Silver and Halfway creeks. Total polychlorinated biphenyl (PCB) presence was greater than the PEC in Shantee Creek and in Detwiler Ditch samples. Sediment from these last two streams also contained elevated metal concentrations. Overall, samples from Shantee, Silver and Halfway creeks and from Detwiler Ditch were sufficiently contaminated to infer resident aquatic life is continuously stressed by sediment pollution.

Table 8. Exceedances and violations of aquatic life use criteria (ALU, OAC 3745-1) for chemical water quality parameters (mg/l) based on surface water sampling in the Tenmile Creek and Ottawa River study area, 2011. Relevant criteria are presented below Table 9.

Location	RM	ALU	Parameter	Issue
Tenmile Creek				
Headwaters Tenmile Creek 04100001-03-04				
Fulton CR T	18.25	WWH	DO (3.47)	Minimum criterion violation
SR 64	16.03	WWH	DO (3.71, 4.01)	Minimum violation, average criterion exceedance
Fulton CR 1	15.00	WWH	DO (4.28)	Average criterion exceedance
Kilburn R	9.17	WWH	DO (4.79)	Average criterion exceedance
Tenmile Creek 04100001-03-06				
Herr R	5.94	WWH	DO (4.48)	Average criterion exceedance
Ottawa River				
Heldman Ditch-Ottawa River 04100001-03-07				
Edgehill R	14.42	WWH	DO (4.59)	Average criterion exceedance
Sibley Creek-Ottawa River 04100001-03-08				
Monroe S	9.25	WWH	DO (4.25, 4.85)	Average criterion exceedance
Prairie Ditch				
Prairie Ditch 04100001-03-03				
Golf Course	1.41	MWH	DO (2.46, 2.83)	Minimum violation, average criterion exceedance
Detwiler Ditch				
Detwiler Ditch-Frontal Lake Erie 04100001-03-09				
Detwiler Park	0.67	MWH	DO (3.29)	Average criterion exceedance

Table 9. Summary of dissolved oxygen concentrations (mg/L) measured by Datasonde® continuous monitors deployed in the Tenmile Creek and Ottawa River study area, 2011-2012. **Bold** values highlighted in gray boxes violate pertinent aquatic life use (ALU) criteria. *Italicized* values exceed ALU average criterion. ***Bold italicized*** range values are likely to be associated with ALU impairment. Relevant criteria are presented below.

Stream (ALU)	RM	Hours	Mean	Median	Min	Max	Range
June 21 to June 23, 2011							
Tenmile Creek (WWH)	16.03	45	6.3	5.7	**3.4**	10.1	6.7
	15.00	48	7.9	7.3	**2.5**	15.9	***13.4***
	9.17	45	7.2	6.6	*4.8*	10.8	6.0
	5.94	45	6.2	6.3	5.2	7.3	2.1
	2.97	46	8.4	7.5	6.1	11.8	5.7
Ottawa River (WWH)	19.50	46	8.3	7.2	5.9	13.3	***7.4***
	14.42	47	5.7	5.2	*4.5*	8.1	3.6
	11.15	46	6.8	6.7	5.0	9.0	4.0
	9.25	47	5.9	5.6	*4.4*	7.1	2.7
North Tenmile Creek (WWH)	0.12	45	6.6	5.6	*4.6*	10.2	5.6
Heldman Ditch (MWH)	0.15	47	6.4	6.3	5.0	8.2	3.2
August 16 to 18, 2011							
Tenmile Creek (WWH)	5.94	46	5.8	5.5	*4.1*	7.8	3.7
Ottawa River (WWH)	11.15	47	9.5	7.8	5.1	17.4	***12.3***
Prairie Ditch (MWH)	0.36	47	5.2	4.8	*3.1*	7.8	4.7
Silver Creek (MWH)	1.70	48	6.1	5.9	4.7	7.9	3.2
Shantee Creek (MWH)	0.70	47	7.3	7.2	4.6	9.9	5.3
July 31, to August 2, 2012							
Tenmile Creek (WWH)	16.03	46	**3.8**	*3.0*	**0.7**	9.4	***8.7***
	15.00	46	**3.5**	*1.5*	**0.0**	14.2	***14.2***
	9.17	46	**4.1**	*3.9*	**2.5**	6.6	4.1
	5.94	46	**2.4**	*2.4*	**1.8**	**3.2**	1.4

Dissolved Oxygen criteria (mg/l)		
ALU	Average	Minimum
WWH	5.0	4.0
MWH (HELP)	4.0	2.5
LRW	3.0	2.0

Table 10. Sediment metal and organic compound concentrations (mg/kg dry weight) at selected Tenmile Creek and Ottawa River study area sites, 2011-2012. Sediment Reference Values (SRV, noted after parameter) are Statewide (Pb, Hg) or ecoregional (HELP) background metal concentrations (Ohio EPA 2010). Results highlighted in gray exceed the SRV. Results less than Threshold Effect Concentrations (TEC, in *italics* after parameter) are unlikely to be harmful (MacDonald, et.al 2000). *Italicized* results highlighted in gray exceed the TEC. Results exceeding the Probable Effect Concentration (PEC, in ***bold italics*** after parameters) appear in ***bold italics*** with gray highlights.

	TenmileCreek	**Ottawa River**							
	Brint Rd.	Harroun Rd.	Sylvania Ave.	Central Ave.	Edgehill Rd.	Talmadge Rd.	Ust. Secor dam	Douglas Ave.	Monroe St.
Parameter (SRV, *TEC*, ***PEC***) / RM	3.0	19.5	16.84	15.05	14.42	13.16	11.8	10.86	9.25
Metals									
Lead (47, *35.8*, ***128***)	5.31	16.5	13.0	11.5	12.0	6.87	5.62	9.62	7.11
Cadmium (0.96, *0.99*, ***4.98***)	0.249	0.456	0.365	0.401	0.322	0.237	0.176	0.257	0.245
Chromium (51, *43.4*, ***111***)	7.15	11.3	11.3	9.03	15.4	5.31	4.36	5.96	4.65
Copper (42, *31.6*, ***149***)	7.48	14.4	9.80	11.9	12.4	6.59	4.86	6.07	7.96
Nickel (36, *22.7*, ***48.6***)	9.19	9.25	7.82	9.40	9.59	5.75	4.80	5.32	5.62
Zinc (190, *121*, ***459***)	32.4	83.1	56.8	52.5	40.8	30.8	17.4	28.5	23.0
Mercury (0.12, *0.18*, ***1.06***)	0.044	0.040	0.043	0.056	<0.037	0.035	<0.028	0.043	0.042
Polycyclic Aromatic Hydrocarbons (PAHs)[1]									
Benzo(a)anthracene (*0.11*, ***1.05***)	< RL	*0.85*	< RL	***2.06***	***1.17***	***1.11***	< RL	*0.89*	*0.83*
Benzo(a)pyrene (*0.15*, ***1.45***)	< RL	*0.96*	*0.80*	***2.98***	***1.53***	*1.34*	< RL	*1.39*	*0.93*
Benzo[b]fluoranthene	< RL	1.04	1.04	3.81	1.75	1.44	< RL	1.68	1.00
Benzo[k]perylene	< RL	0.71	0.67	2.59	1.17	0.89	< RL	1.27	0.64
Benzo[k]fluoranthene	< RL	0.63	0.60	2.22	1.19	0.94	< RL	1.12	0.71
Chrysene (*0.17*, ***1.29***)	< RL	*1.08*	*0.96*	***3.82***	***1.82***	***1.53***	< RL	***1.67***	*1.15*
Fluoranthene (*0.42*, ***2.23***)	*0.60*	***2.52***	*1.75*	***7.71***	***3.96***	< RL	*0.85*	***3.17***	***2.34***
Indeno(1,2,3-cd)pyrene	< RL	0.67	0.60	2.31	1.00	0.81	< RL	1.12	0.61
Phenanthrene (*0.2*, ***1.17***)	< RL	***1.43***	*0.62*	***2.51***	***1.77***	***1.17***	< RL	*0.86*	*0.98*
Pyrene (*0.2*, ***1.52***)	< RL	***1.88***	*1.30*	***5.75***	***2.99***	***2.35***	*0.64*	***2.41***	***1.72***
Total PAHs (*1.61*, ***22.8***)	0.60	*11.77*	*8.34*	***35.76***	*18.35*	*11.58*	1.49	*15.58*	*10.91*

Table 10 (continued). Sediment metal and organic compound concentrations (mg/kg dry weight) at selected Tenmile Creek and Ottawa River study area sites, 2011-2012. Sediment Reference Values (SRV, noted after parameter) are Statewide (Pb, Hg) or ecoregional (HELP) background metal concentrations (Ohio EPA 2010). Results highlighted in gray exceed the SRV. Results less than Threshold Effect Concentrations (TEC, in *italics* after parameter) are unlikely to be harmful (MacDonald, et.al 2000). *Italicized* results highlighted in gray exceed the TEC. Results exceeding the Probable Effect Concentration (PEC, in ***bold italics*** after parameters) appear in ***bold italics*** with gray highlights.

	Shantee Creek Stickney Ave.	**Silver Creek** Futura Dr.	**Halfway Creek** State Line Rd.	**Detwiler Ditch** Detwiler Park
Parameter (SRV, *TEC*, ***PEC***) / RM	0.7	1.7	5.1	0.67
Metals[2]				
Lead (47, *35.8*, ***128***)	*67.9*	17.2	23.3	*55.9*
Cadmium (0.96, *0.99*, ***4.98***)	*1.43*	0.781	0.565	*4.65*
Chromium (51, *43.4*, ***111***)	30.3	15.0	10.2	27.2
Copper (42, *31.6*, ***149***)	*51.1*	16.6	14.6	*44.8*
Nickel (36, *22.7*, ***48.6***)	21.5	19.5	9.27	*32.6*
Zinc (190, *121*, ***459***)	*253*	77.4	83.3	*432*
Mercury (0.12, *0.18*, ***1.06***)	NA	NA	0.059	NA
Polycyclic Aromatic Hydrocarbons (PAHs)[1]				
Benzo(a)anthracene (*0.11*, ***1.05***)	***1.87***	*0.63*	***1.81***	< RL
Benzo(a)pyrene (*0.15*, ***1.45***)	***2.32***	< RL	***2.31***	< RL
Benzo[b]fluoranthene	2.81	< RL	2.69	1.21
Benzo[k]perylene	1.83	< RL	1.87	< RL
Benzo[k]fluoranthene	2.10	< RL	2.11	< RL
Chrysene (*0.17*, ***1.29***)	***3.09***	*0.84*	***3.03***	***1.32***
Fluoranthene (*0.42*, ***2.23***)	***6.13***	*1.65*	***6.21***	***2.56***
Indeno(1,2,3-cd)pyrene	1.77	< RL	1.71	< RL
Phenanthrene (*0.2*, ***1.17***)	***2.46***	***7.06***	***1.87***	< RL
Pyrene (*0.2*, ***1.52***)	***4.47***	***1.65***	***4.63***	***1.92***
2-Methylnaphthalene	< RL	18.4	< RL	< RL
Total PAHs (*1.61*, ***22.8***)	***28.85***	***30.23***	***28.24***	*7.01*
Polychlorinated Biphenyls (PCBs)[1]				
Arachlor -1242	184	< RL	< RL	< RL
Arachlor -1260	129	< RL	< RL	61.4
Total PCBs (*0.06*, ***0.68***)	***313***			***61.4***

1) < RL: result less than method Reporting Limit
2) NA: sample was Not Assessed for parameter

Fish, Macroinvertebrate and Habitat Results

In 2011, fair habitat conditions (QHEI $\bar{x}$=46.5) were typical at 33 Tenmile Creek and Ottawa River study area biological sampling stations (Table 11). Despite the presence of larger aggregate including boulders and cobble at many sites, substrate quality was universally degraded by the lack of interstitial voids at all locations. The embedded substrates were usually smothered by an overabundance of silt. Although good pool depth was often present, the absence of fast current coupled with little functional instream cover was commonly more limiting.

The Ottawa River harbored the best array of habitat attributes in the study area. A narratively good average QHEI score (QHEI $\bar{x}$=62.1, n=9) suggested habitat in the Ottawa River was sufficient to support an aquatic community compliant with WWH expectations. Excluding the Ottawa River, smaller residential and urban study area streams lacked sinuosity, tended to be severely entrenched, and many were devoid of riffles. Overall, fair habitat quality predominated in these streams (QHEI $\bar{x}$=45.8, n=12). Poor habitats were encountered in the rural part of the study area upstream from Sylvania on Bear and Tenmile Creeks and Prairie Ditch (QHEI $\bar{x}$=41.2, n=12). Aside from the adequate pool depth, the absence of most warmwater habitat qualities in these streams was further influenced by ongoing drainage maintenance practices.

Macroinvertebrate communities (Table 12, Appendix Tables 1 and 2) achieved the relevant biocriterion at nearly half (48%, 16/ 33) of the Tenmile Creek and Ottawa River study area sampling sites. Good (9/ 33) or marginally good (3/ 33) macroinvertebrate community performance was noted at one-third (36%, 12/ 33) of the study stations, while fair assemblages were present at nearly half the sites (48%, 16/ 33). Poor evaluations were recorded at five locations (7%, 5/33). Bear Creek (RM 8.4) was home to an uncommon, pollution sensitive mayfly, *Paracloeodes fleeki*. Four freshwater mussel species were collected live or fresh-dead during the study. *Anodontoides ferussacianus* (cylindrical papershell), *Lasmigona complanata* (white heelsplitter), and *Strophitus undulatus* (creeper) were found at five, one and one sites, respectively, in Tenmile Creek. *Pyganodon grandis* (giant floater) was present at a single Bear Creek site. All of these mussel species are silt tolerant or adapted to headwater conditions. Overall, Tenmile Creek at Kilburn Road (RM 9.2) had more total mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera) taxa (18 EPT) and more sensitive taxa (10) compared to all other study area locations. This site, upstream from the Prairie Creek confluence, benefitted from increased drainage compared to sites further upstream bracketing the Metamora WWTP. Tenmile Creek macroinvertebrate abundance significantly declined downstream from Prairie Creek while the Metamora treatment facility appeared to have little influence.

