MI/EGLE/WRD-23/010

MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY
WATER RESOURCES DIVISION
JULY 2023
STAFF REPORT

Biological, Water Chemistry, and Sediment Chemistry Surveys of Selected Stations in the River Raisin Watershed in Lenawee, Monroe, and Washtenaw Counties, Michigan, June-September 2018

INTRODUCTION

Biological, chemical, and physical habitat conditions of selected water bodies in the River Raisin watershed in Lenawee, Monroe, and Washtenaw Counties were assessed by staff of the Michigan Department of Environment, Great Lakes, and Energy (EGLE)[1], Surface Water Assessment Section (SWAS), in June-September 2018. The primary objectives of the assessments were to:

1. Assess the current status and condition of individual water bodies and determine if Michigan Water Quality Standards (WQS) are being met.
2. Evaluate biological community temporal trends.
3. Address monitoring requests submitted by internal and external customers.
4. Identify nonpoint sources (NPS) of water quality impairment.

WATERSHED INFORMATION

The River Raisin watershed (HUC #04100002) contains warmwater streams (Michigan Department of Natural Resources [MDNR], 1997). The length of the mainstem of the river, from where it originates inland down to its confluence with Lake Erie, is approximately 149 miles (Figure 1). This watershed has an area of approximately 1,037 square miles.

Three different landscape ecosystems run through the River Raisin watershed (Albert, 1995). Most of the eastern and southern portion of the watershed is in the Maumee Lake Plain ecosystem. The central portion of the watershed is primarily in the Ann Arbor Moraines ecosystem, and the northwestern portion is primarily in the Jackson Interlobate ecosystem.

The Maumee Lake Plain ecosystem has “beech-sugar maple forest, elm-ash forest, deciduous swamp, white oak-black savannas, wet prairies, coastal marshes” and is a “flat, clay lake plain dissected by broad glacial drainageways of sandy soil. The lake-moderated climate and productive loamy soils resulted in early and intensive agricultural development” (Albert, 1995). The Ann Arbor Moraines ecosystem has “oak-hickory

[1] Known as the Michigan Department of Environmental Quality (MDEQ) prior to April 2019.

forest, beech-sugar maple forest, and deciduous swamp forest;" loamy, fine- and medium-textured end and ground moraines; and, while agricultural development has been relatively extensive, "many of the lowlands and steeper upland ridges remain forested." The Jackson Interlobate ecosystem has "coarse-textured end moraine, outwash, and ice-contact topography; oak savanna and oak-hickory forest, hardwood swamps, prairie fens, bogs" and is "characterized by relatively steep end-moraine ridges surrounded by pitted outwash deposits;" "kettle lakes and wetlands are common within the outwash" (Albert, 1995).

Land use within the River Raisin watershed is dominated by cultivated agriculture (49 percent), with hay/pasture (18 percent), developed (12 percent), natural terrestrial (12 percent), and open waters/wetlands (10 percent) making up the remaining significant land use types (Table 1).

Table 1. Land use summary for the River Raisin watershed region. Original source of data: National Land Cover Database (NLCD) 2011 (Multi-Resolution Land Characteristics [MRLC], 2014).

Watershed	Cultivated Agriculture	Hay or Pasture	Developed	Natural Terrestrial	Open Water or Wetlands	Barren Land (Rock/Sand/Clay)
River Raisin	49%	18%	12%	12%	10%	0.3%

Additional information about the River Raisin watershed can be found in an MDNR report by Dodge (1998).

HISTORICAL SAMPLING EFFORTS AND INFORMATION

The most recent surveys of the River Raisin watershed were conducted in 2008 (Schmitt, 2010) and 2013 (Noffke, 2015). In 2008 and 2013, all (40 of 40) and nearly all (28 of 29) macroinvertebrate sampling stations, respectively, were found to have community ratings between acceptable and excellent, while the remaining 2013 station rated as poor (Bear Swamp Creek at Dennison Road) (Schmitt, 2010; Noffke, 2015). Information about earlier historical biosurvey sampling efforts, plus some water chemistry and 2008 *E. coli* data can be found in those reports. Cooper (2015) did limited sampling of total and soluble reactive phosphorus in the spring of 2015 in Black Creek, Wolf Creek, and Lake Adrian.

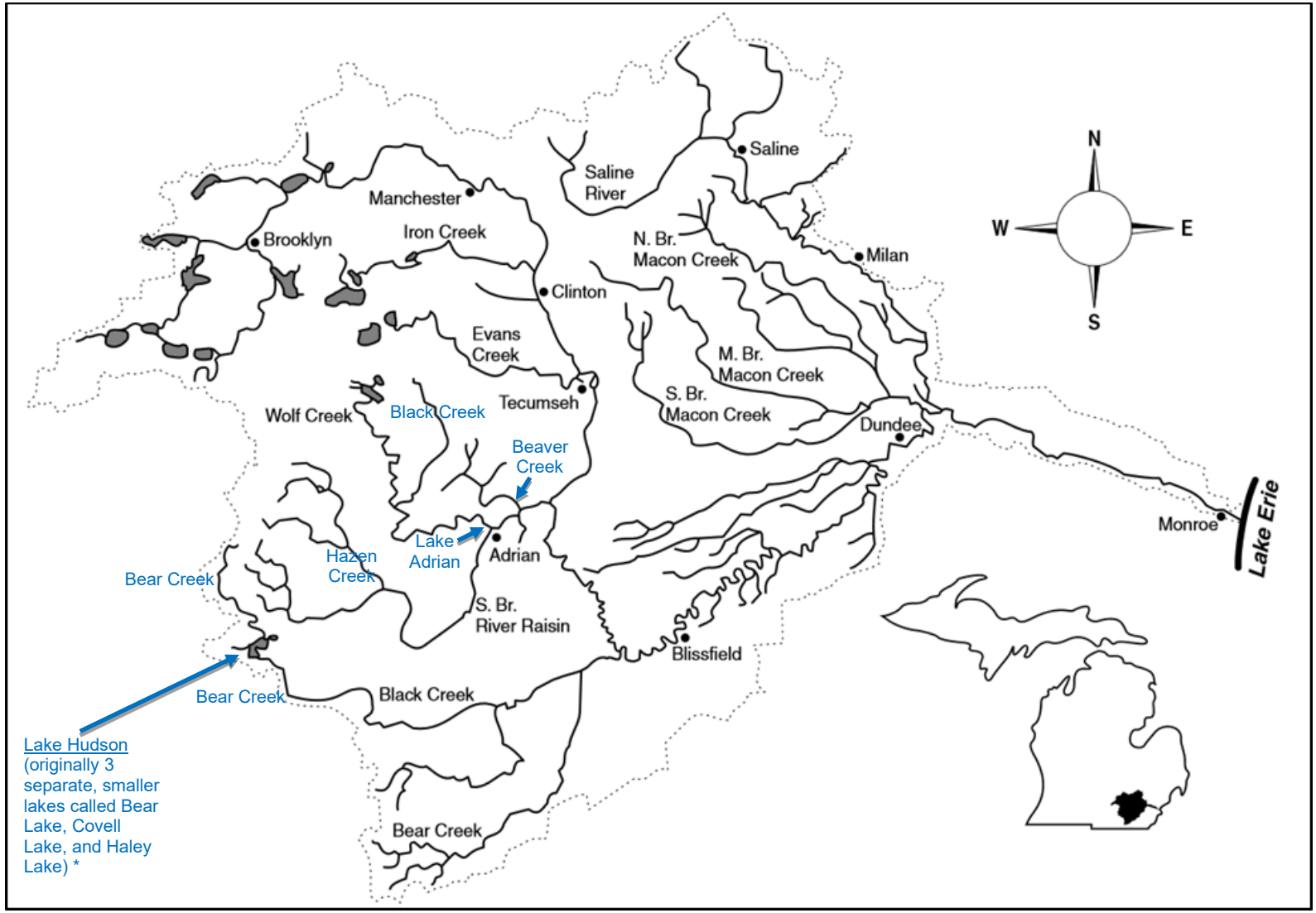

Figure 1. The River Raisin watershed in southeastern Michigan showing major tributaries and towns. (Adapted from Dodge [1998] *with modifications in blue*.) *See en.wikipedia.org/wiki/Lake_Hudson_State_Recreation_Area and the United States Geological Survery's (USGS) National Map for more information about Lake Hudson and nearby streams.

METHODS

Biological Community and Habitat Monitoring

Wadeable Sites

Macroinvertebrate community and physical habitat conditions were qualitatively assessed at 34 wadeable stations in 2018 (Table 2, Figure 2) using the SWAS Procedure 51, a rapid bioassessment tool (EGLE, 2014). If a wadeable station was at a road crossing, it was sampled upstream, unless noted otherwise. Procedure 51 assigns scores to macroinvertebrate communities that rate Excellent (+9 to +5), Acceptable (+4 to -4), or Poor (-5 to -9) based on the macroinvertebrate community composition and structure. Habitat conditions rate Excellent (> 154), Good (154 to 105), Marginal (104 to 56), or Poor (< 56) based on several parameters that describe in-stream and riparian conditions (Creal et al., 1996). Negative macroinvertebrate scores in the acceptable range are considered tending towards a poor rating, while positive scores in the acceptable range are tending towards an excellent rating.

Nonwadable Site

Macroinvertebrate community and physical habitat conditions were assessed at one station on the River Raisin (Station NW-1; Table 2, Figure 2) using the SWAS Procedure 22 (MDEQ, 2013). The range of scores possible for nonwadeable macroinvertebrate community metrics is 0-100, with scores from 25-100 typically representing communities having better than poor conditions (i.e., fair, good, or excellent).

Water and Sediment Chemistry Sampling

At some locations, water chemistry measurements were made, or samples were collected (Figure 2, Table 2). Field measurements of dissolved oxygen (DO), pH, specific conductance, and water temperature in surface waters were generally made using a YSI EXO1 sonde, though a YSI 600 XL sonde was used on August 14, 2018, because an EXO1 was not available. In streams approximately 1-2 feet deep, water grab samples were collected mid-depth. In deeper waters, grab samples were collected approximately 1 foot below the water surface. For most water quality parameters, 500 milliliter (mL) plastic bottles were used to collect samples. Alternatively, 40 mL glass vials were used for volatile organics and gas range organics, while one-liter amber glass bottles were used for diesel range organics, oil range organics, and semivolatile organics.

At one location (i.e., approximately 350 feet upstream of Ridge Highway, near Station 16 [South Branch Macon Creek at Ridge Highway]), sediment chemistry samples were collected. Samples of the upper 3 to 5 inches of stream sediment were collected using a stainless-steel spoon, taking care to avoid losing any organic matter that had settled on the sediment surface. Samples were taken from a 4- to 5-inch-wide representative portion of a depositional area in the margin of the stream. Additionally, some tree roots submerged in the stream were disturbed and shaken to try to release

contaminants that had become attached to them. Sheens observed during this sampling process were noted and photographed or recorded on video. Each sample was placed into a stainless-steel bowl, composited, and homogenized with the spoon, and then subsampled to fill up a wide-mouth, 250 mL glass container. During volatile organics sediment sampling, a methanol trip blank was transported to the site in a 40 mL glass vial.

Containers for sediment and water samples were preserved, kept on ice in a cooler, and handled according to MDNR (1994) and MDEQ Environmental Laboratory (2018) guidance, and then analyzed by the MDEQ Environmental Laboratory (with the exception of sediment Total Organic Carbon samples, which were analyzed by Pace Analytical Services [Grand Rapids, Michigan]).

SITE SELECTION

Typically, two site-selection methods are used to assess watersheds: (1) stratified random; and (2) targeted. Within the River Raisin watershed, 23 randomly selected sites were chosen to support the SWAS Status (13 sites) and Trend (10 sites) Program. Status sites are randomly chosen each basin cycle to allow extrapolation of results statewide, whereas trend sites were originally randomly chosen and are now fixed to allow evaluation of changes over time (trend sites will be resampled every five years). All sites will be used, in part, to determine attainment status for the Other Indigenous Aquatic Life and Wildlife (OIALW) designated use component of Rule 100 (R 323.1100(e)) of the Part 4 Rules, WQS, promulgated under Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451 (MDEQ, 2015). All 2018 biosurvey stations in this report were in warmwater streams, rivers, or drains.

Status sites will be part of a future statewide status report. Two reports have been completed, one for 2006-2010 (Great Lakes Environmental Center [GLEC], 2015) and one covering 2011-2015 (GLEC et al., 2018). Trend sites will be used to facilitate a measurement of statewide and watershed biological community temporal trends (MDEQ, 2015). Statewide trend information will be summarized in a report after 2021, once a sufficient amount of data has been collected and analyzed.

Targeted sites were solicited statewide from internal and external customers in the fall of 2017. Requests were ranked following a series of meetings involving Water Resources Division (WRD) SWAS supervisors, watershed biologists, permit biologists, NPS staff, district staff, and water quality/topic specialists based on the water quality concern, potential ongoing impacts to surface waters, available resources, division priorities, and other factors. The time and resources required to complete each request was calculated, and a cutoff score was chosen that worked with staff capacity. For the River Raisin watershed, 12 targeted sites were prioritized and selected for monitoring macroinvertebrates in 2018, while 13 other sites were prioritized and selected for site visits or various forms of water chemistry monitoring.

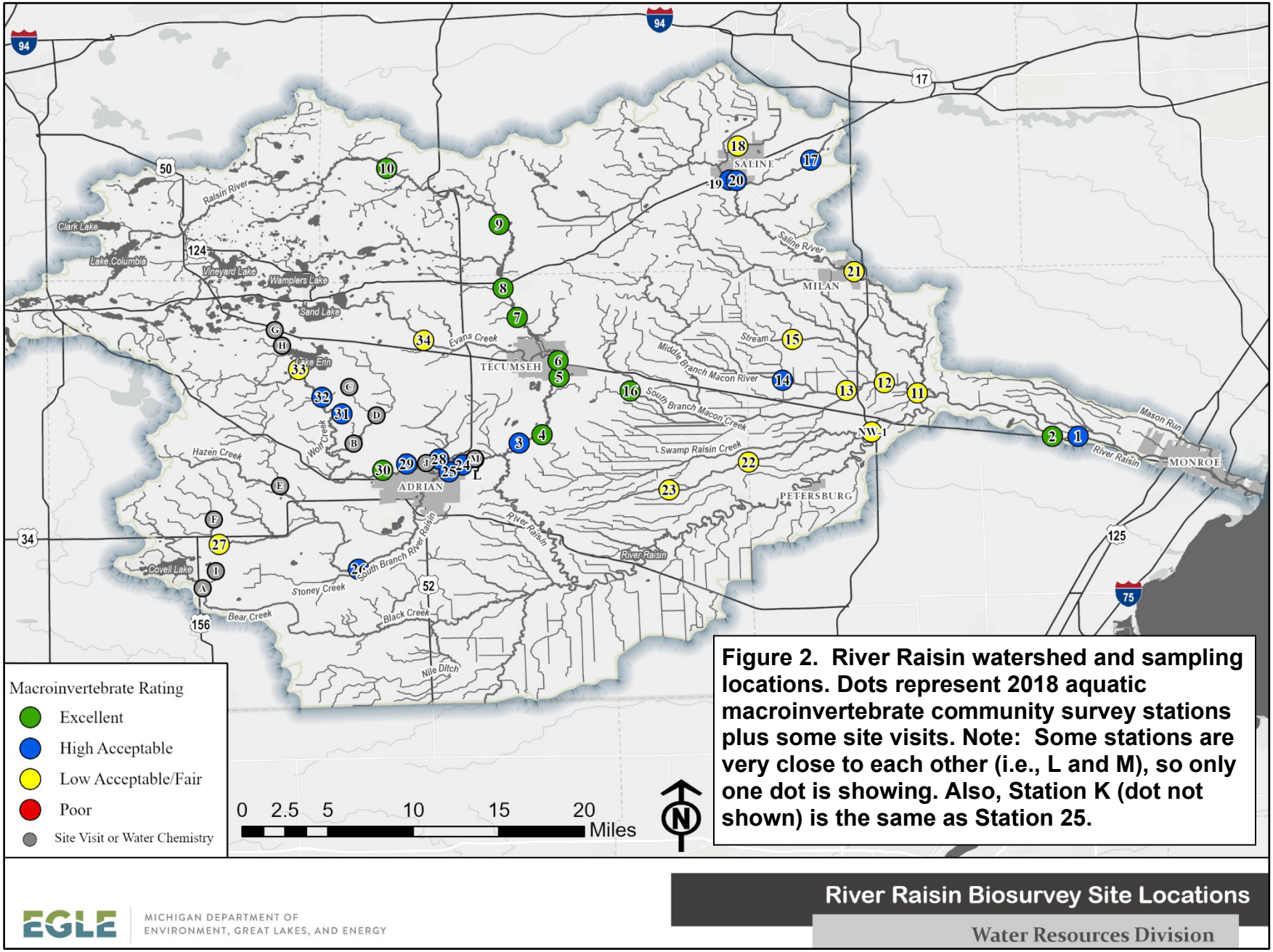

Figure 2. River Raisin watershed and sampling locations. Dots represent 2018 aquatic macroinvertebrate community survey stations plus some site visits. Note: Some stations are very close to each other (i.e., L and M), so only one dot is showing. Also, Station K (dot not shown) is the same as Station 25.

2018 SAMPLING RESULTS

Table 2. Summary of the aquatic habitat and macroinvertebrate community evaluations for selected stations in the River Raisin watershed, June-September 2018. Abbreviation explanations are listed at the bottom of the table. Site type noted with (Permits) was selected and monitored by biologists in the WRD, Permits Section.

Station #	Eco-region	Stream Name	Road Crossing*	STORET #	County	Township	Latitude	Longitude	Habitat Evaluation Rating	Score [2]	Macroinvertebrate Evaluation Rating	Score [3]	Site Type
1	HELP	River Raisin	off N Custer Road	580624	Monroe	Raisinville	41.94214	-83.49195	Good	118	Acceptable	2	Status
2	HELP	River Raisin	off Dixon Rd	580572	Monroe	Raisinville	41.94208	-83.51378	Good	143	Excellent	5	Trend
3	ECBP	River Raisin	North Wilmouth Hwy; d/s of Wacker Chem Corp	460082	Lenawee	Raisin	41.93639	-83.96417	Good	139	Acceptable	4	*Targeted (**Permits**)*
4	ECBP	River Raisin	N Raisin Center Hwy; u/s of Wacker Chem Corp	460244	Lenawee	Raisin	41.94317	-83.94496	Good	151	Excellent	8	*Targeted (**Permits**)*
5	ECBP	River Raisin	E Russel Rd; d/s of Tecumseh WWTP	460468	Lenawee	City of Tecumseh	41.99222	-83.93056	Good	137	Excellent	6	*Targeted (**Permits**)*
6	ECBP	River Raisin	u/s M-50 (and Evans Creek / Globe Mill Pond outlet)	460212	Lenawee	City of Tecumseh	42.00576	-83.93147	Excellent	163	Excellent	6	Trend
7	ECBP	River Raisin	Staib Rd; d/s of Clinton WWTP	460325	Lenawee	Clinton	42.04250	-83.96612	Excellent	161	Excellent	9	*Targeted (**Permits**)*
8	ECBP	River Raisin	Tate Park (W. Michigan Ave); u/s of Clinton WWTP	460469	Lenawee	Clinton	42.06707	-83.97795	Good	132	Excellent	7	*Targeted (**Permits**)*
9	ECBP	River Raisin	d/s of Wallace Rd.	810620	Washtenaw	Bridge-water	42.12121	-83.98127	Good	130	Excellent	8	Status
10	SMNITP	River Raisin	Sharon Valley Road	810098	Washtenaw	Sharon	42.16832	-84.07625	Good	139	Excellent	5	Status
11	HELP	Macon Creek	d/s Stowell Rd (d/s of Holcim US Inc [4])	580420	Monroe	Dundee	41.97861	-83.62750	Good	140	Acceptable	-1	*Targeted (**Permits**)*

[2] Habitat Evaluation Scoring: < 56 is Poor, 56-104 is Marginal, 105-154 is Good, >154 is Excellent.

[3] Macroinvertebrate Community Scoring: 9 to 5 is Excellent, 4 to -4 is acceptable, -5 to -9 is poor.

[4] Holcim US Inc was formerly Holnam Inc.

Station #	Eco-region	Stream Name	Road Crossing*	STORET #	County	Township	Latitude	Longitude	Habitat Evaluation Rating	Score [2]	Macroinvertebrate Evaluation Rating	Score [3]	Site Type
12	HELP	Macon Creek	Dundee-Azalia Rd / Hatter Rd; (u/s of Holcim US Inc)	580570	Monroe	Dundee	41.98745	-83.65552	Marginal	102	Acceptable	-3	*Targeted (**Permits**)*
13	HELP	Macon Creek	Wilcox Road	580424	Monroe	Dundee	41.98079	-83.68776	Marginal	84	Acceptable	-2	Status
14	HELP	Macon Creek	Hiser Road	580625	Monroe	Dundee	41.98954	-83.74171	Marginal	73	Acceptable	1	Status
15	HELP	Bear Swamp Creek	Dennison Rd	580567	Monroe	Milan	42.02410	-83.73360	Marginal	58	Acceptable	-2	Trend
16	ECBP	South Branch Macon Creek	Ridge Highway	460473	Lenawee	Ridgeway	41.98031	-83.87043	Good	109	Excellent	5	Status (+ WC, SC)
17	ECBP	Koch-Warner Drain	Warner Rd	810570	Washtenaw	Pittsfield	42.17560	-83.71787	Good	135	Acceptable	0	Trend
18	ECBP	Wood Outlet Drain	Downstream Maple Road	810569	Washtenaw	City of Saline	42.18736	-83.77940	Good	128	Acceptable	-3	Trend
19	ECBP	Saline River	Curtiss Park; u/s Monroe St & Saline WWTP	810221	Washtenaw	Saline	42.15861	-83.78667	Excellent	156	Acceptable	0	*Targeted (**Permits**)*
20	ECBP	Saline River	adjacent to Woodingham Ct; d/s of Saline WWTP	810341	Washtenaw	City of Saline	42.15833	-83.78083	Excellent	175	Acceptable	2	*Targeted (**Permits**)*
21	HELP	Saline River	Gump Lake Rd; d/s of Milan WWTP	580426	Monroe	City of Milan	42.07732	-83.67695	Good	112	Acceptable	-4	*Targeted (**Permits**)*
22	HELP	Little River Raisin	N County Line Rd	460406	Lenawee	Deerfield	41.92011	-83.77050	Marginal	63	Acceptable	-3	Trend
23	HELP	Little River Raisin	Sisson Highway	460472	Lenawee	Deerfield	41.89668	-83.83770	Marginal	70	Acceptable	-4	Status
24	ECBP	South Branch River Raisin	Howell Hwy	460050	Lenawee	City of Adrian	41.91783	-84.01192	Good	143	Acceptable	3	Trend
25	ECBP	South Branch River Raisin	Island Park; u/s of Adrian WWTP	460467	Lenawee	City of Adrian	41.91225	-84.02361	Good	136	Acceptable	2	*Targeted (**Permits**)*
26	ECBP	South Branch River Raisin	Sand Creek Highway	460474	Lenawee	Madison	41.82993	-84.10005	Good	152	Acceptable	4	Status
27	ECBP	South Branch River Raisin	Wheeler Highway	460471	Lenawee	Dover	41.85056	-84.21789	Good	125	Acceptable	-3	Status
28	ECBP	Beaver Creek	Carson Hwy	460414	Lenawee	Adrian	41.92268	-84.03219	Good	139	Acceptable	3	Trend
29	ECBP	Wolf Creek	Birnwick Drive	460412	Lenawee	Adrian	41.91858	-84.05949	Marginal	102	Acceptable	0	Status

Station #	Eco-region	Stream Name	Road Crossing*	STORET #	County	Township	Latitude	Longitude	Habitat Evaluation Rating	Score [2]	Macroinvertebrate Evaluation Rating	Score [3]	Site Type
30	ECBP	Wolf Creek	Wolf Creek Highway	460334	Lenawee	Adrian	41.91338	-84.07935	Good	110	Excellent	5	Status
31	ECBP	Wolf Creek	off Wolf Creek Hwy	460410	Lenawee	Adrian	41.96103	-84.11393	Good	133	Acceptable	2	Trend
32	ECBP	Wolf Creek	Townline Highway	460359	Lenawee	Adrian	41.97516	-84.13081	Good	140	Acceptable	1	Status
33	ECBP	Wolf Creek	Gilbert Hwy; u/s of Onsted WWTP	460470	Lenawee	Cambridge	41.99861	-84.15056	Good	111	Acceptable	-1	*Targeted (**Permits**)*
34	ECBP	Evans Creek	Wisner Hwy	460417	Lenawee	Franklin	42.02330	-84.04507	Marginal	102	Acceptable	-4	Trend
NW-1	HELP	River Raisin	near US-23	580626	Monroe	Dundee	41.94584	-83.66646	N/A	N/A	Fair	25 **	Status [**NW**]
Targeted Site Visit, Water Chemistry, and/or Sonde Measurement Sites													
A	--	Bear Creek	Medina Road	460388	Lenawee	Dover	41.81356	-84.23165	--	--	--	--	SND, SV
B	--	Black Creek	Wolf Creek Hwy; west of Adrian	460314	Lenawee	Adrian	41.93607	-84.10412	--	--	--	--	SND, SV
C	--	Fisk Drain	Teachout Road	460440	Lenawee	Adrian	41.98369	-84.10808	*Water was too shallow to immerse YSI sonde.*				SV
D	--	Fisk Drain	u/s of Knight Hwy	460479	Lenawee	Adrian	41.95999	-84.08490	--	--	--	--	SND, SV
E	--	Hazen Creek	Plank Road	460462	Lenawee	Rome	41.90024	-84.16655	--	--	--	--	SND, SV
F	--	South Branch River Raisin	W Cadmus Road	460465	Lenawee	Dover	41.87179	-84.22219	--	--	--	--	SND, SV
G	--	Wolf Creek	Springville Hwy	460460	Lenawee	Cambridge	42.03193	-84.17074	--	--	--	--	SND, SV, WC
H	--	Wolf Creek delta/inlet to Loch Erin	Stephenson Road	460466	Lenawee	Cambridge	42.01865	-84.16468	--	--	--	--	SND, SV, WC
I	--	Rice Lake Drain	Haley Road	460387	Lenawee	Dover	41.82819	-84.22063	--	--	--	--	SND, SV
J	--	Lake Adrian	upper end, under powerline near Saw Mill Court	460463	Lenawee	City of Adrian	41.91935	-84.04311	--	--	--	--	SND, SV, WC
K (25)	--	South Branch River Raisin	at Island Park[5]	460467	Lenawee	City of Adrian	41.91075	-84.02450	--	--	--	--	SND, SV, WC

[5] Water sampling was done immediately below Island Park/Mill Road footbridge, approximately 600 feet upstream biosurvey location (STORET #460467).

Station #	Eco-region	Stream Name	Road Crossing*	STORET #	County	Township	Latitude	Longitude	Habitat Evaluation Rating	Score [2]	Macroinvertebrate Evaluation Rating	Score [3]	Site Type
L	--	South Branch River Raisin	near Heritage Park; u/s of junction w/ Beaver Creek	460464	Lenawee	Raisin	41.92273	-84.00139	--	--	--	--	SND, SV, WC
M	--	Beaver Creek	near Heritage Park	460461	Lenawee	Raisin	41.92320	-84.00166	--	--	--	--	SND, SV, WC

* u/s = upstream; d/s = downstream; WWTP = wastewater treatment plant

** nonwadeable (NW) site macroinvertebrate community scoring: scores from 25-100 typically represent communities having better than poor conditions (i.e., fair, good, excellent).

N/A not applicable

Site Type Abbreviations or Footnotes

SC sediment chemistry
SND sonde measurements
SV site visit
WC water chemistry

SUMMARY OF FINDINGS BY MONITORING OBJECTIVE

Note Regarding Weather, Fine Soils/Sediments, and Turbidity

In 2018 the River Raisin watershed was observed to have moderate to high turbidity conditions at many of the stations visited. A variety of factors can be involved in determining whether a water body at a given location is turbid. The upper watershed area ("Headwaters to Tecumseh" per Dodge [1998]) is "characterized by hilly terrain and permeable soils that reduce runoff during precipitation events and limit turbidity." Much of the remaining watershed, however, is more prone to having turbid water conditions due to factors including intense agricultural land use, increased erosion, and in-stream habitat dominated by silt and/or clay substrate in many places. In the "Tecumseh to Dundee" section of the River Raisin for example, Dodge (1998) noted that "intensive agricultural use particularly downstream of Palmyra in combination with the soil types results in high levels of turbidity during all but extreme low flow periods..."

While weather was relatively dry before and during sampling at many stations, summertime rain events occasionally occurred prior to sampling and likely contributed to, or augmented, the turbidity observed at some stations on their sampling days. Due to (typically) dryer conditions accompanied by less saturated watershed soil conditions, most summertime rain events likely impact or intensify watershed/stream erosion and turbidity less than they would during other (wetter) seasons. One unexpectedly heavy rainfall event, which occurred overnight midway through a multi-day sampling trip the evening of July 31, 2018, however, produced about 2 inches of rain and likely had a significant impact on turbidity at the sites sampled the next day.

Silts and clays generally have lower settling velocities than larger sediment particles (e.g., sand) and, as long as the water is moving, silt and clay tend to stay in suspension longer than coarse sediments (Phillips et al., 2019; United States Department of Agriculture, Natural Resources Conservation Service [USDA-NRCS], 1983; National Research Council, 1992; Mooneyham and Strom, 2018). So, it is possible that some reaches of stream systems with abundant silt and clay sediments might have slightly to moderately turbid water conditions, even if it has not rained significantly recently (e.g., for a couple of days).

Many stations in this 2018 biosurveys report were noted in the field as having turbid water conditions on the day they were surveyed, while some others were not.

- Stations 5 through 10, located on the upper River Raisin mainstem (i.e., within or upstream of Tecumseh), all had silt and/or clay making up < 20 percent of their stream bottom substrates. Three of these stations (5, 8, and 10) did not have turbid water, and two of these stations (7 and 9) were only slightly turbid. Just one of these stations (6) was turbid and it had rained approximately 0.3 inches 2-4 days before sampling there).
- In addition to Station 6, a couple of other stations (14 and 29) also had silt and/or clay making up < 20 percent of their stream bottom substrates and field notes describing turbid water conditions. These stations had approximately 2 and

1 inches of rain occurring the night before and 7 days prior to sampling visits, respectively.

- Stations that had silt and/or clay making up > 20 percent of their stream bottom substrates in various places across the watershed (other than the upper mainstem) included Stations 11, 12, 13, 15, 16, 17, 18, 22, 23, 26, 27, and 31.
    - While most of these stations only had a bit of rain before the sampling date (i.e., < 0.5 inches of rain, but with 3-7 days of dry weather prior to being sampled), Stations 13 and 16 had roughly 2 inches of rainfall overnight before sampling occurred there.
    - Five of these 12 stations were specifically noted in the field as having moderately or heavily turbid water conditions at the time of sampling (i.e., Stations 11, 12, 13, 26, and 27); a sixth station (16) was slightly turbid upon arrival.
    - Aside from Station 17, all the remaining stations having silt and/or clay making up > 20 percent of their stream bottom substrates (i.e., Stations 15, 18, 22, 23, and 31) had very slow water velocities (which may not have been fast enough to keep silts and clays suspended).
- The nonwadeable, large river site (Station NW-1), which had very turbid water, was sampled using a nonwadeable procedure, so percentages of substrate types are not available. Still, the substrate was noted as being dominated by sand; however, there was silt covering most stable substrates (e.g., wood) and likely a significant portion of the river bottom in the sampling reach. This area received approximately 1.5 inches between 3-7 days prior to sampling.
- Note: Determining how much of the turbidity at sites was due to precipitation versus in-stream substrate conditions, inputs from land-use activities or erosion was beyond the scope of this monitoring effort.

More details about sampling stations, their biological communities, and habitat conditions are discussed below. Most information included about weather or precipitation conditions occurring before or during sampling is based upon local climatological stations, data, and observations tracked down at NCEI.NOAA.gov/Maps/lcd, Water.Weather.gov/Precip, and Weather.gov. In most cases, weather observed at the Adrian Lenawee County Airport (KADG) was used as a proxy for the entire watershed, recognizing that there was likely some variability (e.g., in rainfall amounts) across the watershed.

Objective 1: Assess the current status and condition of individual waters of the state and determine whether Michigan WQS are being met.

In 2018 aquatic macroinvertebrate community and habitat assessments were conducted at a total of 35 stations (13 Status, 10 Trend, and 12 Targeted locations) in the River Raisin watershed. (All 12 targeted macroinvertebrate sampling stations in this report were selected and monitored by WRD, Permits Section biologists.) The OIALW designated use was met at all 13 Status stations, all 10 Trend stations, and all 12 Targeted stations (i.e., fair, acceptable, excellent macroinvertebrate communities). Refer to Figure 2 and Table 2 for a summary of the monitoring locations and their

macroinvertebrate and habitat rating results. Tables 3 and 4 provide more detailed information about the habitat conditions and macroinvertebrate communities at the survey stations. Appendix A contains details about the nonwadeable site's (Station NW-1) macroinvertebrate community.

RIVER RAISIN MAINSTEM (LOWER PORTION)

Three biological surveys were conducted in the (roughly) lower half of the mainstem River Raisin (i.e., the portion of the mainstem downstream of Tecumseh, Adrian, and where the South Branch of the River Raisin drains into the mainstem), and each were found to have a substantially different macroinvertebrate community rating.

River Raisin off North Custer Road (Station 1)

The most downstream station monitored in 2018, Station 1, was approximately 9.4 river miles upstream of where the River Raisin flows into Lake Erie. The land use immediately upstream of this station was predominantly agricultural, with some residences scattered along rural highways. While much of the river corridor upstream only had a thin ribbon of forested riparian buffer, there were some occasional larger patches of forest. A small amount of riverbank stabilization was observed where an agricultural field met the side of the river at this station. This sampling reach was relatively wide (154 feet) compared to many other stations in this report. Large rocks (mostly cobble, a few boulders) made up about half of the river's inorganic substrate, while the remainder was mostly sand with a bit of silt. While the glide/pool habitat conditions scored good (118) overall, about half of the individual metrics scored marginal (i.e., epifaunal substrate/available cover[6], pool substrate, pool variability, flashiness, and riparian vegetative conditions).

The macroinvertebrate community at Station 1 rated acceptable (+2) with 29 taxa present. Six mayfly and 3 caddisfly taxa were found, comprising 45 percent and 5 percent, respectively, of the community. Leptohyphid (formerly called tricorythid) mayflies were the dominant taxon (24 percent). Other common taxa, each comprising 10-12 percent of the community, included coenagrionid damselflies, heptageniid mayflies, Chironomidae (a.k.a., midges), and elmid beetles.

[6] Epifaunal substrate/available cover can include submerged structures such as cobble (riffles), large rocks, fallen trees, logs and branches, and undercut banks, available as habitat, shelter, feeding areas, or sites for spawning and nursery functions of aquatic macrofauna (e.g., macroinvertebrates and fish) (EGLE, 2014). Epifauna refers to the animals that live on the surfaces of rocks or other submerged structures on or near the bottom of aquatic ecosystems such as streams and rivers.

River Raisin off Dixon Road (Station 2)

The River Raisin off Dixon Road (Station 2) (Figure 3) was located approximately 1.3 river miles upstream of Station 1. The surrounding land was predominantly agriculture with pockets of light residential areas. No obvious, recent stream modifications (e.g., bank stabilization or channel dredging) were noted. The river corridor adjacent to and upstream of Station 2 also had a thin ribbon of forested riparian buffer with occasional larger patches of forest. While mature trees lined the river's edges, large in-stream wood habitat (e.g., downed logs, tree trunks) was sparse. The southern side of the river channel looked like a typical stretch of rocky riffle, while the northern side was predominantly a large sediment bar covered with annual vegetation (e.g., grasses). Like Station 1, the average width of the sampling reach was relatively wide (140 feet). The inorganic substrate was cobble-dominated (50 percent) but, overall, there was a diverse mix of bedrock, boulder, cobble, gravel, sand, and silt in the wetted part of the channel. Habitat rated good (143) overall in this riffle/run reach, though some individual metrics scored marginal (sediment deposition and flashiness) or poor (frequency of riffles/bends).

Figure 3. River Raisin off Dixon Road (Station 2). A large, vegetated sediment bar can be seen on the right side of the photo.

The macroinvertebrate community rated excellent (+5) with numerous taxa (39) present, 12 of which were mayflies (7) or caddisflies (5). Mayflies comprised 51 percent of the community and caddisflies made up 9 percent of the community. The first- and second-most dominant taxa, baetid (18 percent) and heptageniid (15 percent) mayflies, belong to scraper/collector/gatherer and scraper functional feeding groups, respectively (Bouchard, 2004), and likely thrive feeding on algal biofilms growing on rocky substrate in this reach. The presence of cobble/gravel substrate and riffle/run habitat at Station 2 likely allowed for an abundance of heptageniid (flatheaded) mayflies and the presence of some snail-case-maker (helicopsychid) caddisflies. These taxa are typically clingers that are adapted either by shape (flattened) or behavior (case-making), respectively, to live in swift, moving water in erosional habitat areas on stable structures like cobbles and logs (Merritt et al., 2019; Bouchard, 2004).

River Raisin Near US-23 (Station NW-1)

Figure 4. River Raisin near US-23 (Station NW-1).

Station NW-1, the River Raisin near US-23 (Figure 4, Appendix A), was situated just upstream of Dundee and was a nonwadable survey reach located roughly 13 river miles upstream of Station 2. This reach was primarily surrounded by agriculture land use, but some residential developments and patches of forest were also present. Roughly half of the survey reach was upstream of US-23 and roughly half was downstream. A small section immediately downstream of US-23 had a lot of rip rap on the left bank, indicating significant erosion problems there. This erosion could partly have been a result of constriction of the floodplain by the highway bridge.

This river reach was mostly slow, deep, and turbid. (It had rained approximately 1.5 inches, cumulatively, between 3-7 days prior to sampling.) Water depths in the thalweg[7] ranged from about 6 to 10 feet. While there occasionally was stable inorganic substrate such as boulder, cobble, and gravel in the thalweg of the channel, the locations where macroinvertebrates were sampled (as dictated by Procedure 22) were predominantly fine inorganic and organic substrates plus some occasional wood, macrophytes, overhanging vegetation, and/or undercut banks. Much of the wood that was present was mostly covered with silt. Heavy amounts of silt can limit stable habitat available to macroinvertebrate colonization (MDEQ, 2013).

Overall, the biological community rated low fair (25) (Appendix A). Twenty-eight taxa were found, including with 2 mayfly families but no caddisflies or stoneflies. The top 3 taxa found at Station NW-1 were Corixidae (water boatmen) (63 percent), midges (9 percent), and Physidae (lunged snails) (8 percent). These taxa generally are somewhat to very tolerant of stressful environmental conditions (e.g., slow flowing water, low DO, and/or limited stable substrate conditions) (Voshell, 2002; Bouchard, 2004), which was consistent with the habitat conditions observed (slow, silty, and turbid, with limited stable substrate).

[7] The thalweg is the deepest longitudinal path along the channel.

RIVER RAISIN MAINSTEM (UPPER PORTION)

General Conditions

Seven biosurveys were conducted in the (roughly) upper half of the River Raisin mainstem (i.e., the portion of the mainstem upstream of where the South Branch River Raisin enters). One of the most visible patterns observed in this group of biological surveys was that, aside from Station 3, which had a macroinvertebrate score of +4 (high acceptable), all of the upper River Raisin mainstem stations (i.e., Stations 4-10) had macroinvertebrate communities that rated excellent (i.e., with scores ranging from +5 to +9).

Examination of the river corridor between Stations 3 and 10, using aerial imagery plus a land use map (Figure 5), reveals generally a very sinuous (curvy, crooked) river with a relatively intact, wide ribbon of riparian forest and/or woody wetlands (dark and light green colors in Figure 5) – especially relative to the lower mainstem River Raisin. No obvious stream modifications, such as channelization, dredging, or bank hardening/stabilization were noted at these sites despite the human land use activities occurring in this portion of the watershed. Dominant land use along the river was cultivated crops and pasture/hay fields, with a few small towns occasionally seen with their associated urban land uses (e.g., wastewater treatment plants, impoundments[8], residential, golf course, commercial, and industrial lands). Riparian/wetland lands likely buffered against environmental or human-caused stressors (e.g., by providing shade and helping to filter pollutants from overland runoff) and contribute to the overall health of the river and its biological communities. (For more information about the benefits of healthy riparian forests and streamside woody wetlands, see Sargent and Carter [1999] and USDA [2021]).

[8] There are two impoundments between Stations 6 and 7 (Standish Pond and Red Millpond), one between Stations 9 and 10 (at the southeastern end of Manchester), and there are also other impoundments further upstream.

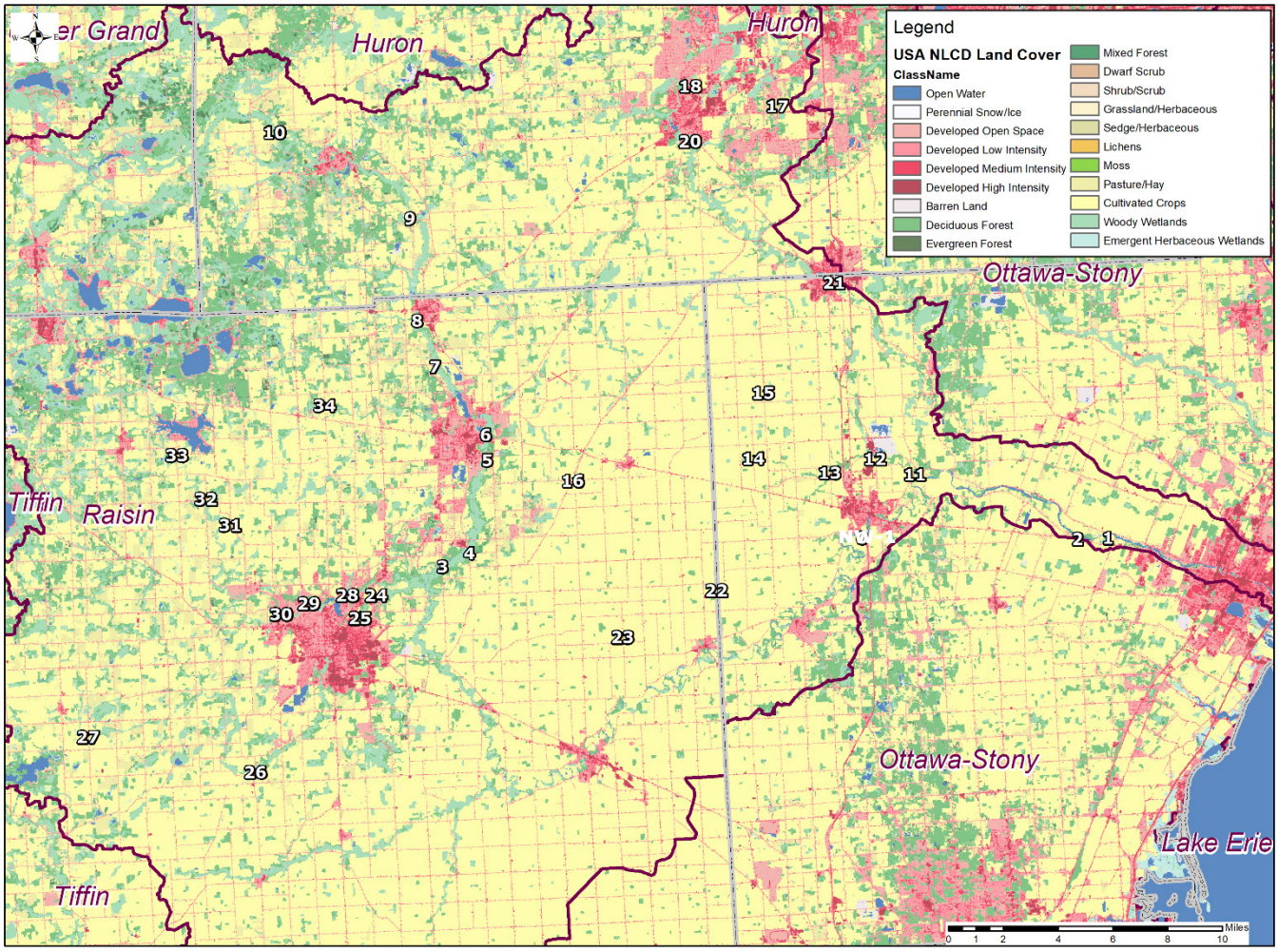

Figure 5. Image of 2018 land use characteristics of the River Raisin watershed (Geographic Information System data source: NLCD layer [MRLC, 2021]).

River Raisin at North Wilmouth Downstream of Wacker Chem Corp (Station 3)

River Raisin at North Wilmouth (Station 3) was located approximately 58 river miles upstream of Station NW-1. The low gradient pool/glide habitat at this station rated good (139) overall. Most individual habitat metrics scored as good or excellent, though sediment deposition and flashiness scored marginal. The inorganic substrate was predominantly sand (85 percent), with some gravel and silt. Large wood and coarse-sized organic detritus had an extensive/heavy presence.

The macroinvertebrate community rated acceptable (+4). Overall taxa richness was 17. Four of the 5 most common taxa were in caddisfly (hydropsychid; 21 percent) or mayfly (leptohyphid, heptageniid, and baetid; 10-18 percent) families. Amphipoda (scuds) were also common (17 percent).

River Raisin at North Raisin Center Highway Upstream of Wacker Chem Corp (Station 4)

At River Raisin at North Raisin Center Highway (Station 4), the low gradient pool/glide habitat rated good (151) overall. Most individual habitat metrics scored as good or excellent, but sediment deposition and channel sinuosity scored marginal. Note the reach that was sampled was fairly straight, but aerial imagery indicates the river in this area generally is quite sinuous. Sand was the dominant inorganic substrate type (80 percent), but some gravel and silt were also present.

The macroinvertebrate community here rated excellent (+8). The total number of taxa present was 20. Other than scuds (9 percent), the most common taxa (7-24 percent) were mayfly families (leptohyphid, baetid, heptageniid) and caddisfly families (leptocerid, hydropsychid, brachycentrid). The combined percentage of the community that was mayflies (44 percent) or caddisflies (32 percent) was relatively high (76 percent).

Moving in an upstream direction (starting with Station 1), Station 4 is the first station where a stonefly was observed. Stoneflies generally are one of the most environmental-stress-sensitive groups of aquatic insects (EGLE, 2014; Hilsenhoff, 1988; Bouchard, 2004; DeWalt, 2009). Generally, the presence of stoneflies is a reliable indicator of very good water quality, and many species are restricted to habitats with high levels of DO (Bouchard, 2004). Only one family of stoneflies was found in all the surveys described within this report: Perlidae. It was only observed at 4 stations in this study, and all 4 of those stations were in the upper portion of the River Raisin mainstem.

River Raisin at East Russel Road Downstream of Tecumseh WWTP (Station 5)

Located downstream of the Tecumseh WWTP, the riffle/run habitat at Station 5 rated good (137) overall. Most individual metrics were either good or excellent, though sediment deposition and flashiness were marginal, and the frequency of riffles/bends was poor. Most of the inorganic substrate was fines (sand [60 percent] or silt [19 percent]); the remaining inorganic substrate was gravel, cobble, and an occasional boulder. A moderate amount of organic substrate (large wood and other coarse detritus) was present.

The macroinvertebrate community rated excellent (+6), with 23 total taxa present. Mayflies and caddisflies comprised 66 percent of the community, but no stoneflies were observed. The two most common taxa were leptohyphid mayflies (30 percent) and hydropsychid caddisflies (22 percent). Other somewhat common taxa included baetid mayflies, elmid beetles, and chironomid flies (7-12 percent).

River Raisin Upstream of M-50 and Evans Creek/Globe Mill Pond Outlet (Station 6)

Station 6, also located in Tecumseh, was sampled upstream of both M-50 and a dam spillway/outlet from Globe Mill Pond (i.e., sampled at the same location as Schmitt [2010] and Noffke [2015]). Globe Mill Pond is an impoundment of Evans Creek, but this

pond is also connected to Standish Pond (an impoundment of the River Raisin mainstem) via a manmade canal[9]. The low gradient glide/pool habitat at this station (Figure 6) rated excellent (163) overall; all individual metrics scored either good or excellent. The water was turbid on the sampling date (it had rained approximately 0.3 inches 2-4 days before sampling). The inorganic substrate was mostly gravel (60 percent) and sand (25 percent), but also included some silt, cobble, and boulder. Large wood, other coarse organic detritus, and overhanging vegetation were moderately abundant.

Figure 6. River Raisin upstream of M-50 and outflow from the Evans Creek impoundment (Globe Mill Pond) (Station 6).

Station 6 had a macroinvertebrate community that rated excellent (+6). Community composition was surprising given the habitat and overall community scores. The two most dominant taxa were scuds (16 percent) and Chironomidae (13 percent). In general terms, organisms in the order Amphipoda and the family Chironomidae are often considered overall to be moderately to highly tolerant of environmental stresses; however, this order and family are quite diverse, and some genera can be restricted to low stress waters that are cool, clean, and well-oxygenated (Voshell, 2002; Bouchard, 2004). Because a relatively high taxa richness (30) was observed at this station, and because 7 mayfly taxa and 5 caddisfly taxa were present, there is no obvious reason to be concerned about an abundance of scuds and midges.

River Raisin at Staib Road Downstream of Clinton WWTP (Station 7)

The low gradient glide/pool habitat at Station 7 rated excellent (161) overall; all individual metrics scored either good or excellent. The inorganic substrate was approximately half gravel with the remaining half being fine sediments (i.e., 40 percent sand and 10 percent silt). Large wood was observed to be moderate, while coarse

[9] apps.nationalmap.gov/viewer/; michiganradio.org/families-community/2019-07-25/tecumseh-is-full-of-surprises-and-this-couple-doesnt-want-you-to-miss-out

organic detritus in general was heavily abundant. The water was slightly turbid at the time of sampling; it had rained a little (approximately 0.3 inches) about 6 days earlier. Curly leaf pondweed (an invasive species in Michigan) was present in about 10 percent of the survey reach.

Total taxa richness was 26 at this station, and the macroinvertebrate community rated excellent (+9). Five mayfly and 5 caddisfly taxa were present, and they made up 29 percent and 41 percent, respectively, of the community. One stonefly taxon, the family Perlidae, was present. Hydropsychid (19 percent) and brachycentrid (16 percent) caddisflies were the most common organisms. Midges, and baetid and heptageniid mayflies, were somewhat common (9-14 percent).

River Raisin at Tate Park (West Michigan Avenue) Upstream of Clinton WWTP (Station 8)

The River Raisin at Tate Park (Station 8) was located south of West Michigan Avenue (US-12) in Clinton Township, approximately 0.7 miles downstream of an unnamed impoundment, numerous mobile homes, and some commercial development. The river channel configuration near this station was unique. The river split about midway down the length of Tate Park. The western channel, where the biosurvey station was located, had Tate Park on its west side and an “island” on its east side. The eastern channel (not sampled) had the “island” on its west side and a logging company and some woods on its east side. Aerial imagery suggests both channels may have been straightened and channelized years ago – especially the eastern channel. The riffle/run habitat scored good (132) overall, with most individual metrics scoring good or excellent. Exceptions included bank stability and vegetative protection, which scored marginal, and flashiness, which scored poor. Inorganic substrate composition in the reach was mostly gravel and sand with some cobble and a small amount of silt. Moderate amounts of wood, undercut banks, and coarse organic detritus were present.

The macroinvertebrate community rated excellent (+7), though a “full bucket count” was noted for this station (i.e., organisms were not abundant in the composite sample, so all 239 organisms in the bucket had to be counted). A total of 26 taxa were present. Hydropsychid (common netspinner) caddisflies were the most dominant taxa (at 21 percent). Other somewhat common taxa (6-13 percent of the community) were Chironomidae, elmid beetles, heptageniid mayflies, polycentropodid (trumpnet or tubemaking) caddisflies, and brachycentrid (humpless case maker) caddisflies. Five families of both mayflies and caddisflies were present, comprising 19 percent and 38 percent of the community, respectively. According to Bouchard (2004) and Voshell (2002), hydropsychids are collector-filterers that use their nets to filter food particles from the water. Polycentropodids are either collector-filterers (that use their nets to filter/collect food) or engulfer-predators. While the food strategies of brachycentrids are more variable, including shredder-herbivore, collector-gatherer, and scraper, some brachycentrids are collector-filterers (which filter and feed upon food particles collected from the water by fringes of long, fine hairs on their legs). Being downstream of an impoundment may partly explain the abundance of filter-feeders, which can be common downstream of productive lakes or reservoirs (Voshell, 2002).

River Raisin Downstream of Wallace Road (Station 9)

Much of the watershed upstream of Station 9 (River Raisin downstream of Wallace Road) was agricultural, though it was approximately 4.9 river miles downstream an impoundment on the edge of the town of Manchester. Some of the riparian corridor upstream of this station was just a thin ribbon, but there also were some large patches of riparian forest. Habitat here rated good (130) overall (Figure 7) in this low gradient riffle/run reach. All individual metrics scored good or excellent except for velocity/depth regime, flashiness, and riparian vegetation zone width, which scored marginal. The stream bottom here was dominated by sand (50 percent) and gravel (30 percent), but there was also some cobble and silt present. Coarse-sized organic detritus was moderately abundant, and large wood was sparse.

Figure 7. River Raisin downstream of Wallace Road (Station 9).

The macroinvertebrate community rated excellent (+8), with a total of 39 taxa present. Eight mayfly taxa, 8 caddisfly taxa, and 1 stonefly taxa (Perlidae) were present, with mayflies and caddisflies comprising 16 percent and 20 percent of the community, respectively. Chironomidae were the most abundant (18 percent). Other somewhat common taxa (7-9 percent of the community) were hydropsychid caddisflies, Amphipoda, elmid beetles, and water boatmen.

River Raisin at Sharon Valley Road (Station 10)

The River Raisin at Sharon Valley Road (Station 10) was a low gradient glide/pool reach with wide forested riparian buffers and/or woody wetlands on both sides of the channel (Figure 8). The upstream watershed was mostly a mix of agriculture and forest and included an impoundment roughly 1.8 river miles upstream of the station. Habitat scored good (139) overall. Every individual habitat scored good or excellent except for pool variability, which scored poor. The inorganic substrate at this location was mostly cobble, gravel, and sand, with a small amount of boulder and silt. Large wood, other coarse organic detritus, overhanging vegetation, and rootwads were present in moderate amounts.

The macroinvertebrate community rated excellent (+5), and it had a total taxa richness of 36. Mayflies (5 taxa) and caddisflies (6 taxa) made up 14 percent and 12 percent of the community, respectively. One stonefly taxa (Perlidae) was present. A snail family, Bithyniidae, was the most dominant taxa (18 percent) present in this community. Interestingly, Voshell (2002) notes that Bithyniid snails were introduced to the Great Lakes region from northern Europe in the 1870s, and they have spread from at least Wisconsin to Pennsylvania and New York. After Bithnyiidae, the next 5 most common taxa (from 14 percent down to 5 percent) were elmid beetles, Amphipoda, heptageniid mayflies, Chironomidae, and brachycentrid caddisflies.

Figure 8. River Raisin at Sharon Valley Road (Station 10).

Macon Creek (and Tributaries) Subwatershed

Macon Creek Downstream of Stowell Road (Station 11)

Station 11, Macon Creek (mainstem) downstream of Stowell Road, northwest of Dundee and approximately 1.2 miles downstream of Holcim US Inc – Dundee. Besides the Holcim facility, agriculture was also a dominant land use in the watershed upstream of this monitoring station, along with a few manufacturing facilities. Riparian forest buffers in the watershed immediately upstream of this station were a roughly even mix of narrow and moderate widths. The surveyed reach mostly hugged a curved stretch of road. Overall, habitat scored good (140) in this glide/pool reach, with all individual metrics scoring either good or excellent except for flashiness, which scored marginal. Some bank stabilization was present, and the water was turbid on the day of sampling (it had rained approximately 0.4 inches rain 5-7 days before sampling). About a third of this reach's inorganic substrate was boulder, cobble, and gravel, with the remaining portion being dominated by fine sediments (sand [40 percent] and silt [26 percent]). Moderate amounts of large wood and other organic detritus were present.

The macroinvertebrate community at this station rated acceptable (-1). There were 20 total taxa present. Many of the taxa present can do well in slower, fine

sediment-dominated streams including coenagrionid damselflies (the most dominant taxa at 25 percent) plus other taxa such as Corixidae (water boatmen), Gerridae (water striders), and caenid mayflies (each about 8 percent). And despite their family's common name (riffle beetles), Elmidae were the second-most dominant species present (17 percent). Voshell (2002) notes that while elmid beetles are common in swift, shallow streams, a few species inhabit sandy bottoms of slow sections of streams. There were 4 mayfly and 2 caddisfly taxa present, making up 15 percent and 1 percent of the community, respectively. The percent of the community that was surface air breathers was 17 percent.

Macon Creek at Dundee-Azalia Road/Hatter Road (Station 12)

Station 12 was sampled on the mainstem of Macon Creek upstream of a concrete terminal (Holcim US Inc – Dundee). This station was located approximately 2.2 river miles upstream of Station 11. A tributary, the North Branch of Macon Creek, flows north of the mainstem and is situated between the concrete terminal and Station 12. Agriculture is a dominant land use in the watershed upstream of this monitoring station, but other land uses include some manufacturing facilities, US-23, a few homes, and some patches of riparian forest.

Locally, this glide/pool stretch of stream was noted as having been dredged. Aerial imagery suggested this station, and long stretches of the channel upstream, were largely straightened. The water was turbid the day of sampling, and the average surface water velocity was fairly slow (0.3 feet/sec). (Like Station 11, it had rained approximately 0.4 inches 5-7 days before sampling.) This station rated marginal (102) overall for habitat. While about half of the individual habitat metrics scored good, sediment deposition, flashiness, bank stability, and vegetative protection scored marginal and channel sinuosity scored poor. An outfall to the stream was noted as having erosion issues. Large wood and other organic detritus were moderately and heavily abundant, respectively. Large inorganic substrate (boulder, cobble, gravel) comprised about a third of the stream bottom while fine sediments dominated the channel bottom (sand [35 percent], silt [30 percent], and clay [5 percent]).

The macroinvertebrate community rated acceptable (-3). Like Station 11, Station 12 had 20 taxa overall and the same 3 most-dominant taxa: water boatmen (43 percent), coenagrionid damselflies (20 percent), and elmid beetles (8 percent). Nearly half (43 percent) of the community was comprised by surface air breathers and just 9 percent of the taxa were either in the mayfly or caddisfly families. These community characteristics together suggest this reach is being impacted by environmental stressors and human disturbance such as dredging/channelization, drainage practices, and pollutant runoff (e.g., likely from US-23 and agricultural lands).

Macon Creek at Wilcox Road (Station 13)

Aerial imagery indicates that much of the creek at, and upstream of, Station 13 has been channelized and straightened. While streamside trees and shrubs appeared to be

growing back and providing shade to the stream, the immediate stream banks were mostly grasses and bare soil (Figure 9). Although sampled on a different day, Station 13 was like Station 12 in that the water was turbid and fairly slow (0.3 feet/sec) on the day of sampling. (It had rained heavily [approximately 2 inches] the night before the sampling occurred.) There were many downed trees, but they were mostly sticking out of the water and unavailable for colonization by stream macroinvertebrates. The low gradient riffle/run habitat here was marginal (84) overall. While 4 of the individual metrics were good or excellent, most were marginal or poor. Metrics that were poor included: epifaunal substrate/available cover, sediment deposition, flashiness, and bank stability. Cobble was very sparse, and gravel was only moderately present. Sand (40 percent) and silt (40 percent) dominated the channel bottom.

Figure 9. Macon Creek at Wilcox Road (Station 13).

The macroinvertebrate community rated acceptable (-2) overall, with 26 total taxa present. Like Stations 11 and 12, the community was dominated by water boatmen (29 percent). The remaining 4 most abundant taxa were hydropsychid caddisflies, heptageniid mayflies, elmid beetles, and midges (6-14 percent). Three mayfly families and 3 caddisfly families were present, making up 15 percent and 7 percent of the community, respectively. Surface air breathers were common (34 percent).

Macon Creek at Hiser Road (Station 14)

Figure 10. Macon Creek at Hiser Road (Station 14).

Aerial imagery showed that Station 14, and the reaches upstream of it, were very channelized and straightened. No other obvious stream modifications were noted during the survey. While there were some streamside trees that provided shade for the surveyed reach, the riparian zone was narrow or nonexistent for about two miles upstream. The water here was turbid (it had rained heavily [approximately 2 inches] the night before the sampling occurred). Sand was the dominant inorganic substrate type (60 percent), followed by gravel (30 percent). Some silt and cobble were also present. There were some small branches and twigs in the water, but generally large wood in the water was sparse. The streambanks were quite unstable, and there were a fair number of trees that had recently fallen towards or into the stream (Figure 10). Generally, only the tips of these fallen trees were in the water, so their in-stream habitat benefit was limited. The glide/pool habitat rated marginal (73) overall. Aside from a few individual metrics that score good or excellent, most metrics scored marginal or poor. Metrics that scored poor included: pool variability, flashiness, and bank stability. Given these various indicators of instability (plus other visual observations), it appears this stream may be experiencing a period of channel widening.

The macroinvertebrate community rated acceptable (+1), had 26 taxa present, and was dominated mostly by aquatic insect families having at least some species that are moderately or highly tolerant of stressful conditions. The top 4 taxa were caenid mayflies, midges, elmid beetles, and water boatmen (from 24 percent down to 9 percent). Elmid beetles are generally thought to have a moderate tolerance to stress as a family overall (Bouchard, 2004). A few species can inhabit the sandy bottom of slow sections of streams (Voshell, 2002), which often are more stressful environments than faster flowing riffles or glides. Three mayfly taxa and 3 caddisfly taxa were present, comprising 34 percent and 4 percent, respectively, of the community.

Bear Swamp Creek at Dennison Road (Station 15)

Figure 11. Bear Swamp Creek at Dennison Road (Station 15).

Station 15 was located on Bear Swamp Creek at Dennison Road. Bear Swamp Creek is a tributary to the north branch of Macon Creek. The watershed of this station is nearly all agricultural land. This location appeared to have been recently dredged (i.e., 2017 or 2018), as had been similarly noted in Noffke (2015), and the channel has been mostly straightened, to facilitate drainage. The trees have all been removed at this station and, for the most part, reaches upstream only had a thin ribbon of streamside trees (Figure 11). The low gradient habitat, which was nearly 100 percent glide, rated marginal (58) overall. The individual metrics were almost all marginal or poor, with the poor metrics including pool substrate characterization, pool variability, channel alteration, channel sinuosity, and riparian vegetation zone width. Inorganic substrate was all fine sediments (40 percent silt, 60 percent clay), and any other colonization structures were absent except for a thin band of overhanging streamside grasses.

Bear Swamp Creek (Station 15), which rated acceptable (-2), required a full bucket count because it only had 175 individuals in the entire sample, suggesting a somewhat sparse population of macroinvertebrates. The recent dredging appeared to have scraped away most of any channel substrate complexity, which likely was a major cause of the sparse population. The five most common taxa at this station were Chironomidae, Decapoda (crayfish), and Pisidiidae (fingernail clams) (each approximately 23 percent of the community), followed by water boatmen (15 percent) and oligochaete worms (4 percent), indicating a community tolerant of disturbance. No caddisfly taxa were present. Only 1 mayfly taxa, the generally tolerant family Caenidae, was present, comprising only 2 percent of the overall community. Surface air breathers made up 17 percent of the community.

South Branch Macon Creek at Ridge Highway (Station 16)

The south branch of Macon Creek at Ridge Highway (Station 16) was downstream of a major road (M-50) and flowed through land use dominated by agricultural and light residential/industrial/commercial areas. The Tecumseh Mills Airport is approximately 4.6 river miles upstream in the headwaters. The upper half of the survey reach had a moderately wide riparian zone, which provided a fair amount of shade. The stream

reaches upstream of the station alternated between having moderately sized patches of riparian forest adjacent and having only a thin (or non-existent) ribbon of streamside trees.

Figure 12. South Branch Macon Creek at Ridge Highway (Station 16).

Habitat rated good (109) overall. No individual metrics scored poor. While a few scored good or excellent, most metrics scored marginal (epifaunal substrate/available cover, embeddedness, sediment deposition, flashiness, bank stability, vegetative protection, and riparian vegetation zone width). Large riprap was abundant near the downstream end of the survey reach, and the shade provided mostly by grasses and shrubs was limited (generally approximately 20 percent canopy cover). The inorganic substrate was mostly sand (50 percent), silt, and gravel, with a minute amount of cobble and clay. Most of the channel bottom material had at least a light covering of silt. The water was slightly turbid upon arrival. The photo taken after the survey showed it as quite turbid, likely due largely to EGLE biologists walking and sampling a fine-sediment-dominated stream (Figure 12). It had rained substantially (approximately 2 inches) the night before this station was sampled, which could have added to the turbidity. Undercut banks and overhanging vegetation were present in moderate amounts and likely, in addition to gravel, were an important habitat for this low gradient, riffle/run station.

Despite what appeared to be habitat limitations at the station, the macroinvertebrate community rated excellent (+5). The total number of taxa was 26. Mayflies and caddisflies made up almost half of the community, with 2 and 4 taxa present, respectively. Hydropsychid caddisflies were the most dominant taxon (31 percent). Other somewhat common taxa were elmid beetles, baetid mayflies, and midges (19 percent down to 9 percent). The moderate amounts of gravel substrate, undercut banks, and overhanging vegetation, occasional patches of riparian forest, and cool water temperature (67 ^{o}F that afternoon) could have provided enough stable substrate, refuge, and cover to allow this reach to support an excellent community. Additionally, the upstream reaches of stream located in patches of forest may support a diverse community of macroinvertebrates that periodically drift downstream and colonize the surveyed location.

Towards the end of the biosurvey effort at this station, occasional oil sheens were seen on the water surface after walking through the stream. Details about follow-up site visit and water/sediment sampling results are provided in Appendix B. Briefly, water and

sediment samples were collected approximately 350 feet upstream of the Ridge Highway culvert. Lab analyses of those samples found:

- "Probable petroleum product(s) present" in the water sample (see qualifier/note "Y17" in Table B-1 of Appendix B); however, no specific semi-volatile organic compounds (e.g., certain kinds of polycyclic aromatic hydrocarbons [PAH] or base/neutral and acid extractable compounds)[10] were detected.
- Diesel range organics in both the water and sediment sample.
    - The lab noted that diesel range organics results may also include non-diesel organic compounds.
- Oil range organics in both the water and sediment sample.
    - The lab noted that oil range organics results may also include non-oil organic compounds.
- Unremarkable concentrations of some metals (e.g., barium, chromium, copper, iron, lead, nickel, and zinc) in the water and sediment sample.

The diesel range organics and oil range organics concentrations in the August 14, 2018, sediment sample were well under United States Environmental Protection Agency (USEPA) Region 4 (USEPA, 2018) ecological screening values. For sediment metals, concentrations were all below the MacDonald et al. (2000) threshold effect concentration (i.e., the concentration below which harmful effects are unlikely to be observed) and within the range of sediment background concentrations for Michigan reference streams (Jones and Gerard, 1999).