Fish communities (Table 13, Appendix Tables 3-6) achieved the relevant biocriteria at one-third (33%, 11/ 33) of the Tenmile Creek and Ottawa River study area sampling sites. Unique habitat conditions buoyed three good fish assemblages. Otherwise, fish community performance at most locations was fair (58%, 19/ 33) or poor (33%, 11/ 33). In total, 27,779 fish were collected among 50 samples from twelve differently named streams. Pollution tolerant detritivores, bluntnose (29%) and fathead minnows (11%), along with the herbivorous central stoneroller (10%) comprised half of the individual fish counted among the 45 fish species collected in the survey. Silverjaw minnow (6%) followed creek chub (6%) as the next most numerous species. Silverjaw minnows were exclusively collected in Bear Creek. Alternatively, least darters were exclusively collected in the Tenmile Creek and Ottawa River drainage. This native, prairie stream inhabitant was previously noticed in Tenmile Creek in 2005 by University of Toledo researcher, Todd Crail (Crail et al. 2011). In the 2011 survey, least darters (360 individuals, 1% total catch) were the fifteenth most abundant fish. A Lake Erie invasive species, the round goby was also numerous in the Tenmile Creek and Ottawa River watershed (1,426 individuals, 4% total catch, 7^{th} most abundant).

From an overall perspective, the fish community of Tenmile Creek and the Ottawa River appeared to be adjusting to the contemporary removal of two Ottawa River dams. The 2007 Secor Road dam removal was preceded by removal of a dam upstream at Camp Miakonda in 2003. Golden redhorse (47 individuals) were present at six of nine Ottawa River mainstem sampling locations and at the two most downstream Tenmile Creek sites. One shorthead redhorse was present in the Ottawa River at Edgehill Road (RM 14.4). Redhorse are insectivorous sucker type fish that are moderately intolerant to degraded water quality. Ohio EPA had previously only collected pollution tolerant omnivorous white suckers in this basin. Likewise, moderately intolerant logperch (141 individuals) were present at all Ottawa River mainstem sampling locations and at the downstream Heldman Ditch and Tenmile Creek sites. Ohio EPA had not recorded this darter species in earlier watershed sampling. Northern pike, although present in prior surveys, were well distributed and more numerous in 2011 (21 individuals, present at 7 of 9 Ottawa River mainstem sites and at the 3 most downstream Tenmile Creek locations). Collectively, these migratory fish were more prolific in 2011. The combination of improved water quality and unimpeded access to the entire stream was the most plausible explanation for these range expansions.

Table 11. Qualitative Habitat Evaluation Index (QHEI) matrix with Warmwater Habitat (WWH) and Modified Warmwater Habitat (MWH) attribute totals and ratios for the Tenmile Creek and Ottawa River study area, 2011.

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	Hi-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.+1/WWH+1 Ratio
04-065-000 Bear Creek																																		
Year	**2011**																																	
13.0	37.0	4.42		•									1	•			•	•	3		•		•	•	•			•	•	•		7	2.00	4.00
11.6	39.0	5.70		•									1	•			•	•	3		•		•	•	•			•	•	•		7	2.00	4.00
8.4	31.5	3.40		•							•		2	•			•		2		•		•	•	•	•	•	•	•		•	9	1.00	3.33
04-067-000 Halfway Creek																																		
Year	**2011**																																	
5.1	50.0	13.51	•				•				•		3		•		•		2		•		•	•				•	•		•	6	0.75	1.75
04-068-000 Shantee Creek																																		
Year	**2011**																																	
3.1	29.0	4.67											0		•	•	•	•	4	•	•			•				•	•		•	6	5.00	7.00
0.7	35.0	4.10									•		1				•		1	•	•		•	•	•		•	•	•		•	9	1.00	5.00
04-069-000 Silver Creek																																		
Year	**2011**																																	
4.5	43.0	7.46	•				•						2				•	•	2		•		•	•				•	•	•		6	1.00	2.33
1.1	41.0	0.10						•			•		2		•		•		2	•	•			•	•			•	•		•	7	1.00	2.67
04-300-000 Ottawa River																																		
Year	**2011**																																	
19.5	78.0	9.26	•	•		•	•	•			•		6						0						•			•	•	•		4	0.14	0.71
16.9	68.5	2.24	•	•		•		•			•		5				•		1		•		•		•			•	•	•		6	0.33	1.17
14.4	59.3	2.00	•								•		2				•		1		•			•	•			•	•	•		6	0.67	2.33
12.2	67.0	3.79	•	•		•		•	•		•		6				•		1		•		•		•				•	•		5	0.29	0.86
11.8	59.3	3.79	•			•			•		•		4			•	•		2		•		•	•	•				•	•		6	0.60	1.40
11.6	63.0	3.79	•			•			•		•		4				•		1		•			•	•				•	•		5	0.40	1.20
11.1	48.5	3.91				•					•		2	•		•	•		3		•			•				•	•	•		5	1.33	2.00
10.9	43.0	3.91									•		1	•		•	•		3		•			•	•			•	•		•	6	2.00	3.50
9.4	72.0	3.91	•	•		•		•			•		5						0		•			•	•			•	•	•		6	0.17	1.17
04-300-005 Heldman Ditch																																		
Year	**2011**																																	
2.8	39.0	10.42					•				•		2		•		•		2	•	•		•	•			•	•	•		•	8	1.00	3.00
0.1	59.0	13.51	•	•		•	•	•			•		6						0		•						•	•	•	•		5	0.14	0.86

Table 11 (continued). Qualitative Habitat Evaluation Index (QHEI) matrix with Warmwater Habitat (WWH) and Modified Warmwater Habitat (MWH) attribute totals and ratios for the Tenmile Creek and Ottawa River study area, 2011.

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	Hi-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.+1/WWH+1 Ratio
04-300-006 Zink Ditch																																		
Year 2011																																		
0.7	43.5	11.63					•	•					2	•			•	•	3	•				•	•			•	•		•	6	1.33	2.33
04-300-007 Hill Ditch																																		
Year 2011																																		
2.6	64.5	15.63	•	•		•		•			•		5				•		1	•					•			•	•	•		5	0.33	1.00
2.2	55.0	12.82		•							•		2				•		1	•	•			•	•			•	•	•		7	0.67	2.67
04-301-000 Detwiler Ditch																																		
Year 2011																																		
0.5	35.0	0.10						•			•		2		•		•		2	•	•			•	•		•	•	•		•	8	1.00	3.00
04-320-000 Tenmile Creek																																		
Year 2011																																		
18.3	37.3	6.41											0	•		•	•	•	4		•		•	•	•			•	•		•	7	5.00	8.00
16.0	41.5	4.90		•							•		2	•		•	•		3		•		•	•			•	•	•	•		7	1.33	2.67
15.0	32.5	4.76		•									1	•		•	•	•	4		•		•	•	•	•		•	•		•	8	2.50	4.50
9.2	49.0	3.62		•							•		2	•			•		2		•			•	•		•	•	•	•		7	1.00	2.67
5.9	52.5	5.26	•	•			•				•		4				•		1	•	•		•	•				•	•	•		7	0.40	1.60
3.0	51.0	3.79	•	•							•		3				•		1		•			•	•			•	•		•	6	0.50	1.75
0.5	77.0	14.29	•	•		•	•	•		•	•	•	8						0									•	•			2	0.11	0.33
04-320-003 Prairie Ditch																																		
Year 2011																																		
1.4	27.0	2.44											0	•	•	•	•	•	5		•		•	•		•		•	•		•	7	6.00	8.00
0.3	19.0	2.44									•		1	•	•	•	•		4		•		•	•		•	•	•	•		•	8	2.50	4.50
04-321-000 North Branch Tenmile Creek																																		
Year 2011																																		
0.9	54.0	12.50	•	•		•	•						4				•	•	2		•			•				•	•		•	5	0.60	1.20

Table 12. Summary of macroinvertebrate data collected in the Tenmile Creek and Ottawa River study area, 2011. Taxa numbers are from natural substrate (qualitative) sampling. If applicable, the second EPT and sensitive taxa values include those from artificial substrates (quantitative sampling). Organism density is reported by natural (Qualitative Density) and if applicable, artificial substrates (HD).

RM	mi^2	Flow	Taxa	EPT	Sensitive Taxa	Qual. Density	HD	CW	ICI[a]	Narrative
	Predominant natural substrate organisms (tolerance)									
Bear Creek										
12.9	18.7	-	64	15	8	Moderate	-	-	-	Good
	hydropsychid caddisflies (F), *Caenis* mayflies (F), midges (F)									
11.6	20.3	-	46	11	4	Moderate	-	-	-	Good
	hydropsychid caddisflies (F), midges (F), flatworms (F)									
8.4	22.9	-	53	12/ 12	6/ 6	Low	202	-	38	Good
	midges (F,T), hydropsychid caddisflies (F), mayflies (MI,F)									
Tenmile Creek										
18.3	9.5	-	55	10	4	Low	-	-	-	M Good[ns]
	flatworms (F), water mites (F)									
16.0	22.5	-	47	13	4	Low	-	-	-	Good
	flatworms (F), baetid mayflies (F), hydropsychid caddisflies (F)									
15.0	25.9	*SF*	41	11/ 11	5/ 5	Low-Moderate	102	-	(20)	Good
	flatworms (F), riffle beetles (F), hydropsychid caddisflies (F)									
9.2	43.0	*NF*	50	18/ 18	10/ 10	Moderate	659	-	(22)	Good
	hydropsychid caddisflies (F), baetid mayflies (MI,F), midges (F), flatworms (F)									
5.9	64.5	*SF*	55	8/ 9	2/ 2	Low	396	-	18*	Fair
	midges (F,MT), hydropsychid caddisflies (F)									
2.9	70.0	-	40	9/ 9	5/ 5	Low	460	-	26*	Fair
	midges (F), water mites (F), crayfish (F)									
0.5	81.0	-	51	8/ 8	4/ 6	Low-Moderate	489	1	38	Good
	hydropsychid caddisflies (F), baetid mayflies (F), flatworms (F)									
Ottawa River										
19.5	124.6	-	28	7/ 8	3/ 5	Moderate	338	1	34	Good
	baetid mayflies (F)									
16.9	127.6	-	32	6/ 7	2/ 4	High	524	-	30[ns]	M Good
	baetid mayflies (F)									

Table 12 (continued). Summary of macroinvertebrate data collected in the Tenmile Creek and Ottawa River study area, 2011. Taxa numbers are from natural substrate (qualitative) sampling. If applicable, the second EPT and sensitive taxa values include those from artificial substrates (quantitative sampling). Organism density is reported by natural (Qualitative Density) and if applicable, artificial substrates (HD).

RM	mi^2	Flow	Taxa	EPT	Sensitive Taxa	Qual. Density	HD	CW	ICI[a]	Narrative
	Predominant natural substrate organisms (tolerance)									
Ottawa River (continued)										
14.4	131.6	-	27	4/ 6	2/ 2	Moderate	222	-	28*	Fair
	baetid mayflies (F)									
12.2	133.0	-	27	5/ 7	1/ 1	Moderate	650	-	30[ns]	M Good
	baetid mayflies (F)									
11.8	133.0	-	29	5/ 7	1/ 3	Moderate	959	-	36	Good
	hydropsychid caddisflies (F)									
11.6	154.0	-	24	4/ 4	1/ 2	Moderate	245	-	22*	Fair
	hydropsychid caddisflies (F)									
11.1	154.0	-	25	4/ 6	0/ 1	Moderate	816	-	28*	Fair
	hydropsychid caddisflies (F)									
10.9	155.0	*SF*	16	0/ 1	0/ 1	Low	206	-	16*	Fair
	midges (MT,F)									
9.4	155.6	-	18	4/ 4	1/ 1	Moderate	515	-	24*	Fair
	baetid mayflies (F)									
Prairie Ditch										
1.4	16.9	*I*	43	4	1	Moderate	-	-	-	Fair
	snails (T,MT), water boatman (MT), beetles (MT)									
0.3	17.3	*I*	42	5	0	Low-Moderate	-	-	-	Fair
	snails (T,MT), water boatman (MT), midges (MT,F), sowbugs (T,MT)									
North Tenmile Creek										
0.6	42.0	-	49	7	3	Low	-	-	-	Fair*
	hydropsychid caddisflies (F), heptageniid mayflies (F)									
Heldman Ditch										
2.7	8.4	-	38	5	0	Low-Moderate	-	-	-	Fair
	hydropsychid caddisflies (F), water mites (F), sowbugs (T)									
0.2	21.0	-	25	4	0	Low-Moderate	-	-	-	Fair
	hydropsychid caddisflies (F), midges (F,T), water mites (F)									

Table 12 (continued). Summary of macroinvertebrate data collected in the Tenmile Creek and Ottawa River study area, 2011. Taxa numbers are from natural substrate (qualitative) sampling. If applicable, the second EPT and sensitive taxa values include those from artificial substrates (quantitative sampling). Organism density is reported by natural (Qualitative Density) and if applicable, artificial substrates (HD).

RM	mi^2	Flow	Taxa	EPT	Sensitive Taxa	Qual. Density	HD	CW	ICI[a]	Narrative
	Predominant natural substrate organisms (tolerance)									
Zink Ditch										
0.7	3.5	-	34	3	1	Low-Moderate	-	1	-	Low Fair*
	flatworms (F), midges (F), sowbugs (T)									
Hill Ditch										
2.6	3.5	-	19	2	1	Moderate	-	-	-	Poor*
	hydropsychid caddisflies (F)									
2.2	6.3	-	24	4	0	Moderate	-	-	-	Low Fair*
	hydropsychid caddisflies (F)									
Shantee Creek										
3.1	7.7	-	32	0	0	Moderate	-	-	-	V. Poor*
	midges (VT,T,F)									
0.7	9.1	-	36	3	0	Low-Moderate	-	-	-	Low Fair*
	hydropsychid caddisflies (F), baetid mayflies (F)									
Silver Creek										
4.4	4.6	-	34	2	0	Mod.-High	-	-	-	Poor*
	hydropsychid caddisflies (F), midges (F,T), flatworms (F)									
1.7	5.7	-	21	0	0	Low-Moderate	-	-	-	Poor*
	aquatic segmented worms (T), damselflies (F)									
Halfway Creek										
4.8	22.1	-	33	5	0	Moderate	-	-	-	Fair*
	hydropsychid caddisflies (F), baetid mayflies (F), water mites (F)									
Detwiler Ditch										
0.5	6.2	-	38	1	0	Low-Moderate	-	-	-	Poor*
	damselflies (F), midges (MT,T,F), beetles (F)									

RM: River mile.
mi^2: Drainage area in square miles.
Flow: *NF*=non-detectable current, *I*=intermittent or near-intermittent conditions, *SF*=current >0.0 fps but <0.3 fps (feet per second).
EPT: Mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera) taxa richness based on natural substrate qualitative sampling.
Sensitive Taxa: MI (moderately intolerant) or I (intolerant).
HD: Hester-Dendy artificial substrates are used for quantitative sampling where density is expressed in organisms per square foot.

ICI[a]: Invertebrate Community Index values in parentheses are invalid due to insufficient current speed over the artificial substrates. The station evaluation is based on the qualitative sample narrative evaluation.

Tolerance categories: VT=very tolerant, T=tolerant, MT=moderately tolerant, F=facultative, MI=moderately intolerant, I=intolerant.

Table 13. Summary of fish community data based on pulsed D.C. electrofishing samples collected in the Tenmile Creek and Ottawa River study area, 2011. Total including non-native species is cumulative where multiple samples were obtained. Relative number or weight is normalized to 300 or 1000 meter sampling distances for wading (150 meter zone) or boat (500 meter zone) sites, respectively. Weights are not recorded and the Modified Index of well-being is not applicable at headwater locations.

Stream RM	mi^2	Total Species	Relative Number/ less tolerants	Relative Weight	QHEI	MIwb	IBI	Narrative Evaluation
	Predominant species (percent of catch)							
Bear Creek								
12.9	18.7	15	4149/ 1459	-	37.0	-	32	Fair
	bluntnose minnow (34%), fathead minnow (28%), silverjaw minnow (18%)							
11.6	20.3	16	3745/ 1719	11.1	39.0	8.7	28	Good-Fair
	bluntnose minnow (32%), silverjaw minnow (22%), fathead minnow (15%)							
8.4	22.9	16	1756/ 616	12.8	31.5	7.8	<u>26</u>*	M Good-Poor
	bluntnose minnow (35%), fathead minnow (19%), redfin shiner (12%)							
Tenmile Creek								
18.3	9.5	12	1222/ 282	-	37.3	-	30	Fair
	bluntnose minnow (53%), fathead minnow (18%), least darter (11%)							
16.0	22.5	13	1732/ 900	10.8	41.5	8.1	33	Good-Fair
	bluntnose minnow (28%), striped shiner (17%), Johnny darter (10%)							
15.0	25.9	15	2491/ 806	7.0	32.5	7.4	<u>26</u>*	M Good-Poor
	bluntnose minnow (52%), striped shiner (12%), fathead minnow (9%)							
9.2	43.0	17	569/ 268	6.0	49.0	6.7*	31^{ns}	Fair
	creek chub (26%), bluntnose minnow (15%), striped shiner (14%)							
5.9	64.5	21	464/ 163	3.8	52.5	6.9^{ns}	34	Fair-M Good
	green sunfish (22%) bluntnose minnow (18%),bluegill sunfish (14%)							
2.9	70.0	15	215/ 127	3.7	51.0	<u>5.8</u>*	37	Poor-M Good
	green sunfish (38%), striped shiner (20%), redfin pickerel (10%)							
0.5	81.0	16	686/ 440	9.5	77.0	7.4	39	M Good-Good
	creek chub (21%), orangethroat darter (19%), central stoneroller (15%)							
Ottawa River								
19.5	124.6	18	819/ 626	44.8	78.0	6.3*	37	Fair-M Good
	central stoneroller (33%), orangethroat darter (17%), striped shiner (12%)							
16.9	127.6	19	1225/ 719	4.6	68.5	7.5	28^{ns}	M Good-Fair
	central stoneroller (39%), bluntnose minnow (28%), blackside darter (7%)							
14.4	131.6	18	167/ 88	6.9	59.3	<u>5.5</u>*	34	Poor-M Good
	green sunfish (19%), blackside darter (16%), creek chub (13%)							
12.2	133.0	21	959/ 701	5.3	67.0	8.2	30^{ns}	Good-Fair
	central stoneroller (34%), bluntnose minnow (16%), round goby (14%)							

Table 13 (continued). Summary of fish community data based on pulsed D.C. electrofishing samples collected in the Tenmile Creek and Ottawa River study area, 2011. Total including non-native species is cumulative where multiple samples were obtained. Relative number or weight is normalized to 300 or 1000 meter sampling distances for wading or boat sites, respectively. Weights are not recorded and the Modified Index of well-being is not applicable at headwater locations.

Stream RM	mi^2	Total Species	Relative Number/ less tolerants	Relative Weight	QHEI	MIwb	IBI	Narrative Evalutation
	Predominant species (percent of catch)							
Ottawa River (continued)								
11.8	133.0	18	426/ 330	3.4	59.3	6.8^{ns}	29^{ns}	Fair
	round goby (30%), central stoneroller (23%), bluntnose minnow (11%)							
11.6	154.0	22	400/ 257	31.1	63.0	4.3*	27*	V Poor-Poor
	round goby (46%), bluntnose minnow (22%), green sunfish (9%)							
11.1	155.0	26	545/ 431	8.5	48.5	7.1^{ns}	33	Fair
	round goby (57%), bluntnose minnow (9%), bluegill sunfish (6%)							
10.9	155.0	24	476/ 322	32.3	43.0	6.2*	30^{ns}	Fair
	round goby (47%), bluntnose minnow (24%), bluegill sunfish (7%)							
9.4^{B}	155.6	25	472/ 293	45.9	72.0	8.4^{ns}	25*	M Good-Poor
	gizzard shad (20%), white sucker (16%), bluntnose minnow (15%)							
Prairie Ditch								
1.4	16.9	8	550/ 65	-	27.0	-	28	Fair
	central mudminnow (75%), redfin pickerel (10%), creek chub (10%)							
0.3	17.3	4	128/ 15	-	19.0	-	28	Fair
	central mudminnow (84%), redfin pickerel (12%), yellow bullhead, green sunfish (2%)							
North Tenmile Creek								
0.6	42.1	16	2730/ 1004	-	54.0	-	28^{ns}	Fair
	bluntnose minnow (43%), central stoneroller (19%), creek chub, least darter (11%)							
Heldman Ditch								
2.7	8.4	12	778/ 133	-	39.0	-	22	Poor
	bluntnose minnow (32%), creek chub (25%), Johnny darter (13%)							
0.2	21.0	16	814/ 398	-	59.0	-	32	Fair
	central stoneroller (19%), creek chub (18%), bluntnose minnow (16%)							
Zink Ditch								
0.7	3.5	9	1274/ 918	-	43.5	-	38	M Good
	central stoneroller (65%), creek chub (18%), white sucker (9%)							
Hill Ditch								
2.6	3.5	8	1040/ 128	-	64.5	-	22	Poor
	bluntnose minnow (49%), fathead minnow (27%), central stoneroller (12%)							
2.2	6.3	11	2428/ 480	-	55.0	-	22	Poor
	bluntnose minnow (51%), green sunfish (13%), hybrid sunfish (10%)							

Table 13 (continued). Summary of fish community data based on pulsed D.C. electrofishing samples collected in the Tenmile Creek and Ottawa River study area, 2011. Total including non-native species is cumulative where multiple samples were obtained. Relative number or weight is normalized to 300 or 1000 meter sampling distances for wading or boat sites, respectively. Weights are not recorded and the Modified Index of well-being is not applicable at headwater locations.

Shantee Creek								
3.1	7.7	2	12/ 0	-	29.0	-	12*	V Poor
	creek chub (75%), goldfish (25%)							
0.7	9.1	12	235/ 55	-	37.0	-	24	Poor
	goldfish (30%), fathead minnow (22%), gizzard shad (18%)							
Silver Creek								
4.4	4.6	4	743/ 0	-	43.0	-	16*	V Poor
	fathead minnow (66%), creek chub (29%), white sucker (4%), common carp (1%)							
1.7^{B}	5.7	14	740/ 262	11.2	41.0	7.0	22	Fair- Poor
	fathead minnow (37%), gizzard shad (20%), emerald shiner (13%)							
Halfway Creek								
4.8	22.1	19	640/ 335	-	50.0	-	36	M Good
	pumpkinseed sunfish (20%), round goby (20%), white sucker (18%)							
Detwiler Ditch								
0.5^{B}	6.2	12	774/ 654	117.6	35.0	7.2	34	Fair-M Good
	bluegill sunfish (59%), common carp (11%), gizzard shad (8%)							

RM: River mile.

9.4^{B}: the ^{B} superscript denotes a boat sample site. Wading techniques were employed at all other sites.

mi^2: Drainage area in square miles.

Relative Number less pollution tolerant fish is an IBI metric. MIwb calculations exclude these fish deemed tolerant by Ohio EPA: central mudminnow, white sucker, common carp, goldfish, golden shiner, blacknose dace, creek chub, bluntnose minnow, fathead minnow, green sunfish, yellow bullhead, brown bullhead, and eastern banded killifish.

Stream Summaries

BEAR CREEK

Bear Creek is a tributary, via Black Creek, to Michigan's River Raisin, a 1,059 mi^2 western Lake Erie tributary. The River Raisin Watershed Council (http://www.riverraisin.org/) coordinates efforts to improve environmental conditions across the entire basin. Their 2009 management plan (http://www.michigan.gov/documents/deq/wb-nps-rr-wmp1_303614_7.pdf) identifies the Black Creek subbasin as a high priority for nutrient and sediment load abatement. Black Creek macroinvertebrate communities were characterized as poor to fair.

With 25 mi^2 drainage among three different USGS 12-digit watersheds, Ohio's portion of the 150 mi^2 Black Creek basin is small and unequally subdivided. In 2011, full WWH attainment was determined at two sampling locations in the Headwaters Bear Creek HUC 12-04100002 0301 watershed (IBIx̄=30, MIwb=8.7, ICIx̄=Good). Downstream at one site in the Little Bear Creek-Bear Creek HUC 12-04100002 0304 watershed, a poor IBI score resulted in non-attainment (IBI=26, MIwb=7.8, ICI=38).

Full PCR-B recreational use attainment was recorded at one site in the Headwaters Bear Creek watershed (geox̄=81 cfu/100ml). This achievement was rivaled at only two other study area sites. High *E. coli* concentrations (geox̄=450 cfu/100ml) downstream at one site resulted in non-attainment of the PCR-B recreational use in the Little Bear Creek-Bear Creek HUC (04100002-03-04). No source for the increased downstream bacteria presence was determined.

Agricultural row crop land use (88%) intermixed with rural home and farm sites (8%) have left few tree lots or pastures in Ohio's Bear Creek drainage (Fry et al. 2011). The stream system is more accurately understood as a managed network of ditches and field tile. Poor stream habitat conditions (QHEIx̄=35.8, n=3) were common. The prevalence of silty sand and extensive embeddedness was apparently offset by the presence of larger boulder and cobble aggregate as substrate quality was sufficient to support good macroinvertebrate assemblages at all three Bear Creek sample sites. Fish community performance declined with increasing drainage.

Bear Creek fish communities were predominated by pollution tolerant (x̄=61%, n=5) and omnivorous species (x̄=55%, n=5). Lithophilic fish require clean, well swept substrates with ample interstitial voids into which their spawn is randomly cast. Among 18 fish species in Ohio's Bear Creek, only five were lithophils. The proportional poor lithophil presence (6%, 12%, & 18%, downstream, respectively) supports the perception that substrates were compromised by an overabundance of fines. Compared to upstream fish abundance, a numerical decline to half as many total fish at the most downstream site was the most obvious difference associated with the underachieving fish community.

Although Bear Creek macroinvertebrate assemblages achieved pertinent biocriteria, EPT (15, 11, & 12, downstream, respectively) and sensitive taxa diversity (8, 4, & 6, downstream, respectively) declined with drainage. Caddisfly diversity based on qualitative sampling followed this pattern as well (7, 5, & 1, downstream, respectively). Likewise, overall density declined from moderate to low at the most downstream site.

Daytime D.O. concentrations ranged from 5.5 mg/l to 11.2 mg/l (x̄=8.0 mg/) in 15 field measurements among the three sample locations. These wide ranging values, high dissolved inorganic nitrogen (DIN) concentrations (geox̄=2.8, 2.6, & 2.0 mg/l, downstream, respectively) and modest TP presence (geox̄=0.03, 0.04, & 0.04 mg/l, downstream, respectively) suggested chronic nutrient stress may be sufficient to influence biological communities. Water chemistry and biological sampling results from the two upstream sites bracketing the Lyons WWTP controlled discharge did not indicate any facility influence.

Prior to 2011, Ohio EPA had not evaluated Bear Creek water quality. Lacking trend data or other information, the observed declining macroinvertebrate and fish abundances were most consistent with decreasing habitat quality (QHEI=37, 39, & 31.5, downstream, respectively). In particular, the most downstream sample site lacked functional riffles. Instead, silty, sandy shallow places served to separate deeper pool reaches. The relative disparity in riffle oriented darter density present upstream (411 & 455, respectively) but lacking at the downstream location (120) further supported this observation. Overall, fine sediment trapped within the Bear Creek channel was considered to have the strongest negative influence on biological community performance.

TENMILE CREEK

Beginning in the Headwaters Tenmile Creek HUC 12-04100001 0304 watershed, the principal waterway is joined by the Prairie Ditch HUC 12-04100001 0303 watershed to establish the upstream node of the Tenmile Creek HUC 12-04100001 0306. The confluence of the principal waterway with the North Tenmile Creek HUC 12-04100001 0305 watershed serves as the downstream terminal node for the Tenmile Creek watershed and the upstream initial node for the Heldman Ditch-Ottawa River HUC 12-04100001 0307 watershed. In 2011, Ohio EPA assessed aquatic life use status at four Headwaters Tenmile Creek and at three Tenmile Creek sites. Full WWH attainment was recorded at the two most upstream Headwaters Tenmile Creek sites and at the most downstream Tenmile Creek site. Two sites in non-attainment bracketed two middle sites in partial attainment split evenly among both HUCs. In general, Tenmile Creek aquatic community performance was fair (IBI$\bar{x}$=33, MIwb$\bar{x}$=7.1, ICI$\bar{x}$=32, n=7)

Four of 21 Tenmile Creek bacteria evaluations from three sample sites returned values less than the PCR-B recreational use criterion (*E. coli*<161 cfu/100ml). Eight samples were in excess of 1,000 cfu/100ml. Seven other samples were at least twice the criterion (≥320 cfu/100ml). Geometric mean *E. coli* concentrations at one Headwaters Tenmile Creek site (416 cfu/100ml) and at both Tenmile Creek sites (606 cfu/100ml & 316 cfu/100ml, downstream, respectively) determined each HUC was in non-attainment of the designated recreational use.

The Headwaters Tenmile Creek watershed is almost entirely devoted to agricultural row crops (89%) and associated farm and home sites (7%). Woodlots or pastures are scarce (4%). One-third of the Tenmile Creek HUC is also devoted to row crops (28%). Another half consists of Sylvania area housing developments (51%). A large quarry (8%) and a mix of wooded or undeveloped property (13%) comprise the remainder of the area (Fry et al., 2011).