SALINE RIVER (AND TRIBUTARIES) SUBWATERSHED

Koch-Warner Drain at Warner Road (Station 17)

The watershed upstream of Koch-Warner Drain at Warner Road (Station 17) was a mix of suburban residential neighborhoods, agriculture, and patches of woods. The station had a low gradient, flowing channel, but it also was very wetland-like in its wide floodplain area. Most of the station had low banks and thick, herbaceous wetland vegetation on both sides (Figure 13). The upper part of the survey reach had braided channel with some woody riparian shrubs and the downstream end was near an intersection of two roads.

[10] For example, the lab analyzed for 17 commonly measured PAHs, but there are more than 17 kinds of PAHs (Hansen et al., 2003).

Figure 13. Koch-Warner Drain at Warner Road (Station 17).

Aquatic plants were abundant in the channel, with about 75 percent of the survey reach having rooted emergent and rooted submergent plants and/or duckweed, though it did not appear to be nuisance conditions. The water was clear and cool (65 ºF) at the time of the survey. This glide/pool habitat rated good (135) overall. Nearly all individual metrics scored good or excellent, with pool variability (poor) being the exception. The inorganic substrate was very soft and nearly 100 percent silt. While large wood was sparse, overhanging vegetation, aquatic macrophytes, and organic detritus were very abundant.

The macroinvertebrate community rated acceptable (0) overall. Total taxa richness was relatively low (18). The community appeared well suited for the habitat available at this station. It was dominated by midges (52 percent), and while there are some species in the family Chironomidae that live on rocks or logs, many can thrive in soft, fine sediments or on aquatic vegetation (Voshell, 2002). The next four most common taxa were Pisidiidae (fingernail clams), hydropsychid and phryganeid caddisflies, and Hirudinea (leeches) (19 percent down to 4 percent). No mayfly taxa were present; 3 caddisfly taxa were present, comprising 13 percent of the community.

Wood Outlet Drain Downstream of Maple Road (Station 18)

Wood Outlet Drain downstream of Maple Road (Station 18, Figure 14), was also located in an area that was a mix of suburban residential neighborhoods, agriculture, and patches of woods. There also are several industrial facilities scattered throughout the watershed, and the Ann Arbor Municipal Airport is near the headwaters. While the station is within a forest patch, much of the channel upstream is straightened, with reaches alternating between those lacking streamside trees and others having small patches of forest. Water here was clear and cool (64 ºF) at the time of the survey. Average water velocity was slow (0.2 feet/sec). The low gradient riffle/run habitat rated good (128) overall, with most individual metrics scoring good or excellent. Two metrics were marginal (epifaunal substrate/available cover and velocity/depth regime), and one was poor (frequency of riffles/bends), reflecting how the habitat was not very diverse in this location. The channel was 90 percent run, with the remaining habitat being riffle or depositional. Cobble and gravel comprised approximately 20 percent of the inorganic substrate, while fine sediments dominated the stream bottom (sand [20 percent], silt

[60 percent]). Other than the limited riffle habitat, there was little other structure available for macroinvertebrate colonization.

Figure 14. Wood Outlet Drain downstream of Maple Road (Station 18).

Even though 28 taxa were present, the macroinvertebrate community rated low acceptable (-3), consistent with the limited habitat diversity observed. The five most dominant taxa at this station are considered generally to be somewhat or very tolerant of stressful conditions and can do well in fine-sediment-dominated streams (Voshell, 2002; Bouchard, 2004). Chironomidae was the most dominant taxa (20 percent), followed by Physidae ("lunged" snails), water boatmen, oligochaete worms, and Pisidiidae (15 percent down to 8 percent). No mayflies were present, and <1 percent of the community was caddisflies (with only 1 taxon [Hydropsychidae]). Some leeches and mosquito larvae were present, and isopod/snail/leech was 21 percent. Surface air breathers was 22 percent. Mosquito larvae are generally not found in a stream unless it has some very slow or near-stagnant habitat.

Saline River at Curtiss Park Upstream of Monroe Street and the Saline WWTP (Station 19)

Station 19, on the Saline River, was located at the lower end of Curtiss Park. It also was just downstream of Mill Pond (an impoundment of the river) and US-12 but upstream of Monroe Street and the Saline WWTP. The land use upstream of this station was mostly a mix of parks, woods, dense and light residential areas, a major roadway (US-12), and agricultural lands. While much of the river at, and immediately upstream of, this station had riparian forest buffer >100-feet wide, there were some occasional areas where manicured lawn or parklands went to the edge of the river. The riffle/run habitat here rated excellent (156) overall, and all individual metrics were either good or excellent. Average water velocity was rapid (2.0 feet/sec) and no stream modifications were obvious. Approximately 10 percent of the river reach had either rooted submergent plants or attached algae, but it was noted as sparse. Inorganic substrate was primarily cobble (75 percent), with some gravel (10 percent) and small amounts of sand and silt. Overhanging vegetation was present in moderate amounts.

The macroinvertebrate community rated acceptable (0) overall. Taxa richness was 16. Mayflies (2 taxa) and caddisflies (1 taxa) accounted for 2 percent and 5 percent of the community, respectively. Simuliidae and Chironomidae were by far the most dominant taxa (59 percent and 18 percent, respectively), followed by elmid beetles and

hydropsychid caddisflies (each approximately 5 percent of the community). These taxa all have at least some species that can tolerate moderately stressful environments.

Most black flies (Simuliidae) and hydropsychid caddisflies are filter feeders. Most black flies (Simuliidae) have fan-like mouthbrushes, while hydropsychid caddisflies spin mesh nets to collect food. These organisms can sometimes be very abundant in streams having moderate to high amounts of organic *seston* (Voshell, 2002; Wallace and Webster, 1996; Wotton, 1987; Merritt et al., 1978), which is a collective term for free-floating particles that include small organisms, organic matter, and sometimes inorganic sediment. Lake and pond outlets, like the habitat at this site, typically discharge high quality organic seston.

Saline River (adjacent to Woodingham Court Downstream of the Saline WWTP) (Station 20)

Station 20 on the Saline River was downstream of the Saline WWTP. It was about 0.3 river miles downstream of Monroe Street and 0.4 river miles downstream of Station 19. It was mostly surrounded by riparian forest, although there was some lawn on the right bank. The riffle/run habitat at this station rated excellent (175). Almost all the individual habitat metrics scored excellent; 2 metrics scored good (sediment deposition and riparian vegetation zone width). Like Station 19, no major stream modifications were noted, and average water velocity was rapid (2.4 feet/sec). Rooted submergent plants and attached algae were mostly sparse. Most of the stream bottom was rocky (5 percent boulder, 40 percent cobble, 40 percent gravel), with the remaining 15 percent being sand. Additional structure (e.g., large wood, undercut banks, overhanging vegetation) available for macroinvertebrate colonization was sparse.

The macroinvertebrate community rated as acceptable (+2). The community looked similar to Station 19, though taxa richness was higher (22 versus 16 at Station 19). Mayflies (3 taxa) and caddisflies (2 taxa) accounted for 3 percent and 4 percent of the community, respectively. Again, black flies and midges were by far the most dominant taxa (70 percent and 12 percent of the community, respectively), followed by elmid beetles (5 percent) and hydropsychid caddisflies (4 percent).

Saline River at Gump Lake Road Downstream of the Milan WWTP (Station 21)

The Saline River at Gump Lake Road (Station 21) was located downstream of a railroad crossing and the Milan WWTP. It was in the town of Milan, but much of the watershed upstream was agricultural land, residential developments, and patches of forest alongside the river. An impoundment of the river, adjacent to the Milan Nature Park, was approximately 0.5 river miles upstream of Station 21. Habitat rated good (112) overall. Some individual metrics scored good or excellent, but a little over half scored marginal (epifaunal substrate/available cover, pool substrate characterization, sediment deposition, channel sinuosity, bank stability) or poor (flashiness). No major stream modifications were noted. Most of the stream bottom was sandy (90 percent), with a small amount of gravel and silt. Approximately 80 percent of

this glide/pool reach was pool, and habitat colonization structures (e.g., undercut banks, overhanging vegetation, large wood, and aquatic macrophytes) were either sparse or absent. A grey water-type smell was noted during the survey.

The macroinvertebrate community rated low acceptable (-4). Total taxa richness was 16, organisms were sparse, and a whole bucket count was needed at this station. The community was dominated by moderately or highly tolerant taxa including midges (the most abundant taxon at 24 percent), elmid beetles, water boatmen, hydropsychid caddisflies, scuds, crayfish, and caenid mayflies. Three mayfly taxa and 2 caddisfly taxa, comprising 10 percent and 13 percent, respectively, of the community were present. Surface air breathers comprised 12 percent of the community. The relative uniformity of the substrate and habitats likely contributed to this low acceptable community. Neither DO nor *E. coli* bacteria levels were measured here, but they may have been impacted by whatever was causing the grey water smell.

LITTLE RIVER RAISIN SUBWATERSHED

General Conditions

The two Little River Raisin locations in Deerfield, Stations 22 (at North County Line Road) and 23 (at Sisson Highway), are situated in a watershed that is heavily dominated by agricultural fields. The river had been dredged and straightened/channelized at both stations and many areas throughout the watershed. Even though they were evaluated as glide/pool channels (since there were no riffles present), both stations rated poor for pool variability. Almost half of the individual habitat metrics scored poor at both stations.

Little River Raisin at North County Line Road (Station 22)

Habitat conditions rated marginal (63) at Station 22 (Figure 15). Individual metrics that rated poor included epifaunal substrate/available cover, pool substrate characterization, pool variability, channel sinuosity, and riparian vegetation zone width. Some tall shrubs dotted the sides of channel at this station, otherwise riparian forest buffer was minimal or absent at, and upstream of, this station. Inorganic substrate was 100 percent silt. Surface velocity was very slow (0.03 feet/sec), which likely hinders reaeration of water at this location. Approximately 40 percent of the channel had duckweed on the water surface; some sparse rooted submergent plants were also present. Habitat structure available for

Figure 15. Little River Raisin at North County Line Road (Station 22).

macroinvertebrate colonization (e.g., large wood, overhanging vegetation) was sparse and anything present was buried in silt.

The macroinvertebrate community rated low acceptable (-3). The 22 taxa found were moderately or highly tolerant of, and can thrive in, very slow-moving, silty water. The reach was heavily dominated by oligochaete worms (73 percent), followed by leeches, Pisidiidae, large Viviparid snails, and midges (4-5 percent of the community). No caddisflies were present, and while 1 mayfly taxon was present, it comprised <1 percent of the community.

Little River Raisin at Sisson Highway (Station 23)

The habitat at this station rated marginal (70) with the following individual metrics scoring poor: pool variability, flashiness, channel alteration, channel sinuosity, and riparian vegetation zone width. There was virtually no riparian forest buffer alongside the channel near, or upstream of, this station and the channel was lined with grasses (Figure 16). The channel bottom was primarily silt (75 percent), but it also had minor amounts (≤10 percent each) of gravel, sand, and clay. Average surface velocity was a little faster (0.4 feet/sec) than at Station 22. Approximately 40 percent of the channel had rooted emergent vegetation; duckweed was also present. Other than emergent vegetation, macroinvertebrate colonization structures were generally sparse.

Figure 16. Little River Raisin at Sisson Highway (Station 23).

Like Station 22, the macroinvertebrate community here rated low acceptable (-4) and was also comprised mostly of moderately or highly tolerant taxa that can thrive in slow-moving, mostly-silty-bottomed waters. Taxa richness was 17 and was dominated by scuds (44 percent). The next most common taxa were lunged snails, midges, and oligochaete worms (20 percent down to 5 percent). As with Station 22, no caddisflies were present. Two mayfly taxa were present, but they comprised only about 3 percent of the community. Since organic detritus is the most common food source of scuds (Voshell, 2002), the fact that detritus was moderately abundant at Station 23 but sparse at Station 22 may partly explain why scuds were more common here.

SOUTH BRANCH RIVER RAISIN AND TRIBUTARIES (INCLUDING WOLF CREEK) SUBWATERSHED

General Conditions – South Branch River Raisin

Habitat and macroinvertebrate community ratings at the South Branch River Raisin stations all were quite similar (good for habitat; moderately high to high acceptable for macroinvertebrate communities) with one exception: the uppermost station (#27 at Wheeler Highway) where the macroinvertebrate community rated low acceptable. Stations 24 and 25 were located near the downstream edge of the City of Adrian, while Stations 26 and 27 were situated in rural, agricultural parts of the watershed.

South Branch River Raisin at Howell Highway (Station 24)

The South Branch River Raisin at Howell Highway (Station 24; Figure 17) is located downstream of the Adrian WWTP. Further upstream are a cemetery and Island Park. Much of the riparian corridor is forest except for some occasional lawn areas near the WWTP and park and treeless areas near a powerline. Habitat at this station rated good (143) overall in this riffle/run reach, with almost all individual metrics scoring good or excellent except for frequency of riffles/bends and vegetative protection, which rated marginal. Most of the inorganic substrate was either gravel (40 percent) or sand (40 percent), with the remainder being cobble (2 percent) or silt (18 percent). Large wood and other organic detritus were present in moderate abundance, which may partially explain why there was a good mix of riffle, run, and pool habitats (plus some depositional areas), and fast and slow water areas.

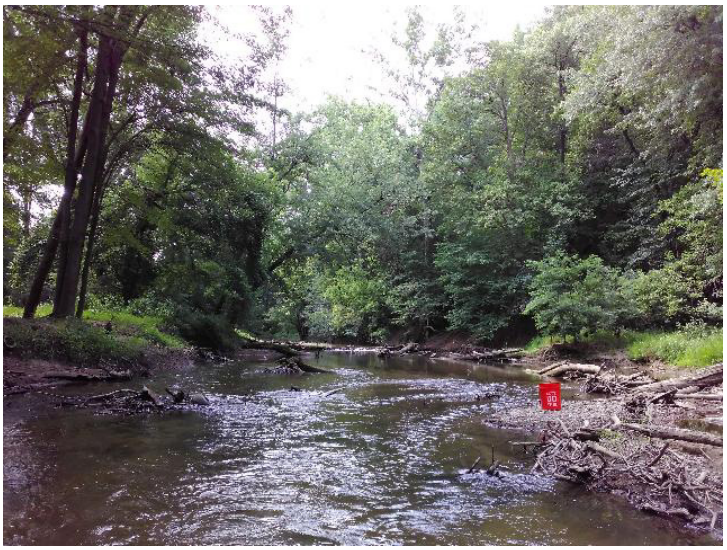

Figure 17. South Branch River Raisin upstream of Howell Highway (Station 24).

The macroinvertebrate community rated high acceptable (+3), likely reflecting the relatively good mix of diverse habitats. Taxa richness was 26. The three most dominant organisms were moderately to highly tolerant taxa (midges, hydropsychid caddisflies, and scuds [31 percent down to 21 percent of the community]). Four mayfly taxa and 1 caddisfly taxa were present, representing 7 and 22 percent of the community, respectively.

A mussel specialist was part of this survey, and some mussels (Unionidae) were informally observed during the survey, including white heelsplitter, mucket, and Wabash pigtoe mussels. While the mussel species mentioned here are common in Michigan, it is notable that 43 percent of Michigan's recognized mussel species are listed as

threatened or endangered (Michigan Mussel Committee, 2022). Many taxa are sensitive to pollutants, especially pesticides, ammonia, and the effects of impoundments, as well as the introduction and spread of invasive zebra mussels (Haag and Williams, 2014; Badra, 2020).

South Branch River Raisin at Island Park upstream of the Adrian WWTP (Station 25)

Station 25 was downstream of M-52, Island Park and the Adrian Dog Park, and where Wolf Creek and its impoundment, Lake Adrian, flows into the south branch of the River Raisin, but upstream of the Adrian WWTP. The riparian corridor at and immediately upstream of this station alternated between patches of forest and some lawn areas for the parks. Bank stabilization practices were noted. Much of the inorganic substrate was large or moderately sized (80 percent boulder, cobble, or gravel) with the remainder being fine sediment (10 percent sand, 10 percent silt). Habitat rated good (136) overall. While most individual metrics scored good or excellent, some metrics scored marginal (sediment deposition, maintained flow volume) or poor (flashiness), indicating this stretch of river may be experiencing some instability and possibly undergoing some channel widening/enlargement. This reach is downstream of a major road and a small city with lots of impervious surfaces. It is not uncommon for urban streams and rivers to experience channel instability since a significant portion of rain runs immediately off impervious surfaces, into storm drainage networks, and ultimately into the river rather than slowly infiltrating into the ground and reaching the stream as baseflow (Walsh et al., 2005; USEPA, n.d.). Besides large rocks, macroinvertebrate colonization structures were sparse or absent.

The macroinvertebrate community rated acceptable (+2) overall. The community was dominated by moderately to highly tolerant taxa, which is consistent with what appears to be a frequently disturbed channel. The five most common taxa were scuds, midges, black flies, elmid beetles, and baetid mayflies. Twenty-three taxa were present. Four mayfly taxa and 2 caddisfly taxa were present, representing 10 percent and 3 percent of the community, respectively.

South Branch River Raisin at Sand Creek Highway (Station 26)

Station 26 was situated well upstream of Adrian. The watershed upstream of this location was dominated by agricultural land. And while there were some moderate sized patches of riparian forest alongside the river, encroachment on the river by agricultural land or light-density residential lawn was common. Habitat rated good (152) overall, with all individual metrics scoring good or excellent. Large, in-stream wood and other organic detritus, as well as root masses in the water, were abundant. It had rained about a week earlier (i.e., only trace amounts during the 5 days prior to sampling, but also about 1 inch between 6-7 days prior to sampling) and the water was turbid. Most of the inorganic substrate was heavily dominated by fine sediments (sand 58 percent, silt 38 percent), with the remaining 4 percent being gravel.

Although a full bucket count was needed at this station, the macroinvertebrate community rated high acceptable (+4) overall. Twenty taxa were present. Elmid beetles were the most common organisms (25 percent), followed by flat-headed mayflies (Heptageniidae), scuds, and hydropsychid caddisflies (10-12 percent of the community). Mayflies made up 19 percent of the community and had 3 taxa present, while caddisflies made up 13 percent of the community and had 2 taxa.

South Branch River Raisin at Wheeler Highway (Station 27)

Station 27 was within a patch of woods downstream of mostly agricultural land plus the town of Clayton. Additionally, a wastewater stabilization lagoon was located approximately 1.3 river miles upstream. The riffle/run habitat rated good (125) overall, with most individual metrics scoring good. A few metrics scored marginal (epifaunal substrate/available cover, velocity/depth regime, frequency of riffles/bends). While there were some mature trees and shrubs adjacent to the river and no obvious channel modifications were observed, parts of one side of the channel had been mowed recently. Only about 7 percent of the channel bottom was gravel; the remaining 93 percent was fine sediments (31 percent sand, 31 percent silt, 31 percent clay). Approximately 90 percent of the reach was run, with riffles and pools only representing about 5 percent each. Large wood and other organic detritus were moderately abundant in the channel. Note: Approximately 0.4 inches of rain had fallen in the area between June 9-10, 2018, and the station had very turbid and muddy water on the day it was sampled (June 13, 2018) (Figure 18).

Figure 18. South Branch River Raisin at Wheeler Highway (Station 27).

The macroinvertebrate community rated low acceptable (-3). The most abundant taxa were tolerant with the three most common taxa (midges [38 percent], Ceratopogonidae [biting midges, 26 percent], and lunged snails [20 percent]) comprising 84 percent of the community. Total taxa richness was 19, and no mayflies, caddisflies, or stoneflies were present. Given the river water was still very muddy and turbid in this small river a few days after a modest rainstorm suggests the macroinvertebrate community may frequently be subjected to suspended sediments in turbid, muddy water.

Beaver Creek at Carson Highway (Station 28)

Figure 19. Beaver Creek at Carson Highway (Station 28).

Station 28, Beaver Creek at Carson Highway, was located approximately 2.3 river miles upstream of where the creek empties into the South Branch River Raisin. The watershed land uses upstream of this station were mixed, dominated by agricultural lands, but also with some residential developments and riparian forest lands present. The riffle/run habitat rated good (139) overall. All the individual metrics scored good or excellent except for vegetative protection (marginal) and riparian vegetation zone width (poor). Some occasional trees, shrubs, and tall grasses (e.g., reed canary grass) lined the stream (Figure 19), but there also was a significant amount of lawn along the channel. The inorganic substrate was mostly cobble and gravel (70 percent), but there was still a significant amount of fine sediment (15 percent sand, 12 percent silt, 3 percent clay).

The macroinvertebrate community rated high acceptable (+3). Taxa richness was 25. Two mayfly families and 3 caddisfly families represented 4 percent and 49 percent, respectively, of the community. The dominant taxon was hydropsychid caddisflies (47 percent). As mentioned earlier, hydropsychids can sometimes be quite abundant below pond outflows or downstream of WWTPs (Bouchard, 2004; Voshell 2002). The name Beaver Creek implies there may be (or may have historically been) beaver ponds in this subwatershed. While large ponds were not readily observed in aerial imagery, there did appear to be at least a little bit of beaver activity (e.g., beaver hut/lodge) in the imagery.

General Conditions – Wolf Creek

Habitat and macroinvertebrate ratings at the Wolf Creek stations were mostly similar. Most stations rated good for habitat, except for the most downstream station (#29), which rated marginal. Most stations rated mid-acceptable for macroinvertebrates, except for the second-most downstream station (#30), which rated excellent. Most of this watershed was dominated by agricultural land. The lower locations (Stations 29-30) were also downstream of some residential subdivisions and, additionally, Station 29 was downstream of a golf course.

Wolf Creek at Birnwick Drive (Station 29)

Figure 20. Wolf Creek at Birnwick Drive (Station 29).

In addition to being in a predominantly agricultural watershed, Wolf Creek at Birnwick Drive (Station 29) was also downstream of some residential subdivisions and a golf course. The riffle/run habitat rated marginal (102) overall, and individual metrics were a mix of marginal, good, and excellent. Two metrics were poor: sediment deposition and frequency of riffles/bends. The water was turbid on the sampling day (it had rained approximately 1 inch about a week prior to sampling) and bank stabilization structures were present. The reach was 90 percent run, 4 percent riffle, and 6 percent depositional. Cobble was the most common inorganic substrate size, with the remainder being a mix of gravel (15 percent), sand (25 percent), and silt (5 percent). Lots of silt covered the rocks. Other macroinvertebrate colonization structures were sparse or absent. Houses and lawns were near the river on the left bank (Figure 20). Sparse moss was observed on some rock in riffles.

The macroinvertebrate community rated acceptable (0). Twenty-two taxa were identified at this station. Scuds were the dominant taxon (42 percent). The remaining four most abundant taxa were Corixidae, Chironomidae, Ancylidae (limpets), and Elmid beetles (15 percent down to 5 percent). Limpets were rarely found to be one of the most common taxa during this report's biological surveys. These scrapers scrape algal biofilms off of rocks. Limpets are most commonly found on firm substrates in riffles (Voshell, 2002), which is consistent with cobble being abundant in this reach. Two mayfly taxa and 2 caddisfly taxa were present, representing 7 percent and 2 percent, respectively, of the community. Fifteen percent of the community were surface air breathers.

Wolf Creek at Wolf Creek Highway (Station 30)

The land uses near Wolf Creek at Wolf Creek Highway (Station 30, Figure 21) included some offices, light residential development, a school complex, and patches of woods, otherwise the watershed was predominantly agriculture. The riffle/run habitat rated good (110) overall. Most individual metrics rated good or excellent, but a few rated marginal (channel alteration, frequency of riffles/bends, vegetative protection), or poor (riparian vegetation zone width). Bank stabilization and canopy removal were noted at the station, especially on the left bank. This was a residential and small business area with lawn and riprap right up to the edge of the stream in many places. A lot of sunlight could reach the stream, especially on the left side. Sand was the dominant inorganic substrate type (45 percent), with the remainder being a mix of cobble and gravel with a small amount of silt. Other than a moderate amount of some root masses in the water, additional structure for macroinvertebrate colonization was sparse or absent.

Figure 21. Wolf Creek at Wolf Creek Highway (Station 30).

The macroinvertebrate community rated excellent (+5), and 27 species were present. The most common taxon was hydropsychid caddisflies (24 percent). Other common taxa included scuds, water boatmen, heptageniid mayflies, and elmid beetles (19 percent down to 10 percent). The presence of a moderate amount of cobble and gravel, and plenty of sunlight, is likely what allowed for a moderate abundance of flat-headed mayflies, which feed primarily on algal biofilms on rocks. Two mayfly taxa and 5 caddisfly taxa were present, comprising 15 percent and 27 percent of the community, respectively. Surface air breathers was 19 percent.

Wolf Creek off Wolf Creek Highway (Station 31)

Though still in a mostly agricultural watershed, much of Station 31 and the reaches immediately upstream of it, had relatively wide riparian forest buffers on either side of the channel. Habitat rated good (133) overall in this pool/glide reach (Figure 22). About half of the individual metrics scored as good or excellent, while the other half scored marginal (epifaunal substrate/available cover, pool substrate characterization, flashiness) or poor (pool variability, vegetative protection). Average water velocity was very slow (approximately 0.1 feet/sec). The inorganic substrate was dominated by silt (90 percent), with the remainder being a small amount of sand (8 percent), gravel (1 percent), and cobble (1 percent). Large wood and other organic detritus were abundant.

Figure 22. Wolf Creek off Wolf Creek Highway (Station 31).

Macroinvertebrate community rated acceptable (+2). Nineteen taxa were present, and the five most abundant taxa were relatively tolerant: scuds (34 percent) followed by oligochaete worms, hydropsychid caddisflies, midges, and elmid beetles (18 percent down to 8 percent). Two mayfly taxa and 1 caddisfly taxa, making up 4 percent and 16 percent, respectively, of the community, were observed.

Wolf Creek at Townline Highway (Station 32)

Like Station 31, Wolf Creek at Townline Highway (Station 32; Figure 23), and continuing upstream for approximately 1 mile, had relatively wide riparian forest buffers on either side of the channel. Habitat rated good (140) overall in this riffle/run reach. All individual metrics scored good or excellent except for embeddedness, which scored marginal. The water was slightly turbid on the sampling day. The stream bottom was predominantly sand (70 percent) and silt (20 percent), with some gravel (10 percent). Large wood and other organic detritus were abundant. The riffles present were mostly created by the presence of pea gravel and/or fallen pieces of wood. Riffles only comprised about 10 percent of the sampling reach, with the remaining parts of the channel being slow runs, pools, or depositional areas.

Figure 23. Wolf Creek at Townline Highway (Station 32).

The macroinvertebrate community rated acceptable (+1). Total taxa richness was 24. The community was dominated by scuds (49 percent). Other somewhat common taxa included hydropsychid caddisflies, midges, and baetid mayflies (14 percent down to 8 percent). Organic detritus is a preferred food source for scuds, and its abundance may partly explain their dominance. Two mayfly taxa and 1 caddisfly taxa, representing 9 percent and 14 percent, respectively, of the community, were present.

Wolf Creek at Gilbert Highway Upstream of the Onsted WWTP (Station 33)

Wolf Creek exited Loch Erin and flowed approximately 0.8 miles through a wooded patch before reaching Station 33. The glide/pool habitat at Station 33 rated good (111) overall. Several individual metrics scored marginal (pool substrate characterization, maintained flow volume, channel sinuosity, riparian vegetation zone width) or poor (pool variability). Canopy removal had occurred in parts of the reach (especially close to Gilbert Highway). Some rooted submergent vegetation (including curly leaf pondweed) and attached algae was present. Gravel was the dominant inorganic substrate (80 percent). Boulder, cobble, sand, and silt were also present. Moderate amounts of overhanging vegetation and organic detritus were present.

The macroinvertebrate community rated acceptable (-1). Total taxa richness was 18. Scuds were heavily dominant (63 percent), followed by black flies, midges, hydropsychid caddisflies, and turbellaria (flatworms) (10 percent down to 4 percent).

One mayfly taxon and 2 caddisfly taxa were present, accounting for <1 percent and 6 percent, respectively, of the community.

Black flies and hydropsychid caddisflies were moderately abundant at this location, which was <3/4 mile downstream from its outlet from Loch Erin. As mentioned earlier, being downstream of a lake may partly explain the abundance of filter-feeders such as black flies and/or hydropsychid caddisflies, which can be common downstream of productive lakes or reservoirs (Voshell, 2002).

EVANS CREEK SUBWATERSHED

Evans Creek at Wisner Highway (Station 34)

One location was sampled on Evans Creek at Wisner Highway (Station 34) on July 24, 2018, in Franklin, west of Tecumseh. While most of the watershed upstream of this location is used for agricultural purposes, there are some patches of forest and wetland. There is a small impoundment of the creek approximately 3.2 river miles upstream of the station, and the headwaters of the creek are Evans Lake and the Twin Lakes. As noted in Noffke (2015), the biosurvey station is located downstream of a landscaping business.

When conducting the survey at this station, a manure-type smell was noticed, and what appeared to be a whitish bacterial slime or “sewage fungus” was observed in much of the stream’s survey reach (Figure 24). While leaving the site, a manure pile was noticed adjacent to the stream where the smell and slimes had been observed. (This station and issue are discussed more under Objectives 2 and 4.)

The riffle/run habitat rated marginal (102) at this location, and the metrics do not even factor in organic pollution. No individual habitat metric scored lower than marginal. Inorganic substrate was a mix of gravel (30 percent), sand (50 percent), and silt (19 percent), with 1 percent cobble. The channel appeared to have been dredged historically, and there was some canopy removal.

The macroinvertebrate community rated low acceptable (-4; trending towards poor). Not all of the reach (i.e., the upstream 25 percent portion) appeared to be (potentially) impacted by the manure pile, which may have kept the community from rating poor overall. No mayfly, caddisfly, or stonefly taxa were observed. Surface air breathers was, surprisingly, 2 percent. The four most dominant taxa were tolerant including: midges (68 percent), oligochaete worms (21 percent), Physidae (7 percent), and Turbellaria (flatworms) (1 percent). The dominance of chironomids, oligochaetes, and physids appears to be reflecting organic pollution and signaling that oxygen conditions here may be low (even though a DO meter was not on hand that day). Many species of oligochaete worms and midges can tolerate low oxygen concentrations and/or organic pollution such as sewage (Hilsenhoff, 2001; Rosa et al., 2014; Welch and Jacoby, 2004). In fact, some species of Chironomidae are referred to as “blood worms,” are red and contain a hemoglobin-like pigment that retains oxygen, and can tolerate extremely low oxygen concentrations (Hilsenhoff, 2001).

Figure 24. Evans Creek at Wisner Highway (Station 34). *Top left*: A representative photo of the stream reach with some shrubs and trees. *Top right*: A manure pile adjacent to the stream. *Bottom left and right*: What appears to be possible whitish bacterial or "sewage fungus" slimes on the stream bottom.

Objective 2: Evaluate biological community temporal trends.

Within the River Raisin watershed, five sites were randomly selected for inclusion as statewide trend station(s) and will be sampled every five years. Statewide trend information will be summarized in a statewide report after 2021 once a sufficient amount of data is collected.

To understand watershed-specific biological integrity temporal trends, an additional five sites were randomly selected within the River Raisin watershed, bringing the total trend sites to ten. These ten sites within the River Raisin watershed were monitored once every five years from 2008 to 2018. Trends in macroinvertebrate scores were evaluated using linear mixed models (watershed-wide) as described in the SWAS Procedure 27 (MDEQ, 2015). No significant watershed-wide trend was evident from 2008 to 2018 in the River Raisin watershed (p = 0.192). Figure 25 and Table 5 compile the most recent individual biosurvey scores for these trend locations.

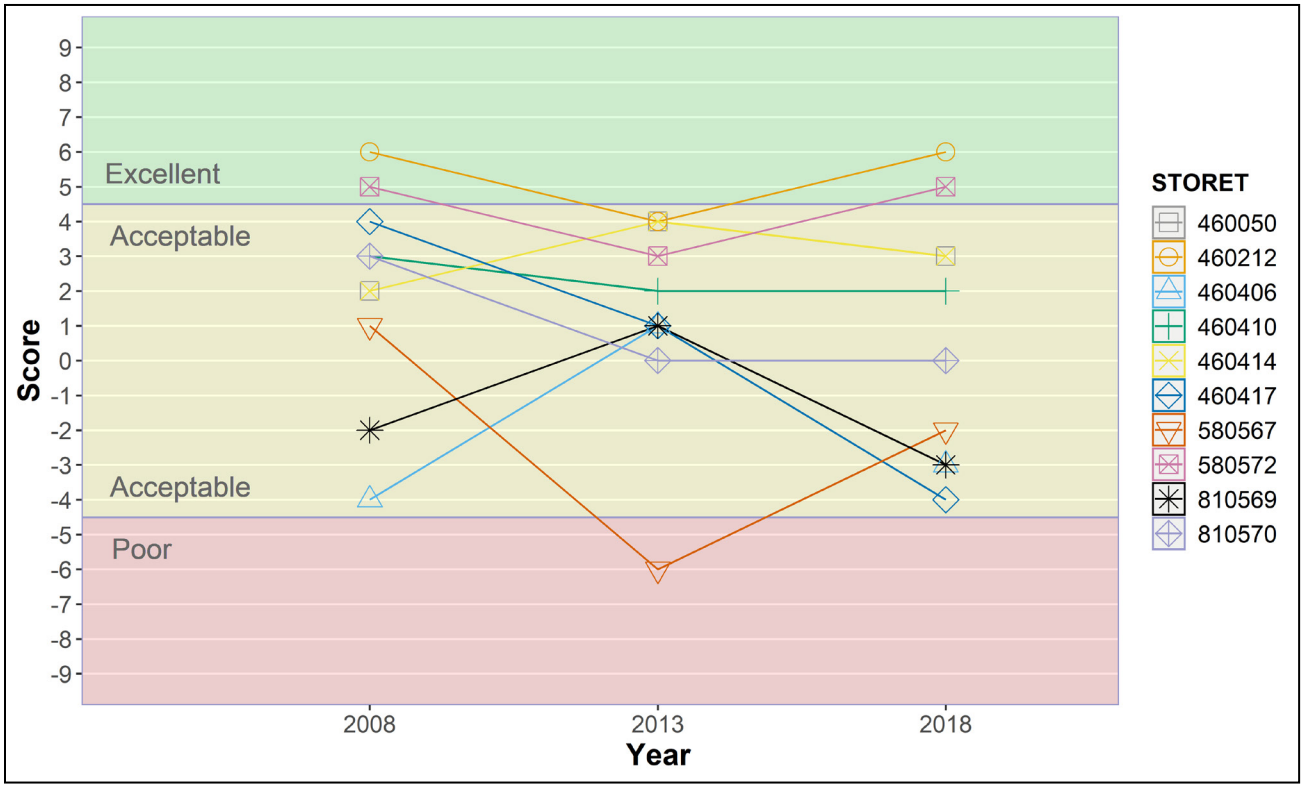

Figure 25. Trend sites and Procedure 51 macroinvertebrate scores for the River Raisin watershed.