Stream habitat quality mirrored the surrounding land use. Poor habitat (QHEI$\bar{x}$=40.1, n=4) in the channelized Headwaters Tenmile Creek HUC reach was a condition of agricultural drainage. Silt smothered this shallow reach where cover was sparse. Downstream from Prairie Ditch, a wooded riparian corridor and better pool depth contributed to generally fair habitat conditions (QHEI$\bar{x}$=51.8, n=2). The most downstream Tenmile Creek and the two most upstream Ottawa River sites were unique in the study area for having very good stream habitat (QHEI$\bar{x}$=74.5, n=3). Dolomite bedrock at these locations provided good substrate and the presence of root wads with woody debris were functional cover options.

The macroinvertebrate community improved with larger drainage at the four most upstream sites. Downstream from Prairie Creek, the macroinvertebrate community declined with half as many EPT taxa (9) and fewer (2-5) sensitive types present (Figure 5). Predominated by moderately pollution tolerant midges, this reach with low organism density was at odds with the improving trend. Better habitat at the most downstream Tenmile Creek site (RM 0.5) was consistent with more abundant hydropsychid caddisflies and baetid mayflies, the presence of six sensitive and one coldwater taxa and a modest density increase. Despite a good ICI score (38) relatively few EPT taxa (8) at the most downstream location suggested some limiting influences were extant.

Tenmile Creek fish community performance was most affected by the absence of species with narrow niches (Figure 6). No pollution intolerant species were collected in Tenmile Creek. All samples achieved moderate total native species IBI metric scores, and better substrates at the most downstream site were associated with an abundance of darters (37%). The macroinvertebrate decline downstream from Prairie Creek was consistent with limited riffle availability and the smallest darter population (5%). Although pool conditions were good at this location, striped shiners were disproportionately represented. This pool dependent fish and other lithophils were more prevalent at adjacent sites (RM 9.2 had 14% striped shiner and 29% lithophils, RM 5.9 had 3% striped shiner and 12% lithophils, and RM 3.0 had 21% striped shiner and 27% lithophils). These shifts imply some unsuitability beyond habitat at the downstream Prairie Creek location. Seasonality and possibly nutrient availability were evident downstream from the Metamora WWTP where bluntnose minnow, redfin shiner and Johnny darter abundance doubled between the July and August sampling events, while this trend was less pronounced or reversed at other Tenmile Creek sites.

Balanced distribution of species richness, abundance, and biomass are necessary for achievement of the MIwb biocriterion (Figure 6). Tenmile Creek fish assemblages failed to achieve the MIwb criterion upstream from Prairie Ditch and downstream from the quarry influenced area. Nonsignificant MIwb departure was recorded immediately downstream from Prairie Ditch. Low abundance and limited biomass were especially evident downstream from Prairie Ditch and downstream from the quarry. Although the site upstream from Prairie Ditch had more biomass than either downstream site, the upstream biomass was disproportionately represented by pollution tolerant fish (numerically 53% tolerant, biomass 74% tolerant). The unbalanced biomass of tolerant fish influenced MIwb component calculations.

The prevalence of pollution tolerant aquatic assemblages in Tenmile Creek was consistent with the presence of various stressors documented through water chemistry analysis. Daytime D.O. concentrations were often less than the 5.0 mg/l average concentration expected in WWH streams. During sample acquisition on July 25 and July 26, 2011, the two most upstream sites had D.O. concentrations less than the 4.0 mg/l minimum WWH concentration (Figure 7). Wide ranges or critical low diurnal D.O. concentrations were routine at the five Tenmile Creek locations where Datasonde® continuous monitors were used. This pattern was even more pronounced at four locations where deployment was repeated 2012. Repetitive variation or lengthy periods of limited D.O. availability are harmful to most aquatic species. Daily supersaturated D.O. conditions downstream from the Metamora WWTP are depleted with each day's sunset. On August 2, 2012, D.O. values at 0.0 mg/l were measured over a seven hour period in the morning (Figure 8, upper plot). Most of Tenmile Creek upstream from this site is maintained as a treeless ditch. Although the most downstream reach of Prairie Ditch and sporadic places along Tenmile Creek upstream from the confluence lacked tree shade, better riparian presence seemed to moderate diurnal D.O. swings downstream from Prairie Ditch. Additional flow at this site was credited for lower and more stable daytime temperature measurements (RM 15.0 $\bar{x}$=23.1˚C, RM 9.2 $\bar{x}$=22.7˚C, RM 5.9 $\bar{x}$=21.2˚C, n=5/site). However, the additional flow was accompanied by increased conductivity (RM 15.0 $\bar{x}$=528umhos/cm, RM 9.2 $\bar{x}$=526umhos/cm, RM 5.9 $\bar{x}$=611umhos/cm, n=5/site). Lower temperatures and higher conductivity were also recorded in Prairie Ditch (RM 1.4 $\bar{x}$=21.7˚C, $\bar{x}$=683umhos/cm, n=5). Water from Prairie Ditch entering Tenmile Creek was noticeably discolored. Its tannin stain appeared to derive from flocculent organic debris distributed throughout the water column. The observed organic load and associated increased conductivity was considered sufficient to induce a chronic low D.O. episode from July 31 to August 2, 2012 (Figure 8, lower plot). Collectively, Tenmile Creek data indicate an unreliable and chaotic D.O. regime exists from its headwater origin downstream to near the Brint Road location (RM 2.9) where D.O. values were consistently above the 5.0 mg/l average WWH criterion.

Increased conductivity was apparent at all locations draining the Oak Openings sand. Increased total dissolved solids, also evident at these locations, were noticeably more concentrated in proximity to the thin till over limestone setting west of Sylvania (Figures 9 and 10). The potential for surface spills to enter ground water varies with local depth to the water table (D), net recharge capacity (R), aquifer media (A), soil media (S), topography (T), impact of the vandose zone media (I), and hydraulic conductivity of the aquifer (C, Sprowls 2012). Greater DRASTIC index values correspond to settings where polluted surface water has less resistance to join subsurface flow. The permeability of a medium through which liquids may flow is a function of hydraulic conductivity. Lower hydraulic conductivity is more restrictive to subsurface flow. In Figure 26, the component hydraulic conductivity metric is appended to the general DRASTIC index score to highlight the differential facility for ground water movement in the Sylvania area. Tenmile Creek stream temperature declined downstream from the Glacial Lake Plains Deposits with low hydraulic conductivity (purple settings). Settings with high hydraulic conductivity and greater DRASTIC values augmented stream flow resulting in cooler temperatures. After peaking at Brint Road (RM 2.9), TDS concentrations declined while specific conductance remained elevated at downstream sample sites (Figure 10). TDS concentrations at Brint Road (RM 2.9) ranged from 654 mg/l to 1060 mg/l ($\bar{x}$=876 mg/l, n=5). Specific conductance ranged from 1030 umhos/cm to 1410 umhos/cm ($\bar{x}$=1238 umhos/cm, n=5). Although these parameter values are sufficient to stress aquatic life, significant community compositional changes were unnoticed. Low densities of macroinvertebrates with few pollution sensitive taxa in the reach confounded more specific analysis. The lack of unique species and proportional similarities among trophic and other functional groups at other Tenmile Creek sites suggested other limiting factors were more compelling.

Low D.O. availability with wide diel ranges, abundant periphyton measured as benthic chlorophyll-*a* (Chl-a), and elevated nutrient concentrations are fundamental to assessing beneficial use impairment due to nutrient enrichment. Geometric mean concentrations of ammonia (NH3-N) and nitrate+nitrite (NOx-N) are combined and expressed as dissolved inorganic nitrogen (DIN). This, and the geometric mean total phosphorus (TP) concentration, can be used to determine the extent of nutrient enrichment. The 2011 longitudinal status of these parameters in Tenmile Creek and the Ottawa River is displayed in Figure 11. Surprisingly, the Brint Road site (RM 2.9) had the highest geometric mean DIN concentration among all mainstem sampling sites. Ammonia should not be detectable in most Ohio streams. Its presence is typically associated with ineffective sewage treatment, livestock waste, an unintended industrial process discharge or as an accidental spill. The routine presence of ammonia in all Brint Road (RM 2.9) samples was rivaled by its frequent detection at tributary locations in co-occurrence with elevated chloride measurements (e.g. Table 17).

Breen and Dumouchelee (1991) with the USGS assessed area ground water in 1987. They inferred possible domestic sewage influences on well water with higher nitrate and chloride concentrations in the Oak Openings region. Hanson Aggregates continuously de-waters quarries using two discharges with a combined 11 MGD capacity upstream from the Brint Road (RM 2.9) sample site. Increased TDS and specific conductance values in Figure 10 were attributable to the quarry discharge.

Nitrate and TP amounts were consistent with the agricultural land use in Tenmile Creek. Nutrient concentrations rose in a predictable fashion with seasonal and storm induced runoff, though geometric means were below statewide targets. Total phosphorus concentrations increased in the presence of low D.O. availability downstream from the Metamora WWTP and from Prairie Creek (Figure 11). The extreme diel D.O. ranges at these sites were exacerbated by ample nutrient input and a broken riparian corridor. The combination of pulsed nutrient concentrations, excessive sunlight, drainage tile exacerbated low flow conditions, and smothering sediment acted to create a stressful aquatic environment. However, where habitat conditions improved, so did biological community performance.

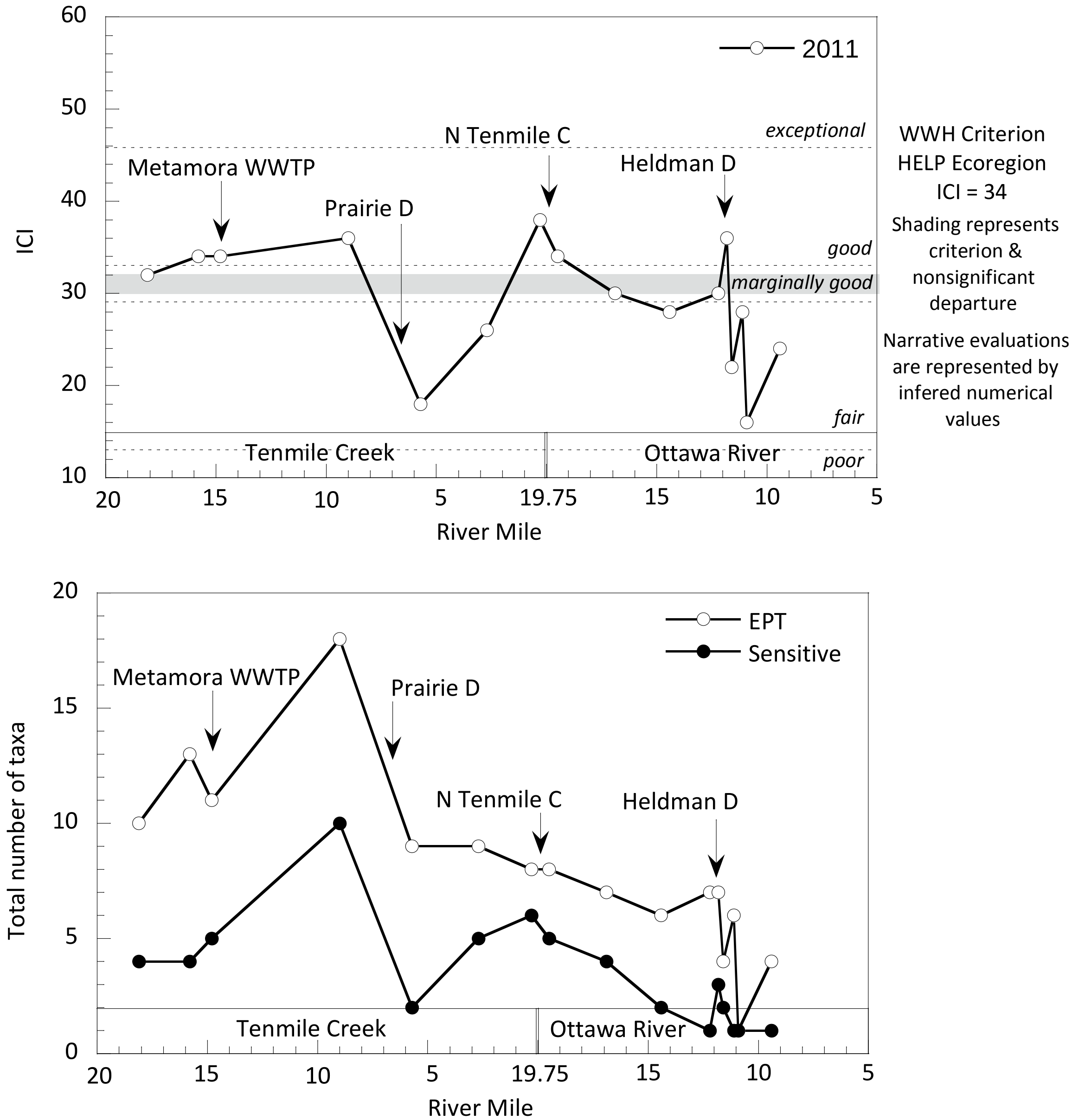


Figure 5. Longitudinal performance of the ICI (upper plot) with comparative total EPT (Ephemeroptera, Plecoptera, and Trichoptera taxa) and sensitive taxa (intolerant and moderately intolerant, lower plot) in Tenmile Creek and the Ottawa River, 2011.

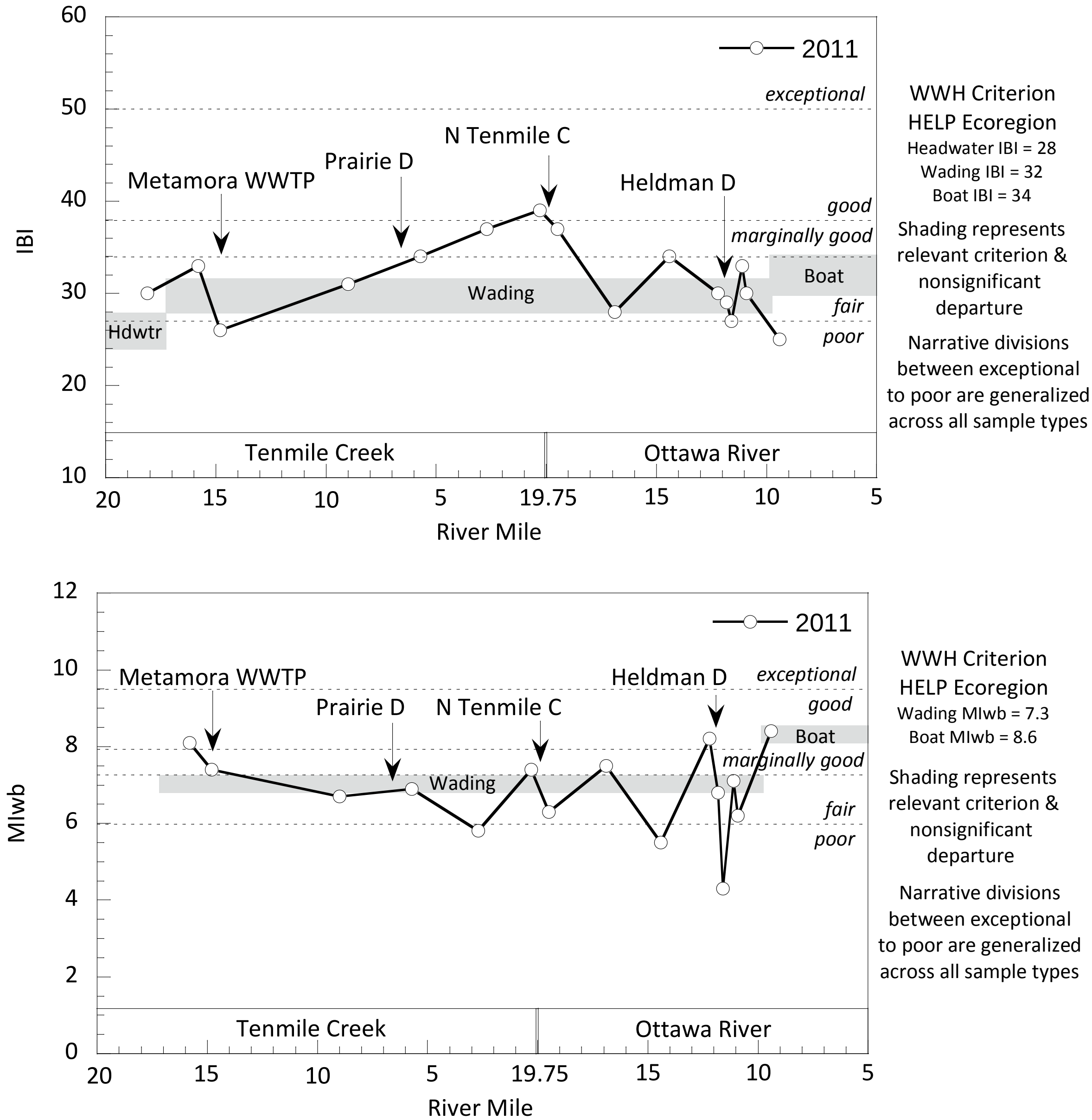


Figure 6. Longitudinal performance of the IBI (upper plot) and of the MIwb (lower plot) in Tenmile Creek and the Ottawa River, 2011.

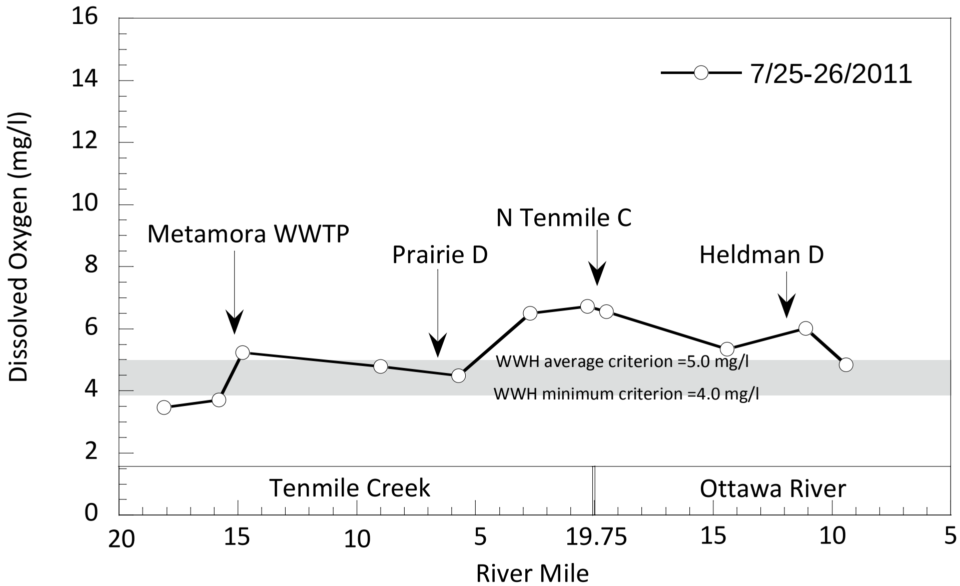


Figure 7. Mean daytime dissolved oxygen (D.O.) concentrations at Tenmile Creek and Ottawa River sampling sites, July 25-26, 2011. Values in the gray bar are below the WWH average criterion. Values below the gray bar violate the WWH minimum criterion.

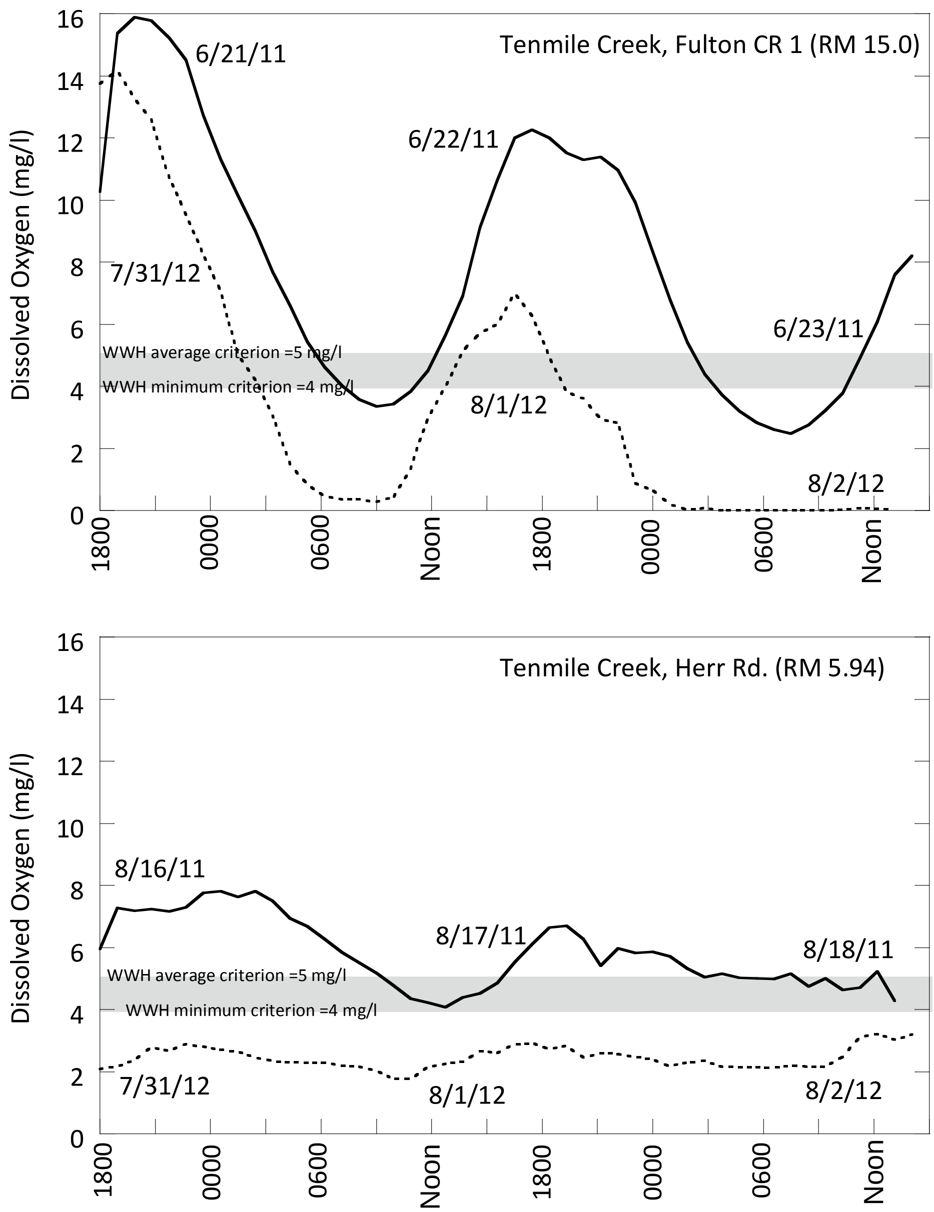


Figure 8. Diurnal D.O. concentrations recorded with Datasonde® continuous monitors deployed in Tenmile Creek downstream from the Metamora WWTP (RM 15.0, upper plot) and downstream from Prairie Creek (RM 5.9, lower plot). Data was obtained at each location over a two day period in both 2011 and in 2012.

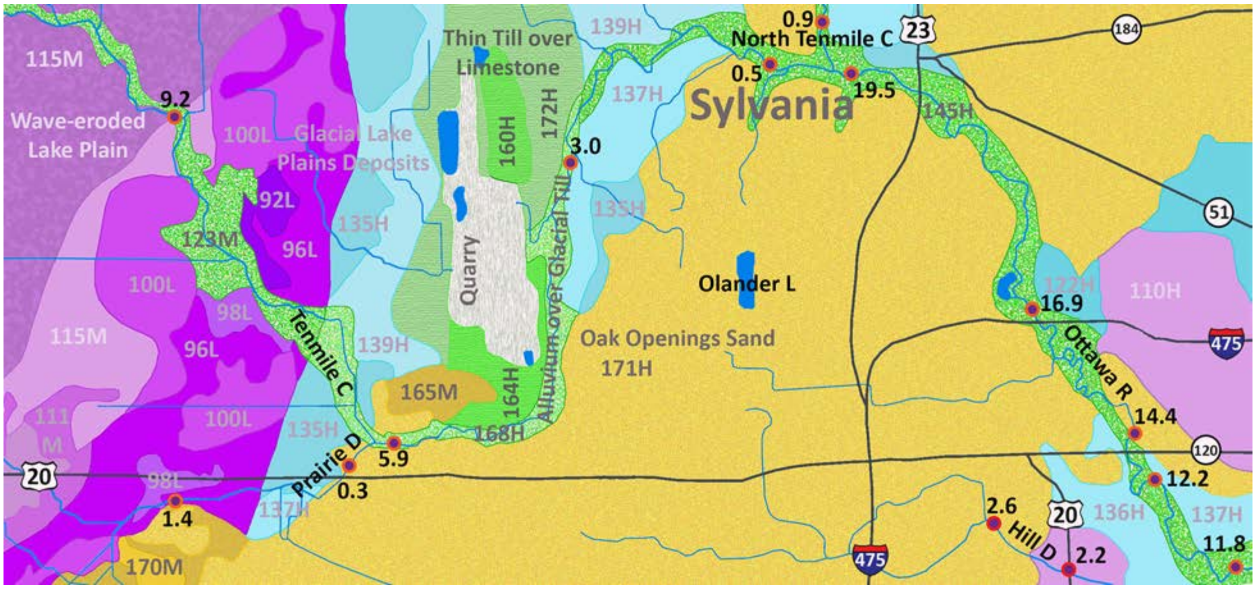


Figure 9. Hydrogeologic settings adjacent to Tenmile Creek and the Ottawa River near Sylvania with sampling sites indicated by river miles (e.g. RM 19.5). High (H=300-700 gpd/ft^2), medium (M=100-300 gpd/ft^2) or low (L=1-100 gpd/ft^2) hydraulic conductivity is noted as a suffix to general ground water pollution potential ratings (DRASTIC index values). Increased specific conductance was associated with ground water influence from the Oak Openings Sand setting. High total dissolved solids (TDS>1000 mg/l) were associated with ground water influence from the Thin Till over Limestone setting. Figure based on Sprowls, K. 2012. after M. Hallfrisch, 2002. Ground Water Pollution Potential of Lucas County. Ohio Division of Soil and Water Resources. Columbus, OH.

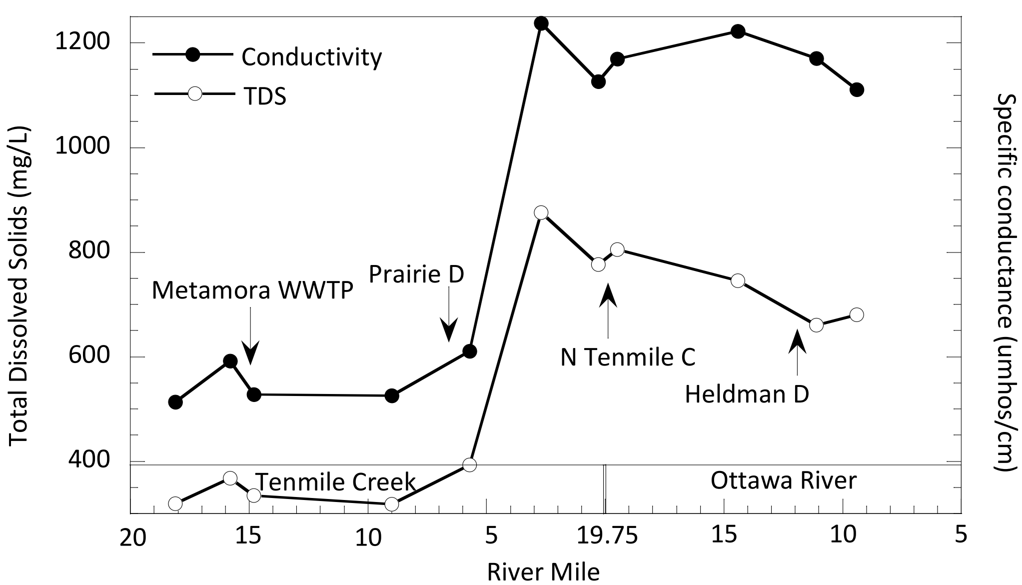
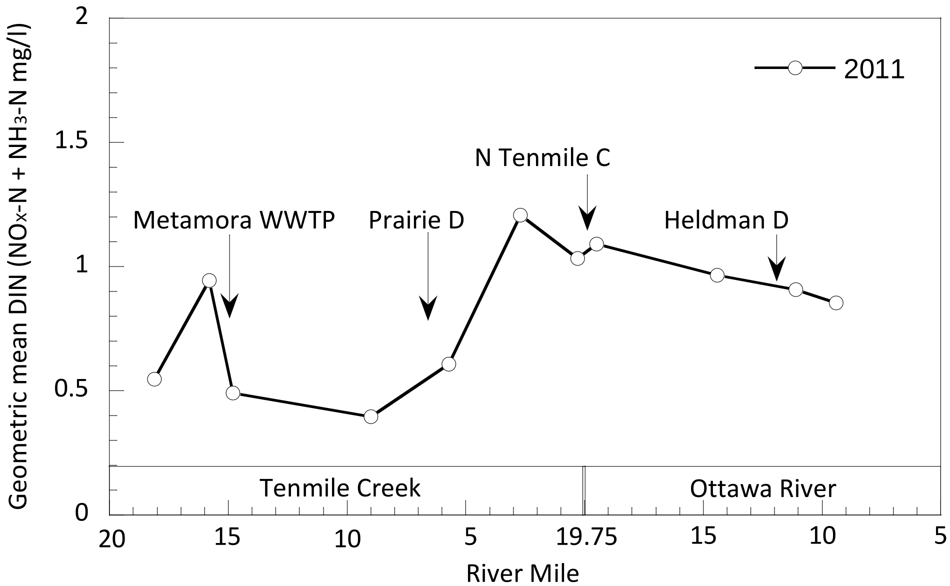


Figure 10. Mean total dissolved solids (TDS) concentrations and specific conductance values at Tenmile Creek and Ottawa River sampling sites, 2011.