At Station 34 (STORET #460417; Evans Creek at Wisner Highway), conditions found in the stream in 2018 (i.e., a near-stream manure pile and whitish bacterial or “sewage fungus” slimes) were not reported by biologists for earlier visits, which suggests that conditions may be deteriorating. Because this is a trend station, it will be likely be revisited in 2023. If, in 2023, conditions are similar to what they were in 2018, the situation could be investigated further (see also “Objective 4” below).

Objective 3: Address monitoring requests submitted by internal and external customers.

The following is a summary of monitoring done to address targeted monitoring requests submitted by external customers.

DO AND PHOSPHORUS CONCERNS

(Rice Lake Drain, Bear Creek, Hazen Creek, South Branch River Raisin, Fisk Drain, Black Creek, Wolf Creek)

(Targeted Monitoring Request Numbers: 2018322, 2018323, 2018324, 2018325, 2018326, 2018327)

In response to targeted monitoring requests from local citizens regarding DO, nutrient (e.g., phosphorus, nitrogen), and *E. coli* bacteria concerns, site visits (including reconnaissance-level sonde measurements) were made at 9 locations (Stations A through I) in the western portion of the River Raisin watershed in July and/or August 2018. (*E. coli* monitoring requests were outside the scope of this report.) Sonde measurements were made at all locations due to no additional incurred costs. Phosphorus samples were also collected at 2 locations on Wolf Creek, upstream and downstream of concerns about livestock having access to the stream.

Five of 9 stations where site visits occurred in July and/or August 2018 had instantaneous DO readings lower than 5 milligrams per liter (mg/L). See Appendix C for details.

- Two of these five stations do not appear to need follow-up DO monitoring (at least in the short term):

    - For Rice Lake Drain at Haley Road (Station I), given the very short stretch of channelized and/or man-made surface water channel and the stagnant water conditions, plus a thick cover of duckweed and black water and sediment underneath, it was not unexpected that the drain here had low DO concentrations (see Appendix C for more details).
    - Some sonde measurements were made by EGLE staff in July and August 2018 from a causeway (Station H at Stephenson Road) near what was essentially a transition area from a Wolf Creek delta, to a wetland type area, to a shallow embayment of Loch Erin (which is an impoundment of Wolf Creek). The causeway was essentially within a shallow margin of the lake bisected by a road, which appeared to be affecting water flow or circulation patterns. These physical features, combined with the fact that Loch Erin has recently been determined by EGLE, WRD, to be not supporting the OIALW designated use due to ongoing problems with elevated nutrients, excessive algal growth, and a hypereutrophic lake classification, provide insight into why DO concentrations were low at this location.

- It is not unusual for DO concentrations to be low in stagnant waters relative to flowing waters (Minnesota Pollution Control Agency [MPCA], 2009; USGS, 2018; EGLE, n.d.).

- The remaining 3 stations (South Branch River Raisin at West Cadmus Road [Station F]; Fisk Drain upstream of Knight Highway [Station D]; and Bear Creek at Medina Road [Station A]) may be worth revisiting, and rechecking early-morning, summertime DO concentrations in 2023 (the next time River Raisin biosurveys will occur). If future visits occur, they should make sure to include determination of whether the water body is flowing and to gather more detailed flow velocity and flow condition measurements and observations (e.g., using Procedure 51, if appropriate). If the South Branch River Raisin at West Cadmus Road (Station F) is to be revisited, it should be confirmed that the culvert blockage is no longer occurring.

Phosphorus samples collected at Stations G and H appeared to be somewhat elevated for total phosphorus; however, a clear pattern was not evident based upon a single set of samples: ortho phosphate concentration was slightly higher (0.015 mg/L) at the downstream station (H) than the upstream station (G) (0.011 mg/L); conversely, total phosphorus was slightly higher (0.065 mg/L) at the upstream station (G) than the downstream station (H) (0.063 mg/L).

PETROLEUM CONCERNS

(Beaver Creek, South Branch River Raisin, and Lake Adrian)

(Targeted Monitoring Request Numbers: 2018333, 2018334)

In response to externally submitted, targeted monitoring requests concerned about a variety of contaminants, including those from potential spills or leaks from nearby oil wells and pipelines in the region, water chemistry sampling and sonde measurements were made in 2018 at 4 locations in the South Branch River Raisin subwatershed. Sample parameters included:

- *Select* volatile organics (i.e., benzene, toluene, ethylbenzene, and xylenes [BTEX], methyltertiarybutylether [MTBE], and trimethylbenzene [TMB])
- Barium
- Strontium
- Chloride
- Calcium
- Magnesium

While this was neither an intensive sampling effort nor a conclusive study, no concentrations measured in this study (Table D-1 in Appendix D) were found to be above Michigan's WQS values or abnormally outside of the expected range of conditions described in Appendix D-supp. on the days they were sampled.

See Appendix D for details.

Objective 4: Identify NPS of water quality impairment.

One example of NPS pollution observed in the field was what appeared to be unrestricted access for cattle to Wolf Creek downstream of Springville Highway, between Stations G and H, in August 2018. Another example was a pile of manure observed next to Evans Creek at Wisner Highway (Station 34), which appeared to be reflected in the degraded macroinvertebrate community at that location. In both cases, staff in EGLE, Jackson District Office, were notified of the observed situations. The unrestricted cattle access issue was eventually referred by the district to the Michigan Department of Agriculture and Rural Development's Right to Farm Program for follow-up.

Additionally, a variety of land uses in the watershed (observable using geographic information systems, online mapping programs, and other technologies) were observed that have the potential to contribute NPS pollution to the River Raisin and its tributaries. The most notable of those land uses include, but are not limited to:

- Agricultural crop land.
- Animal feeding operations and concentrated animal feeding operations.
- Urban impervious surfaces (roadways, parking lots, rooftops, etc.) and automobiles.
- Residential and commercial lawns.
- Golf courses.

These types of land-uses commonly result in degraded stream or river ecosystems due to issues such as altered hydrological conditions; increased erosion, sedimentation, channelization, and loss of in-stream habitat integrity; loss of healthy and natural riparian vegetation zone conditions (which reduces shade, input of food for stream organisms [in the form of leaves and wood], and bank stability; and increased amounts of pollutant runoff (e.g., nutrients, pesticides, road salt, metals, PAHs, etc.) (Allan and Castillo, 2007; Carpenter et al., 2011; Capel et al., 2018; Stone et al., 2014).

SOME OTHER SOURCES OF WATER QUALITY DATA FOR THE RIVER RAISIN WATERSHED

There are other useful sources of water quality data or information in this watershed that are beyond the scope of this report. While not meant to be an exhaustive list, some additional sources of information include:

- *E. coli* bacteria (Michigan.gov/EGLEEcoli).
- Per- and poly-fluoroalkyl substances (PFAS) information (Michigan.gov/PFASResponse/).
- Lake Erie watershed nutrients / "Taking Action on Lake Erie" (Michigan.gov/LakeErieDomesticActionPlan).

- Water Quality Portal (WaterQualityData.US/).
- How's My Waterway (EPA.gov/WaterData/Hows-My-Waterway).

CONCLUSIONS AND FUTURE MONITORING RECOMMENDATIONS

A sizeable portion of the upper mainstem of the River Raisin (Stations 3-10) appears to be relatively intact – likely due to relatively wide riparian buffers and low amounts of disturbance adjacent to the river. Macroinvertebrate communities all rated excellent except for Station 3, which still rated high (+4, high acceptable).

While no stations rated poor for macroinvertebrate communities, a few stations rated -4 (low acceptable) and warrant being revisited at some point in the future:

- Station 21 – Saline River Gump Lake Road; downstream of the Milan WWTP.
- Station 23 – Little River Raisin at Sisson Highway.
- Station 34 – Evans Creek at Wisner Highway (trend site).

Evans Creek at Wisner Highway (Station 34) is a trend site and should be revisited to see if the manure pile is still adjacent to the stream. The Saline River at Gump Lake Road (Station 21) may need to be revisited to try to determine the source of the grey water smell.

Sites with DO values below 5.0 mg/L are recommended to have follow-up monitoring considered (see Objective 3 and Appendix C) where the site is a *flowing* stream or drain, keeping in mind issues such as human alterations to the waterway/channel, stream/drain size and possible intermittency, potential backwater or seiche effects, etc. can impact flow and DO levels.

While some sheen was observed in South Branch Macon Creek (Station 16) after biologists walked through the stream or agitated submerged tree roots by hand, there currently does not appear to be significant risk to the ecosystem based upon the limited water and sediment samples collected in August 2018, thus making this a relatively low priority on a statewide level at this time. However, if schedules and resources allow, staff might consider revisiting Station 16 again to look for potential sources of possible petroleum products or other contaminants.

There appears to be instability, flashiness, channel/bank instability, and a lack of sinuosity at most of the Macon Creek stations that were sampled (e.g., Stations 12, 13, 14, and to some extent, 11). It is not clear what is/are the primary cause(s) of these issues. There are many potential causes including, but not limited to, past channel modification and relocation activities plus recent/current agricultural drain management and/or flood control practices, storm water runoff issues (e.g., related to large roads such as US-23 or permitted facilities) and possible resulting channel enlargement, and NPS issues such as excessive runoff of eroded soils and sediments.

Watershed stakeholders and land owners are encouraged to consider collaborating with local conservation, watershed, and agricultural organizations to employ best management practices on agricultural, residential, and urban lands alongside, near, and within drains, streams, rivers, and other water bodies to help minimize NPS pollution inputs and habitat degradation. Sources of information on these practices and associated organizations include, but are not limited to:

- EGLE's Nonpoint Source Program.
- Michigan Agriculture Environmental Assurance Program.
- Michigan Conservation Districts.
- EGLE's NPS Information & Education Publications.
- Riparian Forest Buffers (USDA).

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Table 3. Habitat evaluation for selected stations in the Raisin River watershed, June-September 2018. Notes: Maximum score possible for individual metrics shown in parentheses. * Applies only to Riffle/Run stream Surveys. ** Applies only to Glide/Pool stream Surveys.

	STATION 1 River Raisin, off North Custer Road 7/31/2018	STATION 2 River Raisin, off Dixon Road 7/31/2018
HABITAT METRIC	**GLIDE/POOL**	**RIFFLE/RUN**
Substrate and Instream Cover		
Epifaunal Substrate/ Avail Cover (20)	10	16
Embeddedness (20)*		14
Velocity/Depth Regime (20)*		11
Pool Substrate Characterization (20)**	8	
Pool Variability (20)**	8	
Channel Morphology		
Sediment Deposition (20)	13	15
Flow Status - Maint. Flow Volume (10)	9	10
Flow Status - Flashiness (10)	5	7
Channel Alteration (20)	19	19
Frequency of Riffles/Bends (20)*		15
Channel Sinuosity (20)**	13	
Riparian and Bank Structure		
Bank Stability (L) (10)	8	7
Bank Stability (R) (10)	4	7
Vegetative Protection (L) (10)	6	7
Vegetative Protection (R) (10)	4	7
Riparian Vegetation Zone Width (L) (10)	8	4
Riparian Vegetation Zone Width (R) (10)	3	4
TOTAL SCORE (200):	118	143
HABITAT RATING:	**GOOD**	**GOOD**
Date:	7/31/2018	7/31/2018
Weather:	Cloudy	Rainy

	STATION 1 River Raisin, off North Custer Road 7/31/2018	STATION 2 River Raisin, off Dixon Road 7/31/2018
Air Temperature: ºF	73	70
Water Temperature: ºF	72	75
Ave. Stream Width: Feet	154	140
Ave. Stream Depth: Feet	2.5	1
Surface Velocity: Feet/Second	0.521	0.958
Estimated Flow: Cubic Feet/Second	150.884	160.620
Stream Modifications:	Bank Stabilization	None
Nuisance Plants (Y/N):	N	N
STORET No.:	580624	580572
County Code:	58	58
TRS:	06S08E21	06S08E19
Latitude (dd):	41.94214	41.9422263
Longitude (dd):	-83.49195	-83.5142336
Ecoregion:	HELP	HELP
Stream Type:	Warmwater	Warmwater
USGS Basin Code:	4100002	4100002

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Table 3 continued.

	STATION 3 River Raisin, North Wilmouth 7/26/2018	STATION 4 River Raisin, N Raisin Center Hwy 7/26/2018	STATION 5 River Raisin, E Russel Rd 7/27/2018	STATION 6 River Raisin, u/s M-50 (and Evans Creek / Globe Mill Pond outlet) 7/24/2018
	GLIDE/POOL	**GLIDE/POOL**	**RIFFLE/RUN**	**GLIDE/POOL**
HABITAT METRIC				
Substrate and Instream Cover				
Epifaunal Substrate/ Avail Cover (20)	14	13	14	12
Embeddedness (20)*			15	
Velocity/Depth Regime (20)*			15	
Pool Substrate Characterization (20)**	13	15		11
Pool Variability (20)**	15	14		14
Channel Morphology				
Sediment Deposition (20)	8	10	10	18
Flow Status - Maint. Flow Volume (10)	7	8	7	10
Flow Status - Flashiness (10)	3	7	5	7
Channel Alteration (20)	20	20	20	19
Frequency of Riffles/Bends (20)*			5	
Channel Sinuosity (20)**	14	10		19
Riparian and Bank Structure				
Bank Stability (L) (10)	7	8	6	8
Bank Stability (R) (10)	8	9	6	8
Vegetative Protection (L) (10)	7	9	7	9
Vegetative Protection (R) (10)	8	8	7	9
Riparian Vegetation Zone Width (L) (10)	9	10	10	10
Riparian Vegetation Zone Width (R) (10)	6	10	10	9
TOTAL SCORE (200):	139	151	137	163
HABITAT RATING:	**GOOD**	**GOOD**	**GOOD**	**EXCELLENT**
Date:	7/26/2018	7/26/2018	7/27/2018	7/24/2018
Weather:	Cloudy	Sunny	Partly Cloudy	cloudy
Air Temperature: ºF	70	75	78	

	STATION 3 River Raisin, North Wilmouth 7/26/2018	STATION 4 River Raisin, N Raisin Center Hwy 7/26/2018	STATION 5 River Raisin, E Russel Rd 7/27/2018	STATION 6 River Raisin, u/s M-50 (and Evans Creek / Globe Mill Pond outlet) 7/24/2018
Water Temperature: ºF	72	72	75	74
Ave. Stream Width: Feet	51	37	51	56.3
Ave. Stream Depth: Feet	1	2	1	2
Surface Velocity: Feet/Second	1.308	0.872	1.641	0.669
Estimated Flow: Cubic Feet/Second	79.456	51.814	99.826	62.051
Stream Modifications:	None	None	None	
Nuisance Plants (Y/N):	N	N	N	N
STORET No.:	460082	460244	460468	460212
County Code:	46	46	46	46
TRS:	06S04E20	06S04E22	06S04E03	05S04E34
Latitude (dd):	41.936392	41.943167	41.992222	42.0039855
Longitude (dd):	-83.96417	-83.944958	-83.930555	-83.9316555
Ecoregion:	ECBP	ECBP	ECBP	ECBP
Stream Type:	Warmwater	Warmwater	Warmwater	Warmwater
USGS Basin Code:	4100002	4100002	4100002	4100002

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Table 3 continued.

	STATION 7 River Raisin, Staib Rd 7/26/2018	STATION 8 River Raisin, Tate Park (W. Michigan Ave) 7/26/2018	STATION 9 River Raisin, Downstream of Wallace Road 9/4/2018
	GLIDE/POOL	**RIFFLE/RUN**	**RIFFLE/RUN**
HABITAT METRIC			
Substrate and Instream Cover			
Epifaunal Substrate/ Avail Cover (20)	16	17	11
Embeddedness (20)*		14	16
Velocity/Depth Regime (20)*		15	10
Pool Substrate Characterization (20)**	16		
Pool Variability (20)**	16		
Channel Morphology			
Sediment Deposition (20)	15	15	11
Flow Status - Maint. Flow Volume (10)	9	9	10
Flow Status - Flashiness (10)	8	2	5
Channel Alteration (20)	20	18	15
Frequency of Riffles/Bends (20)*		11	14
Channel Sinuosity (20)**	11		
Riparian and Bank Structure			
Bank Stability (L) (10)	8	2	6
Bank Stability (R) (10)	7	4	6
Vegetative Protection (L) (10)	8	4	8
Vegetative Protection (R) (10)	7	5	8
Riparian Vegetation Zone Width (L) (10)	10	6	4
Riparian Vegetation Zone Width (R) (10)	10	10	6
TOTAL SCORE (200):	161	132	130
HABITAT RATING:	**EXCELLENT**	**GOOD**	**GOOD**
Date:	7/26/2018	7/26/2018	9/4/2018
Weather:	Partly Cloudy	Cloudy	partly cloudy
Air Temperature: ºF	67	65	
Water Temperature: ºF	70	69	78

	STATION 7 River Raisin, Staib Rd 7/26/2018	STATION 8 River Raisin, Tate Park (W. Michigan Ave) 7/26/2018	STATION 9 River Raisin, Downstream of Wallace Road 9/4/2018
Ave. Stream Width: Feet	38	38	49.53333333
Ave. Stream Depth: Feet	1	1	1.78
Surface Velocity: Feet/Second	2.204	1.804	1.066
Estimated Flow: Cubic Feet/Second	114.863	77.541	93.949
Stream Modifications:	None	None	none
Nuisance Plants (Y/N):	N	N	N
STORET No.:	460325	460469	810620
County Code:	46	46	81
TRS:	05S04E17	05S04E05	04S04E20
Latitude (dd):	42.042504	42.067071	42.12121
Longitude (dd):	-83.966115	-83.977945	-83.98127
Ecoregion:	ECBP	ECBP	ECBP
Stream Type:	Warmwater	Warmwater	Warmwater
USGS Basin Code:	4100002	4100002	4100002

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Table 3 continued.

	STATION 10 River Raisin, Sharon Valley Rd 8/14/2018
	GLIDE/POOL
HABITAT METRIC	
Substrate and Instream Cover	
Epifaunal Substrate/ Avail Cover (20)	16
Embeddedness (20)*	
Velocity/Depth Regime (20)*	
Pool Substrate Characterization (20)**	13
Pool Variability (20)**	3
Channel Morphology	
Sediment Deposition (20)	16
Flow Status - Maint. Flow Volume (10)	10
Flow Status - Flashiness (10)	8
Channel Alteration (20)	16
Frequency of Riffles/Bends (20)*	
Channel Sinuosity (20)**	13
Riparian and Bank Structure	
Bank Stability (L) (10)	7
Bank Stability (R) (10)	9
Vegetative Protection (L) (10)	7
Vegetative Protection (R) (10)	9
Riparian Vegetation Zone Width (L) (10)	2
Riparian Vegetation Zone Width (R) (10)	10
TOTAL SCORE (200):	139
HABITAT RATING:	**GOOD**
Date:	8/14/2018
Weather:	partly cloudy
Air Temperature: ºF	
Water Temperature: ºF	74

	STATION 10 River Raisin, Sharon Valley Rd 8/14/2018
Ave. Stream Width: Feet	36.667
Ave. Stream Depth: Feet	1.107
Surface Velocity: Feet/Second	1.054
Estimated Flow: Cubic Feet/Second	42.779
Stream Modifications:	none
Nuisance Plants (Y/N):	N
STORET No.:	810098
County Code:	81
TRS:	03S03E33
Latitude (dd):	42.167781
Longitude (dd):	-84.075838
Ecoregion:	SMNITP
Stream Type:	Warmwater
USGS Basin Code:	4100002

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Table 3 continued.

	STATION 11 Macon Creek, downstream Stowell Road 7/27/2018	STATION 12 Macon Creek, Dundee-Azalia / Hatter Road 7/27/2018	STATION 13 Macon Creek, Wilcox Rd 8/1/2018
	GLIDE/POOL	**GLIDE/POOL**	**RIFFLE/RUN**
HABITAT METRIC			
Substrate and Instream Cover			
Epifaunal Substrate/ Avail Cover (20)	15	13	2
Embeddedness (20)*			10
Velocity/Depth Regime (20)*			11
Pool Substrate Characterization (20)**	12	12	
Pool Variability (20)**	14	13	
Channel Morphology			
Sediment Deposition (20)	14	10	5
Flow Status - Maint. Flow Volume (10)	10	8	6
Flow Status - Flashiness (10)	3	3	1
Channel Alteration (20)	15	13	16
Frequency of Riffles/Bends (20)*			9
Channel Sinuosity (20)**	11	4	
Riparian and Bank Structure			
Bank Stability (L) (10)	7	3	1
Bank Stability (R) (10)	8	3	1
Vegetative Protection (L) (10)	7	4	3
Vegetative Protection (R) (10)	7	4	3
Riparian Vegetation Zone Width (L) (10)	9	6	8
Riparian Vegetation Zone Width (R) (10)	8	6	8
TOTAL SCORE (200):	140	102	84
HABITAT RATING:	**GOOD**	**MARGINAL**	**MARGINAL**
Date:	7/27/2018	7/27/2018	8/1/2018
Weather:	Sunny	Cloudy	cloudy
Air Temperature: ºF	80	80	
Water Temperature: ºF	73	72	66

	STATION 11 Macon Creek, downstream Stowell Road 7/27/2018	STATION 12 Macon Creek, Dundee-Azalia / Hatter Road 7/27/2018	STATION 13 Macon Creek, Wilcox Rd 8/1/2018
Ave. Stream Width: Feet	32	22	20.567
Ave. Stream Depth: Feet	1	2	0.7
Surface Velocity: Feet/Second	0.477	0.271	0.277
Estimated Flow: Cubic Feet/Second	21.528	10.573	3.991
Stream Modifications:	Bank stabilization	Dredged	none
Nuisance Plants (Y/N):	N	N	N
STORET No.:	580420	580570	580424
County Code:	58	58	58
TRS:	06S06E01	06S06E01	06S06E02
Latitude (dd):	41.97861	41.9874508	41.98048
Longitude (dd):	-83.6275	-83.6555204	-83.68757
Ecoregion:	HELP	HELP	HELP
Stream Type:	Warmwater	Warmwater	Warmwater
USGS Basin Code:	4100002	4100002	4100002

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Table 3 continued.

	STATION 14 Macon Creek, Hiser Road 8/1/2018	STATION 15 Bear Swamp Creek, Dennison Road 7/30/2018
	GLIDE/POOL	**GLIDE/POOL**
HABITAT METRIC		
Substrate and Instream Cover		
Epifaunal Substrate/ Avail Cover (20)	5	6
Embeddedness (20)*		
Velocity/Depth Regime (20)*		
Pool Substrate Characterization (20)**	8	3
Pool Variability (20)**	2	1
Channel Morphology		
Sediment Deposition (20)	11	15
Flow Status - Maint. Flow Volume (10)	9	10
Flow Status - Flashiness (10)	1	7
Channel Alteration (20)	16	1
Frequency of Riffles/Bends (20)*		
Channel Sinuosity (20)**	6	1
Riparian and Bank Structure		
Bank Stability (L) (10)	2	4
Bank Stability (R) (10)	1	4
Vegetative Protection (L) (10)	3	3
Vegetative Protection (R) (10)	2	3
Riparian Vegetation Zone Width (L) (10)	3	0
Riparian Vegetation Zone Width (R) (10)	4	0
TOTAL SCORE (200):	73	58
HABITAT RATING:	**MARGINAL**	**MARGINAL**
Date:	8/1/2018	7/30/2018
Weather:	partly cloudy	cloudy
Air Temperature: ºF		
Water Temperature: ºF	68	71
Ave. Stream Width: Feet	17	3.6
Ave. Stream Depth: Feet	1	0.287

	STATION 14 Macon Creek, Hiser Road 8/1/2018	STATION 15 Bear Swamp Creek, Dennison Road 7/30/2018
Surface Velocity: Feet/Second	0.350	0.092
Estimated Flow: Cubic Feet/Second	6.070	0.095
Stream Modifications:	none	dredged,canopy removal
Nuisance Plants (Y/N):	N	N
STORET No.:	580625	580567
County Code:	58	58
TRS:	06S06E5	05S06E29
Latitude (dd):	41.98954	42.0240691
Longitude (dd):	-83.74171	-83.7335789
Ecoregion:	HELP	HELP
Stream Type:		Warmwater
USGS Basin Code:	4100002	4100002

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Table 3 continued.

	STATION 16 South Branch Macon Creek, Ridge Highway 8/1/2018	STATION 17 Koch Warner Drain, Warner Road 7/30/2018	STATION 18 Wood Outlet Drain, Downstream Maple Road 7/30/2018
	RIFFLE/RUN	**GLIDE/POOL**	**RIFFLE/RUN**
HABITAT METRIC			
Substrate and Instream Cover			
Epifaunal Substrate/ Avail Cover (20)	10	11	6
Embeddedness (20)*	7		16
Velocity/Depth Regime (20)*	14		8
Pool Substrate Characterization (20)**		12	
Pool Variability (20)**		2	
Channel Morphology			
Sediment Deposition (20)	9	16	18
Flow Status - Maint. Flow Volume (10)	10	10	8
Flow Status - Flashiness (10)	5	10	8
Channel Alteration (20)	15	15	15
Frequency of Riffles/Bends (20)*	11		5
Channel Sinuosity (20)**		12	
Riparian and Bank Structure			
Bank Stability (L) (10)	4	10	8
Bank Stability (R) (10)	4	10	8
Vegetative Protection (L) (10)	5	8	7
Vegetative Protection (R) (10)	5	8	7
Riparian Vegetation Zone Width (L) (10)	5	6	7
Riparian Vegetation Zone Width (R) (10)	5	5	7
TOTAL SCORE (200):	109	135	128
HABITAT RATING:	**GOOD**	**GOOD**	**GOOD**
Date:	8/1/2018	7/30/2018	7/30/2018
Weather:	partly cloudy	cloudy	
Air Temperature: ºF			

	STATION 16 South Branch Macon Creek, Ridge Highway 8/1/2018	STATION 17 Koch Warner Drain, Warner Road 7/30/2018	STATION 18 Wood Outlet Drain, Downstream Maple Road 7/30/2018
Water Temperature: ºF	67	65	64
Ave. Stream Width: Feet	9.967	3.833	9.333
Ave. Stream Depth: Feet	0.620	0.293	0.473
Surface Velocity: Feet/Second	0.496	0.664	0.161
Estimated Flow: Cubic Feet/Second	3.064	0.746	0.711
Stream Modifications:	bank stabilization		
Nuisance Plants (Y/N):	N	N	N
STORET No.:	460473	810570	810569
County Code:		81	81
TRS:	06S05E6	03S06E34	03S06E30
Latitude (dd):	41.97986	42.1757595	42.18866
Longitude (dd):	-83.87021	-83.7178876	-83.77338
Ecoregion:	ECBP	ECBP	ECBP
Stream Type:		Warmwater	Warmwater
USGS Basin Code:	4100002	4100002	4100002

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Table 3 continued.

	STATION 19 Saline River Curtiss Park Upstream Monroe St & Saline WWTP 7/2/2018	STATION 20 Saline River adjacent to Woodingham Ct 7/2/2018
	RIFFLE/RUN	**RIFFLE/RUN**
HABITAT METRIC		
Substrate and Instream Cover		
Epifaunal Substrate/ Avail Cover (20)	16	17
Embeddedness (20)*	16	18
Velocity/Depth Regime (20)*	14	19
Pool Substrate Characterization (20)**		
Pool Variability (20)**		
Channel Morphology		
Sediment Deposition (20)	12	15
Flow Status - Maint. Flow Volume (10)	8	9
Flow Status - Flashiness (10)	7	9
Channel Alteration (20)	20	20
Frequency of Riffles/Bends (20)*	19	19
Channel Sinuosity (20)**		
Riparian and Bank Structure		
Bank Stability (L) (10)	9	10
Bank Stability (R) (10)	9	10
Vegetative Protection (L) (10)	3	9
Vegetative Protection (R) (10)	9	9
Riparian Vegetation Zone Width (L) (10)	6	3
Riparian Vegetation Zone Width (R) (10)	8	8
TOTAL SCORE (200):	156	175
HABITAT RATING:	**EXCELLENT**	**EXCELLENT**
Date:	7/2/2018	7/2/2018
Weather:	Partly cloudy	Partly cloudy
Air Temperature: ºF	84	83

	STATION 19 Saline River Curtiss Park Upstream Monroe St & Saline WWTP 7/2/2018	STATION 20 Saline River adjacent to Woodingham Ct 7/2/2018
Water Temperature: ºF	79	78
Ave. Stream Width: Feet	43	34
Ave. Stream Depth: Feet	0.893	0.507
Surface Velocity: Feet/Second	2.027	2.359
Estimated Flow: Cubic Feet/Second	77.867	39.966
Stream Modifications:	None	None
Nuisance Plants (Y/N):	N	N
STORET No.:	810221	810341
County Code:	81	81
TRS:	04S05E01	04S05E01
Latitude (dd):	42.158611	42.158333
Longitude (dd):	-83.786666	-83.780833
Ecoregion:	ECBP	ECBP
Stream Type:	Warmwater	Warmwater
USGS Basin Code:	4100002	4100002

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Table 3 continued.

	STATION 21 Saline River, Gump Lake Rd d/s of Milan WWTP 7/2/2018	STATION 22 Little River Raisin, North County Line Highway 7/31/2018	STATION 23 Little River Raisin, Sisson Highway 6/13/2018
	GLIDE/POOL	GLIDE/POOL	GLIDE/POOL
HABITAT METRIC			
Substrate and Instream Cover			
Epifaunal Substrate/ Avail Cover (20)	6	1	6
Embeddedness (20)*			
Velocity/Depth Regime (20)*			
Pool Substrate Characterization (20)**	6	5	6
Pool Variability (20)**	12	0	0
Channel Morphology			
Sediment Deposition (20)	8	10	8
Flow Status - Maint. Flow Volume (10)	8	10	8
Flow Status - Flashiness (10)	2	5	2
Channel Alteration (20)	20	6	4
Frequency of Riffles/Bends (20)*			
Channel Sinuosity (20)**	6	0	2
Riparian and Bank Structure			
Bank Stability (L) (10)	3	6	9
Bank Stability (R) (10)	5	6	9
Vegetative Protection (L) (10)	8	5	7
Vegetative Protection (R) (10)	9	5	7
Riparian Vegetation Zone Width (L) (10)	10	2	1
Riparian Vegetation Zone Width (R) (10)	9	2	1
TOTAL SCORE (200):	112	63	70
HABITAT RATING:	**GOOD**	**MARGINAL**	**MARGINAL**
Date:	7/2/2018	7/31/2018	6/13/2018
Weather:	Partly cloudy	partly cloudy	Partly cloudy
Air Temperature: ºF	85		81
Water Temperature: ºF	79	68	75

	STATION 21 Saline River, Gump Lake Rd d/s of Milan WWTP 7/2/2018	STATION 22 Little River Raisin, North County Line Highway 7/31/2018	STATION 23 Little River Raisin, Sisson Highway 6/13/2018
Ave. Stream Width: Feet	49	9.267	9
Ave. Stream Depth: Feet	1	0.58	1.2
Surface Velocity: Feet/Second	0.682	0.026	0.418
Estimated Flow: Cubic Feet/Second	35.501	0.141	4.522
Stream Modifications:	None	dredged	Dredged
Nuisance Plants (Y/N):	N	N	N
STORET No.:	580426	460406	460472
County Code:	58	46	46
TRS:	05S06E02	07S05E36	07S05E4
Latitude (dd):	42.07732	41.9200515	41.89668
Longitude (dd):	-83.67695	-83.7704384	-83.8377
Ecoregion:	HELP	HELP	HELP
Stream Type:	Warmwater	Warmwater	Warmwater
USGS Basin Code:	4100002	4100002	4100002

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Table 3 continued.