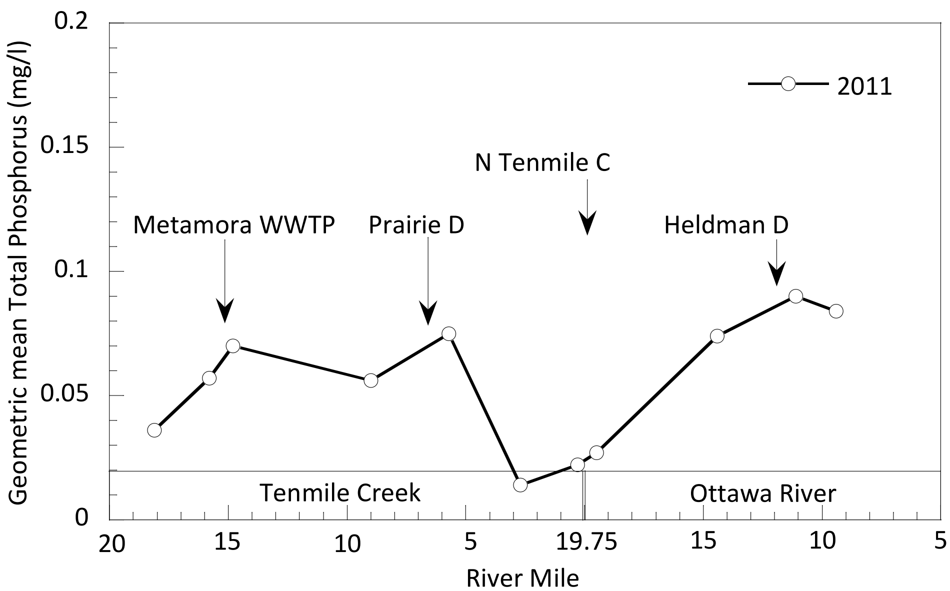


Figure 11. Geometric mean concentrations of dissolved inorganic nitrogen (DIN, NH3-N plus NOx-N, upper plot) and total phosphorus (TP, lower plot) at sampling sites in Tenmile Creek and the Ottawa River, 2011.

LAKE OLANDER

The 28 acre Lake Olander is a former borrow pit for road construction material. After ground water seeped into the basin, the 24 foot deep lake was acquired by The Olander Park System and opened to the public as Milton Olander Park in 1963. Swimming confined to the beach area, boating propelled by hand or electric motor, and fishing are permitted at the park (http://www.olanderpark.com/pages/OlanderPark.htm). An overflow discharge in the lake's northwest corner drains to Heath Ditch which joins Tenmile Creek at RM 0.3 within the Tenmile Creek HUC 12-04100001 0306 watershed.

Ohio EPA's lake sampling strategy is focused on assessing epilimnion water quality for conformance with a suite of proposed and existing criteria. Attainment status determinations of the Lake Habitat aquatic life use and of the Primary Contact Recreation (PCR) use are principal sampling objectives. Other beneficial use status is determined if the lake has been designated accordingly. The strategy is based on ten sampling events evenly divided over a two year period during summer months. Evaluated water quality parameters include total phosphorus, total nitrogen, chlorophyll-a, secchi depth, ammonia, D.O., pH, and total dissolved solids. Concentrations of metals including arsenic, cadmium, chromium, copper, lead, nickel, selenium and zinc in the water column were also analyzed. The sampling protocol is discussed further in Ohio EPA's Surface Water Field Sampling Manual, Appendix 1 (Ohio EPA 2012c, http://www.epa.ohio.gov/portals/35/inland_lakes/Lake_Sampling_Procedures.pdf).

Sampling was conducted at a station designated L1 in the center of the lake and at the beach area. Field measurements of temperature, conductivity, D.O. and pH were recorded in a vertical profile. Clarity was measured with a secchi disc from the surface. Samples for laboratory analysis were collected at 0.5 meter below the surface and 0.5 meter above the bottom. Five samples were collected for water column analysis and *E. coli* cultures at the L1 station and the beach in both 2011 and in 2012. One surface sediment sample was collected in August, 2011 from a near shore location. All data are compiled in Appendix Table 12.

Lake Olander is impaired for the proposed Lake Habitat aquatic life use due to exceedances of Ohio's water quality criterion for copper. Excessive application of copper based algaecide was considered the probable source of this contamination. Half of the water column samples returned results with copper concentrations above the calculated criteria (Table 14). High total nitrogen concentrations were routinely registered over the two year sampling effort. A median sample value (520 µg/l, n=10) greater than the target (450 µg/l) supported a nitrogen enrichment watch listing for Lake Olander. The PCR-A use *E. coli* criterion (geo$\bar{x}$<126 cfu/100 ml) was met at both the L1 (geo$\bar{x}$=5 cfu/100 ml, n=10) and at the beach (geo$\bar{x}$=29 cfu/100 ml, n=10) sampling sites. The beneficial use of Lake Olander fish for human consumption was not assessed. Despite considerable electrofishing effort, fish that were large enough to fillet were not obtained.

Hypoxic conditions (D.O. <2.0 mg/l) were detected once in 2011 and among four of five 2012 samples. The 6 meter deep stratification affected an irregular area less than half the size of the lake's surface appearance. Even so, this zone was conducive to redox reactions that were especially evident in August 2012 when the surface total phosphorus concentration was 13 µg/l while the concentration near the lake bed was 492 µg/l. These periods of sediment bound nutrient re-suspension also coincide with the release of metals contributing to the variable water column copper presence. Beyond the deep depth D.O. stress, hypoxic conditions often lead to algal blooms in consequence of the released nutrients which in turn contribute to limited surface D.O. availability.

Consistent with the excessive amount of copper in the water column, copper was also detected in a significantly high concentration in the sediment (586 mg/kg). At nearly four times greater than the probable effect concentration (PEC=149 mg/kg, MacDonald, et.al 2000) and 14 times more than Ohio reference conditions (SRV=42 mg/kg, Ohio EPA 2010), the quantity of copper in Lake Olander sediment is concerning. Eisler compiled data from hundreds of sources to characterize environmental responses to varying copper concentrations. He concluded "Adverse sublethal effects of copper on behavior, growth, migration, and metabolism occur in representative species of fishes at nominal water concentrations between 4 and 10 ug/L" (1998). Great lakes sediments with copper concentrations greater than 50 mg/kg were considered heavily polluted.

Copper can be extremely toxic to aquatic life. Its bioavailability is affected by water hardness, pH, suspended solids, and other factors. Copper contamination in Lake Olander is sufficient to harm aquatic life. The absence of large fish for tissue analysis pursuant to human consumption beneficial use assessment could be a related effect. No copper based algicides should ever be used in Lake Olander in the future.

Lake Olander sediment is also contaminated with DDE (19.1 mg/kg). The use of DDT (Dichloro-Diphenyl-Trichloroethane) became illegal in the U.S. in 1972 following increased awareness of its harmful effects and long term environmental persistence. Detection of DDT and its degradation metabolites DDD and DDE has waned in recent years. The contemporary presence of DDE in Lake Olander sediment suggests historical mosquito control efforts. The DDE in Lake Olander sediment poses some biomagnification risk but is less likely to be inherently toxic as the detected amount was more than the threshold effect concentration (TEC=3.2 mg/kg) but less than the PEC (31.3 mg/kg).

Other sediment analytes (metals, nutrients, PAHs, PCBs, and pesticides) were detected in concentrations typical of background values or were not detected.

Table 14. Lake Olander proposed Lake Habitat aquatic life use assessment status, 2011-2012. Bold values exceed proposed thresholds. Bold values in gray boxes violate Ohio Water Quality Standards (WQS) criteria. Calculated condition specific criteria are noted parenthetically after detected concentrations.

Parameter (Target[1])	**Chlorophyll-a** ($50^{th}\%_{tile}$≤6.0 ug/l)	**Total Phosphorus** ($50^{th}\%_{tile}$≤18 ug/l)	**Total Nitrogen** ($50^{th}\%_{tile}$≤450 ug/l)	**Ammonia** (mg/l, temp. dependent)	**D.O.**[2] ≥6.0 mg/l OMZA ≥5.0 mg/l OMZM	**pH** >6.5 s.u.-<9.0 s.u.	**Secchi depth** (Transparent to ≥2.60 m)	**Total Copper** (ug/l)
05/17/11	2.7	15	**880**	< 0.05 (1.0)	10.2	7.49	2.73	5.7 (12.1)
06/16/11	2.0	5	150	< 0.05 (0.4)	9.5	8.46	2.9	**12.4** (11.4)
07/11/11	2.1	5	**840**	< 0.05 (0.2)	9.2	8.62	2.3	8.0 (11.2)
08/01/11	3.8	16	**610**	< 0.05 (0.2)	8.7	8.66	1.9	6.2 (11.3)
09/13/11	5.3	5	440	< 0.05 (0.5)	7.2	8.34	2.75	4.4 (11.7)
05/31/12	5.0	14	390	< 0.05 (0.5)	8.2	8.36	2.8	**14.8** (12.3)
06/25/12	3.8	13	**560**	< 0.05 (0.4)	9.7	8.51	1.8	**17.4** (11.3)
07/30/12	3.5	5	440	< 0.05 (0.3)	7.9	8.36	2.8	**33.3** (11.3)
08/20/12	3.1	13	**480**	< 0.05 (0.4)	7.4	8.32	3.5	**14.1** (11.9)
09/27/12	26.7	16	**720**	0.053 (1.3)	8.1	7.83	2.3	7.2 (11.7)
$50^{th}\%_{tile}$	3.6	13	**520**				2.74	
status	meets	meets	***watch***	meets	meets	meets	meets	***impaired***

1 Proposed Lake Habitat aquatic life use chlorophyll-a, nutrient, and Secchi depth targets have not been enacted into the Ohio WQS. Proposed Lake Habitat aquatic life use D.O. and pH targets replicate values applicable to lakes currently designated with the EWH aquatic life use within the Ohio WQS.

2 For D.O., OMZM means outside mixing zone minimum and OMZA means outside mixing zone twenty-four-hour average. The D.O. targets apply in the epilimnion of stratified lakes or throughout the water column in unstratified lakes.

OTTAWA RIVER

The Ottawa River is contained within two 12-digit USGS HUCs. The Heldman Ditch-Ottawa River HUC 12-04100001 0307 incorporates the drainage beginning at the North Tenmile Creek confluence downstream to the Heldman Ditch confluence. The Sibley Creek-Ottawa River HUC 12-04100001 0308 comprises the remainder of the watershed downstream from the Heldman Ditch confluence. Aquatic life use attainment status was assessed at five sites in the upstream HUC and at four sites in the downstream HUC in 2011. Full aquatic life use was recorded at three upstream locations. Six sites harbored aquatic assemblages that failed to achieve expectations. Overall, the Ottawa River aquatic community performance was fair (IBIx̄=30, MIwbx̄=6.7, ICIx̄=28, n=9).

Five *E. coli* samples were collected from three Ottawa River sites while 11 samples were collected from the Stadium Drive (RM 11.15) site. Samples from all four sites obtained in August achieved the PCR-B recreational use criterion (*E. coli*<161 cfu/100ml). Samples from two locations in May also achieved the criterion. Otherwise, 20 of 26 bacteria samples from the Ottawa River exceeded the PCR-B recreational use criterion. Six samples from the Stadium Drive (RM 11.15) site were in excess of 1,000 cfu/100ml. The geometric mean *E. coli* concentration at Central Avenue (RM 15.05, 112 cfu/100ml) attained the PCR-B recreational use. Non-attainment of the designated PCR-B recreational use was determined at the three other locations.

A forested area (19%) occupied by Boy Scout Camp Miakonda and Toledo Area Metroparks Wildwood Preserve was contrasted by the surrounding developed landscape (78%) in the Heldman Ditch-Ottawa River HUC (Fry et al. 2011). The Sibley Creek-Ottawa River HUC was completely developed (97%). Interestingly, the Central Avenue site (RM 15.05), where full recreational use attainment was noted, is downstream from the forested properties. These parcels are situated on Oak Openings Sand. Sand is an effective bacterial filter. Fewer sewers and natural attenuation in the forested riparian corridor likely contributed to the full recreational use attainment.

The forested corridor flanked better stream habitat conditions. Bedrock with a mix of substrate sizes and a moderate array of functional cover at the most downstream Tenmile Creek site (RM 0.5) and the two most upstream Ottawa River sites (RMs 19.5 and 16.9) made for very good habitat in this reach (QHEI$\bar{x}$=74.5, n=3). Faster water current was observed in the next downstream reach (RM 14.4 to RM 11.6) encompassing the former Secor Dam, between the forested area and the University of Toledo (UT). Less functional cover and limited definition among pools, riffles, and runs were constituents of good habitat here (QHEI$\bar{x}$=62.2, n=4). Sparse cover and few riffles in the channelized Ottawa River through the UT campus offered fair habitat quality (QHEI$\bar{x}$=45.8, n=2). In contrast, the most downstream site at Monroe Street (RM 9.4) presented good habitat (QHEI=72.0). This location, at the transition where the flowing river meets Lake Erie impounded conditions, had a suitable variety of substrate and types of cover.

The Ottawa River macroinvertebrate assemblage varied in relation to different geologic settings, associated flow, and with changing stream habitat conditions. Marginally good performance was recorded upstream from the former Secor dam (RM 11.8) (ICI$\bar{x}$=32, n=5). Baetid mayfiles predominated in this reach where seven EPT taxa were typically present. Downstream, hydropsychid caddisflies and midges were more abundant, fewer EPT taxa were collected (≈4), and all communities achieved fair index scores (ICI$\bar{x}$=23, n=4). The channelized reach through the UT campus area was deficient in riffle habitat needed to support many macroinvertebrate species. These observations were consistent with macroinvertebrate performance previously evaluated in this reach in 1992 and 1986.

The fish community of the now free flowing Ottawa River included several species not present in prior surveys. In addition to the previously mentioned shorthead and golden redhorse, logperch and least darters, and more abundant northern pike, spottail shiners, blackside darter, and redfin pickerel were also better represented in 2011. A tadpole madtom at Secor Avenue (RM 11.6) was unique in Ohio EPA's Ottawa River collections. Alternatively, suckermouth minnows present in 1993, 1992 and 1986 were not among collections in 2007 or 2011. In general, Ottawa River fish communities were numerically more abundant and richer with several more species, but biological index scores were similar to values recorded in past surveys.

Compared to the macroinvertebrate assemblages, the disparity between fish community performance was less pronounced in reaches upstream from the former Secor dam (RMs 19.5 – 11.8) and downstream from Secor Avenue (RMs 11.6 - 9.4). While downstream fish collections were more species rich (upstream species $\bar{x}$=19, downstream species $\bar{x}$=24, n=10 & 8, respectively), upstream fish were generally twice as abundant as those in downstream samples except for the especially depauperate Edgehill Road (RM 14.4) community (relative number=167). This assemblage and the one at Secor Avenue (RM 11.6) both achieved poor MIwb scores (RM 14.4 MIwb=5.5, RM 11.6 MIwb=4.3). The previously discussed high conductivity through the entire Ottawa River may have influenced these poor MIwb values, but overall similar trophic and proportional community composition metrics confounded this determination.

Like Tenmile Creek fish communities, those in the Ottawa River had few species intolerant of pollution and all sample scores were limited by moderate numbers of total native species. As with Tenmile Creek, Ottawa River fish communities offered little contrast among all IBI metric values. The increased northern pike population was still insufficient as all samples registered low top carnivore scores. Simple lithophils were fairly abundant at the most upstream site with better substrate (42% RM 19.5). Otherwise, these fish were poorly represented in Ottawa River samples ($\bar{x}$=14% RM 16.9-RM 9.4). Insectivores were proportionately limited ($\bar{x}$=33%, n=18) and all assemblages lacked good numbers of darters, suckers, and sunfish species. Increased siltation along with changing habitat conditions appeared to limit performance through the studied reach. Improving substrate quality was deemed to be the most comprehensive influence likely to lead to better stream health.

The variable water quality influenced by geologic settings with high hydraulic conductivity observed in Tenmile Creek was also apparent in the Ottawa River and tributaries. High specific conductance (1080 umhos/cm to 1400 umhos/cm, $\bar{x}$=1222 umhos/cm, n=5) and high TDS concentrations (632 mg/l to 856 mg/l, $\bar{x}$=745 mg/l, n=5) were recorded in the Ottawa River especially in proximity to the Oak Openings sand setting at Edgehill Road (RM14.4, Figures 26 and 27). Heldman Ditch (21 mi^2) drains the Oak Openings sand and Glacial Lake Plains settings. At the most downstream Heldman Ditch (RM 0.2) site, specific conductance ranged from 1050 umhos/cm to 1460 umhos/cm (Table 17, $\bar{x}$=1218 umhos/cm, n=5). TDS concentrations ranged from 634 mg/l to 810 mg/l ($\bar{x}$=728 mg/l, n=5).

Beyond the aforementioned qualities generally associated with Oak Openings sand, a localized region of increased ground water movement exists upstream and in the vicinity of the Edgehill Road (RM 14.4) sampling site (Breen and Dumouchelee 1991). This region extends northward and underlies the unsewered portion of Whiteford Township in Monroe County, Michigan and the Sylvania Township, Lucas County area immediately south oriented around Alexis Road. The Areawide Water Quality Management Plan prepared by the Toledo Metropolitan Council of Governments (AWQMP 208, TMACOG 2013) identifies this Alexis/Whiteford community to be in critical need of central sewer service. Consistent with this assessment, the USGS studied water quality comparing undeveloped land use conditions to areas developed with septic tanks in the Oak Openings sand in 1987 (Breen and Dumouchelee 1991). They noted elevated parameters associated with septic tanks similar to the values determined at Edgehill Road (RM14.4) in this study.

The USGS study suggests many potential water quality contaminants perceived herein to be derived from association with Oak Openings sand may be exacerbated by development of this porous region. In particular, chloride concentrations in shallow sand ground water were many times greater in the Alexis/Whiteford vicinity compared to samples from wells at the less developed Boy Scout Camp Miakonda and at the Oak Openings park near Swanton (Breen and Dumouchelee 1991). A similar pattern was documented in 2011 (Figure 12). Mean chloride concentrations increased longitudinally with more downstream development. A substantial increase was noticed at Edgehill Road (RM 14.4) downstream from the Alexis/Whiteford critical sewage area.

Other plausible chloride sources also exist upstream from Edgehill Road. Two four-lane highway crossings (US 23 and I475) are present in the upstream reach as are numerous other bridges all of which receive salt for winter deicing. Locally, deeper ground water also had elevated chloride concentrations in the USGS study. Pumping for golf course irrigation, industrial and domestic uses, and spring seeps are plausible routes for this discharge to the Ottawa River.

The reach upstream from Edgehill Road also had more sediment contamination than was measured at adjacent sites. Total PAH amounts at Central Avenue (RM 15.05, 35.76 mg/kg) exceeded the PEC (22.8 mg/kg). High total PAH concentrations at Edgehill Road (RM 14.4, 18.35 mg/kg) provided more insight to the low biological scores in this area.

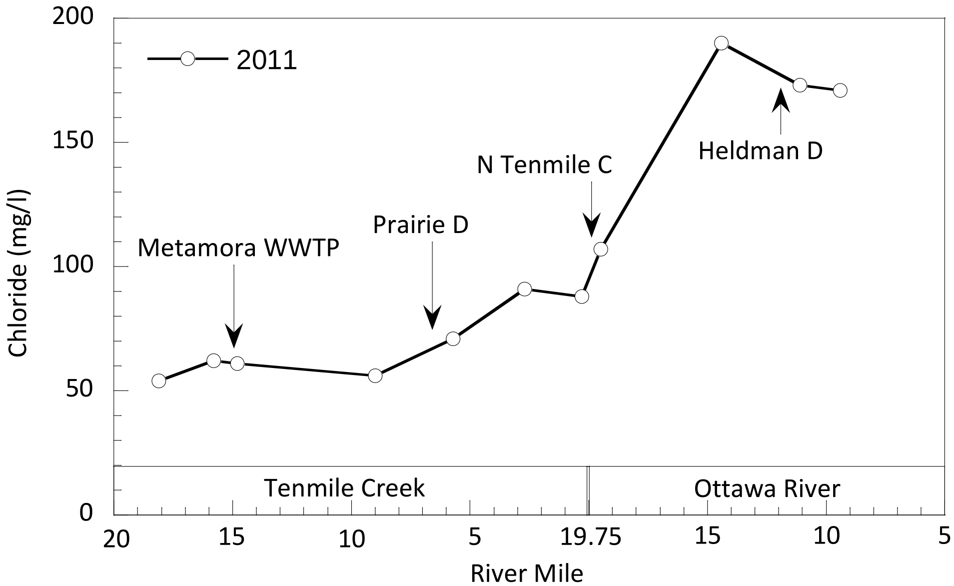


Figure 12. Mean chloride concentrations for Tenmile Creek and the Ottawa River, 2011.

Prairie Ditch

The 18.6 mi^2 Prairie Ditch USGS HUC 12-04100001 0303 watershed encompasses several Oak Openings natural areas (12% forested) mixed among suburban development (11%) in an otherwise mostly agricultural area (70%) (Fry et al. 2011). The entire drainage network was created to facilitate settlement prior to 1900. A portion of the watershed was diverted to the Swan Creek basin in the 1920s. Rainfall is rapidly absorbed in the sandy region and quickly released to the artificial drainage system. Consequently, little flow normally exists in Prairie Ditch. Its conveyance capacity is often challenged by ordinary storms.

Predominated by mudminnows, redfin pickerel, snails, and water boatman, the fair pollution tolerant biological assemblages attained the recommended MWH aquatic life use at two sample locations (IBI$\bar{x}$=28, ICI$\bar{x}$=Fair). Aquatic habitat conditions were very poor (QHEI$\bar{x}$=23, n=2). The PCR-B recreational use was not attained at Tupelo Way (RM 1.41, *E. coli* geo$\bar{x}$=190 cfu/100ml). Exceedances of the MWH minimum and average D.O. criteria were recorded at one water chemistry sample site (2.46, 2.83 mg/l) and during deployment of a Datasonde® continuous monitor (3.1 mg/l). Elevated total phosphorus (TP$\bar{x}$=0.182 mg/l, n=5) and ammonia (NH3-N$\bar{x}$=0.152 mg/l, n=5) with high chloride concentrations (185 mg/l) were consistent with the agricultural land use in the Oak Openings region.

North Tenmile Creek

Ohio's portion (1.1 mi^2) of the North Tenmile Creek USGS HUC 12-04100001 0305 (40.5 mi^2) is small and largely comprised by development (88%) within the city of Sylvania (Fry et al. 2011). In Michigan, North Tenmile Creek is extensively modified and maintained as an agricultural ditch. Pervasive subsurface tile coupled with the open drainage network have lowered the entire subbasin water table. Water chemistry was assessed twice in June, but lack of flow in July and August precluded additional sampling at Monroe Street (RM 0.12).

Inclusion of an additional September sample to obtain the preferred five *E. coli* samples for recreational use assessment resulted in the highest number of colonies produced from site samples (*E. coli* =1700 cfu/100ml). This elevated value pushed the geometric mean (*E. coli* geo$\bar{x}$ =168 cfu/100ml) just above the PCR-B criterion (*E. coli* geo$\bar{x}$<161 cfu/100ml).

Fair habitat quality at Monroe Street (RM 0.12, QHEI=54) was most influenced by interstitial flow, yielding functionless riffles and limited cover effects. Low and high D.O. measurements (4.6 mg/l–10.2 mg/l) recorded by a continuous monitor coupled with elevated TP ($\bar{x}$=0.096 mg/l, n=2) and abundant algal growth were exacerbated by limited flow. Fair fish community performance (IBI=28) with proportionally high fish abundance (relative number=2,730) among a modest species array (16) was consistent with excessive detritus and algae, the preferred foods of the predominant bluntnose minnow (43%) and central stonerollers (19%), respectively. The underachieving fair macroinvertebrate assemblage was marked by low numerical density distributed between 49 taxa of mostly facultative organisms.

Heldman, Zink, and Hill Ditches

Sand within the Oak Openings hydrogeologic setting influenced water chemistry variables at four tributary stations within the Heldman Ditch-Ottawa River USGS HUC 12-04100001 0307. A USGS study associated area development with higher chloride values (Breen and Dumouchelee 1991). Average chloride was twice as concentrated at Hill Ditch and downstream at the Heldman Ditch Edgevale Road (RM 0.15) site compared to the upstream Heldman Ditch (RM 2.72) and Zink Ditch (RM 0.7) locations (Table 15). Beyond urban presence, downstream locations may have been subject to ground water with excess chlorides through spring discharge, via golf course irrigation, or another pumped supply use. Ammonia was frequently detected at all locations (16 of 19 samples, NH_3-N$\bar{x}$=0.09 mg/l).

Table 15. Mean total dissolved solids (TDS), chloride, and specific conductance at tributary sampling sites in the Heldman Ditch-Ottawa River HUC-12. Sites are listed respecting upstream distance from the Ottawa River confluence.

Stream (Heldman D confluence RM)	Location	RM	n	TDS (mg/l)	Chloride (mg/l)	Conductivity (umhos/cm)
Zink Ditch (5.96)	Dorr S	0.7	5	497	108	826
Heldman Ditch	Hill A	2.7	5	483	98	772
Hill Ditch (0.47)	Reynolds R	2.2	4	698	235	1237
Heldman Ditch	Edgevale R	0.1	5	728	207	1218

In addition to the four water chemistry sampling sites, biological sampling occurred at Hill Ditch along Carriage Drive (RM 2.6), upstream from the Toledo Botanical Gardens. Data from this and the downstream site (RM 2.1) were obtained to assess the influence of the subsequent removal of a Botanical Gardens Hill Ditch impoundment. A similar site specific interest was intended regarding Zink Ditch sampling. Pursuant to subdivision development, part of Zink Ditch was relocated downstream from Dorr Street. The “two stage” channel created in 2008 offered an opportunity to document the status of this general approach to ditch maintenance.

Consistent with the ground water influence inferred from chemistry sampling, surprising flow was encountered at the upstream Hill Ditch site and a locally uncommon cold water macroinvertebrate taxon was present in Zink Ditch.

Coincidently, the upstream Hill Ditch (RM 2.6) site and the recently modified Zink Ditch (RM 0.7) reach both drain 3.5 mi^2. As adjacent tributaries, these unique locations offer future prospect for further comparison. In 2011, there was wide disparity in fish community performance. Nine fish species in Zink Ditch combined to register one of the highest IBI scores (38, marginally good) in the study area. Eight fish species in Hill Ditch upstream from the Botanical Garden impoundment earned a poor IBI score (22). Only one bluntnose minnow was collected in Zink Ditch, whereas it was the most common fish upstream in Hill Ditch (49%). This species and other pollution tolerant fish comprised 88% of the upper Hill Ditch assemblage. Predominated by central stonerollers (65%), broadly indifferent to water pollution, only 28% of the Zink Ditch fish were pollution tolerant. Although other proportional IBI metric scores also reflected the stoneroller neutrality effect (78% omnivores, 85% pioneering types in Hill Ditch vs. 9% and 24% in Zink Ditch, respectively), more importance was ascribed to the presence of two darter species in Zink Ditch while none were collected in Hill Ditch. Likewise, white suckers were abundant in Zink Ditch (9%), but incidentally present in Hill Ditch (<1%).

The low to modestly diverse Zink Ditch macroinvertebrate assemblage (34 taxa, low to moderate density) was unique in the subwatershed for exhibiting flatworm predominance. Other subbasin sample sites were predominated by hydropsychid caddisflies. While both taxa are associated with abundant organic detritus, the reduced presence of hydropsychid caddisflies in Zink Ditch mirrored the limited detritivorous fish abundance (1 bluntnose minnow). With only 19 taxa, the upper Hill Ditch site harbored one of the poorest scoring macroinvertebrate communities in the 2011 study area.