	STATION 24 South Branch Raisin River, Howell Highway 7/25/2018	STATION 25 South Branch River Raisin, Island Park 7/27/2018	STATION 26 South Branch River Raisin, Sand Creek Highway 8/13/2018	STATION 27 South Branch River Raisin, Wheeler Highway 6/13/2018
	RIFFLE/RUN	**RIFFLE/RUN**	**GLIDE/POOL**	**RIFFLE/RUN**
HABITAT METRIC				
Substrate and Instream Cover				
Epifaunal Substrate/ Avail Cover (20)	13	15	11	6
Embeddedness (20)*	12	16		12
Velocity/Depth Regime (20)*	18	16		10
Pool Substrate Characterization (20)**			13	
Pool Variability (20)**			13	
Channel Morphology				
Sediment Deposition (20)	13	10	12	15
Flow Status - Maint. Flow Volume (10)	9	5	10	10
Flow Status - Flashiness (10)	6	2	6	7
Channel Alteration (20)	20	19	19	15
Frequency of Riffles/Bends (20)*	10	14		8
Channel Sinuosity (20)**			16	
Riparian and Bank Structure				
Bank Stability (L) (10)	7	5	8	8
Bank Stability (R) (10)	8	6	8	7
Vegetative Protection (L) (10)	4	6	8	8
Vegetative Protection (R) (10)	5	7	8	5
Riparian Vegetation Zone Width (L) (10)	10	5	10	8
Riparian Vegetation Zone Width (R) (10)	8	10	10	6
TOTAL SCORE (200):	143	136	152	125
HABITAT RATING:	**GOOD**	**GOOD**	**GOOD**	**GOOD**
Date:	7/25/2018	7/27/2018	8/13/2018	6/13/2018
Weather:	sunny	Sunny	sunny	cloudy
Air Temperature: ºF		80		
Water Temperature: ºF	74	73	70	67

	STATION 24 South Branch Raisin River, Howell Highway 7/25/2018	STATION 25 South Branch River Raisin, Island Park 7/27/2018	STATION 26 South Branch River Raisin, Sand Creek Highway 8/13/2018	STATION 27 South Branch River Raisin, Wheeler Highway 6/13/2018
Ave. Stream Width: Feet	48.3	43	19.267	12
Ave. Stream Depth: Feet	1.5	1	1.943	0.83
Surface Velocity: Feet/Second	1.256	1.363	0.580	0.702
Estimated Flow: Cubic Feet/Second	60.698	54.184	21.710	9.149
Stream Modifications:		Bank stabilization	none	none
Nuisance Plants (Y/N):	N	N	N	N
STORET No.:	460050	460467	460474	460471
County Code:	46	46		
TRS:	06S03E25	06S03E36	07S03E32	07S01E25
Latitude (dd):	41.917504	41.91225	41.82993	41.85014
Longitude (dd):	-84.010281	-84.023611	-84.10005	-84.2176
Ecoregion:	ECBP	ECBP	ECBP	ECBP
Stream Type:	Warmwater	Warmwater		
USGS Basin Code:	4100002	4100002	4100002	4100002

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Table 3 continued.

	STATION 28 Beaver Creek, Carson Highway 7/26/2018	STATION 29 Wolf Creek, Birnwick Drive 8/13/2018	STATION 30 Wolf Creek, Wolf Ck Hwy 8/14/2018	STATION 31 Wolf Creek, off Wolf Creek Highway 7/24/2018
	RIFFLE/RUN	**RIFFLE/RUN**	**RIFFLE/RUN**	**GLIDE/POOL**
HABITAT METRIC				
Substrate and Instream Cover				
Epifaunal Substrate/ Avail Cover (20)	15	6	11	10
Embeddedness (20)*	13	7	13	
Velocity/Depth Regime (20)*	14	13	14	
Pool Substrate Characterization (20)**				7
Pool Variability (20)**				5
Channel Morphology				
Sediment Deposition (20)	16	5	12	15
Flow Status - Maint. Flow Volume (10)	9	6	10	9
Flow Status - Flashiness (10)	7	5	7	5
Channel Alteration (20)	15	19	8	19
Frequency of Riffles/Bends (20)*	20	4	7	
Channel Sinuosity (20)**				19
Riparian and Bank Structure				
Bank Stability (L) (10)	8	5	9	7
Bank Stability (R) (10)	8	6	7	7
Vegetative Protection (L) (10)	5	8	1	5
Vegetative Protection (R) (10)	5	4	7	5
Riparian Vegetation Zone Width (L) (10)	2	4	1	10
Riparian Vegetation Zone Width (R) (10)	2	10	3	10
TOTAL SCORE (200):	139	102	110	133
HABITAT RATING:	**GOOD**	**MARGINAL**	**GOOD**	**GOOD**
Date:	7/26/2018	8/13/2018	8/14/2018	7/24/2018
Weather:	rainy	sunny	sunny	cloudy
Air Temperature: ºF				
Water Temperature: ºF	65	71	68	76

	STATION 28 Beaver Creek, Carson Highway 7/26/2018	STATION 29 Wolf Creek, Birnwick Drive 8/13/2018	STATION 30 Wolf Creek, Wolf Ck Hwy 8/14/2018	STATION 31 Wolf Creek, off Wolf Creek Highway 7/24/2018
Ave. Stream Width: Feet	17	30.333	21.167	16
Ave. Stream Depth: Feet	1.5	1.273	1.354	0.5
Surface Velocity: Feet/Second	0.382	0.590	0.251	0.137
Estimated Flow: Cubic Feet/Second	3.201	22.779	7.198	1.510
Stream Modifications:	canopy removal	bank stabilization	bank stabilization, canopy removal	none
Nuisance Plants (Y/N):	N	N	N	N
STORET No.:	460414	460412	460334	460410
County Code:	46	46	46	46
TRS:	06S03E26	06S03E27	06S03E28	06S03E07
Latitude (dd):	41.9222682	41.9185234	41.91306	41.96087
Longitude (dd):	-84.0322785	-84.0595125	-84.07927	-84.11412
Ecoregion:	ECBP	ECBP	ECBP	ECBP
Stream Type:	Warmwater	Warmwater		Warmwater
USGS Basin Code:	4100002	4100002	4100002	4100002

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Table 3 continued.

	STATION 32 Wolf Creek Town Line Rd 7/25/2018	STATION 33 Wolf Creek Gilbert Hwy 7/26/2018	STATION 34 Evans Creek Wisner Road 7/24/2018
	RIFFLE/RUN	**GLIDE/POOL**	**RIFFLE/RUN**
HABITAT METRIC			
Substrate and Instream Cover			
Epifaunal Substrate/ Avail Cover (20)	11	12	6
Embeddedness (20)*	10		11
Velocity/Depth Regime (20)*	14		12
Pool Substrate Characterization (20)**		8	
Pool Variability (20)**		4	
Channel Morphology			
Sediment Deposition (20)	12	11	9
Flow Status - Maint. Flow Volume (10)	9	5	7
Flow Status - Flashiness (10)	6	6	4
Channel Alteration (20)	19	18	8
Frequency of Riffles/Bends (20)*	11		13
Channel Sinuosity (20)**		10	
Riparian and Bank Structure			
Bank Stability (L) (10)	7	7	7
Bank Stability (R) (10)	7	8	7
Vegetative Protection (L) (10)	7	7	5
Vegetative Protection (R) (10)	7	6	5
Riparian Vegetation Zone Width (L) (10)	10	2	4
Riparian Vegetation Zone Width (R) (10)	10	7	4
TOTAL SCORE (200):	140	111	102
HABITAT RATING:	**GOOD**	**GOOD**	**MARGINAL**
Date:	7/25/2018	7/26/2018	7/24/2018
Weather:	sunny	Sunny	cloudy
Air Temperature: ºF		85	70
Water Temperature: ºF	69	69	72
Ave. Stream Width: Feet	11	14	6.5
Ave. Stream Depth: Feet	1	0	0.15

	STATION 32 Wolf Creek Town Line Rd 7/25/2018	STATION 33 Wolf Creek Gilbert Hwy 7/26/2018	STATION 34 Evans Creek Wisner Road 7/24/2018
Surface Velocity: Feet/Second	0.590	1.468	0.639
Estimated Flow: Cubic Feet/Second	2.609	7.594	0.815
Stream Modifications:	none	Canopy removal	dredged, canopy removal
Nuisance Plants (Y/N):	N	N	N
STORET No.:	460359	460470	460417
County Code:	46	46	46
TRS:	06S02E01	05S02E36	05S03E22
Latitude (dd):	41.97517	41.998611	42.0233974
Longitude (dd):	-84.13081	-84.150555	-84.0451684
Ecoregion:	ECBP	ECBP	ECBP
Stream Type:	Warmwater	Warmwater	Warmwater
USGS Basin Code:	4100002	4100002	4100002

Note: Individual metrics may better describe conditions directly affecting the biological community while the Habitat Rating describes the general riverine environment at the site(s).

Table 4. Qualitative macroinvertebrate sampling results and metric evaluation for selected stations in the Raisin River watershed, June-September 2018.

TAXA	STATION 1 River Raisin, off North Custer Road 7/31/2018	STATION 2 River Raisin, Off Dixon Road 7/31/2018
PORIFERA (sponges)		1
PLATYHELMINTHES (flatworms)		
Turbellaria		4
ANNELIDA (segmented worms)		
Oligochaeta (worms)		1
ARTHROPODA		
Crustacea		
Amphipoda (scuds)	26	12
Decapoda (crayfish)	4	2
Isopoda (sowbugs)		1
Arachnoidea		
Hydracarina	2	
Insecta		
Ephemeroptera (mayflies)		
Baetidae	13	69
Caenidae	11	16
Ephemerellidae	3	24
Heptageniidae	46	59
Isonychiidae		5
Polymitarcyidae	13	3
Tricorythidae	96	23
Odonata		
Anisoptera (dragonflies)		
Libellulidae	1	
Zygoptera (damselflies)		
Calopterygidae	1	2
Coenagrionidae	47	1
Hemiptera (true bugs)		
Corixidae	13	6
Gerridae	4	1

TAXA	STATION 1 River Raisin, off North Custer Road 7/31/2018	STATION 2 River Raisin, Off Dixon Road 7/31/2018
Mesoveliidae		2
Nepidae	7	
Veliidae	1	2
Neuroptera (spongilla flies)		
Sisyridae		1
Trichoptera (caddisflies)		
Helicopsychidae		3
Hydropsychidae	11	28
Hydroptilidae		2
Leptoceridae	2	
Molannidae		1
Philopotamidae		2
Polycentropodidae	9	
Lepidoptera (moths)		
Pyralidae		4
Coleoptera (beetles)		
Dytiscidae (total)		1
Haliplidae (adults)	2	1
Hydrophilidae (total)	1	2
Psephenidae (adults)	1	
Elmidae	42	40
Psephenidae (larvae)		2
Diptera (flies)		
Ceratopogonidae	1	2
Chironomidae	42	34
Simuliidae		4
Tabanidae	1	
MOLLUSCA		
Gastropoda (snails)		
Physidae	3	1
Viviparidae		5
Pelecypoda (bivalves)		
Corbiculidae		1

TAXA	STATION 1 River Raisin, off North Custer Road 7/31/2018	STATION 2 River Raisin, Off Dixon Road 7/31/2018
Pisidiidae	2	20
Unionidae (mussels)	1	1
TOTAL INDIVIDUALS	**406**	**389**

	STATION 1 River Raisin off North Custer Road 7/31/2018		STATION 2 River Raisin Off Dixon Road 7/31/2018	
METRIC	**Value**	**Score**	**Value**	**Score**
TOTAL NUMBER OF TAXA	29	0	39	1
NUMBER OF MAYFLY TAXA	6	1	7	1
NUMBER OF CADDISFLY TAXA	3	0	5	1
NUMBER OF STONEFLY TAXA	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	44.83	1	51.16	1
PERCENT CADDISFLY COMPOSITION	5.42	0	9.25	0
PERCENT DOMINANT TAXON	23.65	-1	17.74	0
PERCENT ISOPOD, SNAIL, LEECH	0.74	1	1.80	1
PERCENT SURFACE AIR BREATHERS	7.14	1	3.86	1
TOTAL SCORE		**2**		**5**
MACROINVERTEBRATE COMMUNITY RATING	**Acceptable**		**Excellent**	

Table 4 continued.

TAXA	STATION 3 River Raisin, North Wilmouth 7/26/2018	STATION 4 River Raisin, N Raisin Center Hwy 7/26/2018	STATION 5 River Raisin, E Russel Rd 7/27/2018	STATION 6 River Raisin, u/s M-50 (& Evans Creek / Globe Mill Pond outlet) 7/24/2018
ANNELIDA (segmented worms)				
Oligochaeta (worms)			3	1
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	41	23	10	39
Decapoda (crayfish)	1	2	1	4
Isopoda (sowbugs)	3			
Arachnoidea				
Hydracarina				3
Insecta				
Ephemeroptera (mayflies)				
Baetidae	43	30	19	12
Caenidae				1
Ephemerellidae				19
Heptageniidae	28	23	12	17
Isonychiidae			1	1
Polymitarcyidae				1
Tricorythidae	23	63	81	1
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1	1		
Gomphidae		1	1	5
Libellulidae				9
Macromiidae			1	
Zygoptera (damselflies)				
Calopterygidae	1	1	1	1
Coenagrionidae				2
Plecoptera (stoneflies)				
Perlidae		1		
Hemiptera (true bugs)				

TAXA	STATION 3 River Raisin, North Wilmouth 7/26/2018	STATION 4 River Raisin, N Raisin Center Hwy 7/26/2018	STATION 5 River Raisin, E Russel Rd 7/27/2018	STATION 6 River Raisin, u/s M-50 (& Evans Creek / Globe Mill Pond outlet) 7/24/2018
Corixidae	1	3	1	7
Gerridae	1	1	1	3
Mesoveliidae				2
Nepidae		3		1
Trichoptera (caddisflies)				
Brachycentridae	12	38		1
Hydropsychidae	52	25	61	32
Leptoceridae		19		6
Limnephilidae	1			
Philopotamidae		2	4	
Phryganeidae				1
Polycentropodidae			2	14
Coleoptera (beetles)				
Dytiscidae (total)		1		
Gyrinidae (adults)				2
Haliplidae (adults)				1
Elmidae	12	15	22	20
Gyrinidae (larvae)				2
Diptera (flies)				
Athericidae			2	
Chironomidae	19	8	34	33
Dixidae			3	
Simuliidae	2	1	4	
Tabanidae				4
Tipulidae			4	
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)			3	
Physidae	1			
Pelecypoda (bivalves)				
Pisidiidae			3	2

TAXA	STATION 3 River Raisin, North Wilmouth 7/26/2018	STATION 4 River Raisin, N Raisin Center Hwy 7/26/2018	STATION 5 River Raisin, E Russel Rd 7/27/2018	STATION 6 River Raisin, u/s M-50 (& Evans Creek / Globe Mill Pond outlet) 7/24/2018
TOTAL INDIVIDUALS	**242**	**261**	**274**	**247**

	STATION 3 River Raisin North Wilmouth 7/26/2018		STATION 4 River Raisin N Raisin Center Hwy 7/26/2018		STATION 5 River Raisin E Russel Rd 7/27/2018		STATION 6 River Raisin u/s M-50 (& Evans Creek / Globe Mill Pond outlet) 7/24/2018	
METRIC	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
TOTAL NUMBER OF TAXA	17	0	20	1	23	1	30	1
NUMBER OF MAYFLY TAXA	3	0	3	0	4	1	7	1
NUMBER OF CADDISFLY TAXA	3	0	4	1	3	0	5	1
NUMBER OF STONEFLY TAXA	0	-1	1	1	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	38.84	1	44.44	1	41.24	1	21.05	1
PERCENT CADDISFLY COMPOSITION	26.86	1	32.18	1	24.45	1	21.86	0
PERCENT DOMINANT TAXON	21.49	1	24.14	1	29.56	1	15.79	1
PERCENT ISOPOD, SNAIL, LEECH	1.65	1	0.00	1	1.09	1	0.00	1
PERCENT SURFACE AIR BREATHERS	0.83	1	3.07	1	0.73	1	6.48	1
TOTAL SCORE		**4**		**8**		**6**		**6**
MACROINVERTEBRATE COMMUNITY RATING	**Acceptable**		**Excellent**		**Excellent**		**Excellent**	

Table 4 continued.

	STATION 7 River Raisin Staib Rd 7/26/2018	STATION 8 River Raisin Tate Park (W. Michigan Ave) 7/26/2018	STATION 9 River Raisin Downstream of Wallace Road 9/4/2018
TAXA			
ANNELIDA (segmented worms)			
Hirudinea (leeches)		1	
Oligochaeta (worms)		1	8
ARTHROPODA			
Crustacea			
Amphipoda (scuds)	19	12	24
Decapoda (crayfish)	3	5	3
Isopoda (sowbugs)	1	5	
Arachnoidea			
Hydracarina	2		1
Insecta			
Ephemeroptera (mayflies)			
Baetiscidae			3
Baetidae	36	10	14
Caenidae		1	3
Ephemerellidae			1
Ephemeridae			3
Heptageniidae	25	26	12
Isonychiidae	7	3	5
Polymitarcyidae	1		
Tricorythidae	6	6	2
Odonata			
Anisoptera (dragonflies)			
Gomphidae	1		
Zygoptera (damselflies)			
Calopterygidae		2	9
Coenagrionidae		1	8
Plecoptera (stoneflies)			
Perlidae	1		1
Hemiptera (true bugs)			

	STATION 7 River Raisin Staib Rd 7/26/2018	STATION 8 River Raisin Tate Park (W. Michigan Ave) 7/26/2018	STATION 9 River Raisin Downstream of Wallace Road 9/4/2018
Belostomatidae	1		1
Corixidae	1		20
Gerridae	1		1
Naucoridae			1
Nepidae	1		
Veliidae	1	1	
Megaloptera			
Corydalidae (dobson flies)			1
Trichoptera (caddisflies)			
Brachycentridae	40	15	2
Helicopsychidae			1
Hydropsychidae	50	51	25
Leptoceridae	13	7	5
Limnephilidae	2		1
Philopotamidae	1	2	17
Phryganeidae			4
Polycentropodidae		15	
Uenoidae			1
Coleoptera (beetles)			
Dytiscidae (total)		1	
Gyrinidae (adults)	1	2	
Elmidae	15	31	20
Gyrinidae (larvae)		3	
Psephenidae (larvae)			3
Diptera (flies)			
Ceratopogonidae			1
Chironomidae	22	32	50
Simuliidae	3	2	9
Tabanidae			6
Tipulidae		2	
MOLLUSCA			
Gastropoda (snails)			

	STATION 7 River Raisin Staib Rd 7/26/2018	STATION 8 River Raisin Tate Park (W. Michigan Ave) 7/26/2018	STATION 9 River Raisin Downstream of Wallace Road 9/4/2018
Ancylidae (limpets)		1	5
Hydrobiidae			1
Physidae	3		
Viviparidae			1
Pelecypoda (bivalves)			
Corbiculidae			1
Pisidiidae		1	1
TOTAL INDIVIDUALS	**257**	**239**	**275**

	STATION 7 River Raisin Staib Rd 7/26/2018		STATION 8 River Raisin Tate Park (W. Michigan Ave) 7/26/2018		STATION 9 River Raisin Downstream of Wallace Road 9/4/2018	
METRIC	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
TOTAL NUMBER OF TAXA	26	1	26	1	39	1
NUMBER OF MAYFLY TAXA	5	1	5	1	8	1
NUMBER OF CADDISFLY TAXA	5	1	5	1	8	1
NUMBER OF STONEFLY TAXA	1	1	0	-1	1	1
PERCENT MAYFLY COMPOSITION	29.18	1	19.25	1	15.64	1
PERCENT CADDISFLY COMPOSITION	41.25	1	37.66	1	20.36	0
PERCENT DOMINANT TAXON	19.46	1	21.34	1	18.18	1
PERCENT ISOPOD, SNAIL, LEECH	1.56	1	2.93	1	2.55	1
PERCENT SURFACE AIR BREATHERS	2.33	1	1.67	1	8.36	1
TOTAL SCORE		**9**		**7**		**8**
MACROINVERTEBRATE COMMUNITY RATING	**Excellent**		**Excellent**		**Excellent**	

Table 4 continued.

TAXA	STATION 10 River Raisin Sharon Valley Rd 8/14/2018
PLATYHELMINTHES (flatworms)	
Turbellaria	1
ANNELIDA (segmented worms)	
Oligochaeta (worms)	3
ARTHROPODA	
Crustacea	
Amphipoda (scuds)	25
Decapoda (crayfish)	1
Isopoda (sowbugs)	3
Arachnoidea	
Hydracarina	3
Insecta	
Ephemeroptera (mayflies)	
Baetidae	9
Caenidae	3
Ephemeridae	2
Heptageniidae	19
Isonychiidae	1
Odonata	
Anisoptera (dragonflies)	
Gomphidae	5
Zygoptera (damselflies)	
Calopterygidae	5
Coenagrionidae	3
Plecoptera (stoneflies)	
Perlidae	4
Hemiptera (true bugs)	
Corixidae	2
Gerridae	1
Nepidae	3
Notonectidae	1

TAXA	STATION 10 River Raisin Sharon Valley Rd 8/14/2018
Pleidae	1
Veliidae	2
Megaloptera	
Sialidae (alder flies)	4
Trichoptera (caddisflies)	
Brachycentridae	13
Helicopsychidae	5
Hydropsychidae	1
Leptoceridae	6
Limnephilidae	2
Polycentropodidae	3
Coleoptera (beetles)	
Elmidae	34
Gyrinidae (larvae)	1
Psephenidae (larvae)	8
Diptera (flies)	
Chironomidae	14
Culicidae	6
MOLLUSCA	
Gastropoda (snails)	
Ancylidae (limpets)	10
Bithyniidae	45
Pelecypoda (bivalves)	
Pisidiidae	1
TOTAL INDIVIDUALS	**250**

	STATION 10 River Raisin Sharon Valley Rd 8/14/2018	
METRIC	**Value**	**Score**
TOTAL NUMBER OF TAXA	36	1
NUMBER OF MAYFLY TAXA	5	1
NUMBER OF CADDISFLY TAXA	6	1
NUMBER OF STONEFLY TAXA	1	1
PERCENT MAYFLY COMPOSITION	13.60	0
PERCENT CADDISFLY COMPOSITION	12.00	0
PERCENT DOMINANT TAXON	18.00	1
PERCENT ISOPOD, SNAIL, LEECH	23.20	-1
PERCENT SURFACE AIR BREATHERS	6.40	1
TOTAL SCORE		**5**
MACROINVERTEBRATE COMMUNITY RATING	**Excellent**	

Table 4 continued.

TAXA	STATION 11 Macon Creek downstream Stowell Road 7/27/2018	STATION 12 Macon Creek Dundee-Azalia / Hatter Road 7/27/2018	STATION 13 Macon Creek Wilcox Rd 8/1/2018
PLATYHELMINTHES (flatworms)			
Turbellaria			1
ANNELIDA (segmented worms)			
Hirudinea (leeches)			1
Oligochaeta (worms)	4	3	13
ARTHROPODA			
Crustacea			
Decapoda (crayfish)	4	2	15
Arachnoidea			
Hydracarina	2	6	9
Insecta			
Ephemeroptera (mayflies)			
Baetidae		4	7
Caenidae	20	9	13
Ephemeridae	2		
Heptageniidae	16	3	30
Tricorythidae	1	1	
Odonata			
Anisoptera (dragonflies)			
Aeshnidae	1	1	2
Gomphidae		2	
Zygoptera (damselflies)			
Calopterygidae	9	18	2
Coenagrionidae	64	55	
Hemiptera (true bugs)			
Corixidae	23	117	99
Gerridae	21	1	10
Mesoveliidae			4
Pleidae			1
Veliidae			1

TAXA	STATION 11 Macon Creek downstream Stowell Road 7/27/2018	STATION 12 Macon Creek Dundee-Azalia / Hatter Road 7/27/2018	STATION 13 Macon Creek Wilcox Rd 8/1/2018
Megaloptera			
Sialidae (alder flies)	3		
Trichoptera (caddisflies)			
Hydropsychidae	2	6	21
Hydroptilidae	1		
Leptoceridae		1	
Molannidae			1
Phryganeidae			1
Coleoptera (beetles)			
Elmidae	42	21	35
Scirtidae (larvae)			1
Diptera (flies)			
Ceratopogonidae			1
Chironomidae	10	17	48
Culicidae			1
Tabanidae	2		7
MOLLUSCA			
Gastropoda (snails)			
Ancylidae (limpets)	12	3	12
Pelecypoda (bivalves)			
Pisidiidae	15	3	4
Unionidae (mussels)		1	
TOTAL INDIVIDUALS	**254**	**274**	**340**

	STATION 11 Macon Creek downstream Stowell Road 7/27/2018		STATION 12 Macon Creek Dundee-Azalia / Hatter Road 7/27/2018		STATION 13 Macon Creek Wilcox Rd 8/1/2018	
METRIC	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
TOTAL NUMBER OF TAXA	20	0	20	0	26	0
NUMBER OF MAYFLY TAXA	4	1	4	1	3	1
NUMBER OF CADDISFLY TAXA	2	0	2	0	3	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	15.35	0	6.20	-1	14.71	-1
PERCENT CADDISFLY COMPOSITION	1.18	-1	2.55	-1	6.76	0
PERCENT DOMINANT TAXON	25.20	-1	42.70	-1	29.12	-1
PERCENT ISOPOD, SNAIL, LEECH	4.72	1	1.09	1	3.82	1
PERCENT SURFACE AIR BREATHERS	17.32	0	43.07	-1	34.12	-1
TOTAL SCORE		**-1**		**-3**		**-2**
MACROINVERTEBRATE COMMUNITY RATING	**Acceptable**		**Acceptable**		**Acceptable**	

Table 4 continued.

TAXA	STATION 14 Macon Creek Hiser Road 8/1/2018	STATION 15 Bear Swamp Creek Dennison Road 7/30/2018
ANNELIDA (segmented worms)		
Hirudinea (leeches)	1	1
Oligochaeta (worms)	7	7
ARTHROPODA		
Crustacea		
Decapoda (crayfish)	8	40
Arachnoidea		
Hydracarina	8	
Insecta		
Ephemeroptera (mayflies)		
Baetidae	14	
Caenidae	81	4
Heptageniidae	18	
Odonata		
Anisoptera (dragonflies)		
Aeshnidae	1	2
Zygoptera (damselflies)		
Calopterygidae	1	
Coenagrionidae	4	5
Hemiptera (true bugs)		
Belostomatidae		1
Corixidae	30	27
Gerridae	3	
Nepidae		1
Veliidae	1	
Trichoptera (caddisflies)		
Limnephilidae	1	
Molannidae	1	
Phryganeidae	11	
Coleoptera (beetles)		

TAXA	STATION 14 Macon Creek Hiser Road 8/1/2018	STATION 15 Bear Swamp Creek Dennison Road 7/30/2018
Scirtidae (adults)		1
Elmidae	43	1
Scirtidae (larvae)	1	
Diptera (flies)		
Ceratopogonidae	1	
Chironomidae	72	41
Culicidae	6	
Tabanidae	2	
Tipulidae		1
MOLLUSCA		
Gastropoda (snails)		
Ancylidae (limpets)	5	2
Lymnaeidae	1	1
Physidae	5	1
Pelecypoda (bivalves)		
Pisidiidae	9	39
TOTAL INDIVIDUALS	**335**	**175**

	STATION 14 Macon Creek Hiser Road 8/1/2018		STATION 15 Bear Swamp Creek Dennison Road 7/30/2018	
METRIC	**Value**	**Score**	**Value**	**Score**
TOTAL NUMBER OF TAXA	26	0	17	1
NUMBER OF MAYFLY TAXA	3	1	1	1
NUMBER OF CADDISFLY TAXA	3	0	0	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	33.73	1	2.29	-1
PERCENT CADDISFLY COMPOSITION	3.88	0	0.00	-1
PERCENT DOMINANT TAXON	24.18	-1	23.43	-1
PERCENT ISOPOD, SNAIL, LEECH	3.58	1	2.86	1
PERCENT SURFACE AIR BREATHERS	11.94	0	17.14	0
TOTAL SCORE		**1**		**-2**
MACROINVERTEBRATE COMMUNITY RATING	**Acceptable**		**Acceptable**	

Table 4 continued.

TAXA	STATION 16 South Branch Macon Creek Ridge Highway 8/1/2018	STATION 17 Koch Warner Drain Warner Road 7/30/2018	STATION 18 Wood Outlet Drain downstream Maple Road 7/30/2018
PLATYHELMINTHES (flatworms)			
Turbellaria	1		
ANNELIDA (segmented worms)			
Hirudinea (leeches)		9	8
Oligochaeta (worms)	7	7	22
ARTHROPODA			
Crustacea			
Amphipoda (scuds)			5
Decapoda (crayfish)	1	5	18
Arachnoidea			
Hydracarina	13	3	
Insecta			
Ephemeroptera (mayflies)			
Baetidae	32		
Heptageniidae	16		
Odonata			
Anisoptera (dragonflies)			
Aeshnidae	4	2	1
Gomphidae	1		
Libellulidae		1	1
Zygoptera (damselflies)			
Calopterygidae	6	8	3
Coenagrionidae			1
Hemiptera (true bugs)			
Corixidae	1		37
Gerridae	1		5
Mesoveliidae	2		3
Notonectidae			5
Pleidae			1
Megaloptera			

TAXA	STATION 16 South Branch Macon Creek Ridge Highway 8/1/2018	STATION 17 Koch Warner Drain Warner Road 7/30/2018	STATION 18 Wood Outlet Drain downstream Maple Road 7/30/2018
Sialidae (alder flies)			11
Trichoptera (caddisflies)			
Hydropsychidae	93	19	1
Limnephilidae	1		
Molannidae		4	
Philopotamidae	1		
Phryganeidae	2	9	
Coleoptera (beetles)			
Dytiscidae (total)			1
Haliplidae (adults)			1
Hydrophilidae (total)		2	1
Elmidae	58		12
Diptera (flies)			
Ceratopogonidae	5		
Chironomidae	27	132	51
Culicidae	1		2
Ephydridae			1
Simuliidae	3		
Tabanidae	7	1	1
Tipulidae	1	1	
MOLLUSCA			
Gastropoda (snails)			
Ancylidae (limpets)	4		2
Lymnaeidae		1	
Physidae	8	1	39
Planorbidae		1	5
Pelecypoda (bivalves)			
Pisidiidae	4	47	21
Unionidae (mussels)			1
TOTAL INDIVIDUALS	**300**	**253**	**260**

	STATION 16 South Branch Macon Creek Ridge Highway 8/1/2018		STATION 17 Koch Warner Drain Warner Road 7/30/2018		STATION 18 Wood Outlet Drain downstream Maple Road 7/30/2018	
METRIC	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
TOTAL NUMBER OF TAXA	26	1	18	1	28	1
NUMBER OF MAYFLY TAXA	2	0	0	-1	0	-1
NUMBER OF CADDISFLY TAXA	4	1	3	1	1	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	16.00	1	0.00	-1	0.00	-1
PERCENT CADDISFLY COMPOSITION	32.33	1	12.65	0	0.38	-1
PERCENT DOMINANT TAXON	31.00	1	52.17	0	19.62	1
PERCENT ISOPOD, SNAIL, LEECH	4.00	0	4.74	0	20.77	-1
PERCENT SURFACE AIR BREATHERS	1.67	1	0.79	1	21.54	0
TOTAL SCORE		**5**		**0**		**-3**
MACROINVERTEBRATE COMMUNITY RATING	**Excellent**		**Acceptable**		**Acceptable**	

Table 4 continued.

TAXA	STATION 19 Saline River Curtiss Park Upstream Monroe St & Saline WWTP 7/2/2018	STATION 20 Saline River adjacent to Woodingham Ct 7/2/2018
PLATYHELMINTHES (flatworms)		
Turbellaria		2
ANNELIDA (segmented worms)		
Hirudinea (leeches)	4	1
Oligochaeta (worms)		1
ARTHROPODA		
Crustacea		
Amphipoda (scuds)	1	3
Decapoda (crayfish)	1	2
Isopoda (sowbugs)		14
Arachnoidea		
Hydracarina	6	4
Insecta		
Ephemeroptera (mayflies)		
Baetidae		17
Caenidae	2	1
Heptageniidae	5	1
Odonata		
Zygoptera (damselflies)		
Calopterygidae	5	3
Hemiptera (true bugs)		
Gerridae	5	8
Veliidae	1	
Trichoptera (caddisflies)		
Glossosomatidae		1
Hydropsychidae	15	28
Coleoptera (beetles)		
Elmidae	16	32
Diptera (flies)		
Athericidae	5	2

TAXA	STATION 19 Saline River Curtiss Park Upstream Monroe St & Saline WWTP 7/2/2018	STATION 20 Saline River adjacent to Woodingham Ct 7/2/2018
Chironomidae	53	80
Empididae		2
Simuliidae	171	478
Tipulidae	1	1
MOLLUSCA		
Gastropoda (snails)		
Ancylidae (limpets)		1
Pelecypoda (bivalves)		
Pisidiidae	1	1
TOTAL INDIVIDUALS	**292**	**683**

	STATION 19 Saline River Curtiss Park Upstream Monroe St & Saline WWTP 7/2/2018		STATION 20 Saline River adjacent to Woodingham Ct 7/2/2018	
METRIC	**Value**	**Score**	**Value**	**Score**
TOTAL NUMBER OF TAXA	16	0	22	1
NUMBER OF MAYFLY TAXA	2	0	3	0
NUMBER OF CADDISFLY TAXA	1	-1	2	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	2.40	0	2.78	0
PERCENT CADDISFLY COMPOSITION	5.14	0	4.25	0
PERCENT DOMINANT TAXON	58.56	0	69.99	0
PERCENT ISOPOD, SNAIL, LEECH	1.37	1	2.34	1
PERCENT SURFACE AIR BREATHERS	2.05	1	1.17	1
TOTAL SCORE		**0**		**2**
MACROINVERTEBRATE COMMUNITY RATING	**Acceptable**		**Acceptable**	

Table 4 continued.