Biological performance at the downstream Hill Ditch (RM 2.1) location and at both Heldman Ditch (RMs 2.7 and 0.15) sites ranged from poor to fair (IBI$\bar{x}$=25.3, ICI$\bar{x}$=Fair, n=3) and was characteristic of the fair habitat conditions common at all sampling locations within Heldman, Zink and Hill ditches (QHEI$\bar{x}$=52.2, n=5). As their names imply, all of these waterways are maintained to convey storm water flow. An overabundance of silty clay and organic fines smothered interstitial voids, limited stream filtering capacity and precluded more aquatic community diversity.

Shantee and Silver Creeks

Urban development (97%) dominates the 15.8 mi^2 Shantee Creek USGS HUC-12 04100001 0301 watershed (Fry et al. 2011). All of the streams have been repeatedly channelized and all headwater rivulets are contained within storm sewers. Recognizing this condition, the upper reaches of both Shantee and Silver creeks are designated for the LRW aquatic life use. In 2011, very poor biological performance at single sample locations in the LRW designated reaches of both streams failed to attain even this marginal aquatic life use. The downstream reaches of both Shantee and Silver creeks are designated for the MWH aquatic life use. Generally poor biological communities within each of the MWH designated reaches of both streams failed to fully attain the aquatic life use. The area's industrial heritage includes a legacy of sediment contamination. Detections of PCBs or PAHs in both streams sediments were above probable effect concentrations (Table 9).

Poor habitat conditions (QHEI$\bar{x}$=37.0, n=4) were adequate for the assigned aquatic life uses. Both streams maintained at least a marginal amount of flow and offered minimal amounts of cover. Riffle function was mostly eliminated, but some better defined pools provided refuge and overwinter protection. While better stream habitat conditions would support a more robust aquatic assemblage, those improved habitats would also merit more rigorous aquatic life use designations. In 2011, non-attainment of the appropriately designated aquatic life uses in the Shantee Creek subbasin was due to chronic sediment toxicity and related poor water quality.

Pollutant spills and fish kills have occurred frequently in the subbasin. In August 2011, a fish kill was reported in Shantee Creek downstream from Lewis Avenue (RM 3.1). An investigation was inconclusive. Oily sheens in Shantee Creek were attributed to runoff from a Detroit Avenue metal recycling yard on several occasions over multiple previous years.

The PCR-B recreational use was not attained at Futura Drive (RM 1.7) on Silver Creek (*E. coli* geo$\bar{x}$=704 cfu/100ml). This sample site was downstream from an unsewered group of homes on Dearden Place and Birdsall Road. As a "critical sewage area," the Toledo Metropolitan Area Council of Governments reports sanitary sewers will be installed in 2015 (TMACOG 2013).

The phenomenon of elevated chloride and related parameters associated with area hydrogeologic settings was most profound in the Shantee Creek subbasin (Table 18). As discussed previously, urban development has been associated with higher chloride concentrations in local ground water (Breen and Dumouchelee 1991). Ground water may recharge surface flow through springs, from tile drains, via irrigation, or another pumped supply use. Ammonia was especially prevalent in this subbasin (detected in 19 of 20 samples, NH3-N$\bar{x}$ =0.44 mg/l). Ammonia concentrations above 1 mg/l were recorded in three of five samples from Shantee Creek at Lewis Avenue (RM 3.1). Conditions in Shantee Creek at Lewis Avenue were acutely toxic to many aquatic species during June and July, 2011. The source of this pollution should be eliminated.

Table 16. Mean ammonia, total dissolved solids (TDS), chloride, and specific conductance at sampling sites in the Shantee Creek subbasin.

Stream	Location	RM	n	Ammonia (mg/l)	TDS (mg/l)	Chloride (mg/l)	Conductivity (umhos/cm)
Shantee Creek	Lewis A	3.1	5	1.11	738	286	1323
	Stickney A	0.7	5	0.21	805	309	1431
Silver Creek	Lewis A	4.4	5	0.23	677	252	1194
	Futura Dr.	1.7	5	0.19	746	271	1283

Halfway Creek

The 39.9 mi^2 Halfway Creek USGS HUC 12-04100001 0302 principally exists in Michigan. Draining agricultural fields, Halfway Creek gains flow from quarry dewatering and after its confluence with Spring Brook in a suburban region north from Ohio. In Ohio, subbasin land use is urban and industrial development (94%) with an unusual amount of forested riparian corridor (6%). Strong laminar flow in the historically modified channel conveyed organic detritus over extensively embedded sand substrate. A fair QHEI score (50) at one sample site was biased by a lack of riffle function and a sparse amount of cover.

Upstream wetlands were a likely source of flow augmentation, as the marginally good (IBI=36) fish assemblage included many wetland associates. A small northern pike, several large redfin pickerel, and three types of bullhead catfish were among the modesty diverse fish collection (19 species, 640 relative number). The fair macroinvertebrate community was also modestly diverse (33 taxa, moderate density), but the predominance of hydropsychid caddisflies and lack of pollution sensitive taxa were indications of organic loading and environmental stress.

Partial attainment of the recommended WWH aquatic life use was limited by sediment contamination. Sediments contaminated with PAHs above the PEC were documented in Halfway Creek. Average TDS (739 mg/l) and specific conductivity (1059 umhos/cm) were similar to values reported from the Shantee Creek subbasin (Table 16). Average chloride (66 mg/l) concentration was appreciably less and ammonia was detected once (0.23 mg/l) in five samples. The PCR-B recreational use was not attained at the downstream State Line Road (RM 4.9) location (*E. coli* geo$\bar{x}$=287 cfu/100ml).

Detwiler Ditch

Encompassing much of downtown Toledo, land use in the 7.4 mi^2 Detwiler Ditch-Frontal Lake Erie USGS HUC 12-04100001 0309 is mostly urban development (95%). Detwiler Ditch drains several wetlands before flowing through a public golf course and joining Lake Erie. An upstream industrial heritage was revealed by PCB sediment contamination above the PEC. Poor macroinvertebrate community performance at Detwiler Park (RM 0.5) was influenced by polluted sediment and artificially ponded habitat. The marginally good to fair fish community (IBI=34, MIwb=7.2) was representative of a degraded pond (e.g., bluegill sunfish, common carp, and gizzard shad predominated), but the use of boat sampling equipment in a small drainage (6 mi^2) was atypical. The IBI score was skewed by a disproportionate number of bluegill sunfish (59%). Low D.O. values were noted during daytime chemistry sampling (3.3 mg/l, 4.1 mg/l, and 4.4 mg/l). Ammonia was detected in all five chemical evaluations (NH_3-N$\bar{x}$=0.52 mg/l). Field observation and these stressor values supported a perception that the ponded water in Detwiler Ditch only flows following storm events. The lack of flow and comparatively large volume of water in an area with sanitary sewers was credited for the full attainment of the PCR-B recreational use (*E. coli* geo$\bar{x}$=158 cfu/100ml).

REFERENCES

Breen, K.J. and D.H. Dumouchelle. 1991. *Geohydrology and Quality of Water in Lucas, Sandusky, and Wood Counties, Northwestern Ohio*. US Geological Survey, Water-Resources Investigations Report 91-4024. Columbus, Ohio.

Crail, T.D., J.F. Gottgens and A.E. Krause. 2011. "Fish community response to evolving channel complexity in an agricultural headwater system." *Journal of Soil and Water Conservation*. 66(5): 295-305.

Dufour, A.P. 1977. "*Escherichia coli*: The fecal coliform." In *Bacterial Indicators/ Health Hazards Associated With Water*. A.W.Hoadley and B.J. Dutka editors. American Society for Testing and Materials Special Technical Publication 635. Pennsylvania.

Earley, K.G. 2014. *Office of the Lucas County Engineer 5-Year Capital Improvement Program, 2014-2018.* Lucas County Engineer. Holland, OH. http://www.co.lucas.oh.us/documents/91/380/2014CIPReport_201403101411086063.pdf.

Eisler, R. 1998. *Copper Hazards to Fish, Wildlife and Invertebrates: A Synoptic Review*. US Geological Survey, Biological Resources Division, Biological Science Report USGS/BRD/BSR—1997-0002. Washington, D.C.

Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J., 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States, PE&RS, Vol. 77(9):858-864.

Hushak, L. and M. Bielen. 1999. *Valuing the Ottawa River: the Economic Values and Impacts of Recreational Boating*. Ohio Sea Grant http://www.partnersforcleanstreams.org/ValuingtheOttawaRiverFinalReport.pdf.

Lucas County Engineer. 2012. *Storm Water Utility Construction Projects Completed in 2012*. Holland, Ohio. http://www.co.lucas.oh.us/documents/91/2012%20%202013%20Forecast%20and%20Awarded%20Storm%20Water%20Utility%20Projec_2.PDF.

Maumee RAP. 2006. *Maumee Area of Concern Stage 2 Watershed Restoration Plan Volume 1.* Maumee RAP. Toledo, Ohio. http://partnersforcleanstreams.org/images/pdf/watershedstage2/volume1/draft-maumeeaocplan-fullcopy-vol13-9-06.pdf.

Maumee RAP. 2013. Summary of Habitat Inventories and Restoration Sites in the Maumee AOC. Maumee RAP. Toledo, Ohio.

http://partnersforcleanstreams.org/images/pdf/final-sum%20of%20habitat%20inventories%20in%20maumee%20aoc.pdf.

MacDonald, D.D., C.G. Ingersoll and T.A. Berger. 2000. "Development and Evaluation of Consensus-based Sediment Quality Guidelines for Freshwater Ecosystems." *Archives of Environmental Contamination and Toxicology*. 39: 20-31.

Messina, I. April 17, 2014. "$1M in U.S., city grants to construct wetlands." The Toledo Blade. https://www.toledoblade.com/local/2014/04/17/1M-in-U-S-city-grants-to-construct-wetlands.html.

Ohio EPA. 2013. *Surface Water Field Sampling Manual for water column chemistry, bacteria and flows*. Columbus, Ohio. http://epa.ohio.gov/Portals/35/documents/SW_SamplingManual.pdf.

Ohio EPA. 2012a. *Ohio 2012 Integrated Water Quality Monitoring and Assessment Report*. Ohio Division of Surface Water. Columbus, Ohio. http://www.epa.ohio.gov/dsw/tmdl/OhioIntegratedReport.aspx.

Ohio EPA. 2012b. *Sediment Sampling Guide and Methodologies* (3rd Edition). Columbus, Ohio. http://epa.ohio.gov/portals/35/guidance/sedman2012.pdf.

Ohio EPA. 2012c. Inland Lakes Sampling Procedure Manual. Columbus, Ohio. http://www.epa.ohio.gov/portals/35/inland_lakes/Lake_Sampling_Procedures.pdf.

Ohio EPA. 2010. *Guidance on Evaluating Sediment Contaminant Results*. Columbus, Ohio. http://epa.ohio.gov/portals/35/guidance/sediment_evaluation_jan10.pdf.

Ohio EPA. 2008a. State Of Ohio: Cooperative Fish Tissue Monitoring Program: Sport Fish Tissue Consumption Advisory Program. Columbus, Ohio. May 2008. http://www.epa.ohio.gov/portals/35/fishadvisory/FishAdvisoryProcedure08.pdf.

Ohio EPA. 2008b. *Ecological Risk Assessment Guidance Document* (Revised from 2003) DERR-00-RR-031. Columbus, Ohio. http://www.epa.ohio.gov/portals/30/rules/RR-031.pdf.

Ohio EPA. 2003. *Biological, Fish Tissue, and Sediment Study of the Ottawa River, Dura Avenue Landfill, 2002*. Columbus, Ohio. http://www.epa.state.oh.us/portals/35/documents/OttawaRDura2002.pdf .

Ohio EPA. 1991. *Fish Tissue, Bottom Sediment, Surface Water, Ottawa River / Tenmile Creek* Ohio EPA Technical Bulletin MAS/1991-12-7. Columbus, Ohio. http://epa.ohio.gov/portals/35/documents/ottawa91.pdf.

Omernick, James M. 1987. “Ecoregions of the Conterminous United States.” *Annals of the Association of American Geographers* 77(1): 118-125.

Reighard, F.H. editor. 1920. *A Standard History of Fulton County, Ohio.* Lewis Publishing Co. Chicago and New York.

Roberts, S.J., J.F. Gottgens, A.L. Spongberg, J.E. Evans, and N.S. Levine. 2007. “Assessing potential removal of low-head dams in urban settings: An example from the Ottawa River, NW Ohio.” *Environmental Management*. 39(1): 113-124.

Schiefer, M.C. 2002. *Basin Descriptions and Flow Characteristics of Ohio Streams*. Ohio Division of Soil and Water Resources Bulletin 47. Columbus, Ohio. http://www.dnr.state.oh.us/Portals/7/pubs/reports/bulletin47.pdf.

Sprowls, K. 2012. after M. Hallfrisch, 2002. *Ground Water Pollution Potential of Lucas County.* Ohio Division of Soil and Water Resources Ground Water Pollution Potential Report No. 33. Columbus, Ohio. http://soilandwater.ohiodnr.gov/maps/pollution-potential-maps.

Stone, K.L., E.H McConoughey, G.D. Bottrell, and D.J. Crowner. 1980. *Soil Survey of Lucas County, Ohio.* US Department of Agriculture, Soil Conservation Service in cooperation with Ohio Division of Soil and Water Resources and Ohio Agricultural Research and Development Center. http://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=OH.

Stone, K.L. Jr., D.R. Michael. 1984. *Soil Survey of Fulton County, Ohio.* US Department of Agriculture, Soil Conservation Service in cooperation with Ohio Division of Soil and Water Resources and Ohio Agricultural Research and Development Center. http://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=OH.

TASD. 2013. *67th Annual Report, 1946-2013*. Toledo, Ohio. http://www.tasd-mosquitoes.org/TASD%20Annual%20Report%202013.pdf.

City of Toledo. 2013. *Department of Public Utilities Annual Report*. Toledo, Ohio. http://toledo.oh.gov/media/85566/2013-annual-report.pdf.

TMACOG. 2013. *Areawide Water Quality Management Plan*. 208 plan. Toledo Metropolitan Area Council of Governments. Toledo, Ohio.

USACE. 2009. *Western Lake Erie Basin Study Ottawa Watershed Assessment*. US Army Corps of Engineers, Buffalo District. Buffalo, New York. http://www.lrb.usace.army.mil/Home.aspx.