TAXA	STATION 21 Saline River Gump Lake Rd d/s of Milan WWTP 7/2/2018	STATION 22 Little River Raisin North County Line Highway 7/31/2018	STATION 23 Little River Raisin Sisson Highway 6/13/2018
ANNELIDA (segmented worms)			
Hirudinea (leeches)		17	1
Oligochaeta (worms)		235	13
ARTHROPODA			
Crustacea			
Amphipoda (scuds)	13	1	122
Decapoda (crayfish)	13	1	3
Isopoda (sowbugs)	9		
Arachnoidea			
Hydracarina	1	6	1
Insecta			
Ephemeroptera (mayflies)			
Baetidae	2		1
Caenidae	11	1	8
Ephemerellidae	2		
Odonata			
Anisoptera (dragonflies)			
Aeshnidae		1	1
Zygoptera (damselflies)			
Coenagrionidae	2	2	
Lestidae			1
Hemiptera (true bugs)			
Belostomatidae		3	
Corixidae	16	2	3
Gerridae	2		
Mesoveliidae		1	
Nepidae		1	
Notonectidae		1	
Pleidae		1	
Megaloptera			

TAXA	STATION 21 Saline River Gump Lake Rd d/s of Milan WWTP 7/2/2018	STATION 22 Little River Raisin North County Line Highway 7/31/2018	STATION 23 Little River Raisin Sisson Highway 6/13/2018
Sialidae (alder flies)	1		
Trichoptera (caddisflies)			
Hydropsychidae	14		
Odontoceridae	5		
Lepidoptera (moths)			
Pyralidae			1
Coleoptera (beetles)			
Dytiscidae (total)		1	
Haliplidae (adults)		5	
Elmidae	16		
Diptera (flies)			
Chironomidae	35	12	52
Culicidae		1	
Simuliidae	3		7
MOLLUSCA			
Gastropoda (snails)			
Ancylidae (limpets)			2
Lymnaeidae		1	8
Physidae			55
Planorbidae		1	
Viviparidae		13	1
Pelecypoda (bivalves)			
Pisidiidae		14	
TOTAL INDIVIDUALS	**145**	**321**	**280**

	STATION 21 Saline River Gump Lake Rd d/s of Milan WWTP 7/2/2018		STATION 22 Little River Raisin North County Line Highway 7/31/2018		STATION 23 Little River Raisin Sisson Highway 6/13/2018	
METRIC	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
TOTAL NUMBER OF TAXA	16	-1	22	1	17	0
NUMBER OF MAYFLY TAXA	3	0	1	0	2	1
NUMBER OF CADDISFLY TAXA	2	0	0	-1	0	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	10.34	-1	0.31	-1	3.21	-1
PERCENT CADDISFLY COMPOSITION	13.10	0	0.00	-1	0.00	-1
PERCENT DOMINANT TAXON	24.14	-1	73.21	-1	43.57	-1
PERCENT ISOPOD, SNAIL, LEECH	6.21	0	9.97	0	23.93	-1
PERCENT SURFACE AIR BREATHERS	12.41	0	4.98	1	1.07	1
TOTAL SCORE		**-4**		**-3**		**-4**
MACROINVERTEBRATE COMMUNITY RATING	**Acceptable**		**Acceptable**		**Acceptable**	

Table 4 continued.

TAXA	STATION 24 South Branch Raisin River Howell Highway 7/25/2018	STATION 25 South Branch River Raisin Island Park 7/27/2018	STATION 26 South Branch River Raisin Sand Creek Highway 8/13/2018	STATION 27 South Branch River Raisin Wheeler Highway 6/13/2018
ANNELIDA (segmented worms)				
Oligochaeta (worms)	1	2	10	2
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	60	129	23	1
Decapoda (crayfish)		1	1	7
Isopoda (sowbugs)	2	8		1
Arachnoidea				
Hydracarina	12	1		14
Insecta				
Ephemeroptera (mayflies)				
Baetidae	15	11	13	
Caenidae	2	1	1	
Ephemerellidae	1			
Heptageniidae	2	6	27	
Tricorythidae		10		
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1	1	3	
Cordulegastridae				1
Libellulidae	1			2
Zygoptera (damselflies)				
Calopterygidae	1	1	6	
Coenagrionidae		1		
Hemiptera (true bugs)				
Corixidae	3	3	17	4
Gerridae	3	1	1	1
Mesoveliidae	1	1		
Nepidae	1			

TAXA	STATION 24 South Branch Raisin River Howell Highway 7/25/2018	STATION 25 South Branch River Raisin Island Park 7/27/2018	STATION 26 South Branch River Raisin Sand Creek Highway 8/13/2018	STATION 27 South Branch River Raisin Wheeler Highway 6/13/2018
Veliidae		6	1	
Trichoptera (caddisflies)				
Hydropsychidae	63	7	22	
Leptoceridae			6	
Polycentropodidae		1		
Coleoptera (beetles)				
Dytiscidae (total)				1
Haliplidae (adults)				1
Hydrophilidae (total)	2		1	1
Dryopidae			4	1
Elmidae	18	23	54	
Scirtidae (larvae)	1			
Diptera (flies)				
Athericidae		3		
Ceratopogonidae				67
Chironomidae	90	43	14	97
Simuliidae	3	31	10	1
Tabanidae	2		5	1
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)	1	3		
Physidae	1			50
Pelecypoda (bivalves)				
Pisidiidae	1		1	2
Unionidae (mussels)	1			
TOTAL INDIVIDUALS	**289**	**294**	**220**	**255**

	STATION 24 South Branch Raisin River Howell Highway 7/25/2018		STATION 25 South Branch River Raisin Island Park 7/27/2018		STATION 26 South Branch River Raisin Sand Creek Highway 8/13/2018		STATION 27 South Branch River Raisin Wheeler Highway 6/13/2018	
METRIC	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
TOTAL NUMBER OF TAXA	26	1	23	1	20	1	19	1
NUMBER OF MAYFLY TAXA	4	1	4	1	3	0	0	-1
NUMBER OF CADDISFLY TAXA	1	-1	2	0	2	0	0	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	6.92	0	9.52	0	18.64	1	0.00	-1
PERCENT CADDISFLY COMPOSITION	21.80	0	2.72	0	12.73	0	0.00	-1
PERCENT DOMINANT TAXON	31.14	1	43.88	0	24.55	1	38.04	1
PERCENT ISOPOD, SNAIL, LEECH	1.38	1	3.74	0	0.00	1	20.00	-1
PERCENT SURFACE AIR BREATHERS	3.46	1	3.74	1	9.09	1	3.14	1
TOTAL SCORE		**3**		**2**		**4**		**-3**
MACROINVERTEBRATE COMMUNITY RATING	**Acceptable**		**Acceptable**		**Acceptable**		**Acceptable**	

Table 4 continued.

TAXA	STATION 28 Beaver Creek Carson Highway 7/26/2018	STATION 29 Wolf Creek Birnwick Drive 8/13/2018	STATION 30 Wolf Creek Wolf Ck Hwy 8/14/2018	STATION 31 Wolf Creek Off Wolf Creek Highway 7/24/2018
PLATYHELMINTHES (flatworms)				
Turbellaria	1			2
ANNELIDA (segmented worms)				
Oligochaeta (worms)	1	7	3	48
ARTHROPODA				
Crustacea				
Amphipoda (scuds)	8	119	53	92
Decapoda (crayfish)	3	1	1	3
Isopoda (sowbugs)		2	1	
Arachnoidea				
Hydracarina	31	3	1	1
Insecta				
Ephemeroptera (mayflies)				
Baetidae	9	9	4	5
Heptageniidae	4	11	37	7
Odonata				
Anisoptera (dragonflies)				
Aeshnidae	1			
Zygoptera (damselflies)				
Calopterygidae	2	2	2	1
Hemiptera (true bugs)				
Belostomatidae		1		
Corixidae	1	42	43	7
Gerridae			2	1
Mesoveliidae	6		2	3
Nepidae	1		1	
Pleidae	2		1	
Veliidae			2	2
Megaloptera				
Sialidae (alder flies)		1		1

TAXA	STATION 28 Beaver Creek Carson Highway 7/26/2018	STATION 29 Wolf Creek Birnwick Drive 8/13/2018	STATION 30 Wolf Creek Wolf Ck Hwy 8/14/2018	STATION 31 Wolf Creek Off Wolf Creek Highway 7/24/2018
Trichoptera (caddisflies)				
Hydropsychidae	146	6	66	43
Hydroptilidae	4		2	
Leptoceridae	3	1	1	
Limnephilidae			1	
Polycentropodidae			5	
Coleoptera (beetles)				
Hydrophilidae (total)	1			
Elmidae	37	15	27	21
Psephenidae (larvae)			1	
Diptera (flies)				
Athericidae		1		
Chironomidae	18	24	15	24
Culicidae	1		1	
Dixidae	2			
Simuliidae	15	3	1	
Tabanidae	4	1		5
Tipulidae	6	1		1
MOLLUSCA				
Gastropoda (snails)				
Ancylidae (limpets)		21	1	
Physidae	4	10		
Pleuroceridae			1	
Pelecypoda (bivalves)				
Pisidiidae		3	3	1
TOTAL INDIVIDUALS	**311**	**284**	**278**	**268**

	STATION 28 Beaver Creek Carson Highway 7/26/2018		STATION 29 Wolf Creek Birnwick Drive 8/13/2018		STATION 30 Wolf Creek Wolf Ck Hwy 8/14/2018		STATION 31 Wolf Creek off Wolf Creek Highway 7/24/2018	
METRIC	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
TOTAL NUMBER OF TAXA	25	1	22	1	27	1	19	1
NUMBER OF MAYFLY TAXA	2	0	2	0	2	0	2	0
NUMBER OF CADDISFLY TAXA	3	0	2	0	5	1	1	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	4.18	0	7.04	0	14.75	1	4.48	0
PERCENT CADDISFLY COMPOSITION	49.20	1	2.46	0	26.98	1	16.04	0
PERCENT DOMINANT TAXON	46.95	0	41.90	0	23.74	1	34.33	1
PERCENT ISOPOD, SNAIL, LEECH	1.29	1	11.62	0	1.08	1	0.00	1
PERCENT SURFACE AIR BREATHERS	3.86	1	15.14	0	18.71	0	4.85	1
TOTAL SCORE		**3**		**0**		**5**		**2**
MACROINVERTEBRATE COMMUNITY RATING	**Acceptable**		**Acceptable**		**Excellent**		**Acceptable**	

Table 4 continued.

TAXA	STATION 32 Wolf Creek Town Line Rd 7/25/2018	STATION 33 Wolf Creek Gilbert Hwy 7/26/2018	STATION 34 Evans Creek Wisner Road 7/24/2018
PLATYHELMINTHES (flatworms)			
Turbellaria		11	6
ANNELIDA (segmented worms)			
Hirudinea (leeches)		1	
Oligochaeta (worms)	12	3	121
ARTHROPODA			
Crustacea			
Amphipoda (scuds)	194	171	
Decapoda (crayfish)	1	1	
Isopoda (sowbugs)			1
Arachnoidea			
Hydracarina	4	1	
Insecta			
Ephemeroptera (mayflies)			
Baetidae	32		
Caenidae		1	
Heptageniidae	2		
Odonata			
Anisoptera (dragonflies)			
Aeshnidae	1		
Zygoptera (damselflies)			
Calopterygidae	3	2	
Coenagrionidae	1	1	1
Hemiptera (true bugs)			
Corixidae	20		
Gerridae	3	1	1
Mesoveliidae	1		3
Nepidae	1		
Notonectidae	1		2
Pleidae	1	1	
Veliidae	6		

TAXA	STATION 32 Wolf Creek Town Line Rd 7/25/2018	STATION 33 Wolf Creek Gilbert Hwy 7/26/2018	STATION 34 Evans Creek Wisner Road 7/24/2018
Megaloptera			
Sialidae (alder flies)	2	1	
Trichoptera (caddisflies)			
Hydropsychidae	57	15	
Leptoceridae		1	
Coleoptera (beetles)			
Dytiscidae (total)			1
Elmidae	11	7	
Scirtidae (larvae)			1
Diptera (flies)			
Ceratopogonidae	1		
Chironomidae	34	23	385
Culicidae	4		2
Simuliidae		27	
Tabanidae	6		
MOLLUSCA			
Gastropoda (snails)			
Physidae	1	4	40
Planorbidae			1
Pelecypoda (bivalves)			
Pisidiidae			1
TOTAL INDIVIDUALS	**399**	**272**	**566**

	STATION 32 Wolf Creek Town Line Rd 7/25/2018		STATION 33 Wolf Creek Gilbert Hwy 7/26/2018		STATION 34 Evans Creek Wisner Road 7/24/2018	
METRIC	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
TOTAL NUMBER OF TAXA	24	1	18	0	14	0
NUMBER OF MAYFLY TAXA	2	0	1	-1	0	-1
NUMBER OF CADDISFLY TAXA	1	-1	2	0	0	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1
PERCENT MAYFLY COMPOSITION	8.52	0	0.37	-1	0.00	-1
PERCENT CADDISFLY COMPOSITION	14.29	0	5.88	0	0.00	-1
PERCENT DOMINANT TAXON	48.62	0	62.87	0	68.02	0
PERCENT ISOPOD, SNAIL, LEECH	0.25	1	1.84	1	7.42	0
PERCENT SURFACE AIR BREATHERS	9.27	1	0.74	1	1.59	1
TOTAL SCORE		**1**		**-1**		**-4**
MACROINVERTEBRATE COMMUNITY RATING		**Acceptable**		**Acceptable**		**Acceptable**

Table 5. Summary of aquatic habitat and macroinvertebrate community evaluations for trend stations in the River Raisin watersheds between 2008 and 2018.

Date	2018 Station #	Stream Name	Road Crossing	STORET #	Habitat Evaluation Rating	Habitat Evaluation Score	Macroinvertebrate Evaluation Rating	Macroinvertebrate Evaluation Score**	Site Type
7/31/2018	2	River Raisin	off Dixon Rd	580572	Good	143	Excellent	5	Trend
8/15/2013		River Raisin	off Dixon Rd	580572	Excellent	158	Acceptable	3	
8/13/2008		River Raisin	off Dixon Rd	580572	Excellent	164	Excellent	5	
7/24/2018	6	River Raisin	M-50	460212	Excellent	163	Excellent	6	Trend
8/14/2013		River Raisin	M-50	460212	Good	146	Acceptable	4	
7/23/2008		River Raisin	M-50	460212	Good	145	Excellent	6	
7/30/2018	15	Bear Swamp Creek	Dennison Rd	580567	Marginal	58	Acceptable	-2	Trend
8/15/2013		Bear Swamp Creek	Dennison Rd	580567	Poor	27	Poor	-6	
7/24/2008		Bear Swamp Creek	Dennison Rd	580567	Marginal	61	Acceptable	1	
7/30/2018	17	Koch-Warner Drain	Warner Rd	810570	Good	135	Acceptable	0	Trend
8/20/2013		Koch-Warner Drain	Warner Rd	810570	Marginal	89	Acceptable	0	
7/24/2008		Koch-Warner Drain	Warner Rd	810570	Marginal	79	Acceptable	3	
7/30/2018	18	Wood Outlet Drain	d/s of Maple Rd	810569	Good	128	Acceptable	-3	Trend
8/20/2013		Wood Outlet Drain	d/s of Maple Rd	810569	Good	120	Acceptable	1	
7/24/2008		Wood Outlet Drain	d/s of Maple Rd	810569	Marginal	62	Acceptable	-2	
7/31/2018	22	Little River Raisin	N County Line Rd	460406	Marginal	63	Acceptable	-3	Trend
8/14/2013		Little River Raisin	N County Line Rd	460406	Marginal	57	Acceptable	1	
7/29/2008		Little River Raisin	N County Line Rd	460406	Poor	47	Acceptable	-4	
7/25/2018	24	South Branch River Raisin	Howell Hwy	460050	Good	143	Acceptable	3	Trend
8/13/2013		South Branch River Raisin	Howell Hwy	460050	Good	149	Acceptable	4	
7/25/2008		South Branch River Raisin	Howell Hwy	460050	Good	113	Acceptable	2	

Date	2018 Sta-tion #	Stream Name	Road Crossing	STO-RET #	Habitat Evaluation Rating	Habitat Eval-uation Score	Macro-invertebrate Evaluation Rating	Macro-invertebrate Evaluation Score**	Site Type
7/26/2018	28	Beaver Creek	Carson Hwy	460414	Good	139	Acceptable	3	Trend
8/12/2013		Beaver Creek	Carson Hwy	460414	Good	135	Acceptable	4	
7/22/2008		Beaver Creek	Carson Hwy	460414	Good	132	Acceptable	2	
7/24/2018	31	Wolf Creek	off Wolf Creek Hwy	460410	Good	133	Acceptable	2	Trend
8/13/2013		Wolf Creek	off Wolf Creek Hwy	460410	Marginal	93	Acceptable	2	
7/22/2008		Wolf Creek	off Wolf Creek Hwy	460410	Good	115	Acceptable	3	
7/24/2018	34	Evans Creek	Wisner Hwy	460417	Marginal	102	Acceptable	-4	Trend
8/13/2013		Evans Creek	Wisner Hwy	460417	Good	106	Acceptable	1	
7/23/2008		Evans Creek	Wisner Hwy	460417	Good	116	Acceptable	4	

APPENDICES

FOR BIOLOGICAL, WATER CHEMISTRY, AND SEDIMENT CHEMISTRY SURVEYS OF SELECTED STATIONS IN THE RIVER RAISIN WATERSHED IN LENAWEE, MONROE, AND WASHTENAW COUNTIES, MICHIGAN JUNE-SEPTEMBER 2018

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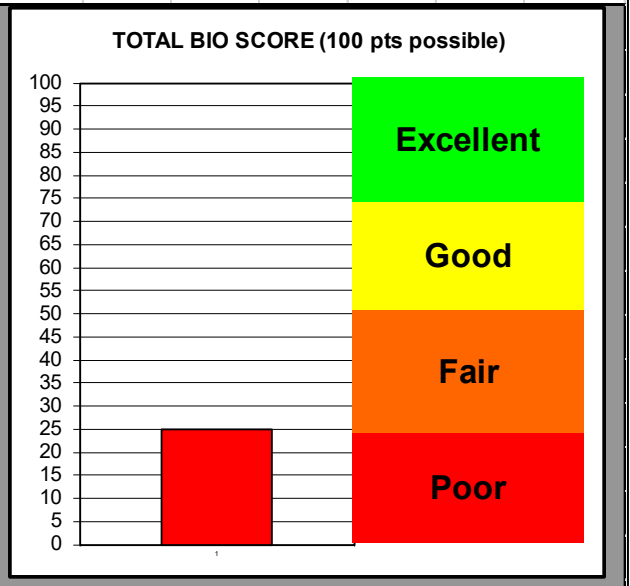
APPENDIX A. Nonwadeable Procedure 22 (MDEQ, 2013) -- Results for the River Raisin Watershed, August 24, 2018.

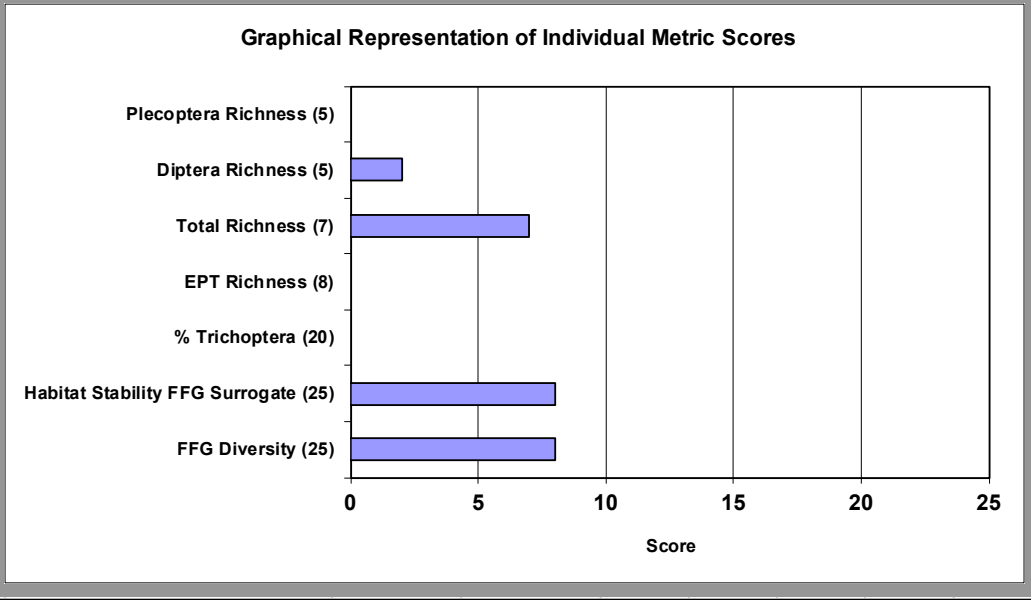
RIVER:	River Raisin		STATION NUMBER:	US-23, Dundee	DATE:	8/24/2018

Attribute	Data Sheet Box #	Value
Total Abundance	1	749
Total Richness	2	28
Number of Ephemeroptera Families	3	2
Number of Plecoptera Families	4	0
Number of Trichoptera Families	5	0
Number of Diptera Taxa	6	2
Trichoptera Abundance	7	0
Abundance of Dominant Taxon	8	475
Shredder Abundance	9	37
Scraper Abundance	10	75
Coll-Filterer Abundance	11	6
Coll-Gath Abundance	12	581
Predator Abundance	13	50

Metric Calculations	Value	Metric Score
FFG Diversity (25)	1.147506982	8
Habitat Stability FFG Surrogate (25)	0.131067961	8
% Trichoptera (20)	0	0
EPT Richness (8)	2	0
Total Richness (7)	28	7
Diptera Richness (5)	2	2
Plecoptera Richness (5)	0	0
% Dominance (5)	63.41789052	0
	Total Score=	25



FFG Diversity Workbook	0.21436133
Numbers calculated automatically	0.33244358
based on FFG abundance above.	0.055785256
	0.284238197
	0.260678619
FFG Diversity =	1.147506982



APPENDIX B. Water and Sediment Chemistry Sampling Related to Oil Sheens in South Branch Macon Creek.

A biosurvey was done at Station 16 (South Branch Macon Creek, upstream of Ridge Highway) on August 1, 2018. Towards the end of the biosurvey effort, occasional oil sheens were seen on the water surface after walking through the stream. Moving up the stream, a possible source (i.e., a black sediment area) was located (Figure B-1). Oil sheens appeared to be coming from this area.

A follow-up visit was made to Station 16 on August 14, 2018, to collect water and sediment samples in the vicinity of where the previously observed sheens were believed to have originated (i.e., near latitude/longitude coordinates 41.98048, -83.870318, approximately 350 feet upstream of Ridge Highway). Disturbance of sediments in the area created some sheen on the surface of the water. Further, disturbing submerged tree roots by hand, created an even greater amount of sheen on the water surface (Figure B-2).

Results from the August 14, 2018, water chemistry and sediment chemistry sampling at this location are presented in Table B-1. Below are lists of what was not and was detected.

Lab analyses did not detect any of the following:

- Volatile organics such as benzene, toluene, ethylbenzene, xylenes (BTEX); methyl tert-butyl ether (MTBE); or trimethylbenzene (TMB).
- Gas Range Organics (GRO).
- Specific semi-volatile organic compounds (SVOC)[1] such as specific Base/Neutral and Acid (BNA) extractable organic analytes or Polycyclic Aromatic Hydrocarbons (PAH).
- Polychlorinated biphenyls (PCB) as Aroclors.

[1] SVOC can be classified into two subcategories of compounds known as Base/Neutral and Acid (BNA) extractable compounds. SVOCs are placed into certain BNA categories based upon how they are extracted: bases and neutrals are extracted using a chemical with a pH > 7, whereas acids are extracted using a chemical having a pH < 7. Phenolic compounds make up the Acid extractables, while PAHs (also known as polynuclear aromatics [PNA]) are a subset of the Base/Neutral compounds (United States Environmental Protection Agency [USEPA], 1984; USEPA, 2016d; Michigan Department of Environment, Great Lakes, and Energy [EGLE], 2019; Austin, 2020; Paragon Laboratories; Eurofins). PAHs are a class of chemicals that occur in coal, crude oil, and gasoline, as well as near forest fires and volcanoes. They also are produced when coal, oil, gas, wood, garbage [e.g., used tires, polypropylene, or polystyrene], and tobacco are burned (often incomplete combustion) and by motor vehicle exhaust (Agency for Toxic Substances and Disease Registry [ATSDR], 2009; Centers for Disease Control and Prevention, 2017).

Figure B-1. Black sediment/substrate color can be seen on left bottom quadrant of the bottom photo (see arrows) at Station 16 (South Branch Macon Creek, upstream of Ridge Highway) on August 1, 2018, though there are also tree shadows in the middle and top parts of the photo.

Figure B-2. Sheens observed after disturbing tree roots at Station 16 (South Branch Macon Creek, upstream of Ridge Highway) on August 14, 2018.

Lab analyses did detect:

- "Probable petroleum product(s) present" in the water sample (see qualifier/note "Y17" in Table B-1); however, no specific SVOCs (e.g., certain kinds of PAHs or BNAs).
- Diesel Range Organics[2] (DRO) in both the water and sediment samples.
- Oil Range Organics[3] (ORO) in both the water and sediment samples.
- Some metals (barium, chromium, copper, iron, lead, nickel, and zinc) in the water chemistry sample.
- Arsenic, barium, chromium, copper, iron, lead, nickel, and zinc in the sediment chemistry sample.

At this location, only one set of water chemistry samples was collected in 2018. (To truly assess water quality standards [WQS], at least 4 water samples need to be collected within a 1-year period.) Also, a water hardness sample was not collected on August 14, 2018. Because of the lack of a hardness sample, actual WQS values for metals at that site and date cannot be computed for water chemistry samples; they can only be approximated. For estimation purposes, the "lowest known" (most conservative) hardness value[4] observed in available local United States Geological Survey (USGS) or EGLE data at nearby South Branch Macon Creek or Macon Creek (i.e., 246 milligrams per liter [mg/L])[5] was used to approximate whether any metal WQS might have been exceeded (using Rule 57 equations [version February 1, 2020]). No measurements from the August 14 sample exceeded applicable WQS values (Table B-1).

A follow-up site visit on October 4, 2019, found no sheens at the South Branch Macon Creek upstream of Ridge Highway (Station 16). Also, on the same date, visits were made to multiple upstream locations near road crossings, and sheens were not observed at those locations either. Water levels (above bankfull height), flow velocity levels, and turbidity appeared relatively high that day, which likely reduced the probability of observing sheens that may have ordinarily been observed if sediment contaminants were present.

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[2] DRO results may also include non-diesel organic compounds (according to the laboratory).

[3] ORO results may also include non-oil organic compounds (according to the laboratory).

[4] The lowest available, known hardness value was used to approximate the worst-case hardness value expected to likely occur at Station 16 since waters with low hardness generally offer a lower protective effect against metal toxicity than waters with high hardness (Gillis et al., 2008; Pyle and Couture, 2011; North Carolina Department of Environment and Natural Resources, 2015).

[5] Local hardness data including: (a) EGLE's Water Chemistry Monitoring Program (WCMP), STORET #580542 Macon Creek at Far Road, years 2005-2015, range 246-370 mg/L; (b) EGLE's STORET #580076, S Br Macon Creek at Wilcox Road, August 27, 2003 data point, 318 mg/L; (c) USGS gage 04176240 on S Br Macon Creek, year 1970, range 340-360 mg/L; (d) USGS gage 04176262 on Macon Creek, years 1970-1991, range 280-360 mg/L.

Table B-1. Water and sediment chemistry data from South Branch Macon Creek upstream of Ridge Highway (Lenawee County) (Station 16), sampling date: August 14, 2018. Hardness was estimated (see report text for more information). WQS = water quality standard. Green cell color and double dagger symbol (‡) indicates that applicable WQS values were not exceeded (however only based upon 1 sample*). "Sed" = sediment results. Trip blank (TB) for sediment volatile organics was prepared on August 9, 2018, by the laboratory. All samples were received by the laboratory on August 15, 2018. Laboratory ID #s and client ID #s (respectively) for samples were as follows: 1808212-01 and "S BRANCH MACON CR - SBM18-01" (water sample); 1808213-01 and "SBM18-01" (sediment sample); and 1808213-02 and "S Br Macon Cr SBM18-01 TB" (trip blank for volatile organics in sediment sample).

General Method/Parameter	Analyte	Units (water results)	RL (water results)	S Br Macon Creek u/s Ridge Hwy (water results)	Qual-ifier (water results)	FCV* (WQS) (water results)	AMV* (WQS) (water results)		Units (sed results)	RL (sed results)	S Br Macon Creek u/s Ridge Hwy (sed results)	Qual-ifier (sed results)	(TB) S Br Macon Creek u/s Ridge Hwy (sed results)	Qual-ifier (sed results)
Organics-Volatiles	Methyltertiarybutylether	µg/L	0.95	ND		--	--		ug/kg	110	ND		ND	
Organics-Volatiles	Benzene	µg/L	0.9	ND		--	--		ug/kg	110	ND		ND	
Organics-Volatiles	Toluene	µg/L	0.95	ND		--	--		ug/kg	110	ND		ND	
Organics-Volatiles	Ethylbenzene	µg/L	0.95	ND		--	--		ug/kg	110	ND		ND	
Organics-Volatiles	m & p - Xylene	µg/L	1.8	ND		--	--		ug/kg	200	ND		ND	
Organics-Volatiles	o-Xylene	µg/L	0.95	ND		--	--		ug/kg	110	ND		ND	
Organics-Volatiles	1,3,5-Trimethylbenzene	µg/L	0.95	ND		--	--		ug/kg	110	ND		ND	
Organics-Volatiles	1,2,4-Trimethylbenzene	µg/L	0.95	ND		--	--		ug/kg	110	ND		ND	
Organics-Volatiles	1,2,3-Trimethylbenzene	µg/L	0.95	ND		--	--		ug/kg	110	ND		ND	
Organics-GRO	Gas Range Organics (C6-C10)	µg/L	90	ND		--	--		ug/kg	4500	ND		ND	
Organics-DRO/ORO	Diesel Range Org (C10-C20)	µg/L	100	**2200**	Y29	n/a	n/a		ug/kg	39000	**70000 ****	Y29		
Organics-DRO/ORO	Oil Range Organics (C20-C34)	µg/L	510	**5000**	Y30	n/a	n/a		ug/kg	160000	**190000 ****	Y30		
Organics-Semivolatiles					**Y17**							**Y20**		
Organics-Semivolatiles	Pyridine	µg/L	19	ND		--	--							
Organics-Semivolatiles	N-Nitrosodimethylamine	µg/L	4.9	ND		--	--		ug/kg	1900	ND			
Organics-Semivolatiles	Phenol	µg/L	4.9	ND		--	--		ug/kg	2500	ND			
Organics-Semivolatiles	Aniline	µg/L	3.9	ND		--	--							
Organics-Semivolatiles	Tetramethylurea	µg/L	1	ND		--	--							
Organics-Semivolatiles	Bis(2-chloroethyl)ether	µg/L	1	ND		--	--		ug/kg	740	ND			
Organics-Semivolatiles	2-Chlorophenol	µg/L	9.1	ND		--	--		ug/kg	2500	ND			
Organics-Semivolatiles	Benzyl Alcohol	µg/L	45	ND		--	--		ug/kg	18000	ND			
Organics-Semivolatiles	2-Methylphenol (o-Cresol)	µg/L	9.1	ND		--	--		ug/kg	2500	ND			

General Method/Parameter	Analyte	Units (water results)	RL (water results)	S Br Macon Creek u/s Ridge Hwy (water results)	Qual-ifier (water results)	FCV* (WQS) (water results)	AMV* (WQS) (water results)		Units (sed results)	RL (sed results)	S Br Macon Creek u/s Ridge Hwy (sed results)	Qual-ifier (sed results)	(TB) S Br Macon Creek u/s Ridge Hwy (sed results)	Qual-ifier (sed results)
Organics-Semivolatiles	Bis(2-chloroisopropyl)ether	µg/L	1	ND		--	--		ug/kg	740	ND			
Organics-Semivolatiles	N-methylaniline	µg/L	1	ND		--	--							
Organics-Semivolatiles	Hexachloroethane	µg/L	1	ND		--	--		ug/kg	740	ND			
Organics-Semivolatiles	N-Nitrosodi-n-propylamine	µg/L	1.9	ND		--	--		ug/kg	1500	ND			
Organics-Semivolatiles	3 & 4-Methylphenol	µg/L	19	ND		--	--		ug/kg	5100	ND			
Organics-Semivolatiles	Nitrobenzene	µg/L	1.9	ND		--	--		ug/kg	1500	ND			
Organics-Semivolatiles	N,N-dimethylaniline	µg/L	4.9	ND		--	--							
Organics-Semivolatiles	Isophorone	µg/L	1	ND		--	--		ug/kg	740	ND			
Organics-Semivolatiles	2-Chloroaniline	µg/L	4.9	ND		--	--							
Organics-Semivolatiles	2-Nitrophenol	µg/L	4.9	ND		--	--		ug/kg	2500	ND			
Organics-Semivolatiles	2,4-Dimethylphenol	µg/L	4.9	ND		--	--		ug/kg	2500	ND			
Organics-Semivolatiles	Bis(2-chloroethoxy)methane	µg/L	1.9	ND		--	--		ug/kg	1500	ND			
Organics-Semivolatiles	2,4-Dichlorophenol	µg/L	9.1	ND		--	--		ug/kg	2500	ND			
Organics-Semivolatiles	1,2,4-Trichlorobenzene	µg/L	1.9	ND		--	--		ug/kg	1500	ND			
Organics-Semivolatiles	Naphthalene	µg/L	1	ND		--	--		ug/kg	740	ND			
Organics-Semivolatiles	4-Chloroaniline	µg/L	9.1	ND		--	--							
Organics-Semivolatiles	Hexachlorobutadiene	µg/L	1	ND		--	--		ug/kg	390	ND			
Organics-Semivolatiles	4-Chloro-3-methyl-phenol	µg/L	4.9	ND		--	--		ug/kg	1500	ND			
Organics-Semivolatiles	2-Methylnaphthalene	µg/L	4.9	ND		--	--		ug/kg	1900	ND			
Organics-Semivolatiles	Hexachlorocyclopentadiene	µg/L	5.1	ND		--	--		ug/kg	2600	ND			
Organics-Semivolatiles	2,4,6-Trichlorophenol	µg/L	3.9	ND		--	--		ug/kg	2500	ND			
Organics-Semivolatiles	2,4,5-Trichlorophenol	µg/L	4.9	ND		--	--		ug/kg	2500	ND			
Organics-Semivolatiles	2-Chloronaphthalene	µg/L	1.9	ND		--	--		ug/kg	1500	ND			
Organics-Semivolatiles	2-Nitroaniline	µg/L	19	ND		--	--		ug/kg	3800	ND			
Organics-Semivolatiles	Dimethyl phthalate	µg/L	4.9	ND		--	--		ug/kg	1900	ND			
Organics-Semivolatiles	Acenaphthylene	µg/L	1	ND		--	--		ug/kg	740	ND			
Organics-Semivolatiles	2,6-Dinitrotoluene	µg/L	4.9	ND		--	--		ug/kg	1800	ND			
Organics-Semivolatiles	3-Nitroaniline	µg/L	19	ND	A05	--	--		ug/kg	3800	ND			
Organics-Semivolatiles	Acenaphthene	µg/L	1	ND		--	--		ug/kg	740	ND			

General Method/Parameter	Analyte	Units (water results)	RL (water results)	S Br Macon Creek u/s Ridge Hwy (water results)	Qual-ifier (water results)	FCV* (WQS) (water results)	AMV* (WQS) (water results)		Units (sed results)	RL (sed results)	S Br Macon Creek u/s Ridge Hwy (sed results)	Qual-ifier (sed results)	(TB) S Br Macon Creek u/s Ridge Hwy (sed results)	Qual-ifier (sed results)
Organics-Semivolatiles	2,4-Dinitrophenol	µg/L	24	ND		--	--		ug/kg	6500	ND			
Organics-Semivolatiles	Dibenzofuran	µg/L	3.9	ND		--	--		ug/kg	1900	ND			
Organics-Semivolatiles	2,4-Dinitrotoluene	µg/L	4.9	ND		--	--		ug/kg	1900	ND			
Organics-Semivolatiles	4-Nitrophenol	µg/L	24	ND		--	--		ug/kg	6500	ND			
Organics-Semivolatiles	Fluorene	µg/L	1	ND		--	--		ug/kg	740	ND			
Organics-Semivolatiles	Diethylphthalate	µg/L	4.9	ND		--	--		ug/kg	1900	ND			
Organics-Semivolatiles	4-Chlorodiphenylether	µg/L	1	ND		--	--		ug/kg	740	ND			
Organics-Semivolatiles	4-Nitroaniline	µg/L	19	ND		--	--		ug/kg	3800	ND			
Organics-Semivolatiles	2-Methyl-4,6-dinitrophenol	µg/L	19	ND		--	--		ug/kg	6500	ND			
Organics-Semivolatiles	N-Nitrosodiphenylamine	µg/L	1.9	ND		--	--		ug/kg	1500	ND			
Organics-Semivolatiles	Azobenzene	µg/L	1.9	ND		--	--		ug/kg	1500	ND			
Organics-Semivolatiles	4-Bromophenyl phenyl ether	µg/L	1.9	ND		--	--		ug/kg	1500	ND			
Organics-Semivolatiles	Hexachlorobenzene	µg/L	1	ND		--	--		ug/kg	1500	ND			
Organics-Semivolatiles	Pentachlorophenol	µg/L	19	ND		--	--		ug/kg	6300	ND			
Organics-Semivolatiles	Phenanthrene	µg/L	1	ND		--	--		ug/kg	740	ND			
Organics-Semivolatiles	Anthracene	µg/L	1	ND		--	--		ug/kg	740	ND			
Organics-Semivolatiles	Carbazole	µg/L	4.9	ND		--	--		ug/kg	1900	ND			
Organics-Semivolatiles	Di-n-butyl phthalate	µg/L	4.9	ND		--	--		ug/kg	1900	ND			
Organics-Semivolatiles	Fluoranthene	µg/L	1	ND		--	--		ug/kg	740	ND			
Organics-Semivolatiles	Pyrene	µg/L	1	ND		--	--		ug/kg	740	ND			
Organics-Semivolatiles	Butyl benzyl phthalate	µg/L	4.9	ND		--	--		ug/kg	1900	ND			
Organics-Semivolatiles	Benz[a]anthracene	µg/L	1	ND		--	--		ug/kg	740	ND			
Organics-Semivolatiles	Chrysene	µg/L	1	ND		--	--		ug/kg	740	ND			
Organics-Semivolatiles	Bis(2-ethylhexyl)phthalate	µg/L	4.9	ND		--	--		ug/kg	1900	ND			
Organics-Semivolatiles	Di-n-octyl phthalate	µg/L	4.9	ND		--	--		ug/kg	1900	ND			
Organics-Semivolatiles	Benzo[b]fluoranthene	µg/L	1	ND		--	--		ug/kg	1500	ND			
Organics-Semivolatiles	Benzo[k]fluoranthene	µg/L	1	ND		--	--		ug/kg	1500	ND			
Organics-Semivolatiles	Benzo[a]pyrene	µg/L	1	ND		--	--		ug/kg	1500	ND			
Organics-Semivolatiles	Indeno(1,2,3-c,d)pyrene	µg/L	1.9	ND		--	--		ug/kg	1500	ND			

General Method/Parameter	Analyte	Units (water results)	RL (water results)	S Br Macon Creek u/s Ridge Hwy (water results)	Qual-ifier (water results)	FCV* (WQS) (water results)	AMV* (WQS) (water results)		Units (sed results)	RL (sed results)	S Br Macon Creek u/s Ridge Hwy (sed results)	Qual-ifier (sed results)	(TB) S Br Macon Creek u/s Ridge Hwy (sed results)	Qual-ifier (sed results)
Organics-Semivolatiles	Dibenz[a,h]anthracene	µg/L	1.9	ND		--	--		ug/kg	1500	ND			
Organics-Semivolatiles	Benzo[g,h,i]perylene	µg/L	1	ND		--	--		ug/kg	1500	ND			
Organics-PCBs as Aroclors	Aroclor 1016	µg/L	0.09	ND		--	--		ug/kg	140	ND			
Organics-PCBs as Aroclors	Aroclor 1221	µg/L	0.09	ND		--	--		ug/kg	140	ND			
Organics-PCBs as Aroclors	Aroclor 1232	µg/L	0.09	ND		--	--		ug/kg	140	ND			
Organics-PCBs as Aroclors	Aroclor 1242	µg/L	0.09	ND		--	--		ug/kg	140	ND			
Organics-PCBs as Aroclors	Aroclor 1248	µg/L	0.09	ND		--	--		ug/kg	140	ND			
Organics-PCBs as Aroclors	Aroclor 1254	µg/L	0.09	ND		--	--		ug/kg	140	ND			
Organics-PCBs as Aroclors	Aroclor 1260	µg/L	0.09	ND		--	--		ug/kg	140	ND			
Organics-PCBs as Aroclors	Aroclor 1262	µg/L	0.09	ND		--	--		ug/kg	140	ND			
Organics-PCBs as Aroclors	Aroclor 1268	µg/L	0.09	ND		--	--		ug/kg	140	ND			
Inorganics-Metals	Hardness (*estimated**)	mg/L		**246**		--	--							
Inorganics-Metals	Arsenic	µg/L	10	ND	I	--	--		mg/kg dry	0.5	**2.8** ***			
Inorganics-Metals	Barium	µg/L	5	**120**		1146 ‡	3250 ‡		mg/kg dry	1	**24** ***			
Inorganics-Metals	Cadmium	µg/L	0.2	ND		--	--		mg/kg dry	0.2	ND ***			
Inorganics-Metals	Chromium	µg/L	1	**4.9**		232 ‡	1786 ‡		mg/kg dry	2	**3.4** ***			
Inorganics-Metals	Copper	µg/L	1	**7.7**		29 ‡	47 ‡		mg/kg dry	1	**5** ***			
Inorganics-Metals	Iron	µg/L	20	**5900**		n/a	n/a		mg/kg dry	5	**6200** ***			
Inorganics-Metals	Lead	µg/L	1	**3.3**		226 ‡	1102 ‡		mg/kg dry	1	**3.3** ***			
Inorganics-Metals	Mercury	µg/L	0.2	ND		--	--		mg/kg	0.08	ND ***			
Inorganics-Metals	Nickel	µg/L	2	**7.4**		123 ‡	1103 ‡		mg/kg dry	1	**8.3** ***			
Inorganics-Metals	Selenium	µg/L	10	ND	I	--	--		mg/kg dry	0.2	ND ***			
Inorganics-Metals	Silver	µg/L	0.2	ND		--	--		mg/kg dry	0.1	ND ***			
Inorganics-Metals	Zinc	µg/L	5	**25**		532 ‡	528 ‡		mg/kg dry	1	**28** ***			
Inorganics-General Chemistry	Total Organic Carbon	mg/L	0.5	**4.2**		--	--		%	0.1	**0.83%**	dry		
	% Total Solids								%	0.1	**63.8%**	N	**100%**	

Notes and Definitions:

*	The Final Chronic Value (FCV) and Aquatic Maximum Value (AMV) WQS values for total (not dissolved) forms of the various trace metals are listed here. Note that to truly assess WQS, at least 4 water samples need to be collected within a 1-year period. Also, hardness was estimated; see text for more information about how it was estimated. WQS values (as of February 1, 2020) mentioned here are for reference purposes only. Refer to Chapter 3 (Assessment Methodology) of EGLE's Integrated Report for more information and Michigan's Rule 57 Water Quality Values (e.g., FCVs, AMVs).
**	Per USEPA Region 4 (2018), the Ecological Screening Values (ESV) for DROs (C10-C20) (CAS #68334-30-5) and OROs (C20-C34) (CAS #68476-53-9) are 340,000 micrograms per kilogram (ug/kg) and 3,600,000 ug/kg, respectively. The values in the South Branch Macon Creek upstream of Ridge Highway sediment sample from August 14, 2018, were well under (i.e., less than 25 percent of) these ESVs. There are no reference stream background value ranges for these parameters in the report by Jones and Gerard (Michigan Department of Environmental Quality [MDEQ], 1999).
***	For sediment metals, concentrations were all below the MacDonald et al. (2000) Threshold Effect Concentrations (TEC) (i.e., the concentration below which harmful effects are unlikely to be observed) (where available), and also within the range of sediment background concentrations for Michigan reference streams (Jones and Gerard, 1999). (Note: Barium, iron, selenium, and silver were not covered in MacDonald et al. [2000].)
A04	Result is estimated due to high matrix spike recovery.
A05	Result and reporting limit (RL) are estimated due to low continuing calibration standard criteria failure.
A07	Result(s) and RL(s) are estimated due to poor precision.
A08	Result(s) and RL(s) are estimated due to low recovery of batch QC.
dry	Sample results reported on a dry weight basis.
I	Dilution required due to matrix interference; RL raised.
KR	RL(s) raised due to low sample volume submitted.
LRB	Laboratory reagent blank was greater than 2.2 times the Method Detection Limit, or greater than 10 percent of the analyte level in the sample.
N	Result is estimated due to non-homogeneous sample.
NA	Not applicable.
n/a	Not available.
ND	Indicates compound analyzed for but not detected.
RL	Reporting limit.
T	Reported value is less than the RL. Result is estimated.
µg/L	Micrograms per liter.
X3	Spike recovery is not applicable due to large target analyte concentration in the source sample.
Y17	Probable petroleum product(s) present.
Y20	RLs raised due to matrix.
Y29	DRO results may also include non-diesel organic compounds.
Y30	ORO results may also include non-oil organic compounds.

APPENDIX C. Targeted Monitoring Requests: Dissolved Oxygen and Phosphorus Concerns (Rice Lake Drain, Bear Creek, Hazen Creek, South Branch River Raisin, Fisk Drain, Black Creek, Wolf Creek/Loch Erin).

(Targeted monitoring requests [TMR] #: 2018322, 2018323, 2018324, 2018325, 2018326, 2018327)

In response to TMRs regarding dissolved oxygen (DO) and nutrient (e.g., phosphorus, nitrogen), and *E. coli* bacteria concerns, site visits (including reconnaissance-level sonde measurements) were made at 9 locations (Stations A through I) in the western portion of the River Raisin watershed in July and/or August 2018. Refer to Figure 2 and Table 2 in the main report for a map and list of sites. Many of these stations were visited during both (roughly) early morning and mid-day hours.

Pre-dawn tends to be when streams, especially productive streams with lots of plants, have the lowest DO concentrations relative to periods of the day with abundant sunlight mainly because, while respiration occurs all day and night long, DO production due to photosynthesis only occurs when there is adequate sunlight (Munn et al., 2018; EGLE, n.d.; Minnesota Pollution Control Agency [MPCA], 2008; Allan and Castillo, 2007). While peak sunlight conditions were often not captured due to scheduling issues, mid-day monitoring attempted to capture DO concentrations under full sunlight conditions as close to mid-day as possible. DO values may have been higher later in the day (e.g., 2:00 or 3:00 p.m.); however, that was not logistically possible in this study.

Some wetlands, such as highly productive wetlands with abundant vegetation in shallow water and high organic content in the sediment, may naturally exhibit low DO levels in the water column (EGLE, 2022; National Research Council, 1995), which may also affect streams or other water bodies connected to them (MPCA, 2009).

While low DO concentrations may partially or entirely be the result of natural processes or conditions as mentioned above, they can also be created or intensified by some human land uses or activities (MPCA, 2008, 2009; EGLE, [n.d.]; USGS, 2018; Munn et al., 2018; Federal Interagency Stream Restoration Working Group, 1998; Allan and Castillo, 2007; United States Department of Transportation, Federal Highway Administration, 2005). For example, excessive runoff of nutrients due to human activities or land use management can stimulate excessive plant growth that eventually dies and consumes oxygen as it decomposes. Drains, or certain reaches of streams, that have been channelized and modified so extensively by humans that they are straightened, widened, and/or deepened, and their habitats simplified, may have reduced flow velocities and loss of water turbulence in the summer, which can result in lowered DO concentrations.

In addition to sonde measurements of parameters such as DO, these stations were quickly examined for possible signs of excessive amounts of nutrients evidenced by excessive/nuisance algae and/or macrophyte growth[6].

Stations with the Lowest DO Observations

Five stations with instantaneous DO readings lower than 5 mg/L in July and/or August 2018 (Table C-1) were:

S Br River Raisin at W Cadmus Road (Station F)

This station had DO values of 0.56 mg/L (11:16 a.m.) and 0.80 mg/L (6:56 a.m.). The water was stagnant, with no riffles in sight (from the road) to help reaerate the water. Wood debris (with some perhaps from a past timber harvest) was blocking the culvert (Figure C-1).

For additional context, according to USGS topographic map imagery, the South Branch River Raisin upstream of W Cadmus Road is mostly flowing in and out of wetlands and is near the start of the river.

It may be warranted that staff of the Surface Water Assessment Section (SWAS) request Jackson District staff to visit this site before summer 2023, when the next River Raisin biosurveys will be conducted, to see if the blockage has been cleared and the river is flowing. If the blockage is cleared and the river is flowing, SWAS staff should revisit the site and check summertime morning DO concentrations again to see whether they are below 5 mg/L.

Figure C-1. S Br River Raisin at W Cadmus Road (Station F).

[6] As part of the Other Indigenous Aquatic Life and Wildlife (OIALW) designated use component of Rule 60 (R 323.1060 [plant nutrients]) of the Part 4 Rules, WQS, promulgated under Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. See also MDEQ (2015).

Rice Lake Drain at Haley Road (Station I)

For this report, Rice Lake Drain, a tributary to the Bear Creek that flows out of Lake Hudson, was monitored at a location that was a very short, upper headwater stretch of the drain. The channel here was likely a manmade or heavily modified agricultural drain channel. According to aerial imagery, the sampling location at Haley Road was only approximately 500 feet downstream of the origin (located in an agricultural field) of the surface water portion of the drain.

This station had DO values of 0.57 mg/L (6:23 a.m.) and 1.25 mg/L (10:56 a.m.). The drain was channelized and very straight, and it may have been dug below the water table. It was covered almost completely with duckweed and the water was stagnant (i.e., it had no noticeable flow velocity; it appeared lentic) – perhaps due to past or recent channelization or dredging activity (Figure C-2). A couple of inches below the water surface, the drain bottom was quite black, perhaps mostly due to the respiration (decomposition) of organic matter (e.g., dead duckweed).

Given the very short stretch of surface water channel, stagnant water conditions, thick density of duckweed, and black water and sediment underneath, it was not unexpected that the drain here had low DO concentrations.

For additional context, this location has been monitored for *E. coli* bacteria (e.g., in 2016 [Rippke, 2018]). Given the amounts of bacteria that were collected in samples, the drain here was determined to be “not supporting” for both the Total Body Contact and Partial Body Contact designated uses (for data summaries, please see Michigan.gov/EcoliTMDL).

Figure C-2. Rice Lake Drain at Haley Road (Station I).

Wolf Creek Delta/Inlet to Loch Erin (Stephenson Road; Station H)

Loch Erin, an impoundment of Wolf Creek, was formed after the Loch Erin Dam was constructed in approximately the late 1960s (Minshall, 2020; Dodge, 1998). “After 1950, several large impoundments were constructed on tributaries in the River Raisin watershed for recreational purposes and to promote residential development” (Dodge, 1998). The watershed of the portion of Wolf Creek upstream of Loch Erin is mostly a mix of agricultural lands, some light residential areas, multiple lakes (some of which have a number of houses around them), wetlands, forest, and some roads like M-50.

Some sonde measurements were made by EGLE staff in July and August 2018 from a causeway (Stephenson Road) near what was essentially a transition area from a Wolf Creek delta, to a wetland type area, to a shallow embayment of the Loch Erin impoundment. The causeway was essentially within a shallow outer margin of the lake (impoundment) bisected by a road, which likely is affecting water flow or circulation patterns.

This station appeared to have physical characteristics more like a pond or open-wetland rather than a stream (Figure C-3), and it had DO values of 2.17 mg/L (6:53 a.m.), 2.64 mg/L (12:20 p.m.), and 2.35 mg/L (7:40 a.m.) (on different dates) (Table C-1).

Figure C-3. Wolf Creek upstream of Stephenson Rd (and inlet to Loch Erin) (Station H).

Water at this location was observed to be flowing slowly in a “reverse” direction through the culvert (i.e., downstream to upstream, from the lake back up into the open-wetland area upstream of Stephenson Road) – at least on the August 14, 2018, visit. While the weather was not breezy at this location on this date, one possible explanation for this situation could be, but is not limited to, a small seiche effect may have been created by wind on the lake. Note that the Wolf Creek inlet to Loch Erin (immediately downstream of Station H and Stephenson Road [i.e., at the bottom end of the culvert) appeared to be more influenced by Loch Erin than Wolf Creek since it had DO concentration values that were nearly double (4.57, 4.50, and 4.77 mg/L) than just upstream of the road.

For some context, water quality monitoring by other EGLE staff on different dates found the following DO values at sites throughout Loch Erin in June through August 2018: a range of 5.46-11.75 mg/L amongst all sites (Parker, 2019). A range of 6.96-9.05 mg/L (Parker, 2019) was found at a location in the lake approximately 220 feet (67 meters) southeast of the Station H described in the present report. Loch Erin has recently been determined by the SWAS (e.g., via the 2018 sampling) to be not supporting the OIALW designated use due to ongoing problems with elevated nutrients, excessive algal growth, and a hypereutrophic classification. (For additional context, SWAS biologists sampled phosphorus concentrations in the Wolf Creek watershed [Wolf Creek, Black Creek, and Lake Adrian] in Lenawee County in April 2015, to estimate

phosphorus loading to Lake Adrian during spring base flow conditions [Cooper, 2015]. The stream was also sampled for phosphorus in 2003 [Wright, 2003]).

Further, Wolf Creek, before it flows into Loch Erin, was recently listed as Not Supporting for the Total Body Contact Recreation designated use due to *E. coli* bacteria data, and it falls within an *E. coli* Total Maximum Daily Load (TMDL) watershed (River Raisin [South Branch]; TMDL approved in 2008). More information, data, and resources, including the *E. coli* TMDL Pollution and Solution Interactive Mapper "Web App," can be found at Michigan.gov/EGLEEcoli and Michigan.gov/EcoliTMDL.

Fisk Drain upstream of Knight Highway (Station D)

This station (Figure C-4) had an early morning value of 4.20 mg/L (7:36 a.m.). The drain here was mostly overgrown with (and shaded by) the mostly grassy streambanks. The road's culvert appeared to be perched. No noticeable aquatic plants were observed in non-grassy (open, unshaded) water areas.

Figure C-4. Fisk Drain upstream of Knight Hwy (Station D).

The entirety of Fisk Drain appears to perhaps be considered an intermittent stream – at least in some cases. It is symbolized by a "blue dashed and dotted line" or "blue dashed line" on the USGS 1963 7.5-minute topographic map [1:24,000 scale] or USGS National Map, respectively). It, however, shows as a solid blue line on the USGS's 2019 Adrian, Michigan topo map. It is not clear why there is a symbology difference.

There are no field notes on whether the drain was flowing (i.e., had some downstream velocity) at the time DO measurements were made. If other sites are revisited on a future date (e.g., 2023), this site could be revisited too (and flow conditions noted in addition to DO concentrations).

Bear Creek at Medina Road (Station A)

This station (Figure C-5) had an early morning value of 4.78 mg/L (6:39 a.m.). This station location on Bear Creek is approximately 0.17 miles (898 feet) downstream of where Rice Lake Drain flows into Bear Creek. Flow field notes are lacking, though the photo (Figure C-5) indicates that it was likely slow or stagnant.

Figure C-5. Bear Creek at Medina Road (Station A).

Potential Causes of Low DO at these Sites

At most stations detailed above, low early morning and midday DO concentrations may be due to a variety of potential reasons (speculative at this point) including, but not limited to, the presence of upstream or connected wetlands (MPCA, 2008, 2009; National Research Council, 1995); flow conditions (very low or stagnant velocity, wetland-like conditions, or even periodic reverse flow) (MPCA, 2009; USGS, 2018; EGLE, n.d.); and/or eutrophication that may be resulting from the input of nutrient runoff from agricultural lands and residential lawns. At Station I (Rice Lake Drain at Haley Road), stagnant flow and the respiration of abundant duckweed, plus the decomposition of dead, decaying duckweed, plus the fact that the drain length upstream of the sampling location was very short, probably all contributed to low DO concentrations.

Possible Next Steps Regarding DO Conditions at these Sites

Please refer to the main report for discussion about possible next steps regarding the sites described above.

Algae/Aquatic Plant Conditions

Excessive/nuisance filamentous algae and/or macrophyte growth were not observed during the 2018 site visits or biosurveys in the River Raisin watershed. Attached filamentous algae (e.g., Cladophora) was only rarely observed at these sites, and when it was, it was in small amounts. For example, Black Creek at Wolf Creek Highway (Station B) did have a small amount (i.e., roughly 5 percent) of its riffle area covered by

attached, filamentous, green algae at what appeared to be (using best professional judgement) non-nuisance level amounts at the time of the site visit.

Long strands of filamentous algae can sometimes be found in the River Raisin watershed, seemingly when the habitat (e.g., substrate conditions, open canopy) and water chemistry conditions are present. For example, on September 22, 2020, abundant strands of long filamentous algae were observed at a shallow, wide section of the River Raisin mainstem at Ida Maybee Road (Figure C-6).

Figure C-6. Filamentous algae growing in the River Raisin mainstem at Ida Maybee Road on September 22, 2020.

Table C-1. River Raisin watershed 2018 targeted site visits and sonde data notes regarding DO and nutrient expression visits. Explanations of abbreviations, and some notes, are at the bottom of the table. In general, most of these drains or streams were low gradient and located within mostly agricultural land uses.

Part A: DO and Nutrient Expression Visits

Sta-tion ID	Water Body	Location	STORET #	Initial Observations and/or Notes	Date (2018)	Time	Water Temp. * (ºF)	Water Temp. * (ºC)	BP (mmHg)	DO * (%)	DO (mg/L)	Spec. Cond. * (µS/cm)	Cond. (µS/cm)	TDS (mg/L)	pH	BGA-PC (RFU)	BGA-PC (µg/L)	Chl (RFU)	Chl (µg/L)	Depth (ft)	Latitude	Longitude
A	Bear Creek	Medina Road	460388	This is Bear Creek downstream of where Rice Lake Drain flows into Bear Creek. No attached filamentous algae (e.g., Cladophora) was observed (at least the portion near the road that was visited). Sonde measurements done d/s of road.	7/26	6:39	67.9	*20.0*	736.6	52.6	4.78	*677*	612	440.0	7.72	0.163	0.18	0.938	3.55	0.16	41.81356	-84.23165
A	Bear Creek	Medina Road	460388	" "	7/26	11:05	68.8	*20.4*	736.8	60.1	5.41	*662*	604	430.2	7.81	0.061	0.06	0.883	3.34	0.26	41.81358	-84.23158
B	Black Creek	Wolf Creek Hwy	460314	Sonde measurements made u/s of road. No riffles observed u/s in the vicinity of the road. Some channelization appears to have occurred historically. Walked creek d/s of road and examined a few riffles; roughly 5% or less of riffle area was covered by filamentous algae (e.g., Cladophora). Suggest as a future possible, targeted P-51 (macroinvertebrate) site d/s of the road.	7/25	7:50	68.5	*20.3*	738.0	62.3	5.62	*659*	600	428.4	8.03	0.180	0.20	1.429	5.42	0.24	41.93607	-84.10412
B	Black Creek	Wolf Creek Hwy	460314	" "	7/26	11:50	69.9	*21.0*	735.7	65.1	5.79	*660*	610	428.6	8.12	0.110	0.12	1.351	5.12	0.00	41.93604	-84.10413
C	Fisk Drain	Teachout Road	460440	Beginning of Fisk Drain, at edge of crop field; also a surface water collection grate/drain present. Water was too shallow to immerse YSI sonde. Topo map indicates channel is intermittent.	7/25																	
---	Fisk Drain	Shepard Road		Water was too shallow to immerse YSI sonde. Very shaded/overgrown by grasses.	7/25																	

Sta-tion ID	Water Body	Location	STORET #	Initial Observations and/or Notes	Date (2018)	Time	Water Temp. * (ºF)	Water Temp. * (ºC)	BP (mmHg)	DO * (%)	DO (mg/L)	Spec. Cond. * (µS/cm)	Cond. (µS/cm)	TDS (mg/L)	pH	BGA-PC (RFU)	BGA-PC (µg/L)	Chl (RFU)	Chl (µg/L)	Depth (ft)	Latitude	Longitude
D	Fisk Drain	u/s of Knight Hwy	460479	Mostly overgrown with (shaded by) grasses; banks were mostly grassy. Culvert appears to be perched. No noticeable aquatic plants observed in non-grassy (open) water areas. Topo map indicates channel is intermittent.	7/25	7:36	64.7	*18.1*	737.5	44.6	4.20	*650*	565	422.7	7.69	0.678	0.75	3.405	12.92	0.02	41.95999	-84.08490
D	Fisk Drain	u/s of Knight Hwy	460479	" "	7/26	12:00	67.3	*19.6*	735.3	57.6	5.27	*633*	568	411.7	7.78	0.828	0.92	3.733	14.17	0.10	41.95995	-84.08495
E	Hazen Creek	u/s Plank Road	460462	Very deep water (3-4 ft). No flow velocity, riffles, or attached filamentous algae observed (at least within vicinity of road).	7/26	7:15	67.3	*19.6*	736.0	75.1	6.87	*627*	562	407.4	8.12	0.060	0.06	0.698	2.64	0.56	41.90024	-84.16664
E	Hazen Creek	u/s Plank Road	460462	" "	7/26	11:28	68.1	*20.0*	736.0	82.7	7.50	*626*	567	407.2	8.14	0.031	0.03	0.630	2.38	0.50	41.90022	-84.16665
E	Hazen Creek	u/s Plank Road	460462	" "	7/26	11:30	67.8	*19.9*	736.0	82.4	7.50	*625*	564	406.6	8.13	0.051	0.05	0.663	2.51	0.25	41.90018	-84.16663
F	S Br River Raisin	W Cadmus Road	460465	No flow velocity or attached filamentous algae (e.g., Cladophora) observed. Water was stagnant, no riffles in sight. Culvert had a log jam in front of it (possibly due to power line clearings). Sonde measurements done u/s of road.	7/26	6:56	68.5	*20.3*	735.2	8.8	0.80	*1245*	1132	809.3	7.83	1.279	1.42	11.527	43.79	0.00	41.87179	-84.22219
F	S Br River Raisin	W Cadmus Road	460465	" "	7/26	11:16	68.3	*20.2*	735.4	6.2	0.56	*1272*	1154	826.4	7.81	1.574	1.75	12.808	48.66	0.01	41.87183	-84.22219
G	Wolf Creek	at Springville Hwy	460460	Horses and pasture were observed upstream of this road, but there appears to be electric fencing that excludes the animals from the creek.	8/14	8:03	73.7	*23.2*			7.62	*574*	554									
H	Wolf Creek	u/s of Stephenson Rd (near inlet into Loch Erin)	460466	Pond/open-wetland like area; mostly lentic; not P-51 appropriate. Sampled near large culvert.	7/25	6:53	73.2	*22.9*	735.7	25.3	2.17	*582*	559	378.2	7.33	0.743	0.83	1.281	4.85	0.00	42.01875	-84.16487
H	Wolf Creek	u/s of Stephenson Rd (near inlet	460466	" "	7/26	12:20	75.0	*23.9*	733.3	31.3	2.64	*581*	568	377.4	7.43	0.601	0.67	1.077	4.08	0.00	42.01875	-84.16487

Sta-tion ID	Water Body	Location	STORET #	Initial Observations and/or Notes	Date (2018)	Time	Water Temp. * (ºF)	Water Temp. * (ºC)	BP (mmHg)	DO * (%)	DO (mg/L)	Spec. Cond. * (µS/cm)	Cond. (µS/cm)	TDS (mg/L)	pH	BGA-PC (RFU)	BGA-PC (µg/L)	Chl (RFU)	Chl (µg/L)	Depth (ft)	Latitude	Longitude
		into Loch Erin)																				
H	Wolf Creek	u/s of Stephenson Rd (near inlet into Loch Erin)	460466	Pond/open-wetland like area; mostly lentic; not P-51 appropriate. Sampled near large culvert. Additionally, water was observed to be *flowing in a downstream to upstream direction* (i.e., from the lake into the pond/wetland area u/s of Stephenson Rd). No noticeable winds were observed. Perhaps the u/s wetland area is at a lower elevation than the nearby d/s lake area.	8/14	7:40	75.0	*23.9*			2.35	*596*	584									
just d/s of H	Wolf Creek / Loch Erin	d/s of Stephenson Rd (inlet of Wolf Cr into Loch Erin)		Loch Erin side of culvert; not P-51 appropriate. Sampled near large culvert.	7/25	6:50	75.6	*24.2*	735.8	54.6	4.57	*520*	512	338.0	7.59	1.661	1.85	1.961	7.44	0.14	42.01865	-84.16468
just d/s of H	Wolf Creek / Loch Erin	d/s of Stephenson Rd (inlet of Wolf Cr into Loch Erin)		" "	7/26	12:19	75.6	*24.2*	733.3	53.8	4.50	*518*	510	336.4	7.66	1.773	1.98	1.977	7.50	0.68	42.01865	-84.16467
just d/s of H	Wolf Creek / Loch Erin	d/s of Stephenson Rd (inlet of Wolf Cr into Loch Erin)		" "	8/14	7:42	80.5	*26.9*			4.77	*510*	529									
I	Rice Lake Drain	Haley Road	460387	Probably channelized. Covered almost completely with duckweed. No noticeable flow velocity (appears lentic); not suitable for P-51. A couple of inches below the surface, the sediments are fairly black; may be mostly decomposing organic matter (e.g., dead duckweed). May be lots of respiration due to all of the duckweed. The channel may	7/26	6:23	65.5	*18.6*	736.4	6.1	0.57	*983*	863	638.7	7.11	0.144	0.16	1.281	4.85	0.00	41.82819	-84.22063

Sta-tion ID	Water Body	Location	STORET #	Initial Observations and/or Notes	Date (2018)	Time	Water Temp. * (°F)	Water Temp. * (°C)	BP (mmHg)	DO * (%)	DO (mg/L)	Spec. Cond. * (µS/cm)	Cond. (µS/cm)	TDS (mg/L)	pH	BGA-PC (RFU)	BGA-PC (µg/L)	Chl (RFU)	Chl (µg/L)	Depth (ft)	Latitude	Longitude
				possibly have been dug below the water table.																		
I	Rice Lake Drain	Haley Road	460387	" "	7/26	10:56	67.3	*19.6*	736.2	13.7	1.25	*990*	888	643.2	7.14	0.197	0.22	1.448	5.49	0.00	41.82818	-84.22064

Part B: Potential In-Stream Petroleum Pollutant Visits

Sta-tion ID	Water Body	Location	STORET #	Initial Observations and/or Notes	Date (2018)	Time	Water Temp. * (°F)	Water Temp. * (°C)	BP (mmHg)	DO * (%)	DO (mg/L)	Spec. Cond. * (µS/cm)	Cond. (µS/cm)	TDS (mg/L)	pH	BGA-PC (RFU)	BGA-PC (µg/L)	Chl (RFU)	Chl (µg/L)	Depth (ft)	Latitude	Longitude
J	Lake Adrian	upper end, under powerline near Saw Mill Court	460463		6/14	10:29	69.0	*20.6*	743.0	78.9	7.09	598	547		7.71	0.239	0.27	1.828	6.99	0.00	41.91939	-84.04296
J	Lake Adrian	upper end, under powerline near Saw Mill Court	460463		7/25	13:07	79.7	*26.5*	739.9	138.9	11.15	*659*	678	428.7	8.16	1.377	1.53	6.203	23.56	0.53	41.91918	-84.04317
J	Lake Adrian	upper end, under powerline near Saw Mill Court	460463	Water appeared quite turbid (muddy brown) on this day.	11/27	12:35	*37.9*	3.3	736.7	90.1	12.03	527	308	342.4	7.74	1.244	1.25	1930.594	78751.86	0.76	41.91917	-84.04302

Station ID	Water Body	Location	STORET #	Initial Observations and/or Notes	Date (2018)	Time	Water Temp. * (°F)	Water Temp. * (°C)	BP (mmHg)	DO * (%)	DO (mg/L)	Spec. Cond. * (µS/cm)	Cond. (µS/cm)	TDS (mg/L)	pH	BGA-PC (RFU)	BGA-PC (µg/L)	Chl (RFU)	Chl (µg/L)	Depth (ft)	Latitude	Longitude
K	S Br River Raisin	N end of Island Park, near footbridge & Mill Rd); (~ 0.2 miles u/s of biosurvey location)	460467		6/14	12:53	70.2	*21.2*	744.1	98.3	8.71	694	644		7.90	0.155	0.17	1.623	6.21	0.20	41.91075	-84.02450
K	S Br River Raisin	N end of Island Park, near footbridge & Mill Rd); (~ 0.2 miles u/s of biosurvey location)	460467		7/25	14:01	74.3	*23.5*	740.8	105.3	8.93	*799*	776	519.1	8.10	0.148	0.16	1.201	4.55	1.26	41.91068	-84.02438
K	S Br River Raisin	N end of Island Park, near footbridge & Mill Rd); (~ 0.2 miles u/s of biosurvey location)	460467	Water appeared quite turbid (muddy brown) on this day.	11/27	10:39	*38.8*	3.8	738.2	90.0	11.85	602	358	391.6	7.77	0.743	0.73	1165.690	47669.73	0.26	n/a	n/a
L	S Br River Raisin	near Heritage Park	460464	u/s of confluence with Beaver Creek	7/25	17:42	74.4	*23.6*	739.9	94.8	8.02	*939*	913	609.9	8.01	0.102	0.11	1.016	3.85	0.89	41.92273	-84.00139
L	S Br River Raisin	near Heritage Park	460464	Water appeared quite turbid (muddy brown) on this day.	11/27	11:41	*39.3*	4.0	738.4	91.0	11.90	624	375	405.9	7.75	0.963	0.96	1318.367	53873.82	0.18	41.92268	-84.00135
M	Beaver Creek	south of Heritage Park	460461		6/14	14:06	64.8	*18.2*	744.1	94.0	8.84	776	676		7.70	0.035	0.04	0.456	1.78	0.33	41.92330	-84.00163
M	Beaver Creek	south of Heritage Park	460461		7/25	17:52	70.5	*21.4*	739.9	96.7	8.54	*753*	701	489.5	8.18	0.014	0.01	0.355	1.34	0.13	41.92320	-84.00166
M	Beaver Creek	south of Heritage Park	460461	Water appeared quite turbid (muddy brown) on this day.	11/27	11:24	*37.5*	3.1	738.6	90.1	12.09	515	299	334.5	7.79	0.863	0.86	573.964	23624.77	0.00	41.92297	-84.00195

Abbreviations

BGA-PC	blue-green algae (a.k.a. cyanobacteria) - phycocyanin
BP	barometric pressure
Chl	chlorophyll
Cond.	conductivity
DO	dissolved oxygen
d/s	downstream
ft	feet
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter
mg/L	milligrams per liter
mmHg	millimeter of mercury
mV	millivolts
P-51	Procedure 51 (EGLE, 2014)
RFU	relative fluorescence units
Spec. Cond.	specific conductance
TDS	total dissolved solids
u/s	upstream

*** FOOTNOTES on Estimated Conversions of ºF to ºC and Conductivity to Specific Conductance**

- Estimated values are shown in italics.
- If specific conductance was not measured in the field directly, then it was estimated using conductivity measured in the field and this equation: SC = AC / (1 + r*(T-25)), where SC = Specific Conductance in microSeimens per cm; AC = Actual Conductivity of the sample in microSeimens per cm; T = temperature of the sample in degrees C; and r = temperature correction coefficient for the sample (Carlson [n.d.], USGS [2019], Radtke et al. [2005]). In this report, the r value that is used is r = 0.0191.
- Water temperature unit conversion: °F = (1.8 × °C) + 32 or °C = (°F – 32) / 1.8 (per Cuffney and Brightbill [2008]).
-
- References for this table:

Carlson, Glenn. [n.d.] Specific conductance as an output unit for conductivity readings. In-Situ Inc., Technical Note 009. Accessed 9/27/2022 at: In-Situ.com/UK/Pub/Media/Support/Documents/Specific-Conductance-as-an-Output-Unit-for-Conductivity-Readings-Tech-Note.pdf.

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Cuffney, T.F. and R.A. Brightbill. 2008. Methods for processing and summarizing time-series temperature data collected as part of the National Water-Quality Assessment Program studies on the effects of urbanization on stream ecosystems. U. S. Geological Survey (USGS) Data Series 330. 23 p. Available online at: Pubs.USGS.gov/ds/330/.

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U.S. Geological Survey. 2019. Specific conductance: U.S. Geological Survey Techniques and Methods, book 9, chapter A6.3, 15 p., DOI.org/10.3133/tm9A6.3. [Supersedes USGS Techniques of Water-Resources Investigations, book 9, chap. A6.3, version 1.2.

Wolf Creek at Springville Highway vs at Stephenson Road

Some phosphorus (water) samples, DO measurements, and observations were collected or made at Station G (Wolf Creek at Springville Highway; Figure C-7) and Station H (Wolf Creek upstream of Stephenson Road [Figure C-3], near/at the inlet into Loch Erin) on the early morning of August 14, 2018 (Table C-2). Some observations were also made in between these stations. Early morning DO was 7.62 mg/L at the upstream location (Station G) and, as mentioned earlier, 2.35 mg/L at the downstream, more pond-like and wetland area location (Station H [Wolf Creek inlet culvert to Loch Erin]). Ortho phosphate concentration was slightly higher (0.015 mg/L) at the downstream station (H) than the upstream station (G) (0.011 mg/L). Conversely, total phosphorus was slightly higher 0.065 (mg/L) at the upstream station (G) than at the downstream station (H) (0.063 mg/L).

Land use activities between the two locations may potentially (at least partly) explain the decrease in DO concentrations; however, the physical characteristics of the two stations were very different (i.e., small stream [G] vs. pond-like and wetland [H] type habitats). While no cattle were observed in the stream between Stations G and H on August 14, cattle did appear to have unrestricted access to parts of the stream (see Figure C-8). The unrestricted cattle access issue downstream of Springville Highway was referred to EGLE's Jackson District Office and then eventually referred to the Michigan Department of Agriculture and Rural Development's Right-to-Farm program for follow-up.

Figure C-7. Wolf Creek upstream of Springville Hwy (Station G).

Figure C-8. Wolf Creek between Stations G and H. Eroding streambanks and streambed (top and bottom); cattle can be viewed off in the distance, with no fencing to restrict access (bottom).

Table C-2. Phosphorus water chemistry data from Wolf Creek (Lenawee County), sampled on August 14, 2018. Samples were analyzed on August 15, 2018. RPD = relative percent difference.

Detail / Parameter Group	Analyte	Units	RL	WOLF CREEK AT SPRINGVILLE	WOLF CREEK AT STEVENSON (*inlet to Loch Erin*)	WOLF CREEK AT STEVENSON (*inlet to Loch Erin*) Field Blank	WOLF CREEK AT STEVENSON (*inlet to Loch Erin*) Field Replicate	RPD (%)
STATION ID:	--	--	--	**G**	**H**	**H**	**H**	--
STORET:	--	--	--	**460460**	**460466**	**460466**	**460466**	--
LAB ID	--	--	--	**1808209-02**	**1808209-01**	**1808209-04**	**1808209-03**	--
Inorganics-General Chemistry	Ortho Phosphate	mg/L	0.010	**0.011**	**0.015**	ND	**0.015**	0.0
Inorganics-General Chemistry	Total Phosphorus	mg/L	0.010	**0.065**	**0.063**	ND	**0.062**	1.6

APPENDIX D. Targeted Monitoring Requests: Petroleum Concerns (Beaver Creek, South Branch River Raisin, and Lake Adrian)

(TMRs # 2018333, 2018334)

In response to externally submitted TMRs concerned about a variety of contaminants, including those from potential spills or leaks from nearby oil wells and pipelines in the region, water chemistry sampling and sonde measurements (Tables D-1 and C-1, respectively) were conducted on June 14, July 25, and November 27, 2018, at the following stations in the South Branch River Raisin subwatershed:

- Lake Adrian (upper end) under the powerline near Saw Mill Court (Station J).
    - Lake Adrian is an impoundment of Wolf Creek.
- South Branch River Raisin at Island Park (Station K)
- South Branch River Raisin near Heritage Park (and upstream of the junction with Beaver Creek) (Station L)
    - This station was added July 25, 2018.
- Beaver Creek near Heritage Park (Station M).

Petroleum-Related Concerns

Oil and gas drilling and hydraulic fracturing, including associated hydraulic fracturing fluids and chemicals or "produced water"[7], may be a potential source of contaminants if leaks or spills occur. Examples of potential contaminants from these kinds of operations (USEPA, 2016a, 2016b) include:

- Salts (e.g., those containing chloride, bromide, sulfate, sodium, magnesium, and calcium).
- Metals (e.g., barium, manganese, iron, and strontium).
- Organic compounds (e.g., BTEX).
- Oil and grease.
- Radioactive materials (e.g., radium).
- Hydraulic fracturing chemicals and their chemical transformation products.

Additional information and background about the above contaminants (especially BTEX, barium, and strontium) are presented in Appendix E.

Water chemistry samples were collected at Stations J, K, L, and M and the results are presented in Table D-1. Below is a list of what was not detected and what was detected in the water samples.

[7] "Produced water" is a term commonly applied to any water, including flowback, that returns to the surface through the production well as a by-product of oil and gas production (USEPA, 2016a).

Lab analyses did NOT detect any of the following on the sampling dates:

- Volatile organics such as BTEX, MTBE, or TMB.
    - Note: a value of 3.1 µg/L was detected in the field blank sample collected on June 14, 2018, but since it was not detected in any of the stream/river samples in 2018, it is likely that the field blank was subjected to some type of contamination in the field or laboratory.
- For broader context within the watershed, BTEX components have been measured occasionally by EGLE's WCMP at a downstream location on the River Raisin (at ERA Dock near the mouth in the City of Monroe; STORET # 580046) in the past; however, the detections of toluene were very low relative to applicable Rule 57 WQS (Aiello [2005, 2006]).

Lab analyses did detect the following:

- Barium, ranging from 54 to 93 µg/L
- Strontium, ranging from 170 to 610 µg/L
- Chloride, ranging from 27 to 100 mg/L
- Calcium, ranging from 62 to 100 mg/L
- Magnesium, ranging from 17 to 31 mg/L
- Hardness, ranging from 220 to 370 mg/L calcium carbonate

While an exhaustive literature review plus analysis of the expected concentrations and potential effects of the elements (e.g., trace metals such as barium, strontium; chloride) detected in this monitoring was beyond the scope of this report, some evaluations and assessments were made. EGLE has Rule 57 surface water quality values for many of the contaminants mentioned above. Parameters that were detected in this study were compared against Michigan's WQS (see Table D-1), where applicable. (Note: to truly assess data against WQS, at least 4 water samples need to be collected within a 1-year period.) Additionally, sample data were examined in the context of a cursory review of background conditions expected for some of those parameters based upon literature, reports, and available data (e.g., from USGS) (see Appendix E). While this was neither an intensive sampling effort nor a conclusive study, no concentrations measured in this study (Table D-1) were found to be above Michigan's WQS values or abnormally outside of the expected range of conditions described in Appendix E on the days they were sampled. For example, barium and strontium values observed in the sampling for this report were above median values observed in streams across Michigan (which has widely varied glacial and bedrock geologies across the state) based upon limited, existing USGS data; however, the barium and strontium values were not above statewide maximum values (Appendix E).

The only parameter that approached Rule 57 WQS was chloride. The South Branch River Raisin near Heritage Park (Station L) had the highest chloride values on July 25, 2018 (100 mg/L), and November 27, 2018 (44 mg/L), relative to the other sites and also compared to the WQS of 150 mg/L. Winter Road salting has been shown to increase chloride levels in at least the northeastern part of the United States (Kaushal et al.,

2005). A USGS study across the northern United States found urban areas to be a leading source of chloride yield to waters; agricultural areas were also sometimes a source of chloride, though generally at much lower levels than urban areas (Mullaney et al., 2009). It can be speculated that summer (July) chloride concentrations may have been greatest, at least partly, due to: (1) generally reduced influence by precipitation and associated dilution in the summer; and (2) also because excess chloride may have been present in the local groundwater due to things such as winter road salting (e.g., see Corsi et al., 2015). The South Branch of the River Raisin is downstream of the City of Adrian (with its roads, parking lots, driveways, sidewalks), and it essentially parallels M-52, much of which likely gets salted regularly in the winter.

According to EGLE's Oil, Gas, and Minerals Division, Lansing District, while oil (or brine) spills are known to occur occasionally, they generally are cleaned up pretty quickly (e.g., via soil removal) and, as of January 2018, they were not aware of any significant, oil-related, water quality concerns for water bodies (e.g., South Branch River Raisin, Beaver Creek) in the vicinity of Heritage Park in Adrian, Michigan. Even if contaminants such as BTEX or apparently high levels of barium, strontium, chloride, etc., had been detected on the days they were sampled, it likely would have been difficult to attribute them specifically to oil and gas production since other commercial and industrial facilities and land uses in the watershed could have also been sources (e.g., gas stations, parking lots, construction sites with heavy machinery, wastewater treatment plants, winter road salting, etc.).

Sonde Measurements

Water quality sonde measurements also made during the visits to the stations described above are presented in Table C-1. Among the four locations, measurements ranged as follows: 7.1 to 12.1 mg/L (DO), 515 to 939 µS/cm (specific conductance), 335 to 610 mg/L (total dissolved solids), and 7.7 to 8.2 (pH). Other sonde measurements included: 0.0 to 1.4 RFUs and 0.0 to 1.5 µg/L (blue-green algae [a.k.a. cyanobacteria] - phycocyanin), and 0.4 to 1,930.6 RFUs and 1.3 to 78,751.9 µg/L (chlorophyll).

BGA-PC and Chlorophyll readings made by the sonde on November 27, 2018, were considerably higher than readings made on monitoring dates in June or July (Table C-1). The November readings were:

- Station J - Lake Adrian: 78,752 µg/L
- Station K - S Br River Raisin N end of Island Park, near footbridge: 47,670 µg/L
- Station L - S Br River Raisin near Heritage Park: 53,874 µg/L
- Station M - Beaver Creek, south of Heritage Park: 23,625 µg/L

Because those particular parameters were not planned for being collected during that day (i.e., they had been selected the previous field day by another biologist and then not been de-selected on the sonde on November 27), calibration steps and checks were not made on November 27 for those parameters. Rainfall events can release both sediment and algae into the water. It is unknown at this time whether high turbidity on

November 27 might have caused (possibly) erroneously high BGA-PC and Chlorophyll readings. It is possible that the high BGA-PC and Chlorophyll readings values are accurate (or close to accurate) and may reflect a high presence of suspended algae that day; however, the values should be treated with caution. Lake Adrian (an impoundment) had the biggest chlorophyll reading but, given that the river/creek sites also had very high values, there seems to be a reduced likelihood that the high values were mostly due to planktonic algae. Regardless, since chlorophyll was not actually sampled in a bottle and later analyzed in a laboratory, it is not possible to verify what the actual chlorophyll, phycocyanin, or algae situation was for that day.

Other Water Quality Parameters

Other water quality parameters were requested as part of these TMRs: phosphorus, nitrogen, PCBs, mercury, pesticides, herbicides, and bacteria. While they were not sampled for this report, EGLE and other agencies collect some of these parameters as part of other monitoring programs. A list of some other sources of this kind of information is presented in the main report under the section entitled, "*Some Other Sources of Water Quality Data in the River Raisin Watershed.*"

Table D-1. Water chemistry data from the South Branch River Raisin, Beaver Creek, and upper Lake Adrian (Lenawee County), 2018, and comparison against Michigan Rule 57 WQS* (where applicable and when the element or compound was present). More information available at the Rule 57 Web page* (as of February 1, 2020). Some WQS for barium are hardness dependent. Green cell color and a double dagger symbol (‡) indicates that applicable WQS values were not exceeded (however only based upon 3 samples*).**

General Method	Analyte (and WQS, where applicable)	Units	RL	Lake Adrian (upper end) (Station J)	S Br River Raisin at Island Park # (Station K)	S Br River Raisin near Heritage Park (Station L)	Beaver Creek near Heritage Park (Station M)	Field Blank	Field Replicate	RPD (%)
QA Sample Site Name								**Beaver Creek (Station M)**	**S Br River Raisin at Island Park ‡ (Station K)**	
LAB ID				1806186-03	1806186-01		1806186-02	1806186-05	1806186-04	
DATE SAMPLED				**6/14/2018**	**6/14/2018**		**6/14/2018**	**6/14/2018**	**6/14/2018**	
DATE RECEIVED				6/19/2018	6/19/2018		6/19/2018	6/19/2018	6/19/2018	
Organics-Volatiles	Methyltertiarybutylether	µg/L	0.95	ND	ND		ND	ND	ND	**
Organics-Volatiles	Benzene	µg/L	0.9	ND	ND		ND	ND	ND	**
Organics-Volatiles	Toluene	µg/L	0.95	ND	ND		ND	**3.1**	ND	**
Organics-Volatiles	Ethylbenzene	µg/L	0.95	ND	ND		ND	ND	ND	**
Organics-Volatiles	m & p - Xylene	µg/L	1.8	ND	ND		ND	ND	ND	**
Organics-Volatiles	o-Xylene	µg/L	0.95	ND	ND		ND	ND	ND	**
Organics-Volatiles	1,3,5-Trimethylbenzene	µg/L	0.95	ND	ND		ND	ND	ND	**
Organics-Volatiles	1,2,4-Trimethylbenzene	µg/L	0.95	ND	ND		ND	ND	ND	**
Organics-Volatiles	1,2,3-Trimethylbenzene	µg/L	0.95	ND	ND		ND	ND	ND	**
Inorganics-General Chem	Chloride	mg/L	1	**28 ‡**	**27 ‡**		**30 ‡**	ND	**36 ‡**	28.6

General Method	Analyte (and WQS, where applicable)	Units	RL	Lake Adrian (upper end) (Station J)	S Br River Raisin at Island Park # (Station K)	S Br River Raisin near Heritage Park (Station L)	Beaver Creek near Heritage Park (Station M)	Field Blank	Field Replicate	RPD (%)
	Chloride FCV	mg/L	1	150	150		150	--	150	
	Chloride AMV	mg/L	1	320	320		320	--	320	
	Chloride HNV	mg/L	1	ID	ID		ID	--	ID	
	Chloride HCV	mg/L	1	NA	NA		NA	--	NA	
Inorganics-Metals	Hardness - Calculated	mg/L	4.6	**280**	**320**		**360**	ND	**310**	3.2
Inorganics-Metals	Calcium	mg/L	1	**76**	**89**		**100**	ND	**87**	2.3
Inorganics-Metals	Magnesium	mg/L	0.5	**21**	**23**		**28**	ND	**23**	0.0
Inorganics-Metals	Barium	µg/L	5	**80** ‡	**67** ‡		**80** ‡	ND	**68** ‡	1.5
	Barium FCV	µg/L	5	1316	1516		1718	--	1466	
	Barium AMV	µg/L	5	3730	4299		4872	--	4156	
	Barium HNV(nd)	µg/L	5	470000	470000		470000	--	470000	
	Barium HNV(d)	µg/L	5	5800	5800		5800	--	5800	
	Barium HCV	µg/L	5	NA	NA		NA	--	NA	
Inorganics-Metals	Strontium	µg/L	5	**320** ‡	**410** ‡		**520** ‡	ND	**410** ‡	0.0
	Strontium FCV	µg/L	5	36000	36000		36000	--	36000	
	Strontium AMV	µg/L	5	40000	40000		40000	--	40000	
	Strontium HNV	µg/L	5	ID	ID		ID	--	ID	
	Strontium HCV	µg/L	5	NA	NA		NA	--	NA	
QA Sample Site Name								**Beaver Creek (Station M)**	**Beaver Creek (Station M)**	
LAB ID				1807370-03	1807370-01	1807370-04	1807370-02	1807370-05	1807370-06	
DATE SAMPLED				**7/25/2018**	**7/25/2018**	**7/25/2018**	**7/25/2018**	**7/25/2018**	**7/25/2018**	
DATE RECEIVED				7/27/2018	7/27/2018	7/27/2018	7/27/2018	7/27/2018	7/27/2018	
Organics-Volatiles	Methyltertiarybutylether	µg/L	0.95	ND	ND	ND	ND	ND	ND	**

General Method	Analyte (and WQS, where applicable)	Units	RL	Lake Adrian (upper end) (Station J)	S Br River Raisin at Island Park # (Station K)	S Br River Raisin near Heritage Park (Station L)	Beaver Creek near Heritage Park (Station M)	Field Blank	Field Replicate	RPD (%)
Organics-Volatiles	Benzene	µg/L	0.9	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	Toluene	µg/L	0.95	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	Ethylbenzene	µg/L	0.95	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	m & p - Xylene	µg/L	1.8	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	o-Xylene	µg/L	0.95	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	1,3,5-Trimethylbenzene	µg/L	0.95	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	1,2,4-Trimethylbenzene	µg/L	0.95	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	1,2,3-Trimethylbenzene	µg/L	0.95	ND	ND	ND	ND	ND	ND	**
Inorganics-General Chem	Chloride	mg/L	1	**48** ‡	**60** ‡	**100** ‡	**31** ‡	ND	**31** ‡	0.0
	Chloride FCV	mg/L	1	150	150	150	150	--	150	
	Chloride AMV	mg/L	1	320	320	320	320	--	320	
	Chloride HNV	mg/L	1	ID	ID	ID	ID	--	ID	
	Chloride HCV	mg/L	1	NA	NA	NA	NA	--	NA	
Inorganics-Metals	Hardness - Calculated	mg/L	4.6	**300**	**350**	**330**	**370**	ND	**370**	0.0
Inorganics-Metals	Calcium	mg/L	1	**76**	**95**	**87**	**98**	ND	**98**	0.0
Inorganics-Metals	Magnesium	mg/L	0.5	**27**	**27**	**27**	**31**	ND	**31**	0.0
Inorganics-Metals	Barium	µg/L	5	**76** ‡	**70** ‡	**58** ‡	**93** ‡	ND	**91** ‡	2.2
	Barium FCV	µg/L	5	1416	1668	1567	1769	--	1769	
	Barium AMV	µg/L	5	4014	4728	4442	5016	--	5016	
	Barium HNV(nd)	µg/L	5	470000	470000	470000	470000	--	470000	
	Barium HNV(d)	µg/L	5	5800	5800	5800	5800	--	5800	
	Barium HCV	µg/L	5	NA	NA	NA	NA	--	NA	

General Method	Analyte (and WQS, where applicable)	Units	RL	Lake Adrian (upper end) (Station J)	S Br River Raisin at Island Park # (Station K)	S Br River Raisin near Heritage Park (Station L)	Beaver Creek near Heritage Park (Station M)	Field Blank	Field Replicate	RPD (%)
Inorganics-Metals	Strontium	µg/L	5	**470** ‡	**500** ‡	**520** ‡	**610** ‡	ND	**610** ‡	0.0
	Strontium FCV	µg/L	5	36000	36000	36000	36000	--	36000	
	Strontium AMV	µg/L	5	40000	40000	40000	40000	--	40000	
	Strontium HNV	µg/L	5	ID	ID	ID	ID	--	ID	
	Strontium HCV	µg/L	5	NA	NA	NA	NA	--	NA	
QA Sample Site Name								**Beaver Creek (Station M)**	**Beaver Creek (Station M)**	
LAB ID				1811238-03	1811238-01	1811238-04	1811238-02	1811238-05	1811238-06	
DATE SAMPLED				**11/27/2018**	**11/27/2018**	**11/27/2018**	**11/27/2018**	**11/27/2018**	**11/27/2018**	
DATE RECEIVED				11/27/2018	11/27/2018	11/27/2018	11/27/2018	11/27/2018	11/27/2018	
Organics-Volatiles	Methyltertiarybutylether	µg/L	0.95	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	Benzene	µg/L	0.9	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	Toluene	µg/L	0.95	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	Ethylbenzene	µg/L	0.95	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	m & p - Xylene	µg/L	1.8	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	o-Xylene	µg/L	0.95	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	1,3,5-Trimethylbenzene	µg/L	0.95	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	1,2,4-Trimethylbenzene	µg/L	0.95	ND	ND	ND	ND	ND	ND	**
Organics-Volatiles	1,2,3-Trimethylbenzene	µg/L	0.95	ND	ND	ND	ND	ND	ND	**
Inorganics-General Chem	Chloride	mg/L	1	**33** ‡	**39** ‡	**44** ‡	**29** ‡	ND	**22** ‡	27.5
	Chloride FCV	mg/L	1	150	150	150	150	--	150	
	Chloride AMV	mg/L	1	320	320	320	320	--	320	

General Method	Analyte (and WQS, where applicable)	Units	RL	Lake Adrian (upper end) (Station J)	S Br River Raisin at Island Park # (Station K)	S Br River Raisin near Heritage Park (Station L)	Beaver Creek near Heritage Park (Station M)	Field Blank	Field Replicate	RPD (%)
	Chloride HNV	mg/L	1	ID	ID	ID	ID	--	ID	
	Chloride HCV	mg/L	1	NA	NA	NA	NA	--	NA	
Inorganics-Metals	Hardness - Calculated	mg/L	4.6	**220**	**260**	**260**	**240**	ND	**240**	0.0
Inorganics-Metals	Calcium	mg/L	1	**62**	**72**	**73**	**65**	ND	**65**	0.0
Inorganics-Metals	Magnesium	mg/L	0.5	**17**	**18**	**18**	**18**	ND	**18**	0.0
Inorganics-Metals	Barium	µg/L	5	**67** ‡	**69** ‡	**63** ‡	**54** ‡	ND	**57** ‡	5.4
	Barium FCV	µg/L	5	1018	1216	1216	1117	--	1117	
	Barium AMV	µg/L	5	2886	3447	3447	3166	--	3166	
	Barium HNV(nd)	µg/L	5	470000	470000	470000	470000	--	470000	
	Barium HNV(d)	µg/L	5	5800	5800	5800	5800	--	5800	
	Barium HCV	µg/L	5	NA	NA	NA	NA	--	NA	
Inorganics-Metals	Strontium	µg/L	5	**170** ‡	**250** ‡	**260** ‡	**190** ‡	ND	**200** ‡	5.1
	Strontium FCV	µg/L	5	36000	36000	36000	36000	--	36000	
	Strontium AMV	µg/L	5	40000	40000	40000	40000	--	40000	
	Strontium HNV	µg/L	5	ID	ID	ID	ID	--	ID	
	Strontium HCV	µg/L	5	NA	NA	NA	NA	--	NA	

Abbreviations, Definitions, and Notes:

* The Rule 57 Web page.
** RPD could not be computed in situations where at least one of the values was non-detect (ND).
*** The FCV and AMV WQS values for total (not dissolved) forms of the various trace metals are listed here.
Note that to truly assess WQS, at least 4 water samples need to be collected within a 1-year period.
WQS values (as of February 1, 2020) mentioned here are for reference purposes only.
Refer to Chapter 3 (Assessment Methodology) of the Integrated Report for more information.

	Michigan's Rule 57 Water Quality Values (e.g., FCVs, AMVs).
AMV	Aquatic Maximum Value (in most cases, 1/2 of the Final Acute Value [FAV]) (an aquatic life value).
FCV	Final Chronic Value (an aquatic life value).
HCV	Human Cancer Values (a human health value).
HNV(nd)	Human Noncancer Value (Non-Drink Value) (a human health value).
HNV(d)	Human Noncancer Value (Drink Value) (a human health value).
ID	Insufficient Data to derive value (per Rule 57 table, August 1, 2019 version).
ND	Indicates compound analyzed for, but Not Detected.
RL	Reporting Limit.
RPD	Relative Percent Difference (comparing "normal" [original] sample with "field replicate").
#	Water sampling done below Island Park footbridge (near Mill Road), ~ 0.2 miles upstream biosurvey location (STORET #460467).

APPENDIX E. Supplemental Information Related to Targeted Monitoring Requests (Petroleum Concerns [Beaver Creek, South Branch River Raisin, and Lake Adrian]): Contaminants Commonly Associated with Petroleum Spills and Leaks and Typical Background Concentrations of Trace Metals Such as Barium and Strontium

Barium, Strontium, and Chloride

In the present study of the South Branch River Raisin and some tributary waters in the vicinity of Adrian, Michigan, lab analyses detected barium, strontium, and chloride in the following ranges:

- Barium, ranging from 54 to 93 µg/L
- Strontium, ranging from 170 to 610 µg/L
- Chloride, ranging from 27 to 100 mg/L

Some ranges of constituents such as barium and strontium associated with fossil fuel extraction can be found in the literature; however, they are not easily compared against the surface water (e.g., river or lake) data that was collected for this study. For example, reported concentrations of metals and metalloids from produced water from unconventional reservoirs (including shale and tight formations) are listed in a 2016 USEPA document (USEPA, 2016c).

Some limited information regarding these parameters in surface waters is presented below. Included in the discussion is a quick analysis (minimum, median, maximum values) (see Table E-1) of USGS-collected raw Michigan streams data, which was downloaded from the USGS's National Water Information System

Table E-1. Summary descriptive statistics (minimum, median, maximum values) of USGS-collected, raw, Michigan streams data (1969-2019), which was downloaded from the USGS's National Water Information System..

Parameter	Minimum (µg/L)	Median (µg/L)	Maximum (µg/L)	Sample Size
Barium	Non-Detect	24	300	1918
Strontium	Non-Detect	130	770	1380

Barium

Barium was found in 99.4 percent of the surface water samples taken from 130 sites located across the United States examined by Kopp and Kroner (1967), with a range of 2-340 µg/L and an average of 43 µg/L. A review of the literature by ATSDR (2007) determined that barium had been found in almost all raw surface waters and public

drinking water supplies sampled (i.e., approximately 99 percent) at concentrations ranging from ≤ 5 to 15,000 µg/L, with *mean* concentrations generally on the order of 10-60 µg/L. Research found that groundwater wells in Texas near (i.e., ≤ 750 meters) brine injection, dry, or plugged gas/oil wells had barium that ranged in concentration from 1.2 to 2,300 µg/L. Barium compounds occur naturally and also are widely used in oil well drilling muds; steel, rubber and plastic products, glass/ceramics, chemical, and pyrotechnics industries; insecticides; and as a smoke suppressant in diesel fuels (ATSDR, 2007).

Strontium

Surveys of strontium in surface waters and municipal water supplies across the United States found that strontium is present in nearly all fresh waters (ATSDR, 2004; USGS, 1963). According to the data of USGS (1963), which sampled (once or a few times each) 75 major rivers and streams across the United States, strontium values ranged from 0.007-13.7 mg/L (7-13,700 µg/L). Strontium concentrations in some areas of the United States (including the upper Great Lakes region [e.g., the Escanaba River, Ford River, Muskegon River, Ontonagon River, Pine River, and Shiawassee River, which were all sampled in January 1960]) generally were < 0.5 mg/L (500 µg/L). The Maumee River in Ohio ranged from 0.44-1.0 mg/L (440-1,000 µg/L) (sampling in April and June 1958) (USGS, 1963). An analysis of a United States surface waters and public water supplies database found an average of 1.10 mg/L (1,100 µg/L) (range: 0.2-3.68 mg/L [200-3,680 µg /L]) (ATSDR, 2004).

Chloride

Chloride is a common chemical constituent of most natural waters (Granato et al., 2015). Values measured by Michigan's WCMP of numerous streams and rivers across the state, located in many kinds of geological settings, were found to range between rare non-detects up to 987 mg/L, with a statewide median of all their sites being 17 mg/L (unpublished data; see also Schoen et al, 2019). In an analysis of 100 streams or rivers in the glaciated region of the northern United States, the USGS found that urban streams generally had the highest chloride concentrations relative to agriculture- or forest-dominated areas (Mullaney et al., 2009).

Petroleum Spill Case Study: Blacktail Creek, North Dakota

In 2015 oil leaked from a pipeline and spilled into Blacktail Creek, North Dakota. One month later, locations downstream of the spill had higher concentrations of barium and strontium. *Barium* concentrations were as high as 0.078 mg/L [78 µg/L] downstream of the spill compared with < 0.034 mg/L [34 µg/L] at sites upstream of the spill. *Strontium* concentrations were as high as 7.1 mg/L [7,100 µg/L] downstream compared with < 1.0 mg/L [1,000 µg/L] at sites upstream of the spill site. Other parameters that were elevated downstream of the spill relative to upstream of the spill (a month after the spill occurred) included chloride (1,030 mg/L), bromide (7.8 mg/L), lithium (0.25 mg/L), and boron (1.75 mg/L) (Cozzarelli et al., 2017).

BTEX

For reference, average, minimum, and maximum concentrations of select organic parameters (including BTEX) in produced water from unconventional reservoirs (e.g., Barnett and Marcellus shale) can be found in USEPA (2016c), though note that the predominant shale formation in the Michigan Basin is the Antrim Shale (Dobson and Houseworth, 2013) and that testing done for the present biosurvey report was done in open surface waters, so comparisons are difficult.